Science Policy and the Role of the National Laboratories

Robert W. Seidel

Federal science policy and funding have supported Los Alamos for fifty years. Now that the Cold War has ended, the Laboratory faces a dramatically different world. Government leaders either will set forth new missions for the Department of Energy (DOE) laboratories or will suffer their obsolescence. What is the future science policy of the United States? How will the national laboratories adapt to changing roles? An examination of the fortunes of science and technology in the United States in general, and in the Laboratory in particular, may help us to answer those questions.

Science and the Federal Government before World War II

Scientific activity is granted certain federal provisions in the United States. The Constitution provides for federal regulation of patents and trademarks, establishment of standard weights and measures, and promotion of science and useful arts. Before World War II, however, those powers were used sparingly. The progress of science was incidental to the pursuit of other national ends.

One such end was exploration. Lewis and Clark's overland expedition to the Pacific, for example, was supported with the aim of providing strategic, geographical, and scientific knowledge about the new nation. Charles Wilkes' nautical expedition to Antarctica and Pacific Islands from 1838 to 1842 helped to develop the nation's maritime economy. Those early expeditions incidentally enriched the nation's storehouse of scientific information. The American Philosophical Society of Philadelphia and the Smithsonian Institution were among the beneficiaries of that increase in scientific knowledge.

Another end that entailed scientific progress was national security. Scientific and technological education found a home in the military academies. West Point, modeled on the French military school *Ecole Polytechnique*, supplied the bulk of engineering talent for the country's canal and railroad systems in early 19th-century America. The Federal arsenals were also a seedbed for technological innovation. Eli Whitney's idea of using interchangeable parts in arms manufacture quickly spread to the manufacture of machine tools, pocket watches, agricultural implements, sewing machines, bicycles, and automobiles. The "American System of Manufactures," was an early, important, but by no means unique, example of technology transfer from the military to the civilian industrial sector.

The Civil War marked a turning point in federal science policy. The Morrill Land-Grant College Act initiated federal support for higher education and the Department of Agriculture, created in 1862, explicitly sponsored scientific research. The department developed programs related to the cure of plant diseases, introduced new crops, and established a system of agricultural experiment stations to promote scientific farming techniques. By World War I the Department of Agriculture had almost two thousand employees engaged in scientific research, far more than any other federal agency. On the eve of World War II, the department was the largest patron of scientific R&D in the federal government. Research flourished in conjunction with the primary economic activity of the nation.

In contrast to its contributions to agriculture, science as a whole had little to offer military and industrial technology. The National Academy of Sciences (NAS) was chartered in 1863 to advise the government on possible applications of science to war, but made no substantial contributions to the Civil War effort. The growing industrial enterprises of the nation supported their own research; laissez faire economics did not endorse government intervention in industrial development. Thomas Edison's small laboratory at Menlo Park, Standard Oil of New Jersey's petroleum research, and Alexander Graham Bell's work on the telephone were all forerunners of industrial research laboratories and instruments of monopolies that resisted any attempts at government interference.

The federal agencies created in the 19th century supported science unevenly. No overall science policy governed the work of those agencies. A proposal made in 1884 to establish a federal department of science won no support from Congress. The nation's patronage of science was shaped by the exigencies of settling a continent, preparing for war, supporting agriculture, and extending commerce.

That fragmented national science policy began to change at the turn of the century. By that time, the growth of American manufactures had created a pressing need for standardized weights and measures. Consequently, in emulation of other industrialized powers, Congress created the National Bureau of Standards (NBS) in 1901. The NBS brought science to bear on some new technologies of the industrial revolution.

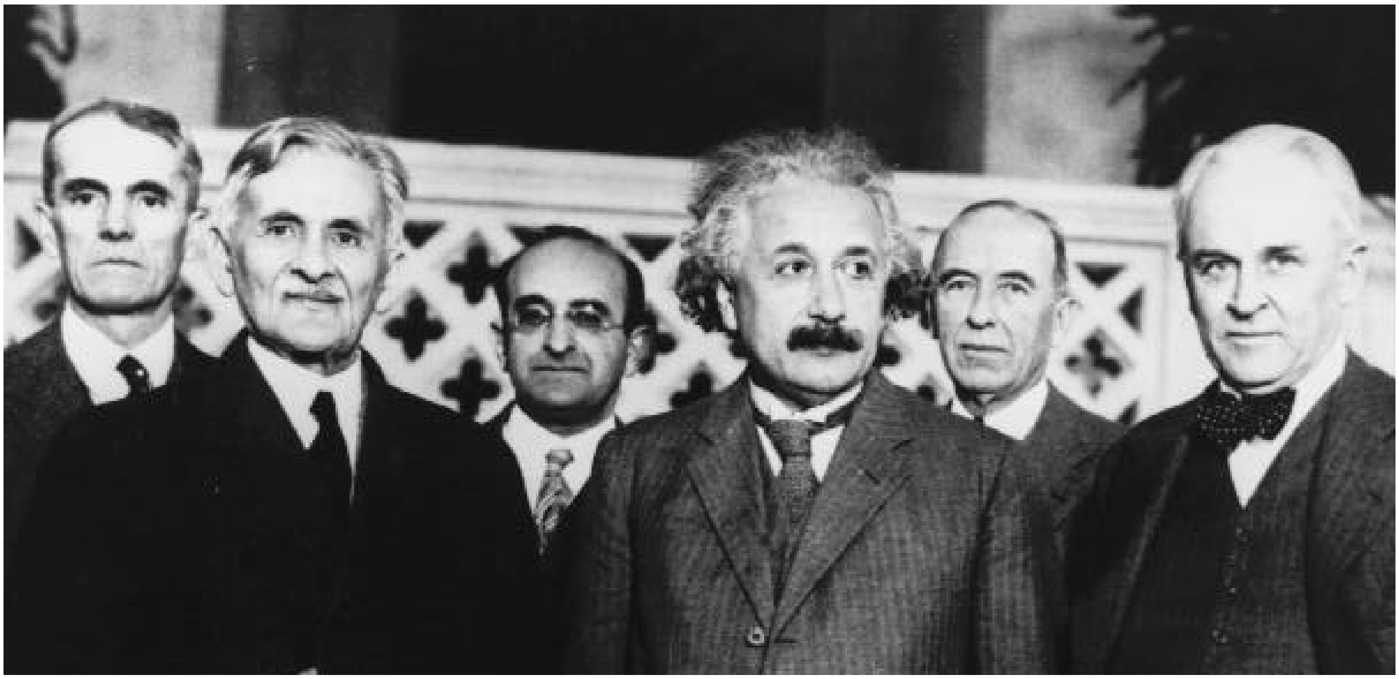
Federal scientific research expanded with American entry into World War I. The NBS undertook research in aeronautical engineering, optics, radio, and armaments design. In addition, the National Academy of Sciences mobilized university research through its National Research Council (NRC) which investigated problems related to sonar, artillery range-finding, and chemical warfare. The Army's Chemical Warfare Service gave academic chemists particular prominence. A Naval Consulting Board led by Thomas Edison recommended the formation of the Naval Research Laboratory (NRL) which transformed a service traditionally reluctant to develop new technologies into an active promoter of research. Although isolationism and the Great Depression reduced both interest in and funding for military R&D, the War and Navy departments, on the eve of World War II, accounted for approximately one-fifth of federal research expenditure.

Eli Whitney first proposed the principle of interchangeable parts in gun manufacture to President Thomas Jefferson early in the 19th century. That technique, developed in Federal armories, was transferred to many other industries.

Science at War

Science was mobilized during World War II in an unprecedented way. The war spawned a large defense research establishment to develop radar, the atomic bomb, and other defense technologies. That infrastructure persisted after the war. Thousands of government and federal contract laboratories, including the national laboratories of the Department of Energy (DOE), were legacies of the wartime mobilization of science. New alliances between the military and academia, and new ways of making national science policies were additional legacies.

The mobilization began in 1939. President Franklin Delano Roosevelt created a "Uranium Project" after



America's first generation of scientific statesmen are pictured here at the California Institute of Technology in about 1930. Albert A. Michelson (left) measured the speed of light, Albert Einstein (center) conceived of the theory of relativity, and Robert A. Millikan (right) led Caltech to the front rank of technical schools. All three men were Noble Laureates in Physics and greatly assisted in the rise of the United States to a world leadership position in science.

The leaders of the wartime mobilization of science are shown here at the Berkeley Radiation Laboratory in 1940. Shown from left to right is Ernest O. Lawrence, leader of the electromagnetic separation effort, Arthur H. Compton, leader of the reactor development effort, Vannevar Bush, leader of the early phases of the Uranium Project, and James Bryant Conant, chief scientific advisor to (?). Also present in the photo are Karl T. Compton, President of MIT, and Alfred T. Loomis, who oversaw the radar research effort.

being alerted by Albert Einstein to the threat posed by Nazi acquisition of heavy water and uranium. The Project was led by NBS Director Lyman Briggs and was designed to investigate nuclear fission.

American defense research proceeded slowly until Vannevar Bush founded the National Defense Research Committee (NDRC) and the Office of Scientific Research and Development (OSRD) which consolidated the research being conducted in universities and in government bureaus. Under contract to those agencies, civilian scientists worked at academic laboratories to perfect radar, sonar, and other defense technologies.

Vannevar Bush recognized that the development of nuclear weapons required a much larger effort. In late 1942, President Roosevelt, spurred on by Bush, decided to pursue nuclear weapons on a high-priority basis. The Army's Manhattan Engineer District (MED) constructed plants at Oak Ridge, Tennessee, and Hanford, Washington, to produce enriched uranium and plutonium to fuel the weapons. Several universities operated the research laboratories supporting that effort, including the new weapons laboratory at Los Alamos. This new "partnership" between the military and university laboratories, in which the universities themselves were hardly knowledgeable, was to become an enduring fixture of the scientific landscape. Secrecy precluded ordinary democratic decision-making as well as academic participation in research policy making. Billions of dollars were spent, and research policies formulated without any substantial knowledge in the Congress as to the nature of the project. Decisions were made by a Top Policy Committee which included Secretary of War Henry Stimson, MED Commander General Leslie Groves, and OSRD scientific leaders. Appropriations were cloaked in War Department budgets.

Although the secret policy carried the risk of failure and condemnation, Stimson and Groves successfully kept Congress in the dark until the atomic bomb was dropped on Hiroshima. The decision to end the war with nuclear weapons was also made in secret, despite agitation by Niels Bohr, Leo Szilard, James Franck, and other Manhattan Project scientists for a non-military demonstration of the weapon's power. Although the British were informed of American plans, French and Soviet allies were not told. Both nations accelerated their own atomic energy programs once they became aware of the American success, leading to the Cold War nuclear arms race.


An early postwar colloquium at the Laboratory saw a rare assemblage of wartime leaders. Left to right are Norris Bradbury, J. Robert Oppenheimer, John Manley, Richard Feynman, Enrico Fermi, and J. M. B. Kellogg.

Science in the Cold War

At the end of the war, Henry Stimson recommended that a new federal agency be set up to control nuclear research and Vannevar Bush, in his influential tract *Science, the Endless Frontier*, advised that a national foundation be established to support basic research. Extended Congressional debates, however, over the exact natures of those two agencies left federal patronage of science in the hands of the military immediately following the war.

MED Commander General Groves took advantage of that opportunity and founded “national laboratories” at Brookhaven, Argonne, and Oak Ridge, funded university laboratories, and built the first permanent facilities at Los Alamos. Basic research in nuclear physics and related fields was undertaken at those laboratories because the prewar stock of knowledge was thought to be exhausted and in need of replenishment, and because such a program of basic research was required to recruit and retain trained scientists.

The Atomic Energy Commission (AEC) took over the MED laboratory system in 1947. The AEC was a new experiment in American science policy—a single government bureau with virtually unlimited control over all nuclear energy R&D. The AEC's supervisory committee, the General Advisory Committee (GAC), included many representatives of AEC laboratories and provided guidance on research policies. Congressional oversight was provided by the Joint Committee on Atomic Energy (JCAE) which expedited appropriations for AEC programs. Despite civilian control of the nuclear research program, the military retained an interest in that research. After the war, in an attempt to gain a foothold in the field, the Navy founded the Office of Naval Research (ONR) to promote nuclear physics

In 1946 Norris Bradbury, General Leslie R. Groves, and Eric Jette (seated, left to right), Colonel L. E. Seeman, and E. E. Wilhoyt (standing, left to right) plan a new technical area for the Laboratory.

research in universities. In the absence of a national science foundation, the ONR played a major role in funding basic scientific research and established a pattern of extramural research support later followed by the Air Force and the Army.

Nuclear weapons were the most important of the AEC's interests. The Baruch Plan of 1946 sought to vest in the United Nations control of all nuclear weapons, but the Soviet Union resisted the Plan's provisions for inspections and resisted limits to the U.N. Security Council's veto in atomic energy matters. Meanwhile the Soviets pursued their own nuclear weapons program and, in 1949, exploded an atomic bomb. Three scientists who had been involved in the Manhattan Project––Edward Teller of Los Alamos, and Ernest Lawrence and Luis Alvarez of the University of California Radiation Laboratory––then lobbied the JCAE and the DOD to pursue the Super, or hydrogen bomb, against the advice of the GAC. In January, 1950, President Harry S. Truman decided to proceed with development of the Super.

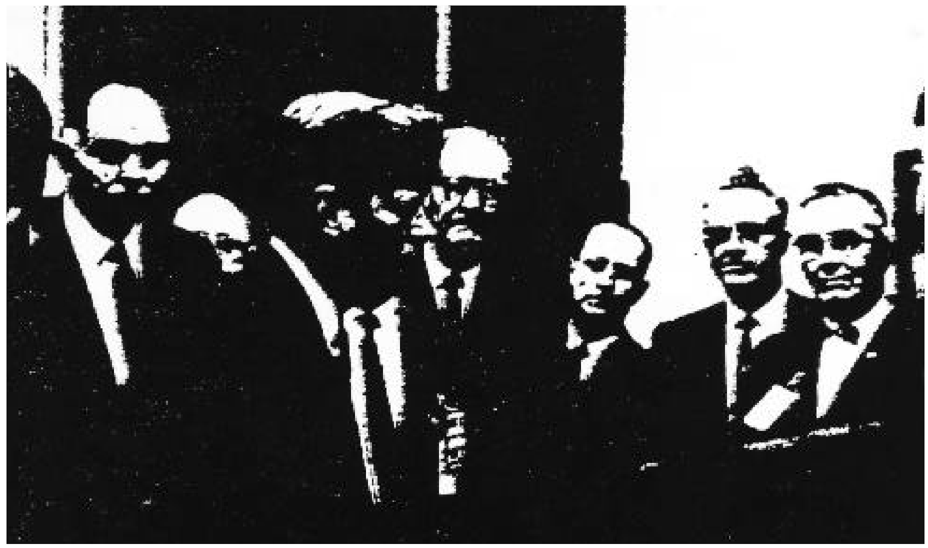
When the Laboratory failed to make what they considered to be adequate progress in developing the hydrogen bomb, Lawrence, Alvarez, and Teller created a second weapons laboratory, again in the face of GAC opposition. The Livermore branch of the Radiation Laboratory at the University of California quickly established itself as a competitor with Los Alamos in the development of innovative weapons concepts, although Los Alamos succeeded in producing the first thermonuclear weapons. Both of the AEC's weapons design laboratories were operated by the University of California. Sandia National Laboratory, which engineered nuclear weapons, was spun off by Los Alamos in 1949 and operated by AT&T thereafter. Originally constituted for the sole purpose of creating nuclear weapons, the laboratories were given new missions by the AEC that included nuclear propulsion studies, biomedical studies of radiation, peaceful applications of nuclear explosives, and development of reactors.

The AEC had few rivals as a supporter of basic scientific research. The AEC's support even dwarfed that of the agency supposedly responsible for supporting basic research, the National Science Foundation (NSF). Vannevar Bush's proposal for such a foundation had languished in Congress during the first half-decade after World War II. When the NSF was finally established in 1950, the AEC and other federal bureaus had already assumed control of much of the basic scientific research that Bush had hoped the NSF might support. The NSF's first appropriation, $225,000, was only a miniscule fraction of the AEC's research budget. Rather than dominating government support for basic research, the NSF tried to fill in gaps left by programmatic agencies.

The remobilization of science following the detonation of the Soviet atomic bomb in 1949, the fall of China to Mao Tse-Tung's Communist forces in 19 **(?)**, and the start of the Korean War in 19 **(?)** led American companies to develop innovative technology to support DoD procurement contracts and the AEC's ambitious expansion program. The record of technology transfers to the civilian sector was not nearly as successful. The National Bureau of

Standards launched Project Tinkertoy, an advanced manufacturing process using modular assembly of ceramic wafers carrying printed circuits under the direction of a punched card computer. Attempts to transfer this technology to the civilian electronics industry failed, although it did inspire Jack Kilby of Texas Instruments to invent the integrated circuit. But theNBS, which lost four major divisions to the DOD in 1953 could not, like the DOD or the AEC, use the leverage of large defense contracts to push major industrial initiatives thereafter.

In the postwar period the AEC and the DOD dominated the patronage of science and technology, except for the life sciences, where the National Institutes of Health (NIH) held sway. Agencies conceived at the end of the war to support basic research received only a fraction of total funding. The mission-oriented agencies of the federal government supplied the bulk of federal money for research, and much of that research was done in government-owned, contractor-operated laboratories—including Los Alamos, Livermore, and Sandia laboratories. As “in-house” laboratories, they were in a good position to develop ties with industrial contractors supplying military needs, but were less effective in influencing the growth of civilian technologies.



On December 7, 1962, President John F. Kennedy visited Los Alamos after announcing the end of nuclear testing in the atmosphere. He is flanked by AEC Chairman Glenn T. Seaborg (left) and New Mexico Senator Clinton P. Anderson (right). A member of the Joint Committee on Atomic Energy (JCAE), Anderson championed Laboratory interests for many years.

Glenn T. Seaborg served as chairman of the AEC from 1961 to 1972. A strong advocate of nuclear power, he helped to redirect the national laboratories towards civilian technologies. Seaborg won the Nobel Prize in 1951 for the discovery of eight transuranic elements, including plutonium.

Science in the Space Age

The Russian launch of the Sputnik satellite in 1957 gave new impetus to scientific activity in the United States. The National Aeronautics and Space Administration (NASA) and the Defense Advanced Research Projects Agency (DARPA) were created in response to a perceived national deficit in science. The passage of the National Defense Education Act (NDEA) also helped to strengthen science education at many levels. Government programs to attract young people into science proliferated.

DARPA helped to put the Department of Defense at the forefront of high technology. The agency transcended the interservice rivalries that had persisted after World War II by funding research relevant to all the military services. Focusing on computer technology, materials science, nuclear test detection, semiconductor research, and other fields of advanced technology, the small DARPA staff stimulated industrial innovation through judicious funding of contract research. In addition, NASA spawned a series of civilian space projects that included Apollo—the program that put a manned rocket on the moon. That project mobilized American science and technology much as the MED had done during World War II.

Federal support for university research––including the granting of fellowships and the construction of new facilities—increased greatly during the space race, amounting to three-quarters of university research budgets and one-quarter of one percent of the U.S. Gross National Product by 1968. The National Defense Education Act provided $1 billion of support for graduate education; the budgets of the NIH, NSF, and NASA shot upwards and helped to support academic science. The expansion of those agencies between 1960 and 1970 sharply reduced the share of university research supported by DOD funding. The Mansfield Amendment, which passed during the Vietnam War, further limited the DOD's support to projects of demonstrable military interest.

The space race also had a great impact on the AEC laboratories. In 1961, when President John F. Kennedy announced the Apollo program, he also told of plans to develop a nuclear rocket which might take men to Mars or beyond. Project Rover—a program to design a nuclear-powered rocket—was begun as a cooperative venture between Los Alamos and the Air Force, and was later taken over by NASA. Los Alamos led the new research effort, while Aerojet General and Westinghouse Corporations cooperated in the engineering development of the project.

Although Los Alamos successfully developed suitable prototype reactors for nuclear pro-pulsion, the objectives of the Rover project were progressively scaled down by the President's Science Advisory Committee (PSAC), which Eisenhower had established in 1958. Concerned that there was no clearly defined mission for a nuclear-powered spacecraft, PSAC successfully lobbied to reduce Rover from a flight test to a research and technology program. The diminished Rover program continued until 1973. Other space programs at the Laboratory found more uses: heat pipes, radioisotopic generators, and Vela satellites (used to detect nuclear tests in the atmosphere and in space) were successful applications of space technologies.

The space program followed the pattern established in World War II and in the postwar arms race. Mission-oriented agencies were created to respond to an external threat by providing advanced scientific research and technological development in contractor-operated national laboratories of the DOD and the AEC. By making use of those laboratories, DARPA and NASA capitalized on the investment those agencies had made in the preceding generation. However, the rise of a new national challenge raised the question of whether the old ones had been satisfactorily met, and the institutions devised to meet them had been rendered obsolete.

Environment, Energy, and Antiscience

The publication of Rachel Carson's *Silent Spring* in 196 **(?)** and Ralph Nader's *Unsafe at any Speed* in 196 **(?)** and the general rise of an anti-science and technology movement heralded in Theodore Roszak's *The Making of a Counter Culture* in 196 **(?)** undermined the cultural and political consensus upon which the AEC and Department of Defense depended for support. The AEC had been in the ambivalent position of both generating and regulating nuclear power since its creation in 1946; radioactive fallout caused by nuclear-weapons tests in the 1950's made the agency a target of environmentalists. The Limited Test Ban Treaty of 196 **(?)**, which restricted nuclear tests to underground, relieved the pressure for a time, but the promotion of nuclear power by Glenn Seaborg and Dixie Lee Ray, successive chairmen of the AEC, created an industry which presented environmental hazards of its own. The energy crisis in the 1970s ended a ninety-year spiral of growth in American energy consumption that coincided with growing concerns about nuclear energy.

The Debate over the Role of the AEC Laboratories

Changes in the AEC's mission and the advent of the Limited Test Ban Treaty raised new questions as to the purposes and potential of the national laboratories. After the Atomic Energy Act of 1954 replaced the government nuclear power monopoly with a licensing regime for private industry to develop reactors, Oak Ridge and Argonne National Laboratories diversified into new fields such as high-energy physics. There was, however, a tendency for those laboratories to become job shops as they sought new work for industry and other governmental agencies to replace the reactor mission.

President Eisenhower's Atoms for Peace program, designed to explore peaceful international uses of atomic energy, and the Test Moratorium from 1958 to 1961 raised further questions about the future of Los Alamos and Livermore laboratories. A study by the Congress's Joint Committee of Atomic Energy in 1960 sought to redefine the role and missions of the national laboratories: Congress eventually expanded

Vice-President Hubert H. Humphrey visited the Laboratory on September 9, 1966, and discussed LAMPF with Norris Bradbury (center) and Louis Rosen (right). New Mexico Senator Clinton P. Anderson succeeded in winning appropriations for the facility despite opposition from the Johnson administration.

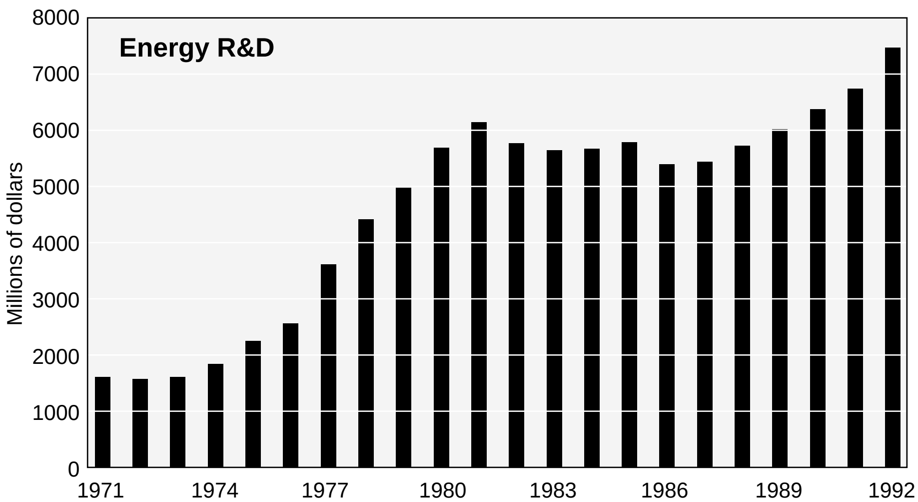
the laboratories' roles to include environmental and safety research, and non-nuclear energy R&D. Throughout the 1960's and 1970's, Congressional committees on science policy sought to redefine and extend the missions of the federal laboratories. However, the new programs that were generated accounted for only a small percentage of the laboratories' total budgets.

Problems in the nation's energy policy became apparent during the 1970s. By 1973 nuclear energy supplied only 1 percent of national needs. Demand for transportation fuels-–which had once been cheap, abundant, and readily supplied by foreign nations-– became acute. The Nixon Administration formulated a more comprehensive energy policy, which led to the absorption of the AEC into ERDA and ERDA into the DOE.

The national laboratories turned their attention to non-nuclear energy sources. At Los Alamos, for example, a broadening of energy-related research in the1970s spawned projects like Hot Dry Rock, a program to tap geothermal energy. Other projects involved research in solar energy and in superconducting electrical transmission and storage. The Laboratory also provided tools like crosswell seismic surveys and computer simulations of oil flow for the petroleum industry. The nation's search for energy independence, however, did not long survive the energy crisis.

Ronald Reagan campaigned on a platform of abolishing the DOE and, after his election, redirected the agency's efforts to deregulation, support for nuclear energy, and nuclear arms development. Although the Reagan administration did not destroy the DOE, it did undermine the department's morale. Morale in the laboratories rose, however, when President Reagan announced his Strategic Defense Initiative (SDI). Based in part upon work on neutral particle beam and rail-gun technologies undertaken at Los Alamos, SDI revived interest in anti-ballistic missile technologies which had been for the most part shelved after the Anti Ballistic Missile Treaty of 1972. In response to Reagan initiatives, the Laboratory also increased its conventional defense research, investigated armor and armor- penetrators for the DOD, and took steps to modernize the nuclear arsenal.

In 1986 Reagan and Soviet President Mikhail Gorbachev signed an agreement to limit strategic warheads to 6,000 for each nation. In June, 1992, their successors, George Bush and Boris Yeltsin, agreed to reduce their respective nuclear arsenals to between 3,000 and 3,500 warheads within a decade. Those agreements, and the dissolution of the Soviet Union, marked the end of an arms race that lasted nearly a half-century.



This chart displays national energy R&D expenditures over a twenty-year period. The steepest rise is between 1971 and 1981 when expenditures grew from $1,064 million to $6,125 million—an increase of only $1,468 million in real dollars. Those funds diverted the DOE laboratories from their traditional nuclear energy missions, but did not replace weapons research as the primary focus of Los Alamos, Livermore, or Sandia Laboratories.

Resuming the Debate

The Department of Energy has not fully defined the role that the national laboratories will play in the future. New government initiatives in environmental and health safety have drastically affected the laboratories' operations, and the national laboratories have found themselves operating in a fluid policy environment where response is difficult and directions unstable. Consequently, the laboratories have looked beyond the DOE for guidance to Congress, which has formulated new policies in the area of technology development and which may afford a new mission for the laboratories.

Recent history suggests there is reason for optimism. In the1970s and 1980s Congress passed technology transfer legislation, created the Human Genome Project, and supported other federal interagency initiatives in high-performance computing, materials science, biotechnology, and mathematics and science education that were formulated by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). Those initiatives enriched DOE research budgets, which rose 29% under the Bush administration. Similar increases have been recorded in the NIH, NSF, NASA, and DOD budgets from which the Laboratory received funding. The end of the Cold War suggests that these kinds of activity will become more important in DOE and defense laboratories which, in the past, have embraced nuclear propulsion, reactor development, non-nuclear energy research, and other initiatives. Those old initiatives are now being succeeded by new ones, to which the laboratories must be able to respond. Their primary mission, the stewardship of nuclear weapons, has not been supplanted by any single one of these activities but probably will be in the future.

In the next four years, the Laboratory may be called upon to respond to new policy initiatives such as a national research program that would be the civilian equivalent of the Defense Advanced Research Projects Agency, work on non-proliferation, health care and the environment, a fiber optic network connecting major supercomputer centers together, and other Clinton-Gore initiatives. These opportunities are appropriate to the capabilities of the Laboratory, if they can be mobilized. The history of the Laboratory, in responding to past departures in science policy, suggests that they will. A larger mission, comparable to the Manhattan Project, Rover, or SDI, may afford the kind of challenge to which the Laboratory has responded best—a large and complex problem that requires scientific creativity and engineering know-how. ■

Robert W. Seidel is a Senior Staff member of the Center for National Security Studies at the Laboratory. He holds a bachelor's degree in chemistry and an M.A. and a Ph.D. in the history of science from the University of California, Berkeley, and is the author of numerous articles on the history of the national laboratories run by the Department of Energy and on the history of military research and development. He wrote *Lawrence and His Laboratory*, Volume I of *A History of the Lawrence Berkeley Laboratory*, published by the University of California Press in 1990.