TECHNOLOGY and SOCIETY

IEEE

CONTRIBUTED PAPERS, REPORTS, REVIEWS, AND
CORRESPONDENCE OF THE COMMITTEE ON SOCIAL IMPLICATIONS OF TECHNOLOGY

EDITOR: NORMAN BALABANIAN **VOL. 9, NO. 2, JUNE 1981 (USPS 321-090)**

Social and Political Perspectives on Nuclear Regulation after Three Mile Island

STEVEN L. DEL SESTO

The near catastrophic accident at Three Mile Island, Pennsylvania in March 1979 prompted policymakers and government officials in the United States to closely examine the regulation of nuclear power, and a host of studies, panels, and special commissions were launched to examine the issue intensively. While the results are currently pouring in seemingly from everyone, the advice and recommendations have a remarkable similarity about them. For example, a study of the Nuclear Regulatory Commission by the United States General Accounting Office offered some fairly typical recommendations. It concluded that the NRC's "performance can be characterized as slow, indecisive, cautious—in a word, complacent." The report said this resulted from a "lack of aggressive leadership as evidenced by the Commissioners' failures to establish regulatory goals, control policymaking, and most importantly, clearly define their roles in nuclear regulation." Several regulatory reforms were suggested to bring about "effective and efficient regulation to the future of commercial nuclear activities." [1] To be sure, almost everyone, including the influential President's Commission on Three Mile Island, believes there ought to be some kind, if not drastic, reform in nuclear power's administrative and regulatory machinery. [2]

There is little doubt that improved regulation can help make the operation of nuclear power plants in the United States and elsewhere safer and more reliable. It is unlikely, however, that such reforms will stifle dissent and mute criticism of the nuclear program as a whole, because they largely ignore the essence of the regulatory enterprise by taking a myopic view of the underlying social and political issues. Many of the proposed reforms drastically oversimplify the nature of regulation. They view it simply as a type of administrative rationality concerned with devising standards, establishing programs, and promulgating rules. New standards and operating procedures, it is argued, will lead to regulatory improvement and thus greater public acceptability of nuclear power.

This plainly ignores the fact that regulation has wider social, political, and economic objectives. This includes functions such as the modification of corporate, organizational, and individual behavior, and the shaping of economic activity. Regulation also has important conflict-reducing functions by managing disputes between different interest groups. Indeed, regulation is a key element in the very definition of public policy itself. This means that new regulatory strategies for nuclear power must consider different goal and value conceptions of competing groups in *(cont. on p. 3)*

The author is an Assistant Professor in the Program on Science, Technology and Society, Cornell University, Ithaca, NY 14853.

In This Issue

Social and Political Perspectives on Nuclear Regulation after Three Mile Island, *Steven L. Del Sesto* . 1
Letters 2
In Support of Nuclear Power, *John Peter Rooney* . . . 5
Reviews 7

Letters

To the Editor:

I am writing in response to the letter of Mr. Adolph Ackerman, as published in your March 1981 issue. In his letter, Mr. Ackerman makes a number of statements which bear some comment. He describes an Engineer, as:

(1) "Every *man* who practices the art of engineering..."
(2) "A professional...carrying high responsibility with independence of choice in applying science for the benefit of mankind."

Further, he comments that, "if we were a society of technicians, there would be need of a society concerned with social and ethical considerations of technology."

I take issue with his use of *man,* since it seems to ignore the female members of our profession. His view of the professional engineer as an individual, operating alone, and with complete control of the various factors of a job, i.e., problem structure, work assignment, material availability, environmental impact and economic considerations, etc., is exceedingly simplistic. Indeed, the most common situation, as it relates to the majority of IEEE members, is for a member to be part of a working group, in which each person must contribute his share of the complete solution. This does not mean that the individual is relieved of his personal responsibilities, but rather that these must be exercised within the constraints of the real world environment.

It is for this very reason that *CSIT* has value to the engineering community, in its role as a medium, in which engineers of diverse attitudes and experience can share their thoughts. Why should such activities be necessary only for technicians? The implications of his final recommendation to reorganize CSIT into an "Advisory Committee on Engineering Responsibility..." seems to imply that CSIT should be making judgements for our members, rather than informing them of the issues, as is now the case.

Peter D. Lubell
Region I COMPOSE Chairman

To the Editor:

It would be comforting to agree with Adolph Ackerman ("Letters" March 1981) that "every man practicing the art of engineering is... 'a professional man of integrity...with independence of choice in applying science for the benefit of mankind' " and hence conclude that an IEEE Society on Social Implications of Technology is redundant. Unfortunately his description fits no known facts. There is, to begin with, a large backlog of IEEE members who are recently graduated from engineering schools where they have been exposed to little or no formal education in social, ethical, or philosophical questions. Further, these young members have not yet had the experience nor opportunity to develop their own professional codes or absorb them ready-made from those like Ackerman. Secondly, most practitioners of engineering lack the essential condition of independent professionalism in that they are employed by corporations and working under the direction of managers who impose their own codes of behavior. These managers may or may not be professional engineers and in the higher policy making levels are apt not to be. For these reasons, an organized approach toward educating our membership in societal/ethical matters is a needed service.

But there is a more compelling reason to reject the thesis that "Social Implications of Technology" is an unnecessary activity. Social responsibility is not merely a matter of "being good" or "doing the right thing." Many societal problems in which we are deeply involved as engineers, citizens, and members of the human race, are awesome in their depth and complexity. Problems such as determining the societal costs and benefits of controlling air pollution, energy sources, or nuclear weapons production, are not resovled by simplistic or single-issue approaches. For example, the mathematics of optimization of multiple-goal choices is by no means obvious nor easy to apply. Sociologists, scientists and engineers, and ethicists debate and disagree on these questions. It is clearly part of our function as a professional society to devote some part of our resources to debate and research on these societal matters that impinge upon us so heavily. To ignore that challenge, to leave the determination of our goals and methods to others, is to default on our responsibility as professional and to condemn ourselves forever to the narrow technical viewpoint. Therefore, as a professional, consultant, and Senior Member of this Institute, I emphatically disagree with Ackerman's conclusions.

Robert J. Bibbero, MBA, PE

TECHNOLOGY AND SOCIETY is published quarterly by the Committee on Social Implications of Technology of the Institute of Electrical and Electronics Engineers, Inc. Headquarters: 345 East 47th Street, New York, NY 10017. Subscription price: $3.00 per year, IEEE members only. Second-class postage paid at New York, NY and at additional mailing offices.

(cont. from p. 1)

society, not just changes in rules and standards of performance for nuclear plants. Reorganization of existing regulatory structures also promises little help if it is done in the absence of new criteria, value priorities, and the key interests of the groups and classes at issue. If future reforms ignore the social and political aspects of the nuclear controversy, they will be cosmetic and short-lived, only temporary technical and administrative "fixes" for broader social, political, and economic questions. The point is that nuclear politics are inextricably tied to key policies concerning appropriate energy use, national and international environmental policy, the control of important natural resources, and the future shape of society's productive-distributive mechanisms.[3]

So what are the interest group, political, and conflict factors regulatory reforms must consider? For one thing, it is now clear that the 1960s and 1970s saw the rise of a powerful constituency of environmentalists, public interest scientists, concerned citizens, and anti-nuclear forces. They have been able to influence public policy in many different areas, and nuclear power has been merely one of their concerns. The central problem for the future of nuclear regulation in the United States (if not the West in general) is that this new constituency poses a significant challenge to traditional bases of power and authority, and accordingly, they are able to call for alternative public policies in the areas mentioned above. More than anything else, this is what the aftermath of Three Mile Island seems to suggest.

But exactly how does this new constituency differ from the traditional bases of power and authority tied to nuclear regulation? First it must be recognized that the original regulatory structure of nuclear energy in the U.S. was created by a certain class of people: scientists, statesmen, politicians, educators, journalists, administrators, and others who testified before Senator Brien McMahon's Congressional committee hearings in 1945 and 1946. They were entirely cognizant of the huge task before them. But war-weary and impressed by the astounding power of the bomb at Hiroshima and Nagasaki, they were resolved that atomic energy need not be the scourge of mankind, but that it should be put to work peacefully, for the general welfare. Robert Hutchins, Chancellor of the University of Chicago, called nuclear energy the greatest single invention since the discovery of fire. He told Congress that it would transform industrial society dramatically, much like electricity had done in the United States in the early twentieth century. Others predicted that the use of nuclear power would greatly alter transportation systems, would transform the social order by greatly reducing or eliminating manual labor, and, as one observer put it, would promise the "greatest future ever spread before mankind with dazzling possibilities of life, liberty, and the pursuit of happiness." [4]

These people, in addition, shared a larger vision of reality—nurtured by long years of depression, war, and hardship—which stessed such values as economic growth, material satisfaction, widespread prosperity, a sense of nationhood, and a belief in freedom and progress which extended individual choice and self-determination to even the ordinary citizen. It was only natural that nuclear development and control in the U.S. would be perceived in terms of these larger value structures. Indeed, by producing power that was "too cheap to meter," to use an oft-quoted phrase, nuclear energy development could help fulfill many of these dreams.

The "subsystem" of nuclear energy regulation which grew out of the Atomic Energy Act of 1946—i.e., the Atomic Energy Commission, the Joint Committee on Atomic Energy, and the nuclear power industry—pursued these goals vigorously, and had demonstration reactors on-line within a decade of the 1946 Act. By 1966, nuclear power appeared on the threshold of commercial acceptability and its great technological success was hailed, as utilities began ordering record numbers of nuclear plants from the manufacturers. [5]

Yet while the reactor business began booming, a new and more powerful resistance to nuclear power emerged. Of course there had always been resistance in one form or another to nuclear energy. But by the middle 1960s it had become larger and more powerful than ever before, and it began calling for the dissolution of the regulatory subsystem and its decidedly promotional policies. Perhaps the most significant indicator that things had changed was the passage of the National Environmental Policy Act of 1969, which gave significant teeth to nuclear opponents for the first time. The Act promulgated a set of environmental policies and principles easily applied to the nuclear enterprise. Through the legal vehicle of the Act, opponents to nuclear power were able to interpret environmental policy in accordance with a different set of values, goals, and ideologies, which contrasted sharply with nuclear advocates' visions. Such values and ideologies reflected a new set of societal priorities, and nuclear power would become one of the symbolic battlegrounds for waging the fight: For fighting the primacy of big government and centralized technology, which seemed on the verge of effectively removing the average citizen from the political arena and hastening his alienation and powerlessness; and for fighting the escalating spiral of resource consumption and environmental degradation that would lead to greater restrictions of individual freedom in a more controlled, resource-scarce society. Far from the optimistic picture of cheap power and rising standards of living painted by the proponents, the opposing forces have viewed nuclear power as symbolic of all that is wrong with social and environmental management.

By 1974 this vision had gained increasing sway over the old subsystem of regulation, whose absolute dominance was threatened for the first time since 1946. With the Energy Reorganization Act of 1974, the AEC was dissolved, and created in its place were the Energy Research and Development Administration and the Nuclear Regulatory Commission, indicating that nuclear regulation was entering a new era by responding to some of the major criticisms and outcries for reform. By 1977 and the dissolution of the Congressional Joint Committee itself, the downfall of the old subsystem of regulation (at least its administrative structure) was nearly complete. The regulatory arena had been expanded to include additional public interest groups, a more diverse number of government agencies and Congressional committees to which the NRC would be responsible, state and local government concerns, the courts, and others. Expanding the arena in this fashion made it more likely that nuclear development would have to place as much emphasis on the health, safety and well-being of people and the integrity of the environment, as on the growth and economic prosperity of the industry.

So it seems clear that the differences between the old and new styles of regulation are more than a disagreement over the use of nuclear power *per se*. Instead they are indicative of significant *social conflict*. What is at stake is the clash of different cultural values, ideologies, and world views of opposing interest groups concerning the eventual disposition of energy and resources and the control of the means of production. The conflict is between traditional interest groups and entrepreneurs, who have their essential roots in American society in the Populist and Progressive classes of the turn of the century, and who first devised the very notion of federal regulation with the establishment of the Interstate Commerce Commission in 1887; and a new interest group of professional and managerial classes ("intelligentsia," if you will), who may also have roots in the Populist tradition, but who do not share the same political vision of progress, economic growth, and the ultimate good of corporate capitalism. Rather, the new group's view of progress is committed to more "humanistic" goals that emanate from their positions in the public and not-for-profit sectors of the occupational structure. To them, nuclear power has an entirely different meaning and significance in terms of their ideological perspectives. Thus the problem of nuclear regulation in America is now, and will continue to be, a problem of social and ideological conflict over the definition of societal goals, the direction and control of social policy, and the very definition of the "good society." Nuclear power is merely the tip of the iceberg.[6]

What is the relevance of these points for the future of nuclear regulation in the United States and elsewhere?[7] First we must recognize that nuclear regulation has a social and political base which establishes its aims, goals, priorities, and indeed, its very structure. Therefore the immediate problem lies not with the regulators themselves, or with regulatory programs *per se*; new regulatory structures, standards, and criteria of performance for nuclear plants will not suffice in the long run. Instead, the burden is upon politicians and policymakers; they must compromise conflicting societal priorities with respect to energy policy and general social and environmental management. Before nuclear regulation can be effective, policymakers must make some difficult decisions concerning the extent to which the health and safety of people and the environment should be compromised for the increased production of electricity, whether it is done by means of nuclear reactors or other generating technologies. Or put in terms of the larger ideologies and world views of the interest groups discussed above, should general energy policy (of which nuclear regulation is a part) continue to rest on values such as unlimited energy consumption, increasing economic growth, and standards of living based on expanding material consumption? Or should it move toward a steady-state economy based on conservation, deemphasis of materialism, and concern for environmental protection? Sooner or later, policymakers must face a serious reevaluation of the "ends" for which nuclear power is only *one* of the "means." Simply devising new regulatory programs and structures at this juncture are no substitute for fundamental political decisions; at best they are merely temporary stop-gaps for long-term social problems concerning energy supply, resource depletion, and social and individual freedom in a changing industrial society.

Second, environmental and anti-nuclear groups are doubtless a permanent feature of the political landscape. Public officials must therefore expand social and political interaction between contesting parties by creating additional participatory arenas for negotiation, compromise of principles, clarification of conflicting data, and harmonizing of actions. Unless such participation is expanded, it is certain that nuclear regulation will suffer a new legitimation crisis; the general public will increasingly doubt regulators' legitimacy in the absence of such arenas. The result will be greater polarization, conflict, and doubtless, continued violence like that at Seabrook, New Hampshire, Crey-Malville, France, and the Calkar facility in West Germany. The importance of fostering interaction between conflicting interest groups must receive sustained emphasis, and current practices of public participation and other participatory devices must be encouraged, not preempted.

Finally, it is evident that pro-nuclear factions will certainly struggle to maintain their positions within society and their relations to the means of production, which have fulfilled their values of material abundance, social mobility, and economic growth. But meanwhile anti-nuclear interests will struggle to implement their own guiding principles and social values concerned with decentralization, slow growth, environmental protection, and citizen participation. Such values will not only redefine the direction of public policy concerning nuclear regulation, energy, and the environment, but will likewise alter nuclear opponents' respective influence over the exercise of social power and their relations to the economic means of production. In this way, decisions concerning nuclear regulation are likely to form a major sphere of influence and dispute regarding the direction of future social, political, and economic change. Clearly what is at stake are serious decisions about the future form of society in which people will live. This is precisely why post-Three Mile Island changes in nuclear regulation and administrative procedures are going to remain a potent source of conflict, reduced only by carefully conceived social and public policies. *(cont. on p. 8)*

In Support of Nuclear Power

JOHN PETER ROONEY

The widespread utilization of electricity is perhaps the greatest technological advance of our age; certainly, electricity has affected every aspect of our lives. For comfort, in summer and winter, we use electricity. For communications, worldwide, and from the basement to the kitchen, we use electricity. For safety, with giant early warning radars and with small household smoke detectors, we use electricity. Appliances cannot distinguish electricity generated by nuclear power from electricity generated by "conventional" means.

In 1978, the latest year whose total figures are available to me, the production and use of electricity rose 3.9 percent to a record 2206 billion kilowatt-hours. The contributions of coal, oil, gas, hydro, and nuclear to the total for the years 1975–1978 are shown in Table I. Coal-fired power plants produced 44 percent of the total electricity used, oil- and natural gas-fired plants accounted for 17 percent and 14 percent, respectively. Nuclear power and hydro-power delivered slightly more than 12 percent each.

National averages tell only part of the story. Some regions are more heavily dependent upon nuclear power than others because of the uneven distribution of oil and gas wells, water falls, and other resources.

In the future, without a change in life-style and without a population decrease, each year will see an increase in demand for electricity. However, our population *is increasing*. Schools, which are emptying now, will be filled when the children of the children of "Baby Boom" reach school age. Further, adults are living longer. Even with "Zero-Population Growth," there will be more people in the US in, say, 2000, than ever before. And those people will consume more energy than ever before.

As the population grows, it also shifts geographically. Where once there was a desert, there will be a city. A desert needs no electricity; the people of the city do. In planning for the future, New Mexico would obviously reject tidal power but it would consider geothermal energy, since it is in the heart of the hydrothermal resource belt. [2]

What of the regions not blessed with geothermal resources? What technologically proven options are open to them? Coal, natural gas and oil all have problems associated with them. Ohio's coal fired power plants cause acid rain, which falls, unmercifully, on the lakes of upstate New York, northern New England, and parts of Canada and kills them. [3]

TABLE I
PRODUCTION OF ELECTRICAL ENERGY (1975–1978)
(BILLION KILOWATT HOURS)

SOURCE	1975 GENERATION	%	1976 GENERATION	%	1977 GENERATION	%	1978 GENERATION	%
Coal	853	44.5	944	46.3	986	46.4	977	44.3
Oil	289	15.1	320	15.7	358	16.9	364	16.5
Gas	300	15.6	295	14.5	305	14.4	305	13.8
Nuclear	173	9.0	191	9.4	251	11.8	276	12.5
Hydro	300	15.6	284	13.9	220	10.4	281	12.7
Other	3	0.2	4	0.2	4	0.2	3	0.1
	1918	100%	2038	100%	2124	100.1*	2206	99.9*

Adapted from [1].
*Error due to rounding

Future demands for Electricity

Even with the shock of the OPEC embargo and the resultant increase in price, each year shows an increase in consumption over the previous year: 1976 over 1975—6.2 percent; 1977 over 1976—4.2 percent; 1978 over 1977—3.9 percent. Preliminary figures show 1979 consumption over 1978—3.3 percent. The downward trend in the rate of increase is encouraging; it is probably due to both the rise in price of electricity and the increase in the conservation-consciousness of the people.

The author is a former editor of the Reliability Society Newsletter and lives in Plymouth, Massachussetts, some 7 miles from the Pilgrim 1 nuclear power plant.

In the case of natural gas, supply disruptions in several states have been experienced in recent years. It is not clear whether the US has a sufficient supply of natural gas or whether the technology to convert coal to natural gas can be developed quickly enough. As for oil, domestic reserves are limited and it is national policy to reduce dependence on imported oil.

Tidal power, solar power, wind power and converting cow manure to methane gas are all examples of small-scale techniques which have produced energy. Wind mills, for example, can produce enough electricity for a farm or an island community. None of these technologies have been demonstrated on a large scale.

NUCLEAR POWER

The generation of electricity by controlled nuclear fission—commonly called nuclear power—is morally neutral, as is any technology. [4] Nuclear power is *not* evil. Morality is a function of the human agent, and therefore can not be ascribed to a collection of machines, instruments or pipes. The good or evil of an act depends upon the human agent. If we use nuclear power for capricious reasons, to fill trivial needs, while we endanger thousands of people and leave a legacy of poison for unborn generations, the *use* of nuclear power would be evil. For the next thirty years, if for no other reason than the immense financial investment in existing plants, nuclear power will have a role in our national electricity supply. The case for or against nuclear power can, therefore, be made by considering three topics: safety, wastes and weapons.

SAFETY: CATASTROPHES

Safety is the essential issue. Not only must nuclear power plants be safe; they must be considered safe by the public. Safety has two dimensions: catastrophes and normal, daily operations.

Three Mile Island is the most famous (infamous) of nuclear power plant accidents. At TMI the destruction of much machinery incurred a tremendous repair bill, but no one, at least no member of the public, was reported being seriously hurt. Nuclear power opponents claim TMI to be a confirmation of their fears and prophecies. Proponents of nuclear power claim the successful shut-down of TMI, despite human blunders, to be a vindication of the "defense-in-depth" concept.

As with all human endeavors, the truth is somewhere between both extremes: neither confirmation nor vindication. From TMI, we should learn and apply the lessons. For example, it appears necessary to change the regulatory management method. The President's Commission, the "Kemeny Commission" was displeased with the Nuclear Regulatory Commission's handling of safety issues: "The NRC commissioners are isolated from the agency's managers, and supervision of safety issues is confused, inadequate and haphazard."[5]

At TMI, blunders of the operators were a contributing factor to the extent of the damage. In March 1975, on the other hand, a fire destroyed the insulation of power cables, making it impossible for the "machine" to handle the two reactors at the Browns Ferry plant, near Athens, Alabama. Human operators intervened. They brought both Browns Ferry reactors to a safe shut-down. The difference in performance between the two operator groups points up the need for more training of nuclear power plant operators. Perhaps there is a requirement for a "nuclear West Point", as the *New York Times* has proposed and Senator Moynihan (D, NY) has endorsed:

> In a lifetime of routine they may not know a single emergency, but their entire training must prepare them for those few seconds. This requires training and subsequent work patterns for which an academy may be the best approach.[6]

These are just two lessons learned from TMI. The safety history of nuclear power plants suggests that TMI and Browns Ferry are exceptions. History demonstrates that the risk of operating nuclear power plants, as quantified in the Rasmussen Report [7], is minimal. Whether or not we are willing to assume that risk is up to the individual, the same individual who assumes far greater risks just by driving to work each morning.

SAFETY: NORMAL OPERATIONS

The major concern with a normally operating nuclear power plant is the plant's emission of certain radionuclides. Some critics of nuclear power feel that any level of radioactive release will harm the environment and mankind, even though those releases would be far below the average external background radiation.

If a case can be made against low level radiation releases, then a case can be made against sun bathing and living in Denver. On a more serious note,

> ...combustion of coal leads to a release of radon 222 from the radium 226 that it (the coal) contains. The radon continues to be released from the fly ash long after combustion and produces a chain of radioactive daughter nuclides.[8]

A normally operating nuclear power plant releases less radioactive gases than does a coal-fired plant.

> Coal-fired power generating plants are up to 80 times riskier than nuclear power generating plants in terms of danger from radionuclides (certain radioactive atoms) emitted during normal operation, according to a preliminary government (EPA) report.[9]

Thus, if the release of small amounts of radioactive material presents a great danger to our health, we must shut down or modify nuclear power plants (12% of our production)—but also coal-fired power plants (44% of our production).

The cure would be worse than the disease!

WASTES

All human enterprises produce waste. Since the 1940's, the United States has been producing radioactive wastes, which will have to be isolated for thousands of years. Over 215 million gallons of liquid, high level radioactive waste, the result of our military nuclear weapons programs, have been stored at three sites: Richland, Washington; Savannah River, South Carolina; and Idaho Falls, Idaho.

The contribution of commerical nuclear power to the overall total has been minimal. However, the nuclear power plants in the United States were built with the idea of temporary storage at the reactor site (the spent fuel pool) and reprocessing of the radioactive waste at some central location. Political decisions have precluded a central reprocessing plant. We shall soon have to make up our collective mind as to what we shall do with nuclear power's radioactive waste.

The issue is a political question, rather than a technical one. No one wants a radioactive dump in his/her back yard.

Dr. Margaret Maxey has stated,

> The American public has not been told that the technology exists to meet the most sensible of "performance criteria" for waste disposal facilities. These criteria require that ultimate waste disposal shall be conducted in such a way that there is *no net increase* in risk of harm by comparsion with the typical ore body of natural uranium which yields the energy from which the wastes are derived."[10]

The technological issues are known and understood; radioactive waste is being isolated in salt mines, successfully and safely, in West Germany. Why not here?

The breeder reactor was cancelled for political reasons. The wastes from the breeder reactor would be fuel for other reactors. France is building the "Phenix" breeder reactor, which will effectively deal with nuclear power's radioactive waste; why not in the United States?

Finally, it is clear that mishandling radioactive wastes can result in disaster. There are towns in the Ural Mountains of Russia where no one can live—not because of political reasons, but for technological ones: radioactive poison is everywhere.[11]

We need a safe, sure program for handling radioactive wastes, now, if for no other reason than to handle the by products of our weapons program.

NUCLEAR WEAPONS

Two arguments often given against power are that: (a) exporting nuclear power reactors can result in nuclear weapons proliferation, and (b) terrorist groups can divert spent nuclear fuel and make sufficient weapons grade material for a bomb.

The issue of the international spread of nuclear weapons should have minimal influence on our decision to continue with a *national* nuclear power program. Even if the US does not sell nuclear power reactors abroad, other countries—on whom we have little or no influence—can and do.

The second argument is not truly believable. The processing plant is immense. The techniques require skilled labor. Sufficient safeguards must be in place to prevent the terrorists from being killed by radioactivity. The radioactivity of the process itself, makes the location easily discoverable. All of these things make such an endeavor highly improbable.

Stealing plutonium from, say, a breeder reactor is more believable, but only slightly so. Plutonium is deadly, to steal sufficient quantities over a long enough period of time so as to defeat the radioactivity detectors, would certainly result in the death of the thief. With the proper safeguards, even a multitude of terrorist thieves, attempting to steal minute quantities of plutonium, would be detected. The diversion of plutonium in sufficient amount for a weapon is not plausible. Weapons, from spent fuel rods, should not be a legitimate concern in the decision for a nuclear power plant.

It is far more likely that a terrorist group in the United States would steal a ready-made nuclear weapon, from a military facility. As usual, fiction has already covered this.[12]

CONCLUSION

In the old fable, King Canute, in a demonstration of his royal powers, ordered the tide not to rise. King Canute got his feet wet.

The choice of future energy sources should be made by an informed electorate; the voters should not become a modern day, democratic version of King Canute, by ordering solar power to spring forth and take the place of nuclear power, or by ordering coal to cleanse itself.

REFERENCES

[1] *Energy Data Report,* DOE/EIA 0191 (78), Table 1, Page ii, "Production of Electric Energy By Electric Utilities, 1975-1978."
[2] "Geothermal Energy and Our Environment," U.S. Department of Energy, Document: DOE/EV-0088
[3] John Mitchell, "The Rain That Kills," *Country Journal,* November, 1979
[4] Margaret Mead put it, "Technological advances are themselves neutral. Each technological advance is, therefore, just what the civilization in which it is made can make of it." *Automation, Education and Values,* edited by William Brickman and Stanley Lehrer. (Thomas Y. Crowell Company, New York, 1969) Apollo Edition, p. 67.
[5] "Kemeny Report: Abolish the NRC," *Science,* Vol. 206, November 16, 1979, p. 796.
[6] Daniel Patrick Moynihan, *New York Times,* Friday, January 16, 1981. Correspondence.
[7] *Reactor Safety Study,* WASH 1400, NRC. October 1975.
[8] "Health Evaluation of Energy-Generating Sorces," *Journal of American Medical Association,* JAMA Vol. 240, No. 20, Nov. 10, 1978, p. 2195.
[9] "EPA Says Coal A Hazard", *Industrial Research and Development,* March 1980, p. 47.
[10]"Energy Needs: A Missing Perspective," speech delivered by Dr. Margaret Maxey, PES 1980 Summer Meeting and reported in the *IEEE Power Engineering Society Newsletter,* PES Dec., 1980, p. 9.
[11]Zhores A. Medvedev, *Nuclear Disaster in the Urals,* W. W. Norton & Co., NY, 1979.
[12]Martin Kaiden, *Almost Midnight,* William Morrow, 1971.

Book Reviews

Godel, Escher, Bach: An Eternal Golden Braid, Douglas R. Hofstadter, New York Vintage Books, 1980. xxi + 777 pp, $12.95 (paper). Index, Bibliography. *Reviewed by Robert J. Bibbero, consultant engineer, Advanced Product Concepts Group, Honeywell Process Management Systems Division, Merion Sta., PA.*

That *Godel, Escher, Bach:* has won a Pulitzer Prize for its author is as much a tribute to the taste and sophistication of the Pulitzer committee as to Professor Hofstadter. It is perhaps unusual that a work devoted in large part to propositional calculus and formal logic should win popular recognition, but then this is an unusual book. It combines in a strange and intricate way the history of J.S. Bach's music, Lewis Carroll's "Jabberwocky" (in German!), the trampe l'oeil paintings of Magritte, the French impressionist, and, of course, the weird and beautiful graphics of Maurits Escher of the title, master of the Mobius strip and relativistic viewpoints. What do these widely diverse elements have in common? Peculiarly, a great deal. And what they signify may be of immense import to the readers of *Technology and Society.*

Briefly, and it is difficult to do justice to this tour de force with any semblence of brevity, these themes are skillfully woven into a tapestry that forms a comprehensive and insightful view of Artificial Intelligence (AI), the ultimate concept of computer science. The goal of this research, no less than the duplication in machine form of human (or inhuman) intelligence, is potentially the most significant event that could impact the human race, comparable with the discovery of an extraterrestrial civilization. AI could result in social, philosophical, and ethical issues that would make gene-splicing look like tiddledywinks!

Hofstadter does not devote himself to this aspect. In a manner often appealing and humorous, he explains the intricacies of recursion in mathematical constructs and computer programs, which, he states, can lead to the ultimate "entanglement" of ideas and symbols. Ultimately, recursion on a near infinity of levels leads to the symbol of "self;" self-awareness and true intelligence, whether in man or machine. Hofstadter demonstrates this thesis delightfully, calling on the dialogues of Achilles and the Tortoise in the style of Lewis Carroll, the fugues and canons of J. S. Bach including the awe-inspring six-part "ricercar" (literally, a seeking-out or research), one of the most complex musical compositions conceived by this master, and the self-engulfing worlds of Escher's art for illustration. A key concept is Godel's proof, the thesis that any self-contained logical system must contain elements or "sentences" that cannot be proven within the system; this stands as a paradigm of a mental process that does not recognize its underlying mechanistic (neurological) basic structures. Hofstadter illustrates this by means of many parallels, some fantastic, such as the analogy of an ant colony to the brain, with the motions of individual ants forming the "neuronic" basis and the colony itself acting as a single aware entity. Elsewhere he compares the self-replicative properties of the DNA molecule with the logic of Godel sentences. The insight into mental constructs, and hence the basis of AI, brought by this juxtaposition is will worth the 500-odd pages of education required to get there. (Hofstadter is a good teacher. It is possible to learn mathematical logic from this book, and I am sure that many of his pupils do so.)

Although this book can be recommended without reservation to any readers, scientists or laymen, who seek an overview of current AI research as well as the author's personal views, it is curiously blank on the one aspect that may most affect the readers of this review. What of the ethical and societal issues? Suppose, as we are lead to believe, AI becomes a reality in this century. What if a machine is constructed that cannot only perform intellectual feats in the service of its inventors, but has also a consciousness and awareness of itself? Who would dare pull the switch on such a computer? Hofstadter's theme, in fact the entire idea of artificial intelligence implies that a successful program will go far beyond the contribution of its programer by creating a layer of symbology so much above its mechanistic underpinnings as to be unaware of them at the "ego" level. It is not too early to ask how we should interact with such an artificial personality. Perhaps it will transcend us in a clarity of thought and vision (although Hofstadter thinks not). The responsibility of the creators of such intelligence will be awesome. Should not the goals of AI be lowered to something a little less mind-boggling, at least until experience is gained on "aware" machines? A cat brain (the favorite subject of psychologists and neurologists) would be a more modest goal and responsibility.

A note about the author: Professor Hofstadter teaches computer science at Indiana University. He is a former physicist and the son of a Nobel prize winner in physics. He has recently succeeded Martin Gardiner as a columnist for the Scientific American (Mathematical Games) and has published therein a treatise on Rubik's Cube, a subject rivalling AI in complexity. An inveterate punster and anagramist, he believes the ideal reader of *Godel, Escher, Bach:* is a bright 15 year old (with an IQ in excess of 180).

(cont. from p. 4)

NOTES

[1] United States General Accounting Office, Report to the Congress of the United States, *The Nuclear Regulatory Commission: More Aggressive Leadership Needed* (Washington, DC: U.S. Government Printing Office, 1980), p. 1.

[2] See The President's Commission, *The Accident at Three Mile Island* (New York: Pergamon Press, 1979).

[3] This discussion draws heavily from Steven L. Del Sesto, "The Social Aspects of Nuclear Regulation," in David Sills, *et al.* (eds.), *The Social Science Aspects of the Accident at Three Mile Island* (Boulder: Westview Press, 1981).

[4] These points of view are considered in Steven L. Del Sesto, *Science, Politics, and Controversy: Civilian Nuclear Power in the United States, 1946-1974* (Boulder: Westview Press, 1979), chapter 7. Hutchins statement was made at the original legislative hearings in 1945–1946, while the statement in quotation marks was made in 1947 by Charles E. Merriam, noted political scientist at the University of Chicago.

[5] See Del Sesto, *Science, Politics, and Controversy.*

[6] A similar discussion is found in Paul H. Weaver, "Regulation, Social Policy, and Class Conflict," *The Public Interest* 50 (Winter 1978): 45–63.

[7] These points are from Del Sesto, "The Social Aspects of Nuclear Regulation."

0459925 F 40N *** MAY15
S H UNGER
COMPUTER SCIENCE DEPT
COLUMBIA UNIV
NEW YORK NY 10027