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NUCLEAR ENERGY PROGRAMS IN THE DEVELOPING WORLD: THEIR RATIONALE AND IMPACTS

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ABSTRACT

Nuclear Energy Programs in the Developing World:
Their Rationale and Impacts

This paper is the first product of Dr. Sábato's research as a Guest Scholar at the Wilson Center, April-June 1979, on the nuclear non-proliferation policy of the United States. It deals with the question of why some developing countries decided "to go nuclear" in the first place. This is an important question because, explicitly or implicitly, it has been assumed in the United States that the main reason for that decision was to develop nuclear weapons. This paper argues that there were several other reasons for nuclear development, some of them of much greater importance. Because these other motives have been ignored in the design of the new U.S. non-proliferation policy, there could be reactions in some countries that will be hard to understand in the United States.

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Introduction

Beginning in the early fifties, research and development on nculear energy was introduced in several developing countries. Atomic Energy Commissions organized on the model of similar institutions in the developed countries were set up and extensive programs established to harness the atomic potential for such areas as the production of power, agriculture, industry, and medicine. About a dozen countries, including Argentina, Brazil, Mexico, India, Israel, South Korea, Egypt, Yugoslavia, Spain, the Philippines, Taiwan, and Turkey, have been involved for more than twenty years in such programs, whose major initial feature was the installation of nuclear research reactors with foreign financial and technical help. The fact is that many of these countries have by now gone beyond the research reactor stage and have sizable nuclear installations, including power reactors and significant capability in several phases of the fuel cycle--milling, fuel element production and reprocessing.

Over the last five years or so, however, the policy to develop a nuclear capability and infrastructure has come under heavy attack in both the developed and developing countries. The main arguments put forward by this body of critics can be summarized as follows:

1) Any advantage that nuclear energy may possess is wiped out by a variety of disadvantages. It is a dangerous and highly risky socio-technical system that is vulnerable to political and social instability and poses both short- and long-term health hazards. It is, in fact, nothing short of an inherent evil.

2) The establishment of nuclear programs, while ostensibly intended for peaceful purposes, nevertheless has weapons and bomb manufacture as their implicit long-term objective.

3) Nuclear programs are not of immediate or direct relevance in meeting the basic needs of the masses in the developing world; they are another manifestation of a centralized mode of organization, production, and distribution that has tended to exacerbate poverty and inequality in the Third World.

4) An important rationale for nuclear program development, namely the cheap and efficient production of electricity, is lost when other hitherto neglected sources of energy sui-generis to much of the developing world are considered seriously. Moreover, these alternative options--which include hydro, solar, geothermal, and bio-mass energy--could be decentralized and made compatible with the local ecological and socio-economic milieu.

We certainly appreciate the fact that a nation must continuously re-examine, in the light of experience gained, its choice of development and technological strategy; and nuclear energy is no exception. However, the validity of the above claims of the "anti-nukes" cannot be judged without first examining the historical, political, and economic framework within which the developing countries have undertaken nuclear activities. Our suspicion is that the arguments now fashionably proclaimed against LDC nuclear programs, after the euphoria with which those programs were greeted in the fifties and sixties, ignore this framework.

The current debate over the necessity and convenience of nuclear energy programs in developing countries has diverted attention from a very basic question: Why were the developing countries interested in nuclear energy in the first place? Almost thirty years after such programs were considered almost de riguer for national development, this question once again merits careful attention.

We will, in this paper, attempt to describe the framework of international political and economic relations over the past thirty years which has provided the major impetus to the widespread acceptance of nuclear energy in the developing world. We do this not with the purpose of apologizing for nuclear energy or to attack "soft energy paths"; instead we seek to restore a certain amount of balance and perspective to an emerging view of nuclear energy that tends to underemphasize the opportunities it has created in technologically backward countries.

Nuclear Programs: A Historical Perspective

Broadly speaking, we can identify three different phases in international relations over the past thirty years which have influenced the course of nuclear energy development in the Third World. The first period, beginning with the Manhattan Project and lasting until about 1952-53, was governed by the U.S. Atomic Energy Act of 1946, which placed an embargo on the export of nuclear information and materials from the U.S. and marked what can be called the "Denial Policy." This policy called for perpetuation of the United States monopoly on nuclear knowledge and capability. It was not only the developing countries who were to be excluded or denied access to the new technology; allies like England were subject to similar bans. Admittedly, the Acheson-Lillienthal plan, which acknowledged that it would be impossible to keep nuclear knowledge a close secret for long, drew attention to the need for the complete internationalization of the nuclear industry as a way of avoiding the attendant risks and

dangers of the imminent prospects for nuclear proliferation. But this plan was, for a variety of reasons, rejected, and the official policy-line continued to be one of denial as far as sharing of materials, equipment, and technology, and provision of technical assistance to other nations, were concerned. No doubt, on a commercial basis, mutually satisfactory arrangements may have been possible, but purely on a cooperative basis, other nations, particularly the developing ones, found it difficult, and practically impossible, to initiate programs in their own countries.

The problem, however, was not as acute for countries like Canada, Germany, France, and the U.K.--which had the necessary scientific and engineering skills and a sufficiently strong native technological tradition--as it was for the developing countries, which at least initially were dependent on external assistance and know-how.

As Glen Seaborg, former chairman of the U.S. Atomic Energy Program has stated, "There were many of us who felt in those early days [of the war], as some feel today, that we could somehow hold back the hands of time--arrest scientific progress--and not cooperate with other countries in providing this nuclear technology and materials for peaceful purposes."[1]

Faced with the cold prospect of little or no assistance from the United States, some developing countries moved ahead, deciding to go on their own, mobilizing help from wherever available and possible. In 1953, for instance, Argentina bought a pilot plant for the production of metallic uranium from West Germany, and installed it in 1954. Also in the fifties, Brazil purchased from Germany ultra-centrifuge machines to work on isotope separation and enrichment. India had taken steps even before the end of the war (as early as 1944) to develop an indigenous nuclear capability; in 1955 with those design and engineering skills it installed a large heavy-water research reactor with Canadian assistance.

The denial policy did not stop nuclear proliferation. The Soviet Union (in 1949) and the U.K. (in 1952) became nuclear-weapon states, and France began a substantial plutonium production program. At the same time, the U.S. nuclear industrial lobby was asking for a different policy, one that could help establish a nuclear business, national as well as international.

The second period, beginning with the announcement of the "Atoms for Peace" plan in 1953, can be termed "the golden period for nuclear energy." Now atomic energy was widely heralded as a panacea for economic backwardness and as a powerful instrument for progress and modernization of the less developed countries. The United States announced the Atoms for Peace Plan in 1953 in the General Assembly of the U.N. The plan called for mobilization of resources under U.S. initiative to apply atomic energy to the needs of agriculture, medicine, and other "peaceful" activities.

Clearly, the main intention of the Atoms for Peace Plan was to deter the emergence of other nuclear-weapon states. The U.S. had become resigned to the fact that the U.S.S.R. and the U.K. were already part of the nuclear club. Canada had decided very early to forego nuclear-weapons production. Germany and Japan were under restrictions that limited their range of options. This left only France and the developing countries. Here, it is interesting to recall Goldschmidt's and Kratzer's observation that there was no prohibition in the Atoms for Peace program against assistance to nations which concurrently were developing independent efforts even of a military nature, namely, France.[2] The plan was, therefore, clearly targeted against the Indias, Brazils, and Argentinas, which had embarked on peaceful nuclear programs--to control them and discourage them from developing nuclear weapons and building up their atomic stockpiles. To quote Goldschmidt and Kratzer again, "the cornerstone of the new Atoms for Peace concept was the policy of offering assistance in peaceful uses in exchange for verified undertakings that the assistance would not be diverted to military purposes."[3]

No doubt the prevailing and evolving cold war atmosphere spurred the U.S. to offer technical assistance in the peaceful applications of nuclear research before the Soviet Union could be in a position to do so. Last but not least, commercial considerations reinforced these political motives with the prospect of providing U.S. business interests with foreign markets, before other developed countries captured them. For, as Goldschmidt and Kratzer observe, "the first power reactor sales as well as the first large research reactor sales, contrary to the common assumption, were of natural uranium units of British, French and Canadian manufacture, not of the U.S. enriched uranium type."[4]

The Atoms for Peace Plan was followed by the Geneva Conferences on the Peaceful Uses of Atomic Energy in 1955 and 1958 and the creation of the International Atomic Energy Agency (IAEA) in 1958. A major outcome of such efforts was the installation of nuclear research reactors in different countries: including India (1955), Brazil (1958), Argentina (1958), Congo (now Zaire), and Yugoslavia (1960), Venezuela, Taiwan, Egypt, and Portugal (1961), Thailand, South Korea, and Turkey (1962), South Vietnam and the Philippines (1963), Colombia, Iran, and Indonesia (1964). It is important to realize that the main "push" for the development of atomic energy programs in LDCs for altruistic, commercial, and geopolitical reasons came from the developed countries themselves and that IAEA launched an ambitious program to promote the development of nuclear research in the developing world.

There were two reactions to this promise of the golden age: some countries adopted a wait-and-see attitude, and were satisfied to receive research reactors and other facilities and get a modest research program underway. These countries, which we may term <u>passive</u>, included nations like Thailand, Venezuela, Congo, Colombia, etc., which were handicapped mainly by the lack of a local scientific and technical cadre and facilities. On the other hand, countries like Argentina and India initially, and later Brazil, South Korea, and Spain, had

what we might call an active response, brought about by the presence of a sufficiently strong indigenous scientific tradition closely aligned with the West. This in essence constituted a "nuclear lobby" in these countries. More importantly, it was the strong political leadership of a Nehru or a Perón which was primarily responsible for these countries adopting a more aggressive approach to establishing a national atomic energy program. No value judgments are intended in this categorization of active and passive countries. Rather, it is a convenient way of distinguishing LDC responses. Moreover, the active countries were not always active, nor were they activated at the same time and for the same reasons. It is a thirty-years perspective that makes it possible and convenient to place them in a simple category, in spite of some striking differences.

In 1968, a major element was introduced in this strategy of "control through cooperation": the Non-Proliferation Treaty (NPT). By now, it is well recognized that the NPT, which uses safeguards as the tool to prevent the proliferation of nuclear weapons, is not so much a treaty for "non-proliferation" per se as it is a treaty for the "non-acquisition" of nuclear weapons by states other than the U.S., U.S.S.R., U.K., France, and China. The greatest weakness of the treaty, in the words of the Stockholm International Peace Research Institute (SIPRI), "is the imbalance between the obligations of and benefits for the non-nuclear weapon parties--the 'have-nots'--and those of and for the nuclear weapon parties--the 'haves.'"[5]

While the U.S. was the prime mover behind the NPT, interestingly enough it is the U.S.S.R. which seems to be the treaty's most enthusiastic promoter--so much so that it has supplied nuclear assistance only to NPT countries and "even had precluded any participation by its partners in any part of the fuel cycle, except the production of uranium concentrates to be sold to the U.S.S.R."[6]

This "golden" era received the coup de grace around 1974 following the oil crisis and the Indian explosion--with a major shift in the perceptions of nuclear supplier states, the creation of a cartel elegantly called the "Club of London" (1975), and the passage of the Nuclear Non-Proliferation Act in the U.S. (1978). The guidelines emerging out of the London meetings were influenced primarily by North American attitudes. Still seething over what it considered to be India's reneging on a pledge not to use the plutonium from the Canadian-supplied reactor except for "peaceful purposes," Canada presented a fait accompli to its customers (Euratom, in particular) in relation to existing and future contracts: either accept new and more stringent (bilateral and multilateral) safeguards or face cut-off of fuel or equipment supplies. The guidelines called for a restraint in the transfer of sensitive facilities, technology, and weapons-usable materials.

Confronted with legitimization of the by now irrelevant distinction between "supplier" and "recipient" nations, developing countries rightly viewed this as a return to the denial policy characteristic of the early post-war years that imposed technological barriers on export and sharing of nuclear knowledge to perpetuate a monopoly. As Goldschmidt

and Kratzer write, "under the London guidelines, certain steps of the fuel cycle were for the first time being considered dangerous under safeguards and singled out a calling for special restraint in the trade with non-nuclear weapons states."[7] Further, another important feature of the guidelines is the adoption for the first time of a requirement which is tantamount to a kind of safeguard on the transfer of sensitive technology itself--as distinct from the attachment of safeguards to sensitive facilities, equipment, or materials.[8]

The U.S. Non-Proliferation Act is a culmination of a number of circumstances that have made the U.S. once again increasingly protective of its nuclear expertise, and it helps to establish a stronger denial policy. It even goes to the extreme of calling for "a program of cooperation with developing countries in helping them meet their energy need through indigenous non-nuclear energy sources." The fear of terrorist acquisition of plutonium, and the strong impetus provided to the "alternative energy movement" in the wake of the OPEC price hike led to a general reevaluation of the traditionally open policy in nuclear cooperation. Suspicion of the developing world was heightened, following the OPEC example, and a pernicious distinction was now explicitly introduced in nuclear policy--between states who were considered responsible and stable and those who were not.

A basic tenet in this "Age of Uncertainty" is the general acceptance among supplier nations that existing contracts can be abrogated, safeguards can be retroactively applied, and new rules can be unilaterally developed and implemented. The purpose is, of course, the same as in the early post-war years--to prevent the emergence of new nuclear-weapons states by essentially denying assistance; or at least by attaching conditions to the assistance, so that very few countries will find it politically attractive to accept.

While the NPT strategy was to control the event of proliferation, the new policy is directed to control the possibility of the event by regulating access to "sensitive" materials and technology.

Rationale for Nuclear Energy Programs in LDCs

Against the background of this historical perspective, we return to the question posed in the beginning: "why developing countries were interested in nuclear energy in the first place," and in the light of the previous description "why the active developing countries established extensive and sophisticated nuclear programs?"

The basis for the choice was the realization at the end of World War II that nuclear energy was going to be a fundamental factor in the whole "game of nations," with far-reaching consequences spreading beyond the specific field of energy and affecting politics, economics, and culture, to name a few. We may categorize the nature of developing-country responses to the nuclear challenge into six major areas. These are:

(1) the raw-material syndrome:

LDCs' experience has shown that whenever a new raw material became economically and technologically important, its exploitation was immediately seized by the developed countries because of power and superior availability of skills and resources. Significant examples include oil, rubber, tin, copper, bauxite, etc. The immediate reaction in the active developing countries (India, Brazil, and Argentina, for instance) was to develop a protective barrier to foreign infiltration and to preserve national interests in raw materials of nuclear importance. Control over their own national resources, recognized as having enormous economic and political potential, was an explicit policy reflected in the early nationalization of these resource assets. The objective was to develop an indigenous capability to survey for the location of minerals useful in connection with nuclear energy, to exploit it in a manner determined locally, and to use it in ways deemed essential for national interests.

(2) the new-technology syndrome:

Historically, every time a new technology for public services was introduced in a developing country, it was introduced directly or indirectly by the developed countries, under their own terms and through their own channels. Examples include railways, telephones, natural gas, electricity, etc. There was no reason to believe that nuclear energy was going to be any different, with the evident pronounced monopoly of a few foreign companies. Once again, this convinced the developing countries that national control and mastery were essential for deriving maximum benefits for the country from the new technology. This involved the development of a self-reliant capability in modern science and engineering as the best insurance policy to protect the country from further technological dependence.

(3) the prestige-and-power syndrome:

Modern science was at the root of technological advancement in the West, and Francis Bacon had stressed that "Knowledge is Power." The feeling in the developing countries was: "yes, nuclear energy may be a wonder, but unless we understand it in all its complex ramifications and manage to acquire all the necessary knowledge and skills, it will be a new and more powerful instrument to further reinforce our dependence." Nuclear energy was invested with a considerable mystique and its extreme degree of technical sophistication was regarded as a formidable challenge for any nation not content to remain a "mute puppet" subjected to perennial manipulation by the "Big Brothers." To be fully conversant in this new "lingo" was therefore perceived as an objective of national priority.

Moreover, military might had always been an important determinant of a nation's prestige and power, and it was believed that, if not through the actual manufacture of a nuclear arsenal itself then at least through the acquisition of a capability to do so, developing countries could increase their "political stock" in the world.

It may be that, in the face of poverty and other urgent development problems, this has been a short-sighted unrealistic approach, but historically the search for prestige and power constitutes "real issues in a real world."

(4) the fallout syndrome:

Developing countries realized that more developed countries, in both the West and the East, would move ahead with their own nuclear programs and that LDCs had to create a capacity related to the protection of their populations from the effects of radiation and fallout produced by nuclear tests and explosions. Instead of being dependent on the atomic nations, which in any case had a vested interest in underplaying the adverse effects of their nuclear activities both domestically and internationally, developing countries needed to assume responsibility for fully understanding the nature of explosions, their magnitude, and possible fallout consequences. The important point to stress once again is that developing countries were unwilling to trust the information provided by the nuclear states. Effective and mutually beneficial negotiations are possible only if each party has full information on what the other is doing and how it will be affected by the other's actions. (It is interesting to note that there is now sufficient evidence to show that the U.S. Atomic Energy Commission did lie about the fallouts from the Nevada tests [in 1953] to people in its own country.) Further, there was a need to develop and implement standards to deal with the public health hazards arising from the use of radiation and radioactive isotopes in medicine, agriculture, and industry.

(5) energy production:

The developing countries--like all other countries in the world--were of course very interested in harnessing the mighty power of the atom for the production of energy. It was, and still is, simply incredible to realize that one single gram of uranium (less than a pinch of salt!) could give as much energy as millions of grams of oil or coal. Who could resist such a wonder? Who will not try to exploit such a new energy resource? Who will accept the denial of this treasure?

More importantly, a key element in the development strategy of the fifties was cheap, abundant, and reliable electricity. It was an element as vital for Nehru in the fifties as it was for Lenin in the twenties. Nuclear energy was often seen as one of the main answers to that demand for electricity, especially when important reserves of uranium and thorium were discovered in several developing countries. It is also worth remembering that, at that time, the "seven sisters" had the oil business under very tight control, so that nuclear energy was considered to be a key source for energy independence.

(6) the spin-off effects:

The development paradigm in the early fifties stressed the creation of a strong industrial base and the acquisition of capabilities

to reduce the economic gaps between the Western and the newly emerging nations. The developing nations believed that if they did not invest in technologically sophisticated programs which demanded both scientific and engineering excellence the gaps would widen.

One of the purposes of research programs in nuclear energy was to demonstrate to the country itself and the world at large that high-quality research could be accomplished locally, to create an atmosphere that would help retain local talent that would otherwise emigrate, and to enable a rapid broadening of the research effort by concentration in areas that have a maximum eventual multiplication factor.[9] Resources, being limited, were to be directed to areas which could start a chain reaction in the advancement of science and the development of technology.

A sizable increase in self-reliance and a boost of confidence in the indigenous capability to achieve a full command of complex technologies were fundamental factors guiding the attention of LDC planners to the deliberate creation and careful fostering of a nuclear energy program. The confidence operated in this way. "If our industry and laboratories were able to deal with complex projects, of course they would be able to do the same for any project that requires less sophistication than a nuclear program." The main reason why a nuclear program was often the starting point was that political support was most readily forthcoming for it, and such support is critical for creating and utilizing skills and resources. In developing countries particularly, where governments have assumed the primary responsibility for a deliberate and conscious development effort, the success of any program is critically dependent on the political and bureaucratic support it can derive. There was a unique confluence of scientific needs and political desires as far as the atomic energy program was concerned.

This complex set of factors did not, of course, operate simultaneously in all active countries, nor perhaps in total in any one of them. In a given country at a given time, one or two factors were prominent, while the rest were not taken into account or even ignored. But implicitly, however, all of them were present, and sooner or later they influenced nuclear policies and programs. In thirty years' time, they became the main elements of similar scenarios.

Impact of Nuclear Development in LDCs

In terms of the historical framework just described, a balance sheet can now be drawn of the impact of nuclear development in the active developing countries:

(a) The nuclear raw materials--uranium, thorium, zirconium, graphite, and lithium--are under total national control, and sufficient scientific, technical, and economic knowledge has been developed to guarantee their best exploitation in relation to national interests. An indigenous capability to deal with these materials from geological surveys, through mining and milling the ores, to the production of fuel elements and other end products, has been created.

(b) Similarly, the active developing countries have been successful in overcoming the "new technology syndrome": they are now able not only to carry out scientific and technical research in the entire field of nuclear energy but also are capable of performing a large number of engineering tasks and even of manufacturing components, equipment, and instruments. Some of the countries have designed and installed research and power reactors largely on their own, and a national nuclear industry has already emerged. Nearly all the "mysteries" of the new technology have been solved, even a problem as complex as reprocessing.

(c) In the field of nuclear foreign policy, these countries not only are no longer mere "mute puppets" but have been able to openly challenge some of the most delicate policies of the more advanced countries. They did it in relation to the NPT and they are doing it now with the new denial policy. While many Western academics may insist that there is no direct correlation between the nuclear status of a developing country and its "prestige-power quotient," the mere existence of an international nuclear fuel cycle evaluation program (INFCE)--proposed by the U.S. as a way of making its new policy more palatable, and in which Egypt, India, Iran, the Philippines, Argentina, South Korea, and Spain do participate very actively--is a clear indication of the international political impact generated by the nuclear programs of these countries, programs which constitute a genuine alternative to traditional "Big Power" domination, as proved by the Argentina-Peru and Spain-Chile deals.

Finally, with respect to the impact of nuclear-weapons development, the Chinese explosion was directly responsible for the break in the Sino-Soviet alliance, and India's explosion has made it absolutely clear that to become a nuclear-weapons state is not a technical problem but a political one. It has also proved that any nonproliferation policy based on controlling "horizontal" proliferation across nations without encompassing "vertical" proliferation in individual nuclear states is bound to fail.

(d) In matters such as "fall-out" control and health physics, the results have been also quite satisfactory. The active developing countries have built up a good technical capability to monitor the fallout produced by nuclear explosions in different parts of the world on national territories. The Peru-France conflict caused by the French nuclear explosion in the Pacific is a good example of such a capability. With respect to the control of radiation and radioisotopes--a pre-condition for any widespread nuclear energy utilization--these countries have achieved a level of competence high enough to make possible a reasonable protection of the population from their adverse effects.

(e) The spin-off from nuclear programs has been responsible for the introduction of new techniques, processes, and materials in different industries; for the creation of new activities in the economic sector; for the definition and implementation of more

stringent standards in quality control; for the creation of new, and strengthening of existing, scientific and technical institutions; for the training of vast numbers of technical personnel, many of whom are now being used in other areas; for the opening of new scientific and engineering disciplines to academic activities; and for the establishment of strong links between the local scientific/technical and international community.

(f) Up to now the production of electricity has been the most important peaceful application of nuclear energy everywhere, and so it is quite natural that it has had a key role in the nuclear programs of the active developing countries. But in their multiple-targeted, multi-objective nuclear policies, power reactors were seen not just as another, albeit important, way of producing electricity but as a mechanism through which other targets could be achieved--overcoming the various "syndromes" [illegible] the "spin-off effects" described earlier--as well as providing a testing ground for indigenous capabilities.[10]

This explains the reluctance of these countries to import power reactors as "black boxes," and the emphasis given to maximum participation of local industry and importance assigned to local involvement in all stages of the fuel cycle. However, power reactors were not introduced without paying due attention to the specific aspects of the energy problem they were intended to solve; on the contrary, they were preceded by in-depth feasibility studies, covering such issues as present and future energy supply and demand for the country and for the specific region, availability and potential use of conventional fuel resources like hydropower and coal, availability of nuclear materials, economic and financial analysis of costs and of foreign collaboration, etc. The technical quality of these studies was excellent and they were as good (or as bad!) as any others produced at the time in the developed world.

Therefore, in terms of the accepted development model and of the scientific and technological knowledge then available, the installation of power reactors was quite rational, or at least as rational as the establishment, in the same countries at about the same time, of industries like iron and steel, petrochemicals, heavy machinery, automobiles, etc.

In summary, on the "positive" side of this balance sheet, the active developing countries have been successful in fulfilling their original objectives of developing self-reliance and establishing their mastery and control over nuclear-energy issues. This has had important consequences in many other sectors, so much so that "self-reliance," "control," and "mastery" have now become key concepts in the LDC fight for technological autonomy. As Weinberg pointed out: "Scientific activity is infectious and a start in one field will surely bear fruit in others."[11]

Certainly, the situation we have described is not the same for all active LDCs and some have achieved more than others. But it is being propagated, and rather fast indeed, in all of them.

For an understanding of the "negative" side of the balance sheet, we now return to the claims put forward by opponents of nuclear-energy programs as outlined in the introduction. It is said that some of these negative aspects are generic to nuclear energy as a whole--such as their potential hazards and dangers--while others are specific to nuclear energy in the developing countries. With respect to the former, much has been said and written, particularly about nuclear power: it is a very complex, capital-intensive, and dangerous technology, and some key problems have not yet been solved, such as commercial reprocessing, waste disposal, and damage produced by low-level radiation. You can, of course, "live with it," but the degree of continuous vigilance required for safeguarding nuclear reactors and fuels would require such safety measures that it would increase the risk of greater centralized "security."

Some of the main specific negative aspects that have been pointed out are:

(a) Nuclear power requires an extensive industrial base and a highly trained cadre of experts for its proper operation. It is being developed primarily by a few industrialized countries, and so it will simply be a tool of the rich, resulting in more consumption, more waste, and further widening of the gap between the rich and the poor. The haves will have more, the have-nots will have less--not only in international terms but also in national ones.

(b) Nuclear power is another example, perhaps the most striking one, of how the introduction of a new technology leads a country to automatically become a market for virtually the whole spectrum of developed countries' technology. Once you fall in the trap and allow one to enter, you will get the whole lot, and the result will be more technological dependence. Furthermore, through nuclear power you are importing a life style, a definite pattern, and the result will be more cultural alienation.

(c) There is also the critical problem of the opportunity costs: the development of nuclear power will exclude the possibility of other options--the solar route, biomass, geothermal, etc.--so that technologies more appropriate to developing countries will be neglected or even discarded.

(d) The inherent dangers of nuclear power would be far more difficult to contain in an LDC than in an advanced country. A Three Mile Island accident in an LDC would end in a horrible catastrophe, in "A hole to China."

(e) The high technological requirements of nuclear power call for a highly sophisticated cadre of experts, an elite that will naturally help to strengthen the already existing elitist nature of many LDCs.

Summing up the negative side of the balance sheet, the "anti-nukes" claim that nuclear power is a very bad choice for LDCs on all counts, a technology that helps to perpetuate the worst aspects of dependence and backwardness.

We arrive now at the fundamental question: is the final balance positive or negative? The debate is far from being over, and in fact it will never be, simply because conditions and circumstances keep changing and at an accelerated rate. We believe, however, that in the fifties it was the right decision, especially because at the time the positive side was more in tune with the political framework and some of the negative aspects were simply unknown. But what was good for the fifties could be bad for the seventies and eighties. It could be that for some countries the seventies are the fifties, the various syndromes are still present, and the positive side is valid. On the other hand, there may be some countries for whom the situation has changed radically, so much so as to abandon or stop existing nuclear programs.

Now, as then, the international political framework must not be ignored. In that respect, a final word of caution: we believe that it would be politically naive to think that nuclear energy will be abandoned by the advanced countries, with all its implied consequences for developing countries. . . . It is of course no more than a belief!

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