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BEYOND THE TECHNOLOGICAL FIX

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ABSTRACT

Both technological and social fixes are likely to bring with them deterimental and unforeseen side effects. Although the perceived side effects of nuclear energy can undoubtedly be ameliorated by improved technology, a permanent institutional infrastructure will probably also be required. It is pointed out that confinement of nuclear energy to relatively few, large sites rather than many small sites may be a first step toward creating this permanent institutional infrastructure.

BEYOND THE TECHNOLOGICAL FIX*

A technological fix is a means for resolving a societal problem by adroit use of technology and with little or no alteration of social behavior. The problem may itself have arisen from a misused or a deficient technology — for example, highway deaths are a social problem stemming from widespread use of automobiles. Or the social problem may have little to do with technology — for example, war or crime in the streets or overpopulation. Thus for the first of these — highway deaths — we have adopted seat belts and may adopt air-bags; for war, technology offers the H-bomb and missile delivery systems which have imposed a peace of mutual deterrence; for crime, better street lighting, as a partial resolution; for overpopulation, the "pill".

At this Energy Exposition we have been discussing many different technological approaches to the resolution of the energy "problematique". Since most of the papers are given by technologists, it is not unexpected that the social components or approaches tend to be overlooked or set aside. Indeed, most of what we have heard, for example, Professor Calvin's ingenious petroleum plants, are proposals for technological resolutions of the problem of energy supply.

It is significant that so much of the discussion has been concerned with supply rather than demand. Again, this is natural since demand ordinarily involves individual actions of many consumers, whereas supply embraces far fewer, but more powerful actors. In principle, it is easier to increase the efficiency of a central station power plant — say by installing low Btu

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gas topping cycles — than it is to persuade millions of people to turn off their lights or to insulate their homes. In the one case — increasing efficiency of supply — the ultimate consumer has little reason to change his style of living; in the other case, his customary habits are intruded upon, and he must readjust at least some of his ways of doing things.

I would suggest that the primary adjustment imposed by social rather than technological approaches to reduction in demand is a loss in our freedom to allocate time. The most striking example of this is our decision to save energy by reducing the speed limit to 55 miles per hour. Now, to be sure, this action has probably saved 10,000 lives per year and therefore may be a good idea in any event. On the other hand, a more efficient car would achieve the original aim — better utilization of oil — <u>without</u> requiring us to make inroads on a resource that many would consider of primary importance and for which no substitute is available: our allotted three score and ten years of time.

This tradeoff between energy and time was first pointed out by Daniel Spreng of the Institute for Energy Analysis and is much more pervasive and far-reaching than had hitherto been realized. Much of the current rumble about soft energy paths — which implies small, decentralized generating systems based largely and ultimately on the sun, as well as upon a myriad of individual social decisions — involves sacrificing time, or at least freedom in our allocation of time, in the interest of saving our scarce resources of oil and gas. This sacrifice of time is a consequence mainly of the inherent intermittency of the sun.

II

Social critics tend to be wary of technological fixes because they do not get to root causes: they often have deleterious and unforeseen side effects — for example, the interstate highway system, one of our most far-reaching technological fixes, has been responsible in good measure for the deterioration of the nation's major cities; central generation of electricity from coal-fired plants has probably been responsible for a fair share of the fatalities in coal mines.

Most technological fixes can do no more than help remedy the immediate problem that invoked the fix. In their wake they leave other problems which, in turn, are amenable to resolution by additional technological fixes: fixes are applied over fixes, and the society, to be metaphorical, becomes a patchwork of band-aids — indeed, I have referred to it as the "band-aid society".

But technological fixes are not unique in this regard for, if we are honest, social fixes also have unforeseen and deleterious side effects. On a grand scale, we have the great revolutionary movements — for example, Marxism, which has brought in its wake massive suffering. We need not delve into history, however. I have already pointed out that some of our visions for restructuring the energy system — particularly those depending on decentralized and renewable sources of energy — would require sacrifices and changes in our daily lives. They imply an erosion of disposable time and an intrusion of our freedom of choice in the use of time. Whether we would consider this uncongenial, or even a serious loss, is, of course, difficult to say. Indeed, the answer may be a subjective one and differ from person to person. But one must concede that neither technological nor social fixes can ever be expected to produce utopia here on earth: our society, I believe, will always be a band-aid society — about all we can hope for is that small incremental improvements, taken as a whole, will lead to happier, more fulfilled people.

III

I turn from this rather philosophic preamble to speculate on some ways of dealing with the inevitable deleterious and unforeseen side effects of nuclear energy. That nuclear energy, at least in its breeder embodiment, constitutes a possible technological fix for the underlying, long-term problem of energy I believe is undeniable — this, despite the current disaffection with nuclear energy and rejection of at least some breeder reactors. Yet, nuclear energy is considered to be unacceptable by a vocal minority. The anti-nuclear constituency advances various reasons for their stance, many of which have been the subject of intense debate since the first chain reaction more than a quarter century ago.

The issues around which the nuclear debate swirls are proliferation, waste disposal, reactor accident, and terrorism and sabotage. Now, in contrast to energy from fossil fuel, the deleterious side effects of fission energy are manifest only when there is a failure of the system: in principle, an adequately safeguarded nuclear energy system is not necessarily a source of nuclear weapons; its wastes, in principle, can be stored or sequestered safely; if properly operating it will not release large amounts of radioactivity; if properly guarded, sabotage and terrorism would not succeed.

By contrast, at least one of the possible side effects of the burning of fossil fuel -- the release of CO_2 — is inevitable even in a properly operating fossil energy system.

Thus the objections to the nuclear system all turn on the question of probability: what is the probability that a system which when operating properly is rather innocuous, will, in fact, malfunction? This is hard to answer a priori: I suppose the best I can say is that whatever the individual probability, the system probability — of accident, terrorism, even proliferation — is small when the overall system is small, it is larger when the system becomes larger. This will hold unless we can continually improve the nuclear system to keep pace with the increase in its size. Rasmussen's a priori probability of a meltdown in a pressurized water reactor is 5×10^{-5} per reactor per year; this is, I would suggest, an acceptable accident rate when the system is very small — say 100 reactors (which leads to an overall a priori meltdown rate of 5×10^{-3} per year). It is probably too high if the system ever got as large as 10,000 reactors — a possibility that must be contemplated if the world energy system eventually reached 50 terrawatts and, let us say, 75 percent of this were provided by reactors each generating 3,000 megawatts of heat.

It seems clear to me that as the nuclear enterprise unfolds (assuming, of course, that it is not aborted as a consequence of a political decision), technological fixes will be devised for reducing probability of failure in the system. Thus we are now engaged in a large reexamination of reactor systems, including reprocessing plants, that are more resistant both to proliferation and to diversion by subnational groups than is the oxide-fueled liquid metal fast breeder reactor. The general idea is to denature the fuel, either by mixing it with a nonfissile isotope, or with a very radioactive contaminant. Such technological fixes are reminiscent of the old ideas put forth in the Acheson-Lilienthal plan of 1946 — to divide nuclear energy into safe and dangerous activities on the basis of whether the primary fissile material was denatured or not. Though it is too early to say what these massive studies will accomplish, I sense a growing realization that technological approaches to subnational diversion are quite likely to be successful but that similar approaches to proliferation, though important, are not sufficient. Political and institutional mechanisms will have to be invented if we are to live in reasonable comfort with the Sword of Damocles called Proliferation: in short, that we shall have to go beyond the Technological Fix.

IV

Of the two underlying problems that nuclear energy poses — proliferation and safety — I think of the first as being more transitory than the second. There are now 150 sovereign countries — of these not more than, say, three dozen are potential proliferators, at least over the next two generations. As we contemplate the long-term future, we shall have to come to terms with proliferation — either by learning to live in a nuclear-armed crowd, or by putting in place social mechanisms which, one way or another, will resolve the proliferation issue.

By contrast, I do not believe we can ever have done with the issue of nuclear safety, in all its manifestations. A 1,000 MWe nuclear reactor contains about 15×10^9 curies, and this will be as true of nuclear reactors 500 years from now as it is today. Thus, if we are seriously contemplating a long-term future energy system in which nuclear energy is to play a large role, we must somehow grasp this fact. We must guarantee, insofar as possible, that radioactivity on a massive scale, whether inside the reactor or in process streams, is handled properly. Can we conceive of social mechanisms that go beyond technology and that will help achieve this end?

First among the social requirements is the necessity for institutional longevity of the nuclear system. A nuclear reactor simply is not something one walks away from — nor, for that matter, are the wastes unless they have been permanently sequestered. Thus an essential institutional element of the nuclear energy system must be a sort of immortality — somewhat like the institutional immortality of the dike system in Holland: a cadre of dedicated professionals, at all levels, has maintained the dikes for about 1,000 years.

It is clearly impossible for us to guarantee that institutions put in place today will persist for times so far beyond our comprehension; one must be sobered by Adolf Hitler's expectation of his Third Reich which was to endure for "1,000 years"; happily, it crumbled in a decade. Nevertheless, we can take heart from the existence of certain structures and institutions in our societies that have persisted century after century — the great cities, cathedrals, and universities of Europe, or the Buddhist temples of the East. In each case the institutional integrity seems to flow from an identified, virtually hallowed site — a place on the map that contained actual imposing edifices of man. Thus, though we cannot guarantee permanence of the nuclear establishment, there are certain actions we can take now that would make it easier to conceive of an eventual permanent nuclear system arising from today's small beginnings.

The most important, first step toward investing the nuclear system with an attribute of permanence is to endow nuclear sites with the same degree of commitment with which we endow, say, our national parks. Relatively few pieces of land should be dedicated, in perpetuity, to the nuclear enterprise. Whether this dedication is explicit or implicit may not be too important: The interstate highways were not considered to be "national monuments" in the sense I speak of, yet I would guess that the interstate system, pretty much as presently laid out, may last for many, many centuries, much as did the Roman roads in Europe.

What I suggest here, as I have suggested repeatedly in the past, is that the nuclear enterprise — reactors, chemical plants, refabricating plants — be confined to relatively few, very large sites. Such action, of and by itself, will tend to invest the system with the permanence I conceive as being desirable. Preliminary studies by Calvin Burwell of the Institute for Energy Analysis suggest that most of these sites could be expansions of existing sites. We now have some 100 nuclear sites in operation, under construction, or in advanced stages of planning. About this many sites could accommodate the entire future nuclear energy system, essentially forever. If, for example, one placed on the average eight 1,300 megawatt reactors on each site, one could contemplate an eventual nuclear system in the United States consisting of about 1,000 gigawatts. If our population eventually levels at 300 x 10^6, this would amount to 3.3 kilowatts per person installed nuclear electrical capacity, compared to the current 2.5 kilowatts per person.

I have, on many occasions, expounded the virtues of such a siting policy: strengthened security, stronger professional staffs, internal lines of communication, minimization of the land that might be contaminated in case of accident, the strength of the consortia that would operate such centers, and the possibility of resident international inspectors who would be better able to ferret out diversions than would spot inspectors. Here, however, I should rather dwell on a less discussed aspect of such a siting policy — the permanence that such a policy tends to confer on the system, and the virtues of permanence.

Many of the objections to nuclear energy — especially those connected with waste disposal — become nonproblems once one concedes that the nuclear energy system is permanent and there will always be people around who know how to handle radioactivity. To be sure, high-level wastes would not require much surveillance because their volume is so small and, as the American Physical Society[1] concludes, they can be sequestered satisfactorily in geologic formations, but this is rather difficult because the low-level wastes are so voluminous — as much as 50,000 cubic feet per year per reactor. But because they are low level, it would be relatively easy to store them on site for, say, a century or so, at which time most of them could be treated as ordinary garbage. Decommissioning used reactors also becomes a nonproblem in a permanently sited nuclear enterprise: the decommissioning need consist only of locking the door. No harm can befall our descendants because the site is a permanent one; the wisdom of not intruding into these relics will be passed down from generation to generation. And eventually, when the induced activities have decayed, the reactors could be dismantled.

V

Are these ideas of permanently committed, large nuclear sites idle dreams? I think not. In the first place, this underlying siting policy is a reality in Canada. Two sites, Pickering and Bruce, account for 90 percent of all the nuclear power now generated in Canada. Each site is scheduled to hold at least 8 reactors. Bruce, for example, is scheduled to generate some 7,000 megawatts, as well as store low-level wastes for at least a century in engineered storage bins.

We may be already witnessing the same trend in the United States: the Palo Verde site in Arizona is scheduled to accommodate five 1,300 megawatt reactors. It seems most unlikely that sites of this magnitude will ever be dismantled: I would argue that because the commitment is so large, we ought to recognize that it is a commitment into perpetuity, and thus exploit the advantages that such commitment or, more accurately, perception of such commitment, brings in its wake.

I would suspect that because of increasing local opposition to opening new sites, as compared with the general acceptance of existing reactors by those who live near them, that the trend will be to expand existing sites rather than open new ones. Thus, the notion that the nuclear enterprise should confine itself to a relatively small number of large sites rather than a large number of small sites may be evolving even without explicit interventions.

Yet there are structural mismatches that may make such a siting policy harder to achieve here than in Canada. The large centralized sites in Canada all are operated by a single, very large utility, Ontario Hydro. This is the second largest utility in North America, with a capacity of 24 million kilowatts. United States utilities, except for the Tennessee Valley Authority, are considerably smaller and are less able to accommodate large centralized sites. To be sure, nuclear generating consortia, like Yankee Atomic Electric Company, have been set up in some parts of the country. But the crazy-quilt pattern of the 300 generating utilities in the United States tends to work against achieving a siting policy which would involve relatively few, large sites as opposed to many small ones.

To be sure, the technology could in principle be tailored to the institutional structure. Better technology may help us to live with small sites even with their largely external lines of communication between reprocessing plant and reactor, large shipments of low-level wastes, more difficult security arrangements. But a more rational approach is not simply to match the technology to the existing institution but to create the institution that better meets the intrinsic demands of the technology. This means creation of large generating consortia (with distribution left pretty much as is) that can take full advantage of centralized siting, and that can make more credible the commitment to permanence that may be necessary for the long-term acceptability of nuclear energy.

I do not underestimate the huge difficulties — legal, institutional, financial — in such a restructuring: I point out only that there are precedents and that the difficulties may not be as large as some believe. The underlying issue is whether it is easier to improve nuclear technology so as to achieve a fully acceptable nuclear system without underlying structural changes, or whether structural changes along the lines I suggest will be needed if the nuclear system is to be a permanent and growing part of our energy system.

That nuclear energy might eventually imply structural changes in a social institution — the electric utilities — is not a new idea. Fear that such restructuring was implicit in the technology gave impetus to the Atomic Energy Act of 1954 which opened nuclear energy to private industry. Today we seem to recognize that this fear may not have been unfounded. We have here an example of a large technological fix, nuclear energy, requiring social adjustments: neither technology alone nor social engineering alone are sufficient. As we contemplate new paths to a rational energy system, we technologists must take this truth to heart lest we be carried away by the elegance of our technological fixes and become insensitive to the social tensions that our technologies create.

REFERENCES

1. Report to the American Physical Society by the Study Group on Nuclear Fuel Cycles and Waste Management, *Reviews of Modern Physics*, Volume 50, No. 1, Part II, January 1978.