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TOWARD AN ACCEPTABLE NUCLEAR FUTURE

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ABSTRACT

The nuclear option is in danger of being foreclosed. The trend toward antinuclearism may be reversed if concerns about low-level radiation insult can be shown ultimately to be without foundation; evidence for this speculation is presented. Nevertheless it is suggested that the nuclear enterprise itself must propose new initiatives to increase the acceptability of nuclear energy. A key element of an acceptable nuclear future is cluster siting of reactors. This siting plan might be achieved by confining new reactors essentially to existing sites.

TOWARD AN ACCEPTABLE NUCLEAR FUTURE*

We lack but a few weeks until the 35th anniversary of the first man-made chain reaction: it is fitting that this nearly coincides with the 75th birthday of Eugene Wigner. For of all men living, none so strongly influenced the intellectual paths along which nuclear reactor technology has developed. The structure of the underlying theory; the configuration of innumerable combinations of moderator, fuel, and coolant, including the graphite-water cooled, the water-moderated, the D_2O moderated; thorium systems, homogeneous systems, fast reactors — almost every reactor system that has found concrete embodiment — can be traced to the early inventions of Eugene's fertile brain. I once thought that the molten fluoride salt system had somehow escaped his extraordinary genius — only to learn that he had, unbeknownst to most of his group, made a survey of uranium halides with an eye toward their possible use as fuel in a nuclear reactor.

We meet here both to honor our friend Eugene Wigner and to try to set the nuclear energy ship back on course. For, in a way that few of us understood in the exhilaration of the first chain reaction in 1942, the enterprise has fallen onto hard times. Nuclear energy, which seemed to us to provide a permanent technological base for man's material well-being, is in danger of being extirpated. To a voluble

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and sometimes violent minority, nuclear energy is an abomination: its problems related to proliferation and diversion, and to control of radioactivity — are insoluble. More than that, say these energy revolutionaries, nuclear energy is not needed: the sun, and its children — hydro, biomass, OTEC, waves — together with geothermal and some fossil energy, can serve as man's ultimate and even proximate energy system. Moreover, such a system would be thermodynamically more elegant than one based on nuclear electricity; it would be less polluting, cheaper, less centralized; and it would, by decentralizing the mode of production of prime energy, lead to a sort of Jeffersonian decentralized society that would be resilient, both against technological catastrophe and against social disturbance. In short, man will enter a solar utopia which in the more radical literature is all things to all men.

As a former nuclear utopian — i.e., one who used to predict that nuclear energy would cost but 2 mills per kWh and that in nuclear energy man had found the key to his ultimate freedom — I cannot really complain too much about solar utopians: their dreams are noble and need encouragement. On the other hand, when these dreams of solar utopia are used as political instruments to eliminate the nuclear option, I believe it is most important to object. None can say whether utopia will be solar or nuclear or fusion powered. It is the course of reason and prudence to be agnostic: to expect utopia to be a combination — and for the real world, especially now, with our dependence on Arab oil increasing — to use every option, including the nuclear option. To deny nuclear energy by promising a solar utopia is unjustifiably drastic. What is needed is not a way to extirpate nuclear energy; what is needed are ways to fix nuclear energy.

— Do We Have to Do Anything to Preserve the Nuclear Option? —

It is conceivable that the nuclear community, simply by hanging tight, can weather the storm — that a combination of increased understanding by the public and better scientific insights into the true hazards of low-level radiation insult could gradually sweep away much of the worries about nuclear energy. I have in mind here the many comparisons by Professor B. L. Cohen of the calculable risk of nuclear energy — say from nuclear wastes — and the corresponding risks from other sources of energy, notably coal. In essentially every instance the nuclear risks turn out to be lower than the risks from coal, especially if one calculates the risk on the basis of the linear hypothesis. Thus the issue, from this point of view, is simply one of public understanding. If the public could be made to understand that the nuclear risks are really very small, then the opposition would be far less intransigent, and would eventually melt away.

Nor is this all. In the estimates of the casualties from a nuclear reactor accident of Class IX, the largest contribution comes from the tail of the distribution — i.e., from the large population exposed to a total exposure of 8 rem over 30 years from dispersed ^{137}Cs. The American Physical Society critique of the Rasmussen report placed the number of casualties due to radiation-induced cancers following the worst Class IX accident at 25 times higher than the Rasmussen report itself.[1] The APS study assumed the strict linear hypothesis with an assumed cancer incidence rate of 1.3×10^{-4} per man-rem, whereas the original report took some credit for protraction of the radiation exposure. The use of the strict linear hypothesis, according to which damage is proportional to dose regardless of how small the dose, may have grossly exaggerated the hazards of even the worst Class IX accident; thus it is important to reexamine, once again, the validity of the linear hypothesis. The best evidence as to the effect of low LET radiation comes from the exposures at Nagasaki with leukemia as end point. If the linear hypothesis were valid, then the number of casualties per man-rem would be constant, independent of the average exposure per individual. In point of fact, the data shows nothing of the sort. At an average exposure of 340 rem for 6.2×10^{6} man-rems, the number of leukemias in excess of the background is 11, or 1.8×10^{-6} per man-rem; at an average exposure of 40 rem, for a total of 5.2×10^{6}, there were 0.1 excess leukemias or $.02 \times 10^{-6}$ leukemias per man-rem. There is <u>no</u> way to reconcile these findings with a linear hypothesis: one must conclude that in the one case where a large population was exposed to low LET radiation, the linear hypothesis is found to be a gross overestimate of the risk. Indeed, if one takes 40 rem as a cutoff, then the worst Class IX accident becomes a far less serious matter than we had been led to believe, especially by the APS critique of the Rasmussen report.

Could it be that low-level environmental insult, particularly radiation insult, has really <u>much</u> less to do with induction of cancer than is conventionally believed to be the case, and that the current environmental hypochondria is badly overdrawn? J. Totter at our Institute for Energy Analysis has pointed to a remarkable inverse correlation between infant mortality and cancer: in those countries where infant mortality is high, incidence of cancer is low. This suggests that cancer is a matter of genetic predisposition — those individuals whose genetic makeup predisposes them to cancer will contract the disease unless they are eliminated beforehand rather independent of the level of environmental insult.

These are hardly more than interesting speculations. They suggest to me, however, that as more scientific information is obtained, our beliefs as to the hazard of radiation may change; and that these hazards may be judged to be less, rather than more. In this sense, then, there is at least a chance that our concerns will be shown to be exaggerated, and that nuclear energy will lose much of the spooky sense of hazard that now surrounds it: that we can simply sit tight and the opposition to nuclear energy based on the hazard of low-level radioactivity will go away.

But in today's real world, the public is not willing to compare the hazards of nuclear energy to those of other energy sources, nor can science say that the linear hypothesis greatly overestimates the hazard of low LET radiation. Moreover, as Sam Zivi of Argonne National Laboratory has put it, the public does not seem to accept the idea of actuarial risk — i.e., that risk is the product of probability of occurrence and severity of consequences: it looks only at consequences.[2] A large catastrophe occurring at a single time is much worse than a series of small accidents that cause in aggregate the same damage. Indeed, the public seems to understand only no accident-no consequence. Thus to construct an acceptable nuclear future, it will be necessary not only to reduce both the probability of mischance and the consequences of mischance, but also to achieve as nearly perfect a safety record as is humanly possible.

The mischance that we must deal with is proliferation and diversion on the one hand, inadvertent and unacceptable spread of radioactivity on the other. Neither of these concerns is new: the first was considered in 1946 and led to the Acheson-Lilienthal plan; the second has never been far from the minds of the nuclear energy community. One of my first jobs on the Manhattan Project was, in collaboration with Edward Teller, to estimate the hazard of ^{14}C, and it was Edward who insisted on elevating the issue of reactor safety to a predominant place, and who was the first chairman of the Advisory Committee on Reactor Safety.

What has given all these matters renewed urgency is the extraordinary success of nuclear energy. Had nuclear energy always been a tiny, incremental sort of thing, the systems problems of a fully deployed nuclear enterprise would not have appeared formidable. If risk is the product of probability of occurrence and magnitude of consequences, then risk is small when the system is small, large when the system is large. And I suppose one way of reaching an acceptable nuclear future is to keep that future small. If, in our ultimate energy system, nuclear plays but a small role — if, say, the world never has as many as 500 or 1,000 reactors, and if nuclear energy were a transitory thing — say, 25,000 reactor years all told — then the risks would be correspondingly lessened: it is easier to devise an acceptable nuclear future that is small than one that is large.

But this begs the question: we do not know how large the nuclear future might be, nor how long it might last. Should we concede that the most likely future is a combination of solar and nuclear, we still have little conception as to how large each component might be. Moreover, in the transition it is most likely that we shall want to depend on more nuclear energy rather than on less. The prudent course, therefore, requires us to do what is needed to fix the deficiencies of nuclear energy. It was on this account that our Institute for Energy Analysis, over the past year, has been trying to design an Acceptable Nuclear Future.

We began our study with a workshop at which both pro- and anti-nuclear people were present: our basic belief is that we must forge a consensus if nuclear energy is to move forward. A set of criteria that are acceptable only to those who are in favor of nuclear energy will hardly do. The nuclear regulatory process cannot operate in the absence of an underlying political consensus: otherwise each decision of the Nuclear Regulatory Commission is likely to be challenged by the vocal minority that holds uranium to be abhorrent. It is as though the Federal Aviation Authority had to certify the safety of a DC-10 or a

Boeing 747 in the face of an implacable minority that believes flying per se is evil and must be destroyed. It is no wonder that the nuclear regulatory process has become so cumbersome and court-ridden: in a democratic, open society, regulation is possible only where there is an underlying consensus. To make nuclear energy acceptable we must arrive at such a consensus — either by awaiting a spontaneous, though gradual, change in public perception (which might be hastened if further scientific research indeed reveals that we have consistently overestimated the risks of low-level insult); or, much more practically, by actively identifying, and then fixing, the deficiencies that we can identify.

— Technical Fixes —

The deficiencies lie in three spheres: proliferation and diversion; disposal of wastes; and reduction both of accident probabilities and accident consequences. Most of the current posture of the United States government is aimed at the first of these — reduction of the probability of proliferation. The major examination of alternative fuel cycles — the NASAP (Non-Proliferation System Assessment Program) in the U.S. and the International Nuclear Fuel Cycle Evaluation — aim at devising schemes that make proliferation more difficult. Let me say that the unilateral commitment to the Liquid Metal Fast Breeder Reactor (LMFBR) as the only path to a long-term nuclear future has never appealed to me: in this I share the view of Eugene P. Wigner who, although he was an inventor of the LMFBR, always doubted the wisdom of pursuing this direction unilaterally. Thus I cannot disagree with the aims of NASAP — to investigate paths other than LMFBR that might be more proliferation resistant.

Yet, the draconic way in which this path is followed troubles me: at this stage it ought not be LMFBR or other breeders; it ought to be LMFBR and other breeders. The great error that we committed was not so much trying to build an LMFBR that worked (along with the reprocessing system); it was rather that we committed to a "viable, competitive" breeder industry long before we had developed the LMFBR technology on which to base such an industry.

And with respect to LMFBR itself, as Milt Levenson of the Electric Power Research Institute has suggested, we have deviated from the original idea of close coupling between reactor and chemical plant. The Experimental Breeder Reactor II (EBR-II) was both a reactor and a chemical plant; the fuel was never fully decontaminated. The present path, based on Purex processing, embeds LMFBR in the framework set by the Light Water Reactors. It decouples reactor and chemical process. But in decoupling the two we have introduced many complexities and difficulties. Collocated siting was very natural for EBR-II; it is somewhat contrived for LMFBR-Purex. And, as Levenson suggests, diversion of contaminated spent fuel is rather harder than diversion of decontaminated fuel. Altogether the whole aspect of our long-range nuclear system — its organizational structure, its resistance to diversion, its siting policy — would be profoundly changed if the system were based on closely coupled rather than loosely coupled chemical processing.

We cannot say at this time whether the difficulties that originally beset the pyroprocessing of EBR-II metal fuel can be overcome. Burn-ups of >5 percent in Pu-bearing metallic fuel have been achieved, a far higher burn-up than had previously been observed; thus it would seem to me that Levenson's suggestion of reexamining the commitment to Purex processing with a view to recoupling breeder and reprocessing ought to be taken seriously in the NASAP. And of course, I cannot refrain from mentioning the ultimate closely coupled breeder system — the molten salt. The system is among those being examined by NASAP. I would hope that in such reexamination we recognize that it is not merely the technical details of the reactor that are at issue, but actually the structure of the industry: the closely coupled systems lead naturally to collocation; and this places a quite different complexion on the proliferation issue.

As for waste disposal, much can be done technically to reduce the hazards of wastes and the probability that wastes can ever be a serious source of harm. Further work on covering mill tailings is probably still needed. And with respect to reactor safety, additional technical devices and insights are being examined: for example we are taken by the possibility, first suggested by D. Okrent, to provide a bunkered cooling system to remove residual heat regardless of what may happen; or the suggestion by Sam Zivi that the model used to estimate consequences of a steam explosion in a reactor accident is far too simple. Rather than a water hammer blowing the top off the pressure vessel, Taylor instabilities will broaden the impulse and thus reduce the pressure the top head of the vessel is subjected to. Zivi estimates this all but eliminates a <u>truly</u> catastrophic accident in a Pressurized Water Reactor

Reactor (PWR) — i.e., one which could cause billions of dollars of damage and result in many thousands of casualties.

— Institutional Fixes —

But, when all is said and done, the problems of nuclear energy are hardly resolvable by technical fixes. After one has exhausted the possibilities offered by technology, one will have to devise better institutional and political arrangements. There are human factors, human interventions that are an ultimate key to an acceptably safe and even acceptably proliferation-resistant nuclear energy system. It is important that we identify and strengthen these human factors as well as the technological factors that to date have largely dominated our thinking about reactor safety and proliferation.

Reactor safety and proliferation share a common characteristic — the larger the system, the greater the probability of failure. If we take 0.5×10^{-4} as the probability of a core meltdown that will release kilocuries of radioactivity (of the order of Windscale), then for 100 reactors the a priori accident frequency is 1 in 200 years, which is surely acceptable; on the other hand, if there are 5,000 reactors in 2020 as suggested at the World Energy Conference (actually 4,300 GWe, and I assume an average of 800 MWe per reactor), then the a priori accident probability becomes 1 in 4 per year. This may be unacceptable; and if the number of reactors doubles again, this probability increases to 1 in 2 per year.

I cannot say what is or is not an acceptable accident rate. Certainly in the current climate an accident rate of 1 every 2 years would not be acceptable. It seemed to us therefore that we must exert our ingenuity to reduce the a priori accident probability — and though we are largely technologists who view these matters from a technical standpoint, we were convinced that we would have to go beyond technology.

Can we conceive of and then create human institutions that can be relied on to handle nuclear energy with sufficient skill and meticulous attention to detail so as to greatly reduce the 1 in 2 per year a priori accident probability? Can we create the institutions equal to the task of controlling the other troublesome aspects of a large nuclear system, aspects that give us little trouble when the system is small, but can devour us if the system becomes big — and beyond that, if the system lasts for an extremely long time — hundreds, even thousands of years?

Clearly, we must guarantee some degree of political stability. We have had at least one instance thus far in which a reactor — the Vietnamese reactor at Da Lat — was defueled and then demolished, in this case to prevent it from falling into enemy hands. This was a small research reactor. Were it a 500 MWe PWR, such a course probably would have been impractical. We must concede then that nuclear energy does demand a certain degree of political stability — or lacking that, some plausible way of decommissioning a reactor and removing its fuel in the face of war-like activities. Perhaps what is needed is something like a Geneva convention that would exempt reactors from bombing attacks, a bit like holy places, hospitals, or "open cities".

Short of such violent political upheavals or of wars (whose probability of occurrence may be reduced by the deployment of nuclear reactors), I believe there are measures that can and should be taken to reduce both the likelihood of accidents as well as their consequences. We have identified two key and interlocking requirements: to reduce to a minimum the land committed to nuclear energy, and to place the enterprise in the hands of highly expert, professional people invested with institutional longevity. These two fundamental desiderata seemed to us to come together, almost automatically, if nuclear energy were confined to large energy centers. These centers would automatically draw to them powerful groups of people — as has been the case at Hanford, Savannah River, Oak Ridge — who could provide the strength in depth that is a prerequisite for successful management of the nuclear enterprise. The centers could be as secure as is necessary; since the centers would be large, the expense of providing adequate security would be reduced. Moreover, the commitment to the centers would have a kind of permanence to it: these places and no others will be the sites for nuclear energy. One asks, in this connection, whether Hanford, Savannah River, Oak Ridge, Idaho Falls are ever likely to be completely dismantled. I simply cannot visualize these places reverting to activities unconnected with nuclear energy. Thus we must recognize that commitments of land to large-scale nuclear activities would probably be permanent.

Centers of this sort would rather readily lend themselves to operation by powerful operating consortia — like the Tennessee Valley Authority or Yankee Atomic Power Company. Only such consortia would have the logistic and financial strength to handle enterprises of this magnitude; only consortia of this sort, probably underwritten by government, would be invested with the longevity required by the enterprise.

Center siting of the sort we advocate could help with the proliferation and diversion problem. I have already mentioned that security is more easily achieved in a center than in a dispersed system. Moreover, center siting lends itself to resident international inspectors. Such inspectors could insinuate themselves into the system and presumably would be in a position to ferret out plans for illegal diversion. The expulsion of such inspectors could be a time-consuming process which of itself would place an obstacle into the path of the state intent on diversion. If, as the present wisdom holds, timely warning of diversion is the essence of preventing diversion, I should think than an inspectorate of the sort we suggest would accomplish much of this end.

The resident inspectorate, conceived primarily as an instrument to reduce the likelihood of diversion, could, with some extension, become an instrument for improving the safety of the nuclear system. All of us in the nuclear enterprise are uncomfortable about nuclear power plants in the hands of countries that do not possess the capability for handling them safely — either because of lack of money or lack of enough manpower, or both. Can we not extend the resident inspectorate to encompass safety as well as diversion — to establish and help maintain worldwide standards of safety in the operation of nuclear power plants?

To some degree, with modern communication so all-pervasive, an accident anywhere is an accident everywhere. It is of advantage to all to keep the operating standards of nuclear reactors uniformly high everywhere.

I would leave the wrong impression if I conceded that the technological schemes that are now current for minimizing proliferation, largely by increasing the warning time, really strike at the heart of the proliferation problem. Rather, I would insist, as J. Barkenbus of IEA has pointed out, that proliferation is not foreordained to follow a pat scenario which can be circumvented by our equally pat technological ingenuity. Proliferation is a far more complex matter — and in fact is never far from the central issue of war itself. I am reminded of my very first testimony before the Joint Congressional Committee early in 1946, when we were wrestling with control of nuclear weapons even as we are struggling now. My contention then, and I have had no reason to change my mind in the interim, was that abolition of nuclear weapons is not sufficient; that the issue was war itself. Eventually a nonnuclear war between competent states would end in a nuclear war if sufficient national interest was at stake. Thus we cannot avoid the question of war itself — the aim is to avoid war, not merely nuclear war.

In a curious way we are returning almost full circle, both as we contemplate means for reducing proliferation and means for reducing the probability of accidents: the first in a partial return to some of the ideas of the Acheson-Lilienthal plan, particularly the use of denatured fuel, the second in a proposal to confine the nuclear enterprise to permanently dedicated sites just as Hanford and Oak Ridge were so dedicated during the war. Indeed, the obvious suggestion for policy, the key action that recommends itself, is to confine the unfolding nuclear enterprise essentially to the existing sites except in very special cases where existing sites are not feasible. As C. Burwell suggests, in the United States perhaps 80 percent of the existing sites can be expanded, and one probably can accommodate the entire U.S. electrical energy system on about 100 sites occupying, say, 4,000 square miles, plus a few waste disposal sites occupying, at most, 1,000 square miles.[3]

It is my belief that such a partial moratorium — not on nuclear energy but on the proliferation of nuclear energy sites — would be extremely important in revalidating the nuclear option. Indeed, there are strong tendencies in this direction now. Palos Verdes in Arizona will accommodate 6,500 MWe — five 1,300 MWe pressurized water reactors — and is therefore already an example of such a siting policy. Hanford and Savannah River are already nuclear centers: the pattern set by these, including the organizational patterns, ought to be copied widely. And the trend toward center siting is discernible elsewhere too: in France I have been informed the existing sites may well be the only nuclear sites; Canada at Pickering has eight reactors with the possibility of building four more; the Soviet Union at Salzburg announced it is considering centers as large as 20,000 to 40,000 GWe.

The question is whether we ought simply to let nature take its course — in which case centralized siting will occur gradually — or to capitalize on this trend and make it a key element in increasing the acceptability of nuclear energy. My impression is that most of the nuclear establishment would object strongly to the imposition of such a policy from above: it would be far better if it evolved gradually, largely through initiatives taken by the industry itself. I recognize the merits of evolution: but I would suggest that the nuclear enterprise may be missing an important opportunity in not embracing such a siting policy actively and publicly. If the utilities of this country, perhaps in concert with the Department of Energy, were to announce, after a fuller study, such a limited moratorium on new sites, I would guess that the impact on the nuclear debate would be profound. I realize there is danger in such a course: that the orphan sites — i.e., those not scheduled for expansion — could be attacked more vigorously, or that such an explicitly stated siting policy would place still another obstacle in nuclear energy's path. Yet I would consider this secondary. We must decide now what siting policy makes sense when the United States has not 200 reactors but 1,000 large reactors, and when these reactors survive for many, many years. It is not that we know the U.S. nuclear enterprise will involve 1,000 reactors someday. It is rather that we cannot be certain that it will be much smaller than that: let us provide for that contingency by doing now what makes the most sense.

To some the essence of our acceptable nuclear future — strongly collocated siting together with strengthening of the cadres and organization entrusted with the enterprise — may seem like a disappointing anticlimax. Here the nuclear Rome is burning — over proliferation, waste disposal, fuel reprocessing, uranium supply, the future of the breeder — and we talk about devising siting policies for a nuclear future that may never come about. Is this somehow entirely unrealistic? How do these not-very-novel suggestions as to siting help resolve immediate concerns and keep the industry from starving to death from lack of orders?

I suppose our basic answer is that the immediate problems are in part in process of being resolved. Knowledgeable technical experts — for example, the recent APS study group on fuel reprocessing — have repeatedly insisted that the issues of waste disposal and reprocessing are not technical issues, that it is a matter of getting going. As for proliferation, reactors are sufficient, not necessary, for proliferation. What we have addressed is, to my mind, a more fundamental question: assuming that these near-term issues are resolved, how then ought we structure the nuclear enterprise so that man can live with fission comfortably for an extremely long time? Our answer: confine the activity to as few sites as possible, and ensure that the people who operate the enterprise are competent and dedicated. This may sound pat and oversimplified — but I believe this is true. And in reforging a public consensus, I am convinced that it is these long-term issues, related primarily to the 15×10^{10} curies of radioactivity in each reactor, that must be fully dealt with not only to the public's satisfaction but to our own.

— The Alternatives to a Nuclear Future —

This meeting is concerned with devising an acceptable nuclear future. In examining this question it is necessary therefore to examine the alternatives: if there are plausible long-term alternatives, then there is no need to waste time over a long-term nuclear future.

We will hear during this meeting that all the alternatives are beset with uncertainties: fusion, despite the great recent progress, remains technically uncertain; coal is confronted with the possibility of a CO_2 catastrophe; geothermal is probably too small; conservation is a necessity, but in the long run it can save only so much; and solar energy is, in its most interesting manifestations, either very expensive or intermittent.

Yet I believe the ultimate issue is, Can the sun replace uranium? The answer, of course, must be yes: the real question is, At what cost? I believe most in the nuclear community would concede that if solar energy could achieve end uses as well as can nuclear energy, that we ought to forego nuclear energy in favor of solar energy, even at some increment in price. Unfortunately, we do not know what that increment is likely to be: my own estimates always suggest that a solar energy system that provides energy as reliably as does a nuclear system — meaning somehow that the storage problem has been solved — will be very much more expensive than a nuclear system — say 3 or 4 times. I cannot prove this, and I would by no means deny the possibility that technical ingenuity can overcome this difference. Nor can I say that a three- or fourfold increase in the cost of energy is intolerable, especially if we could reduce consumption twofold.

I would hope, though, that we maintain an agnostic position at this conference. The notion that the good society is achieved through decentralized, largely nonelectric, nonnuclear energy systems based on "soft technologies" — in short, that solar utopia is what man not only must strive for but must embrace at this time — is dangerous. None can say what utopia will be: for every vision of a solar utopia one can conjure up a mirror image nuclear utopia: the advantages of one are the disadvantages of the other. The only prudent course is to pursue all of these possibilities — to fix the deficiencies in the nuclear utopia even as we work to achieve the technical basis for a solar utopia. The actual utopia almost surely will be a combination. The best we can do, in the great tradition laid down by Eugene Wigner when he almost single-handedly laid out the principles of nuclear reactor engineering, is to exert our strongest efforts to achieving an acceptable nuclear future that will find its place among the other energy systems that our dedicated ingenuity can create.

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