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THE ENERGY CHALLENGE

Budgets Falling in Race to Fight Global Warming

By ANDREW C. REVKIN

DENVER — Cheers fit for a revival meeting swept a hotel ballroom as 1,800 entrepreneurs and experts watched a PowerPoint presentation of the most promising technologies for limiting global warming: solar power, wind, ethanol and other farmed fuels, energy-efficient buildings and fuel-sipping cars.

“Houston,” Charles F. Kutscher, chairman of the Solar 2006 conference, concluded in a twist on the line from the movie “Apollo 13,” “we have a solution.”

Hold the applause. For all the enthusiasm about alternatives to coal and oil, the challenge of limiting emissions of carbon dioxide, which traps heat, will be immense in a world likely to add 2.5 billion people by midcentury, a host of other experts say. Moreover, most of those people will live in countries like China and India, which are just beginning to enjoy an electrified, air-conditioned mobile society.

The challenge is all the more daunting because research into energy technologies by both government and industry has not been rising, but rather falling.

In the United States, annual federal spending for all energy research and development — not just the research aimed at climate-friendly technologies — is less than half what it was a quarter-century ago. It has sunk to $3 billion a year in the current budget from an inflation-adjusted peak of $7.7 billion in 1979, according to several different studies.

Britain, for one, has sounded a loud alarm about the need for prompt action on the climate issue, including more research. [A report commissioned by the British government and scheduled to be released today calls for spending to be doubled worldwide on research into low-carbon technologies; without it, the report says, coastal flooding and a shortage of drinking water could turn 200 million people into refugees.]

President Bush has sought an increase to $4.2 billion for 2007, but that would still be a small fraction of what most climate and energy experts say would be needed.

Federal spending on medical research, by contrast, has nearly quadrupled, to $28 billion annually, since 1979. Military research has increased 260 percent, and at more than $75 billion a year is 20 times the amount spent on energy research.

Internationally, government energy research trends are little different from those in the United States. Japan is the only economic power that increased research spending in recent decades, with growth focused on efficiency and solar technology, according to the International Energy Agency.

In the private sector, studies show that energy companies have a long tradition of eschewing long-term technology quests because of the lack of short-term payoffs.

Still, more than four dozen scientists, economists, engineers and entrepreneurs interviewed by The New York Times said that unless the search for abundant non-polluting energy sources and systems became far more aggressive, the world would probably face dangerous warming and international strife as nations with growing energy demands compete for increasingly inadequate resources.

Most of these experts also say existing energy alternatives and improvements in energy efficiency are simply not enough.

“We cannot come close to stabilizing temperatures” unless humans, by the end of the century, stop adding more CO2 to the atmosphere than it can absorb, said W. David Montgomery of Charles River Associates, a consulting group, “and that will be an economic impossibility without a major R.& D. investment.”

A sustained push is needed not just to refine, test and deploy known low-carbon technologies, but also to find “energy technologies that don’t have a name yet,” said James A. Edmonds, a chief scientist at the Joint Global Change Research Institute of the University of Maryland and the Energy Department.

At the same time, many energy experts and economists agree on another daunting point: To make any resulting “alternative” energy options the new norm will require attaching a significant cost to the carbon emissions from coal, oil and gas.

“A price incentive stirs people to look at a thousand different things,’ ” said Henry D. Jacoby, a climate and energy expert at the Massachusetts Institute of Technology.

For now, a carbon cap or tax is opposed by President Bush, most American lawmakers and

many industries. And there are scant signs of consensus on a long-term successor to the Kyoto Protocol, the first treaty obligating participating industrial countries to cut warming emissions. (The United States has not ratified the pact.)

The next round of talks on Kyoto and an underlying voluntary treaty will take place next month in Nairobi, Kenya.

Environmental campaigners, focused on promptly establishing binding limits on emissions of heat-trapping gases, have tended to play down the need for big investments seeking energy breakthroughs. At the end of "An Inconvenient Truth," former Vice President Al Gore's documentary film on climate change, he concluded: "We already know everything we need to know to effectively address this problem."

While applauding Mr. Gore's enthusiasm, many energy experts said this stance was counterproductive because there was no way, given global growth in energy demand, that existing technology could avert a doubling or more of atmospheric concentrations of carbon dioxide in this century.

Mr. Gore has since adjusted his stance, saying existing technology is sufficient to start on the path to a stable climate.

Other researchers say the chances of success are so low, unless something breaks the societal impasse, that any technology quest should also include work on increasing the resilience to climate extremes — through actions like developing more drought-tolerant crops — as well as last-ditch climate fixes, like testing ways to block some incoming sunlight to counter warming.

Without big reductions in emissions, the midrange projections of most scenarios envision a rise of 4 degrees or so in this century, four times the warming in the last 100 years. That could, among other effects, produce a disruptive mix of intensified flooding and withering droughts in the world's prime agricultural regions.

Sir Nicholas Stern, the chief of Britain's economic service and author of the new government report on climate options, has summarized the cumulative nature of the threat succinctly: "The sting is in the tail."

The Carbon Dioxide Problem

Many factors intersect to make the prompt addressing of global warming very difficult, experts say.

A central hurdle is that carbon dioxide accumulates in the atmosphere like unpaid credit card debt as long as emissions exceed the rate at which the gas is naturally removed from the atmosphere by the oceans and plants. But the technologies producing the emissions evolve slowly.

A typical new coal-fired power plant, one of the largest sources of emissions, is expected to operate for many decades. About one large coal-burning plant is being commissioned a week, mostly in China.

“We’ve got a $12 trillion capital investment in the world energy economy and a turnover time of 30 to 40 years,” said John P. Holdren, a physicist and climate expert at Harvard University and president of the American Association for the Advancement of Science. “If you want it to look different in 30 or 40 years, you’d better start now.”

Many experts say this means the only way to affordably speed the transition to low-emissions energy is with advances in technologies at all stages of maturity.

Examples include:

¶ Substantially improving the efficiency and cost of solar panels;

¶ Conducting full-scale tests of systems for capturing carbon dioxide from power plants and pumping it underground;

¶ Seeking efficient ways to generate fuels from crops;

¶ Finding new ways to store vast amounts of energy harvested intermittently from the wind and sun.

Carbon dioxide levels will stabilize only if each generation persists in developing and deploying alternatives to unfettered fossil-fuel emissions, said Robert H. Socolow, a physicist and co-director of a Princeton “carbon mitigation initiative” created with $20 million from BP and Ford Motor.

The most immediate gains could come simply by increasing energy efficiency. If efficiency gains in transportation, buildings, power transmission and other areas were doubled from the longstanding rate of 1 percent per year to 2 percent, Dr. Holdren wrote in the M.I.T. journal Innovations earlier this year, that could hold the amount of new nonpolluting energy required by 2100 to the amount derived from fossil fuels in 2000 —a huge challenge, but not impossible.

Another area requiring immediate intensified work, Dr. Holdren and other experts say, is large-scale demonstration of systems for capturing carbon dioxide from coal burning before too many old-style plants are built.

All of the components for capturing carbon dioxide and disposing of it underground are already in use, particularly in oil fields, where pressurized carbon dioxide is used to drive the last dregs of oil from the ground.

In this area, said David Keith, an energy expert at the University of Calgary, "We just need to build the damn things on a billion-dollar scale."

In the United States, the biggest effort along these lines is the 285-megawatt Futuregen power plant planned by the Energy Department, along with private and international partners, that was announced in 2003 by President Bush and is scheduled to be built in either Illinois or Texas by 2012. James L. Connaughton, the chairman of the White House Council on Environmental Quality, said the Bush administration was making this a high priority.

"We share the view that a significantly more aggressive agenda on carbon capture and storage and zero-pollution coal is necessary," he said, adding that the administration has raised annual spending on storage options "from essentially zero to over $70 million."

Europe is pursuing a suite of such plants, including one in China, but also well behind the necessary pace, several experts said.

Even within the Energy Department, some experts are voicing frustration over the pace of such programs. "What I don't like about Futuregen," said Dr. Kutscher, an engineer at the National Renewable Energy Laboratory in Golden, Colo., "is the word 'future' in there."

Beyond a Holding Action

No matter what happens in the next decade or so, many experts say, the second and probably hardest phase of stabilizing the level of carbon dioxide will fall to the generation of engineers and entrepreneurs now in diapers, and the one after that. And those innovators will not have much to build on without greatly increased investment now in basic research.

There is plenty of ferment. Current research ranges from work on algae strains that can turn sunlight into hydrogen fuel to the inkjet-style printing of photovoltaic cells — a technique that could greatly cut solar-energy costs if it worked on a large scale. One company is promoting high-flying kite-like windmills to harvest the boundless energy in the jet stream.

But all of the small-scale experimentation will never move into the energy marketplace without a much bigger push not only for research and development, but for the lesser-known steps known as demonstration and deployment.

In this arena, there is a vital role for government spending, many experts agree, particularly on "enabling technologies" — innovations that would never be pursued by private industry because they mainly amount to a public good, not a potential source of profit, said Christopher Green, an economist at McGill University.

Examples include refining ways to securely handle radioactive waste from nuclear reactors; testing repositories for carbon dioxide captured at power plants; and, perhaps more important, improving the electricity grid so that it can manage large flows from intermittent sources like windmills and solar panels.

"Without storage possibilities on a large scale," Mr. Green said, "solar and wind will be relegated to niche status."

While private investors and entrepreneurs are jumping into alternative energy projects, they cannot be counted on to solve such problems, economists say, because even the most aggressive venture capitalists want a big payback within five years.

Many scientists say the only real long-term prospect for significantly substituting for fossil fuels is a breakthrough in harvesting solar power. This has been understood since the days of Thomas Edison. In a conversation with Henry Ford and the tire tycoon Harvey Firestone in 1931, shortly before Edison died, he said: "I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."

California, following models set in Japan and Germany, is trying to help solar energy with various incentives.

But such initiatives mainly pull existing technologies into the market, experts say, and do little to propel private research toward the next big advances.

The Role of Leadership

At the federal level, the Bush administration was criticized by Republican and Democratic lawmakers at several recent hearings on climate change.

Mr. Connaughton, the lead White House official on the environment, said most critics are not aware of how much has been done.

“This administration has developed the most sophisticated and carefully considered strategic plan for advancing the technologies that are a necessary part of the climate solution,” he said. He added that the administration must weigh tradeoffs with other pressing demands like health care.

Since 2001, when Mr. Bush abandoned a campaign pledge to limit carbon dioxide from power plants, he has said that too little is known about specific dangers of global warming to justify hard targets or mandatory curbs for the gas.

He has also asserted that any solution will lie less in regulation than in innovation.

“My answer to the energy question also is an answer to how you deal with the greenhouse-gas issue, and that is new technologies will change how we live,” he said in May.

But critics, including some Republican lawmakers, now say that mounting evidence for risks — including findings that administration officials have tried to suppress of late — justifies prompt, more aggressive action to pay for or spur research and speed the movement of climate-friendly energy options into the marketplace.

Martin I. Hoffert, an emeritus professor of physics at New York University, said that what was needed was for a leader to articulate the energy challenge as President John F. Kennedy made his case for the mission to the moon. President Kennedy said his space goals were imperative, “not because they are easy, but because they are hard.”

In a report on competitiveness and research released last year, the National Academies, the country’s top science advisory body, urged the government to substantially expand spending on long-term basic research, particularly on energy.

The report, titled “Rising Above the Gathering Storm,” recommended that the Energy Department create a research-financing body similar to the 48-year-old Defense Advanced Research Projects Agency, or Darpa, to make grants and attack a variety of energy questions, including climate change.

Darpa, created after the Soviet Union launched Sputnik in 1957, was set up outside the sway of Congress to provide advances in areas like weapons, surveillance and defensive systems. But it also produced technologies like the Internet and the global positioning system for navigation.

Mr. Connaughton said it would be premature to conclude that a new agency was needed for energy innovation.

But many experts, from oil-industry officials to ecologists, agree that the status quo for energy research will not suffice.

The benefits of an intensified energy quest would go far beyond cutting the risks of dangerous climate change, said Roger H. Bezdek, an economist at Management Information Systems, a consulting group.

The world economy, he said, is facing two simultaneous energy challenges beyond global warming: the end of relatively cheap and easy oil, and the explosive demand for fuel in developing countries.

Advanced research should be diversified like an investment portfolio, he said. “The big payoff comes from a small number of very large winners,” he said. “Unfortunately, we cannot pick the winners in advance.”

Ultimately, a big increase in government spending on basic energy research will happen only if scientists can persuade the public and politicians that it is an essential hedge against potential calamity.

That may be the biggest hurdle of all, given the unfamiliar nature of the slowly building problem — the antithesis of epochal events like Pearl Harbor, Sputnik and 9/11 that triggered sweeping enterprises.

“We’re good at rushing in with white hats,” said Bobi Garrett, associate director of planning and technology management at the National Renewable Energy Laboratory. “This is not a problem where you can do that.”