itations. It cannot be denied, however, that none of these has or provides absolute values, because within each of them there is still a rather wide variety of possible solutions. Accordingly, it is very important that we realize that, with regard to design, we must still rely on very subjective judgment. There is grim irony in this situation because more often than not the inputs for such judgment come from engineers who have not really been educated to make such inputs.

Conclusion

In the foregoing discussions we have seen how strongly good design depends on very personal qualifications. This qualification consists of a combination of extensive engineering knowledge and creativity, plus—not to be overlooked—an open, unbiased mind. By its nature, design should be the "first among equals" in its cooperation with the analytical disciplines. We know, however, that in both education and practical engineering emphasis has shifted in recent years toward these analytical disciplines. This is not surprising as there is a general trend in that direction. It should be a matter of concern, however, that such a shift is frequently interpreted as a reduced importance of design. What has actually happened is that other engineering disciplines have increased their contributions, thus reducing the *relative* difference between themselves and design, but not the *absolute* value of design. That thinking should be reinstated in our educational institutions and reinforced and kept alive in all fields of practical engineering.

Two aspects not discussed above should be briefly mentioned here: computer-aided design and a graphological analogy. The former, with all its enormous potential, is a tool and therefore of no pertinence to our present theme. The latter is an interesting subject of definite, though secondary, relevance. It is enough to say that a drawing indeed reflects the personality of the designer, which is understandable once we comprehend that design exists only through personal expression.

The increased capabilities of the analyses are creating an image which implies that in just about any case we can find an answer through mathematical formulation. Those of us, however, who grew beyond their *Sturm und Drang* periods will know that there is much around us which does not submit to formulation and formulas, in our professions as well as in our lives. It behooves us to acknowledge that we shall continue to be confronted with phenomena we cannot formulate. From this insight we gain enormously as human beings; because it is only the unformulated that challenges and calls upon some of the most unique human qualities—our intellect, our imagination, and our creativity.

Notes

1. Generally speaking, the term "design engineer" would probably be expected here. However, the word "designer" does not only have a somewhat degrading connotation but also is used to indicate high creative capability (as the designer of bridge *X*, or airplane *Y*, and so forth). Of course, very few engineers will ever reach such levels. The implication of similar high qualities is intended whenever the word "designer" is used in this article.
2. In no way do I want to imply that we do not still have good and excellent designers. However, their high qualification is due more to their innate talent than to a specific education.

NEWS AND COMMENT

Energy Crisis: Environmental Issue Exacerbates Power Supply Problem

"An abundant supply of low-cost energy is the key ingredient in continuing to improve the quality of our total environment." — LEE A. DUBRIDGE, presidential science advisor, in testimony before the Joint Committee on Atomic Energy

"In other words, those zealots who propose going on without electrical energy or without increasing electrical energy are not speaking for you or for most of the people in the country."— CHET HOLIFIELD, chairman of the Joint Committee

"They are not speaking for themselves, either, because they go home and turn on the air conditioner."— DUBRIDGE

Two powerful forces now at work in American society are headed for a collision that could do damage to both. The first force is the nation's seemingly insatiable appetite for energy to run its factories, commercial establishments, transportation systems, air conditioners, electric toothbrushes, and the whole gamut of labor-saving gadgetry and "modern" conveniences that the American consumer now regards as his birthright. The second force—probably less powerful than the first—is the environmental movement, which seeks to save mankind from smothering in the waste products that result from the generation of energy and from other activities of an industrial civilization. The two forces are not necessarily irreconcilable, but they are already coming into conflict. The resolution of that conflict will determine whether the nation goes through a severe energy crisis, a worsening environmental crisis, or both.

The nation is already experiencing an energy crisis of sorts. It is a crisis which affects virtually all forms of energy, and it cannot be blamed primarily on opposition from the environmentalists. The fact of the matter is that for the past few years the consumers of energy have been escalating their demands faster than the producers of energy can boost their outputs. The supply of natural gas, a relatively "clean" fuel, is dwindling. For the past 2 years production of gas has outrun new discoveries, thus eating into the nation's proved reserves. Coal suppliers, meanwhile, are failing to meet commitments, with the result that stockpiles at some plants have fallen to a mere 10- to 15-day supply as against the 60- to 90-day supply considered desirable. Residual fuel oil is also said to be tight. And nuclear power, once hailed as a panacea, is coming into use at a much slower rate than was predicted just a few years ago.

The energy crisis is particularly apparent in the electric power industry, which uses such primary fuels as coal, oil, gas, uranium, and water power to produce the electrical energy that keeps many of the nation's offices, homes, and factories humming. Overall energy consumption has grown by 5 percent a year since 1965, an explosive jump over the 2.8 percent growth rate that pre-

vailed in the period 1947 to 1965. But electric power use has been growing even faster—by about 9 percent a year for the past 2 years, which is well above the long-term trend. The result, according to S. David Freeman, director of the energy policy staff in the White House Office of Science and Technology, is that "all of the links in the supply chain are being strained almost beyond their yield point."

The strain shows up particularly in the increasing inability of electric utilities in some areas of the country to supply all the power demanded. The most spectacular instance of failure, of course, was the 1965 blackout which plunged most of the northeastern United States into darkness and made the American public realize, for the first time in recent memory, that energy supplies could not be taken for granted. But there have been other, less dramatic cases of deficiencies in recent years as well. The Pennsylvania area experienced a cascading blackout in 1967. And a number of areas have experienced "brownouts"—by which is meant the deliberate rationing of service by utilities which are unable to meet peak demands. To cite but a few examples, Washington, D.C., customers were asked to shut off their air conditioners on the hottest day of the 1969 summer; industries served by the Pennsylvania-New Jersey-Maryland power pool were asked to reduce their power consumption in the summers of 1968 and 1969; the Tennessee Valley Authority and several other power systems reduced voltage to meet peak loads last winter; and Consolidated Edison, serving metropolitan New York, reduced voltage by as much as 8 percent last summer and also appealed for voluntary cutbacks in use of electricity.

The outlook for this summer is equally bleak. A survey released by the federal Office of Emergency Preparedness on 5 May identified many areas where generating reserves are dangerously below the 15 to 20 percent level considered necessary to guard against equipment failures and higher peak loads than predicted. The survey found that "the entire eastern seaboard, except for New England and Florida, will face a tight power capacity problem even if normal summer temperatures prevail, fuel supplies are adequate, and all of the system capacity performs as scheduled." Areas specifically identified as having insufficient reserve capacity included New York City, Chicago, St. Louis, Minneapolis-St. Paul, the Pennsylvania-Maryland-New Jersey area, and the entire Southeast except Florida.

There is some disagreement as to whether this situation can properly be described as a crisis. Utility executives argue that while there may be problems in a few locations, the nationwide electric power supply situation is good and getting better. They also contend that the electric companies have a much better reliability record than most other industries, a statement which would probably win assent from railroad commuters, New York City telephone users, and all purchasers of shoddy manufactured goods. But Freeman, the top energy planner at the Office of Science and Technology (OST), claims that "anyone who looks at the facts on power supply today and doesn't believe that the industry is in trouble is living in a dream world." And Carl E. Bagge, a member of the Federal Power Commission (FPC), recently chastized the electric industry for minimizing its problems. In his keynote address to the American Power Conference in Chicago on 21 April, Bagge found it "incredible . . . that some of your industry leaders maintain that it is 'sheer nonsense' to suggest, as many have, that there presently exists a power crisis of national significance . . . I am obliged to make use of this forum to . . . describe the situation confronting the electric industry today as one which constitutes a 'national crisis.' Minimizing this fact will only make its eventual realization that much more devastating. Inducing the public to ignore it would be catastrophic."

What brought about this critical situation? The easy answer is to blame the environmentalists for opposing new power plants and transmission lines, but, except in a few specific instances, that appears to be a bum rap. As Freeman expressed it in a recent speech: "The conservationists have been receiving more than their fair share of the blame for the present tight power supply situation. After all, the generating facilities coming on the line this year and next were ordered five or more years ago, before the general opposition to power plants became so intense . . . Maybe the environmentalists will cause the brownouts of 1973 and beyond, but I do not think they are the primary cause of our present situation."

If blame is to be apportioned, much of it must be allocated to American industry—to the electric utilities which generate and distribute power, and to the manufacturers that supply the utilities with equipment. The utilities, in many cases, failed to forecast the tremendous surge in demand, a circumstance which is said to result, in part, from lack of previous experience with a heavily air-conditioned society and from overpromotion of "all-electric" living. The manufacturers, for their part, have been producing poor quality equipment and have been delivering it late, thus increasing the breakdown problem and putting the utilities still further behind in the race to catch up with demand. Labor problems have also contributed to the situation. According to the Federal Power Commission, a survey of 85 large steam generating units installed in the period 1966 to 1968 found that about two-thirds of the total were delayed in being put into service. The chief causes of delay, in no particular order, were late delivery of equipment, faulty installation of equipment, equipment failure, labor strikes, and a shortage of construction labor. Only 4 of the 55 units delayed had been affected by "inability to obtain neces-

Bevan Named New AAAS Executive

William Bevan, Jr., vice president and provost of The Johns Hopkins University, Baltimore, Maryland, will become the new executive officer of the AAAS on 1 October. Bevan, a 48-year-old psychologist, was chosen for the post at a special meeting of the board of directors on 30 May.

He will succeed Dael Wolfle, 64, who has headed the AAAS staff since 1954. Wolfle will retire from his post on 30 June and will become a professor of public affairs at the University of Washington in Seattle.

In the 3-month period between Wolfle's departure and Bevan's arrival, Philip H. Abelson, editor of *Science,* will serve as acting executive officer of the AAAS.—P.M.B.

NEWS IN BRIEF

● **APOLLO 13 INQUEST**: The final report of the review board investigating the failure of the Apollo 13 moon flight faulted two companies, North American Rockwell and Beech Aircraft, for installing inadequate thermostatic switches in the heater assembly of one of the spacecraft's oxygen tanks, causing the tank to explode. The report also criticized NASA personnel for not catching the mistake in preflight tests. The board made several recommendations for extensive reviews of NASA manufacturing and testing procedures. The space agency's director, Thomas O. Paine, said that it was still too early to tell whether the recommendations would cause a delay in the flight of Apollo 14, scheduled to be launched in December.

● **POPULATION COMMISSION**: Charles F. Westoff, chairman of the sociology department at Princeton University, has been appointed executive director of the Commission on Population Growth and the American Future by President Nixon. The Commission will study the probable growth of population between now and the year 2000 and what impact this growth will have upon public resources and governmental activities. Establishment of the Commission was requested by the Nixon Administration last summer. The bill, which provided for a 2-year term for the Commission, was signed on 15 March, and John D. Rockefeller III was named Commission Chairman. No further appointments were announced until Westoff's on 15 June.

● **FERMI AWARD**: Dr. Norris E. Bradbury, head of the Atomic Energy Commission's (AEC) Los Alamos laboratory, has been awarded the Enrico Fermi Award for 1970. The AEC's award, worth $25,000, was given for Bradbury's key role in helping revolutionize nuclear weaponry and for his contributions to peacetime uses of atomic energy. Bradbury will receive the award in Los Alamos on 29 August as part of a public ceremony planned in honor of his retirement, which is set for 1 September.

● **VIETNAM ECOLOGY STUDY**: Nine Republican Congressmen, expressing concern about the ecological effects of the war in Vietnam on that country, have asked the President to appoint a study commission of American scientists to work with Vietnamese scientists in recommending steps to rebuild the agriculture, ecology, and industry of Vietnam after the war. The letter writers, led by John Dellenback (Ore.), have received a noncommittal answer from White House aide William Timmons.

● **FEDERAL AID TO DISRUPTIVE STUDENTS:** The Office of Education has reported that federal aid for 676 students was cut off between 16 October 1968 and 1 July 1969 because of their role in campus disorders. Aid to 92 students was terminated under the provisions of various higher education laws. Aid to the other 584 students was cut off when the students were suspended or expelled by their colleges acting in accord with the institutions' own rules.

● **WATER SURVEY:** About 30 percent of the public water supply samples taken in a recent federal survey contained germs and chemicals in amounts that violated at least one federal purity standard. The survey, which was conducted by the Environmental Control Administration, took 3563 samples from the public water supplies of Vermont and nine metropolitan areas. A full report of the survey, complete with statistics and recommendations, will be issued in a few weeks.

● **BARIUM RELEASE EXPERIMENT:** The National Aeronautics and Space Administration (NASA) and the German Ministry for Education and Science have planned a barium release experiment for the second half of 1970. An 18-kilogram mixture of barium metal and copper oxide powder will be ignited and released at an altitude of approximately 5 earth radii. The resulting barium ion cloud is expected to be visible throughout much of the Western Hemisphere. The objective of the participating scientists will be to study the interaction of the cloud with the surrounding collision-free magnetospheric plasma and to investigate magnetic and electric fields in the magnetosphere. Interested parties should contact William A. Brence, Wallops Station, NASA, Wallops Island, Virginia 23337.

sary certifications and other regulatory impediments."

Two of the most savage indictments of industry's failure are contained in the November 1969 issue of *Fortune* magazine, a Bible of the business community. One article, which describes the electric power industry as "clumsy" and "sluggish," asserts that "utility executives are generally unimaginative men, grown complacent on private monopoly and regulated profits." It contends that many utilities "bet too heavily and too hastily on nuclear plants," that they ordered equipment "in fits and starts," and that they do very little research, among other sins of omission and commission. Another article describes the "great nuclear fizzle" at Babcock & Wilcox Co., a highly respected manufacturer of boilers for steam generating plants. Babcock & Wilcox became a major producer of nuclear pressure vessels, but did so poorly at it that customers had to take back some $40 million worth of partially completed vessels and place the business elsewhere, a process which delayed power plants badly needed by the utilities. "The failure, basically, was a management failure, and on a scale that would be cause for concern even in a fly-by-night newcomer to the nuclear industry," *Fortune* concludes.

Industry executives would probably not accept the harsh phrasing of these indictments but, when pressed, they are sometimes willing to concede that industry has played a part in bringing on its own problems. Under questioning before the House Subcommittee on Communications and Power last month, A. H. Aymond, president of the Edison Electric Institute, the national trade association for the investor-owned electric power industry, acknowledged: "The growth [of demand] in the last several years has been above our forecast of five years ago. That is one of the problems. Another problem is we failed to forecast that it is going to take longer to get these facilities built. We failed to forecast the outage rate—the unplanned outage rate—of new facilities would be as high as it has been." Aymond also said the equipment manufacturers "are having difficulty in the shops in meeting specifications to reach the standards that the industry needs for these high temperatures and pressures."

Environmental issues have unquestionably played a role in exacerbating the industry's problems. As Freeman,

OST's energy expert, expressed it in an interview: "Environmental problems, superimposed on an already fragile supply-demand relationship, may be the straw that broke the camel's back." One reason the Minneapolis-St. Paul area will have essentially no reserve generating capacity this summer is because of citizen opposition to new nuclear power plants. Similarly, the Consolidated Edison Company, serving metropolitan New York, is in a delicate reserve position at least partly because of environmental opposition to a proposed pumped storage hydroelectric plant at Storm King mountain. And a proposed extra-high-voltage transmission line connecting New York City with the mid-Atlantic systems has been delayed for years, largely by problems in acquiring rights-of-way through the congested metropolitan area. As Edwin H. Snyder, board chairman of a New Jersey utility noted with some exasperation in congressional testimony last month: "In 1964 we signed a letter of intent [to build the transmission line] with Con Edison and we went to work immediately. We have moved that line, I would say, a hundred times . . . Why? To accommodate the local residents, and yet it is not finished. We need it at this time, this summer, but it is not finished."

Though environmental issues have not yet become the major factor behind the power crisis, they will almost certainly become so in the near future. As George E. Tomlinson, acting chief of the Bureau of Power in the Federal Power Commission, told *Science*: "From here on out, in my opinion, site location, overhead transmission lines, water pollution, air pollution, fear of atomic plants—that whole family of environmental considerations—will be the most important factor [in slowing electric utility growth]. In some cases it will add 2, 3 or 4 years [to the time needed to bring plants on line]."

Virtually all of the industry's problems so far have been caused by its explosive growth, and this same growth will almost inevitably force environmental considerations to the fore. The rough rule of thumb has been that electric power in the United States doubles every decade. That worked fine when the industry was small, but today it is the nation's largest industry in terms of capital investment, with roughly $100 billion worth of facilities. Doubling and redoubling from this base would be a gigantic undertaking. And it could have a profound effect on the environment. There will be problems finding suitable sites for power plants, obtaining rights-of-way for transmission lines, and coping with waste heat and other pollutants. The St. Louis-based Committee for Environmental Information recently predicted, in a report published in the March 1970 issue of *Environment* magazine, that "by the year 2000 we will be in serious environmental trouble unless the increase in

HEW Decentralizers Exempt Research

The Department of Health, Education, and Welfare (HEW) announced last week that it is decentralizing 11 grant programs, primarily in the Social Services Rehabilitation agency and in the mental health programs, and that the decisions as to who gets money will be made in ten different regions rather than in Washington. Regionalization to date is affecting service rather than research agencies.

For the past year, a Federal Assistance Task Force (FAST) has studied the various procedures which HEW granting agencies use in determining which applicants receive awards (*Science*, 10 April). FAST hopes to streamline the money-awarding process by eliminating some of the paper work and removing some of the links in the necessary chain of approvals. Consequently, the time lapse between the filing of applications and the grant decisions should shorten, and thus money and man-days will be saved both for HEW and for those whom it funds. FAST, which has studied the review procedures of 75 of the 260 HEW grant programs, has promised to complete its analysis of the remaining grant programs by June 1971. Until last week Fred V. Malek, HEW deputy undersecretary in charge of FAST, remained uncertain about the fate of the review process for grant applications for basic research. He had previously indicated that review of basic research programs might be partially or completely decentralized.

However, at a news briefing last week, Malek said, "Research grants—these will not be decentralized. We will study the research programs, but will not recommend decentralization. The peer-group view of bringing together the best men in the field is imperative to basic research."

Of the 11 announced moves toward decentralization, that to regionalize community mental health center staffing is undoubtedly the most controversial. In his 2 June letter of resignation, former National Institute of Mental Health (NIMH) director Dr. Stanley F. Yolles remarked on "the premature decentralization of program administration without provision for developing an adequate number of qualified personnel in the regional offices." Yolles stated that regionalization of the decisions in awarding grants would undermine "quality standard-setting now vested in the National Advisory Mental Health Council."

Yolles's successor, Dr. Bertram S. Brown, said that when he took over the NIMH directorship he promised the Administration that he would be "quite willing to work with decentralization that is in the public interest."

Regionalization of decison-making in staff grants for community mental health centers is getting a far from enthusiastic response from other leaders in the mental health field. Dr. Kenneth Little, executive director of the American Psychological Association, said, "I approve of the idea of community involvement. But I'm very leery of complete decisions being made in the regions. There is the danger that, if the final decision is made regionally, the decisions can be politically motivated."

Malek insists that regional men will be held strictly accountable to Washington headquarters and explained that "each regional program representative and program head is required to develop objectives for the coming year and detailed plans as to how they're going to achieve these objectives." Malek said that regional heads will submit monthly reports and attend in-depth quarterly meetings.—SAMUEL Z. GOLDHABER

electric power generation is slowed." One of the committee's most dramatic calculations was that: "In the year 2000, if power consumption continues to increase at the present rate and there is no great increase in overall efficiency (which there is unlikely to be), power plants of all kinds will produce roughly enough heat to raise by twenty degrees the total volume of water which runs over the surface of the United States in a year." The committee also concluded that "the amounts of carbon dioxide and radiation in the atmosphere will probably be increasing at a dangerous rate and will then or shortly thereafter reach unacceptable levels—levels at which carbon dioxide may have drastic effects on the global climate and radiation will have unforeseeable effects on the world's living things, including man."

What's the way out of this dilemma? In broad brush, there are two possible approaches—either slow the rate of growth in demand for electricity and other forms of energy, or find some way to increase the supply of energy without contaminating the environment.

Radical Solutions

The most radical proposed solutions, in a country where growth has almost always been synonymous with "good," involve moderating demand. Freeman, of OST, has suggested that the price of electric power might be made regressive, so that the more a customer uses, the more he pays. At present most utility services—including those that supply electricity, natural gas, and water—reduce their rates for big volume users, thus encouraging maximum use. "I am merely suggesting that one way to help match supply with loads is to take our foot off the accelerator," Freeman explains, "at least until we can catch up and develop power supply technology that will minimize environmental concerns." Lee A. DuBridge, President Nixon's science advisor (and Freeman's boss), has urged that power costs "include the cost of alleviating the damaging impact of its production on the air, land and water," a step which would increase the prices charged and presumably moderate demand somewhat. Higher prices would also provide incentives for using power more efficiently, perhaps through better insulation of homes and through the production of more efficient appliances and other consuming equipment.

The St. Louis-based Committee for Environmental Information has proposed even more radical changes. Noting that industrial uses account for more than 41 percent of the total production of electric power expected in 1970, the committee suggests that a number of industries should probably be restructured so that they would use less energy. If automobiles were designed so that they could be easily reclaimed and reused, the committee says, "energy requirements for the steel in automobiles could be cut dramatically, and one of the nation's worst waste-disposal problems could be solved at the same time." Decisions on the drastic restructuring of whole industries would obviously require much more knowledge than is now available as to just how energy is used and what trade-offs would be involved. What is required, the committee says, "is a much wider look at the activities which create the accelerating demand for electric power, and a detailed evaluation of the cost—in dollars, in environmental damage, and in health—of providing the electricity asked for, as against the costs of doing without it or substituting something else."

No matter what steps are taken to moderate demand, the use of power is expected to continue rising. As DuBridge expressed it in recent congressional testimony: "The growth of electric equipment—refrigerators, air conditioners, vacuum cleaners, TV sets, improved lighting, fast elevators and all the rest—has been one of the great modern developments to make life more pleasant in our homes, offices and factories. We are surely not going to give up these conveniences—which have indeed become necessities." Thus steps must be taken to ensure that power supplies become more reliable and yet do less damage to the environment.

The industry itself has taken a number of steps to increase its reliability, including the establishment of regional councils, better communications, and relay systems, and emergency procedures designed to prevent a recurrence of the 1965 blackout. The system is hardly foolproof, but it is said to be stronger than it was in 1965. Industry is also allowing longer lead times when planning for new equipment to be built and installed. But a number of congressmen, unsatisfied with the progress made, have introduced bills to give the federal government more authority to enforce reliability of service. A number of prominent officials have also called for a streamlining of the procedures by which utilities get permission to build plants and transmission lines, so that a single authoritative body would be in a position to consider all relevant matters, including environmental issues, and then make a yes-or-no decision without bogging the utility company down in repetitive hearings before numerous interested bodies.

More fundamentally, according to John N. Nassikas, chairman of the Federal Power Commission, this nation needs a comprehensive energy policy because "there is no single federal agency to carry out total energy policy to attain a balanced objective of efficient and productive utilization of our energy resources—oil, coal, gas, water, nuclear energy—in harmony with the environment." One step reportedly under consideration within the Nixon Administration would be to remake the Atomic Energy Commission into an agency dealing with all forms of energy.

'Ridiculously' Little Research

The success of the effort to reconcile energy needs with environmental protection will depend, in large part, on research and development. Unfortunately, neither the federal government nor the energy industries have been lavish in their expenditures on R & D. The federal government in fiscal 1970 will spend an estimated $367 million on energy R & D, but more than 84 percent of that will support atomic energy work, leaving what FPC Commissioner Bagge calls a "ridiculously small" amount for energy research related to fossil fuels, which will remain the mainstay of the electric power industry for at least two more decades. The electric power industry itself devotes less than one quarter of one percent of operating revenues to R & D. Thus many crucial research problems have yet to be solved, some of which would increase the availability of energy, and some of

News Interns

Science news interns for this summer are Harvard undergraduates Samuel Z. Goldhaber, class of 1972, and Thomas P. Southwick, class of 1971. Both are members of the board of the Harvard *Crimson*. Their first contributions appear in this issue.

which would lessen its environmental impact. A partial list of the problems that need further investigation would include: removal of sulfur pollutants from stack gases or from the combustion process; technology to place high voltage lines underground; technology to convert coal to gas so as to supplement the dwindling natural gas supplies; development of better, more economical cooling towers to deal with thermal pollution; methods for utilizing our shale oil resources effectively; techniques for applying waste heat to beneficial uses, including, perhaps, the heating of water for homes and commercial establishments; development of magnetohydrodynamics to increase the thermal efficiency of electric power generation; and development of such new sources of power as solar energy, geothermal heat, tidal energy, and fuel cells.

In the long run, the nation's power problems will probably have to be solved by nuclear energy. The recent report "Resources and Man," published by the Committee on Resources and Man of the National Academy of Sciences-National Research Council, gave a rather gloomy picture of the prospects for other energy resources. It estimated that "the earth's coal supplies are sufficient to serve as a major source of industrial energy for two or three centuries. The corresponding period for petroleum, both because of its smaller initial supply and because of its more rapid rate of consumption, is only about 70-80 years." Natural gas, solar energy, water power, geothermal, and tidal energy were all dismissed as holding little promise for meeting future energy needs. Even the current generation of nuclear reactors will deplete the supplies of uranium-235 at an alarming rate and will have to be replaced by breeder reactors before the uranium situation becomes critical in just a few decades. Failure to make the transition to breeders, according to the Academy committee, "would constitute one of the major disasters in human history." Still further on the horizon is the possibility of fusion power, which would offer the advantage of virtually unlimited fuel with relatively little adverse effect on the environment. But no one is certain that fusion power will ever be achieved or will ever prove practical.

Meanwhile, the conflict between the desire for more energy and the desire for a clean environment will continue unabated. The best hope for resolving the conflict probably lies in various technological breakthroughs. Both sides stand to gain from a satisfactory resolution of the problem, for both sides may come out losers if the conflict continues and escalates. The energy industries stand in jeopardy in that their future growth may be curbed. And the environmentalists, if they push the country into a severe energy crisis, may find that they have undermined their own cause. Once the air conditioners and television sets start going off, the public will probably say, "To hell with the environment, give me 'Bonanza.'"

—PHILIP M. BOFFEY

Federal Graduate Aid: Down But Not Out

When the National Institutes of Health (NIH) announced plans last week to phase out its predoctoral fellowship program, the news deepened the gloom of those who see current cutbacks in federal support of graduate education as producing a crisis within a crisis caused by the slump in federal funding of science.

It is still too early to forecast in detail the effects of the cutbacks in the coming academic year, but many departments are anticipating smaller enrollments of graduate students attributable both to a reduction in the number of federal fellowships and traineeships and also to the decreasing availability of research assistantships financed out of research grants.

If there is a bright spot, it is to be found in signs that the Administration is veering away from a policy of changing the primary form of direct federal support to graduate education from fellowships and training grants to guaranteed loans. For those who feared that the prevailing system of federal grants was to be supplanted there is some consolation that the grants are headed down but not out.

Ambiguity in prospects for September arises from the usual fudge factors that afflict science manpower data and projections. On the federal side, Congress has not passed the main appropriations bills carrying funds for support of graduate education for fiscal year 1971. (A substantial part of these funds will actually be spent in the 1971–72 academic year.) The chronic lag in agency data collection and reporting prevents the formation of a clear picture of the situation in graduate support in the academic year now ending or in the progress of awards for the coming year.

Out in the universities, there are doubts about how the draft will affect enrollments in September. And since many universities are facing serious deficits this year, there is talk of emergency economy measures that could affect graduate enrollments. Although some indicators run counter to predictions of contraction of enrollment (the University of California at Berkeley, for example, announced last week that applications for admission to graduate school were up 25 percent over last year), the difficulty of finding financial aid is likely to be a restricting factor on enrollments this year.

The general shape of federal support of graduate education in the coming year seems, however, to be following the outlines set in the Administration budget. An agency-by-agency check last week yielded the impression that, although congressional efforts to increase some items in the science budget may succeed (*Science*, 3 April 1970), the overall contours of the budget and of graduate education support have been set by the Administration's fund requests.

The National Aeronautics and Space Administration (NASA) has for all intents and purposes liquidated its sustaining university program with which it underwrote the rapid buildup of space-science graduate training in a broad range of universities. The NASA doctoral support program peaked in 1968, when some 1300 students were