The writings of Albert Wohlstetter

Perspective on Nuclear Energy*

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D(L)-16568-PR/ISA

January 10, 1968

I. The choice posed by the atom--on the first and most familiar way of looking at it--is that between using it for civilian or military ends, for the benefit of mankind or its destruction. It has been variously phrased as the choice between the benign atom, or the malign one, between one world or none, between a hope and a peril, the quick and the dead, a world of light and the dark chamber of horrors.

Such contrasts have suggested first of all that civilian nuclear energy would open a new world--a rapid increase in standards of living and a closing of the gap between rich and poor countries, and second that civilian nuclear energy would displace the military atom and so make the holocaust less likely. The alternative of continued nuclear arms on the other hand, it was felt at the start, would mean an increase in fear, the transformation of democracies into garrison states, a deterioration in standards of living as populations were dispersed or sheltered, the rapid spread of nuclear weapons and the inevitable holocaust. We like our choices simple. This one sometimes appeared to be black and white.

This turning toward the good atom from the bad reveals the pressure to find some hopeful side to an enormous technological advance whose grim face is all too evident. Dag Hammarskjöld, for example, felt that the civilian use of the atom would expiate the nearly universal feeling of guilt that "man in his folly should have thought of no better use of a great discovery than to manufacture with its help the deadliest instruments of annihilation." Fermi put it more dryly. "It would be nice," he said, "if it could cure the common cold."

Fermi said that in the week of Hiroshima. The dangers of nuclear war are very real. The skull beneath the nuclear cloud in Henry Moore's magnificent sculpture is a *memento mori.* The church-like domed interior of his atom piece expresses some of the awe that the atom inspires even in unreligious men. Sacred texts come easily in talking of the atom: For Rabi "suddenly the day of judgment was the next day and has been ever since." For Robert Oppenheimer, a knowledge of sin. Armageddon, fragments of the apocalyptic books, "The shatterer of worlds." And inevitably the lines of Isaiah about beating swords into plowshares.

But what makes decisions on nuclear energy hard is that they do not call for one final apocalyptic choice between the obviously good civilian uses that lead to peace and the obviously bad military alternatives that lead to war. Some of these civilian uses have a large war potential. And while some military alternatives plainly increase the danger of war, others can and do impart a measure of stability to peace and are essential as at least implicit support for formal treaties to inhibit the further spread of nuclear weapons. We are forced to make a great many decisions about which civilian technologies to support and which to restrict, about what forms of treaties will have a net useful effect and what military alternatives will increase responsible control.

Our problems are many, complex, durable, and present themselves for thoughtful decision piecemeal. Our choices are not a single one between black and white. For the indefinite future they will involve many decisions among shades of gray.

II. The military implications of civilian nuclear programs illustrate the first of two reasons why our choices in the nuclear energy field are not simple ones between good and evil. The civilian and military uses are interdependent and the interdependence is not favorable for our purposes. Though from the start, in the hope of moving inert governments to act, we liked to put the choice in its simple form, it was also understood at the very start that there is a massive overlap between the technology of civilian nuclear energy and that of weapons production. The good military atom therefore doesn't displace the bad military one. Expanding civilian use in general makes it easier, quicker and cheaper to get bombs. The Indian civilian nuclear energy program made it possible some years ago for Prime Minister Nehru to announce that with its help the Indians could detonate a nuclear weapon at a modest extra cost in 18 months. The time lag has undoubtedly gone down since. I would stress that on my view a viable strategic nuclear force including delivery systems and responsible control would by no means be cheap for India, given its other urgent demands. But Indian civilian programs reduce the extra costs of getting bombs.

An essential trouble with nuclear plowshares, therefore, is that they can be beaten into nuclear swords. In some extreme instances of overlap, in fact, they don't need much beating: the civilian nuclear explosive hopefully called "plowshare" is, with only minor adjustments, a pretty good "terrible swift sword." The first reason, then, that our choice in the nuclear field is not a simple one between good and evil is that the military and civilian uses are inseparably mixed.

III. The second reason is that the civilian uses are not so immediately, massively, and directly good, but mainly long-range; and the military alternatives are not unrelieved blackness and certain death. Both call for discriminate and responsible choice.

Immediate bright hopes for civilian nuclear energy have been an emotional counterweight to the immensity of possible nuclear destruction. Also an inducement for countries to accept

international controls. But from the start there were sober estimates by both technologists and economists. Some of these early estimates of the potential for power reactors were conservative. But variations in our hopes on this subject can be measured by changes in the official forecasts for the nuclear generation of electricity. They varied from a low prediction in 1954 to a high in 1957 to another low in 1962, and now the estimate for 1980 stands at 150,000 megawatts. This is not quite back up to the staff estimate of 1957, but nonetheless 150,000 megawatts would represent a great achievement. Nuclear power would then make up more than a quarter of forecast American electrical generating capacity. Large reactors in sizes over 500 and 600 megawatts on order now will be producing electricity in the early 1970's at costs that can compete in much of the country with electricity from fossil fuels. This is most impressive.

Nonetheless it has been clear that such important benefits fall short of ushering in the golden age. They will not abolish want and are unlikely to reduce the great inequalities between rich and poor countries. These points are suggested by the fact that 1) fuel is not the major element in the cost of electric power; 2) electric power is still only 1/5 of the energy used in the U.S., and energy costs in turn make up a very small percentage of the gross national product and a very small percent of the value added by all except a few selected industries; 3) cheap energy can help, but is not the key to economic progress. This can be shown by analyses of regional differences in U.S. fuel costs versus fuel use and income, but much more dramatically when looked at world-wide. For example, in the Middle East energy from oil and natural gas is at its cheapest. If we neglect government royalties and other rents, it might cost as little as 2 or 3 cents per MBTU (Millions of British Thermal Units) - perhaps an order of magnitude less than the average delivered price in the U.S. Yet in the Middle East industrialization and the amount of energy used per capita are among the lowest.

The abundance of cheap energy in the Middle East is one of several reasons for caution about introducing huge nuclear energy plants there - like coals to Newcastle - to desalt water for all the antagonists in the area. (More important, it would also insert large quantities of plutonium in one of the most volatile parts of the world and so place a great burden on inspection and require enormous faith in the durability of agreements where they have been far from lasting.) But for other parts, too, of the less developed world, power reactors seem unlikely to reduce the disparity between rich and poor countries. Poor countries are generally short of capital, but have great need for it - for schools, houses, roads, communications and a great many other things. Therefore their real, that is unsubsidized, rates of interest tend to be very high. Their power facilities are not highly interconnected, load factors are low and the demand for power comes in relatively small concentrations. Power reactors on the other hand are:

--highly capital intensive and sensitive therefore to the supply and cost of money.

--derive much of their benefit from being used a very high

proportion of the time over a long economic life - 80% and even 90% load factors have been assumed.

--and finally involve very large economies of scale. It is the very large economy sizes ranging from 500 to over 1,000 megawatts that have become competitive in the U.S. These call for great concentrations of industrial demand.

The fact that power reactors do not make an immediate large difference in per capita GNP does not mean that the prospects for the peaceful atom are not outstanding. They are. In perspective we must remember that few, if any, individual innovations have had such dramatic effects on GNP. Robert Fogel's careful, theoretically informed, empirical measurement of the total social savings attributable to the railroad, that great innovation of the 19th century, showed that its contribution in the United States came to less than 5% of the gross national product in the year 1890, or roughly the amount of growth that would have occurred without it in two years.

I believe civilian nuclear energy will yield very great future benefits. Power reactors are the major single application so far. But others, like those described yesterday, in biological research, in agriculture and in industry, have already had large effects. The greatest benefits, I suspect, will be in the performance of new functions, the joint results of nuclear energy and other new technologies. These benefits are likely to be indirect and long-term.

The assurance of massive, long-term benefits should make us less compulsive about offering nuclear technology as the solution to all our ills. It isn't necessary for it to cure the common cold. And civilian nuclear technology has political and military dangers that call for caution especially in the short run.

A recognition of the inseparability of military and civilian energy qualified the earliest internal and public government statements of support for civilian nuclear energy. without effective international control, to spread civilian nuclear energy would worsen the military dangers, according to the Truman-Attlee-King declaration of November, 1945, the Acheson-Lilienthal Report, and the Baruch Proposal to the United Nations. Moreover, by international control, the Acheson-Lilienthal and Baruch proposals did not mean merely international inspection. Few then thought international inspection was enough. They meant ownership or management by an international authority of a wide spectrum of dangerous civilian nuclear processes from mining through the operation of many reactors, and the licensing control and inspection of the rest.

Recalling this history can help us see the narrow frame of the present debates about international control in connection with the non-proliferation treaty as well as agreements for economic and technical aid in propagating civilian uses of nuclear energy. We talk today at most of inspection, and even here our strongest hopes are weak indeed by comparison with our early ones. The dangers, however, of the civilian activity are not less evident. If breeder-reactors come into operation as rapidly and as widely

as our Atomic Energy Commission expects, sometime shortly after the year 2000, there may be a million bombs worth of civilian plutonium in the world, doubling every ten years. Early doubts about the adequacy of inspection have lost none of their relevance. No inspection can insure against the diversion of a small percent of material for weapons and a small percentage of a large volume may be enough to cause quite a lot of trouble in volatile parts of the world.

Second, facilities and materials obtained under bilateral or International Atomic Energy Agency control arrangements can make it easier to get facilities and materials that are not subject to such arrangements. The Indians, for example, hope to construct on their own a reactor using natural uranium at Madras. It would not be subject to the control arrangements that go with an international aid program, but plainly it will have been greatly helped by Indian experience with the Canadian and American reactors which are subject to inspection.

A non-proliferation treaty may extend inspection to further civilian facilities. Some of the opposition to such a treaty stems overtly from a concern about the commercial disabilities such inspection might bring in increased costs and losses of industrial secrets to competitors. This resistance might narrow inspection.

Finally, and most important, sovereign nations that are strongly moved by considerations of national safety or other powerful motives like irredentism are not likely to be permanently restrained by treaty arrangements signed years before. And indeed non-proliferation treaty drafts explicitly allow any party to exercise its sovereign national right to withdraw, if it itself determines that "extraordinary events" have jeopardized its "supreme interests."

This suggests that the crucial question will continue to be how to reduce the chance that countries will feel their supreme interests are jeopardized if they do not get nuclear weapons.

IV. Which brings us back to the military atom. There can be little doubt that the experiment at Stagg Field was the most momentous event in the history of war. The first fission devices it presaged multiplied the explosive force of previous weapons a thousand times. Fusion devices a few years later made it more than a million times. Such compact destructive power makes it possible to reach any part of the world from any other with enormous destructive effect. Just a few years have transformed the nature of war. Avoiding rather than winning a world war or any mutual nuclear war has become primary.

This does not mean that no one will threaten or risk nuclear war and it has not made war, even nuclear war, impossible. The close new military interdependence of remote parts of the world did not assure world cooperation for peace or world government, as many hoped. On the other hand it did not - as many feared - mean that without world government, nuclear war was inevitable.

In the last decade, a great many quasi-mathematical arguments, fortunately all faulty, have tried to show that the laws of

probability make an accidental nuclear war inevitable. And a good many individuals have given their personal estimate of the probability of war in some specified interval. These vary from an early 1963 estimate that gave us a less than even chance of surviving the following two years to a very few that number our safe years in the relatively comfortable hundreds. There is, I think, no substance in any of these estimates. Like the prophecies of final disaster by medieval chiliasts, these predictions aim at an early drastic change of heart in the world. But they have not had that effect. They tend in fact to discourage patient acts of intelligence aimed at getting more responsible controls to reduce the dangers. Prophets of imminent disaster tend to run short of wind. When the disaster doesn't come, they often drift off to attach themselves to some other disaster. The rot in our cities, the spreading use of pot.

In the same way, catastrophic predictions of the rapid proliferation of nations getting nuclear weapons are neither well-founded nor much help. They can actually encourage the spread. A distinguished senator and a high official used almost the same words a while ago to say that the Minute Man cost less than the B-52, that nuclear weapons and delivery systems were cheap and getting cheaper, and unless the international system was quickly and drastically revised, they would spread rapidly, since they were equalizers on the world scene. Some Asian friends of mine who doubt such drastic early revision observed only that nuclear weapons were said to be getting cheaper all the time and would make their country the equal of the great powers; and they want some. But in fact nuclear weapons are not equalizers. A small fraction of a major strategic force can eliminate the costly French force with high confidence. And substantial nuclear forces are not getting cheaper. If the $3.3 billion in research and development (R & D) for Minute Man I and II is counted, they cost much more than the B-52. And R & D costs weigh especially heavily on small forces.

Disseminating the complex truths about nuclear forces is more likely to inhibit dissemination of the weapons themselves than the simple scare slogans. The spread was rightly understood at the beginning of the nuclear era as a problem of utmost gravity. But it has gone more slowly than was initially expected, or than was predicted as recently as 1960, when it was said that it would include a dozen new countries by 1966. Four countries have exploded nuclear weapons since our Trinity shot in 1945. And the reasons the spread has not been more rapid suggests ways of inhibiting further spread.

Some countries that could undertake a program have not, because they do not feel threatened, or because they feel that the nuclear threat is adequately checked by a third party, or because they recognize that the problem of nuclear self-defense is likely to be costly in terms of their resources and ineffective against a major adversary, or for some mixture of these reasons. We should fortify those reasons. We should not only make clear the high costs and vulnerabilities of nuclear forces. Where possible we should choose our civilian and military policies in ways that are likely to keep the costs of new national nuclear forces high and their

effectiveness low. Moreover, since for the foreseeable future an assured total nuclear disarmament is unlikely, we have to guide our policies so that a country without nuclear weapons will not feel that its safety is jeopardized. Though the word "commitment" is at present traumatic, this means in one way or another commitments to protect non-nuclear countries against coercion or nuclear attack by some nuclear power. Such commitments might be only tacit; they might be unilateral, or in an alliance, or in the form of a potentially universal collective security arrangement. But in any case these commitments require maintaining defenses that make the risks of fulfilling the commitment smaller than the risks in not doing so. It also means the patient building of common interests to help make the commitment credible. Without such policies treaties are covenants without swords.

This perspective on the dangers of destruction promises no quick and final solution. It involves discriminating acts of choice in both the military and civilian fields of nuclear energy for the indefinite future. And it does not minimize the dangers. The benefits of nuclear energy can be of immense importance, even when they are not immediate and massive. The dangers are very real, even though they are persistent and cannot be dealt with quickly and finally. And we have always to weigh the benefits and the dangers together. It is ironic that this tremendous achievement won by a massive burst of effort in so short a time leaves us as legacy the need for an unending sequence of small careful but unheroic decisions. The genuine alternatives call for such continuing acts of intelligence rather than one final apocalyptic choice.

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* Delivered December 2, 1967, at the final luncheon during the 25th anniversary observance of the first controlled, self-sustaining nuclear reaction at the University of Chicago. The lunch was attended by many of the scientists who had taken part in that experiment. The Henry Moore sculpture, "Atomic Energy," referred to in the talk was unveiled after the lunch. This printed version of the talk is scheduled to appear in the April 1968 *Bulletin of the Atomic Scientists.*

List of Wohlstetter documents