

NEWS

A Sustainable Future, If We Pay Up Front

The oil shocks of the 1970s sparked a short-lived golden age of energy R&D. Today's energy concerns haven't caused a similar bonanza, yet



IT'S BEEN A YEAR SINCE PRESIDENT GEORGE W. Bush called on researchers to help the United States shake off its "addiction" to oil and its reliance on foreign sources of energy. "By applying the talent and technology of America, this country can dramatically improve our environment, move beyond a petroleum-based economy, and make our dependence on Middle Eastern oil a thing of the past," he said. Since then, talk of breaking the petroleum habit has intensified. Political instability in key regions that supply oil and natural gas and oil prices near an all-time high have made energy the issue of the moment, with newspapers, magazines, and TV news programs extolling the virtues of rooftop solar cells, wind turbines, bio-fuels, and hybrid-energy cars.

All this is reminiscent of the late 1970s, when oil shocks prompted a surge of interest in alternatives to conventional sources of oil. But there are some significant differences. Today's concern is driven by worries about climate change in addition to fears of energy insecurity. And whereas the 1970s oil shocks prompted a gusher of new funding for energy-related R&D, this time around, research dollars—or euros—have yet to begin flowing in earnest. The science has also changed over the past quarter-century: Now geneticists and synthetic chemists are tweaking agricultural crops to make better liquid fuels; materials scientists are wringing more efficiency out of

photovoltaic cells; and computer modellers are redesigning nuclear reactors from the ground up. In the following news pages, we profile some of the people who are following these new paths in energy research.

Energy-policy experts and several recent studies agree that if we are to make any substantial change to our energy supply, huge increases in funding will be needed. But prospects for sharp increases in energy research seem unlikely. "There certainly should be [more funding]," says carbon sequestration expert Robert Socolow of Princeton University. Although there are some signs of new money in targeted areas of alternative-energy research both in the United States and elsewhere, "I don't see major increases because of the federal deficit," says physicist Ernest Moniz, an energy-policy specialist at the Massachusetts Institute of Technology in Cambridge and former undersecretary at the U.S. Department of Energy (DOE). "There are tough fiscal times ahead." Indeed, in the United States, the anticipated yearlong budget freeze could delay even some of the projects that have been tapped for increases (*Science*, 15 December 2006, p. 1666).

These dim funding prospects follow a period of relative decline in energy R&D. Paul Runci of the Pacific Northwest National Laboratory in Richland, Washington, pro-

duced an analysis last year of energy R&D investment in 11 nations that together provide 95% of the energy research funding in industrialized countries. Almost all of those countries steadily increased funding until the late 1970s to mid-1980s, when levels tapered off until the mid-1990s. They have remained largely stagnant ever since (see figure, p. 783). The biggest falls have been in funding of nuclear and fossil fuel R&D (see figure, p. 783). In some countries, fossil fuel research is less than 10% of what it was at the peak. The exception is Japan, which kept increasing funding until this decade. Runci blames this drop on a decade of low oil prices and oversupply, changing perceptions of nuclear power following the accidents at Three Mile Island in Pennsylvania and at Chernobyl, Ukraine, and public policies that have shifted R&D responsibility from the public to the private sector.

Industry has so far failed to take up the slack, while government money has dwindled. The U.S. energy industry is a factor of 10 below the average R&D intensity of American business. The shortage of both public and private funding is having a serious impact on new blood coming into this area of research. "Fields saturate [with older researchers]," says Socolow. "Energy keeps not getting enough new recruits."

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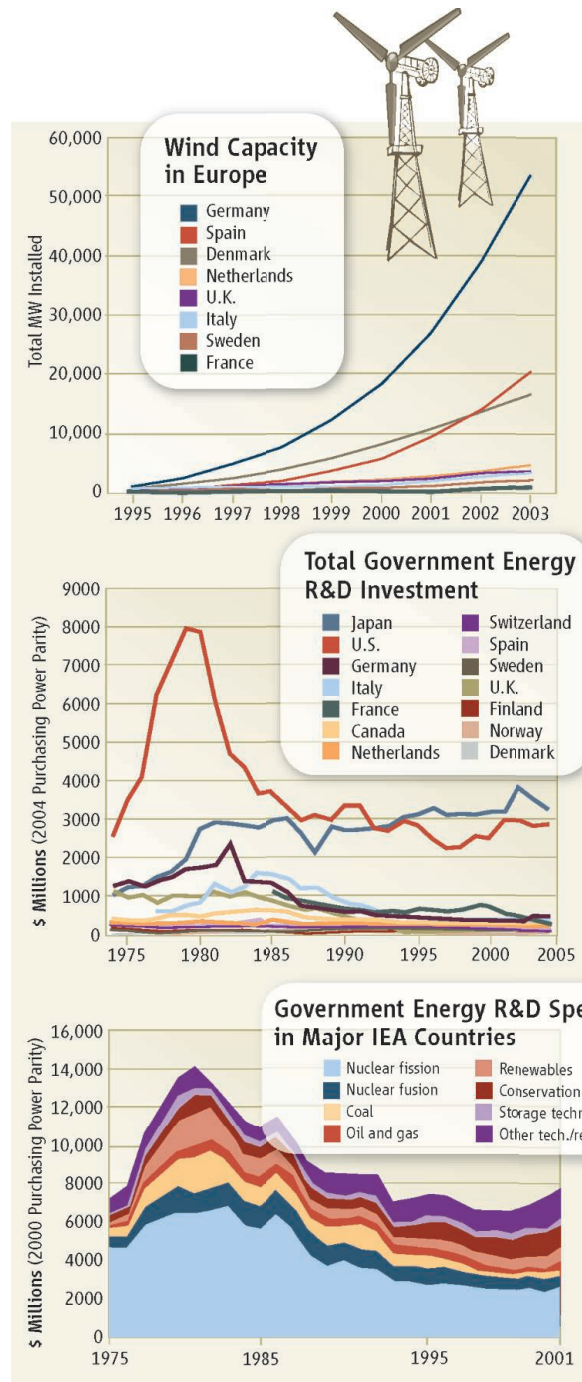
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There are some signs of a revival, however. Runci's report points to energy-conservation research, which grew strongly in the United States and Japan during the late 1990s and into this decade. Runci also singles out the growth of wind energy in Europe. Concern about carbon emissions and a desire to become world leaders in renewables technology spurred the European Union (E.U.) and some national governments to invest in wind energy R&D as well as provide subsidies and tax incentives to energy companies to set up wind farms. The result has been a phenomenal growth in installed wind capacity (see figure, top right) that is now equivalent to 50 coal-fired power stations. The E.U.'s renewables industry now has an annual turnover of \$20 billion, half the world market, and employs 300,000 people.

In his speech last year, Bush voiced new enthusiasm for novel forms of energy technology and announced the launch of his Advanced Energy Initiative. He subsequently proposed a 22% increase in DOE funding for clean energy technology in 2007, focusing on improving the efficiency of cars as well as expanding the use of biofuels and developing fuel cells, and on electricity-generating technologies including clean coal, advanced nuclear power, solar, and wind. These areas received \$1.7 billion in funding during 2006, but some may get caught in the anticipated budget freeze.

One of the most eagerly awaited DOE initiatives is a plan to build two new bioenergy research centers to carry out basic research on microbial and plant systems with the aim of converting inedible plant fibers such as cellulose into ethanol for biofuels. With \$125 million over 5 years on the table for each center, universities, national labs, and other institutions are vying to host them. A decision is expected in the summer. The oil company BP has launched a similar scheme, offering \$500 million over 10 years to an institution to run an Energy Biosciences Institute (see p. 790). A decision on the site—either in the United States or the United Kingdom—is expected by the time this issue is published. “We’ve come to realize that the intersection of biosciences and energy is a very powerful one,” says Steven Koonin, BP’s chief scientist.

The European Union is also backing new energy technologies. In the latest 7-year Framework research program—approved



late last year—\$1.5 billion will be spent on renewables and energy efficiency, an increase of 40% over the previous Framework program and more than 50% of all non-nuclear energy funding. In the United Kingdom, meanwhile, a government energy review completed last summer promised a National Institute for Energy Technologies, with a budget in the region of \$200 million per year.

All of these initiatives are giving energy research a much-needed shot in the arm, but a number of influential reports are calling for increases in energy R&D on an entirely different scale. The G8 meeting of world leaders at Gleneagles, U.K., in July 2005 called on the

International Energy Agency (IEA) to map out scenarios for a future clean energy supply. According to the IEA report, published last year, “there is an acute need to stabilize declining budgets for energy-related R&D and then increase them.” Nicholas Stern, a chief economic adviser to the U.K. government, was more specific. In his influential review on the economics of climate change published last October, he forecast that the impact of doing nothing to counter global warming could amount to between 5% and 20% of global gross domestic product, whereas efforts costing 1% of GDP could counter the worst effects. Those efforts would include at least doubling the current amount of energy R&D funding and a fivefold increase in support for the deployment of new technologies.

An ambitious report released in 2005 by the U.S. National Academies entitled *Rising Above the Gathering Storm* aimed to identify actions to help the United States compete and prosper in the 21st century. Among a number of recommendations, it advocated the creation of a new agency within DOE, akin to the Defense Advanced Research Projects Agency, to fund energy R&D. This new body, dubbed ARPA-E, should start with \$300 million a year and build up to \$1 billion annually over 5 or 6 years. A bill to set up ARPA-E was presented to Congress in December 2005 by Representative Bart Gordon (D-TN). Gordon, now the House science committee chair,

reintroduced the bill last month. Moniz says that research he and his colleagues have conducted for reports on the future of nuclear energy and coal also suggests that a doubling of research spending is necessary.

Ultimately, it will be politics at the highest level that will dictate the fate of energy research. If oil supplies are further threatened by geopolitics, or new evidence of human-induced climate change is sufficient to convince the skeptics, energy research may again prosper. But will it continue to do so if the price of oil later drops again? “That remains to be seen,” says Koonin.

—DANIEL CLERY