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TECHNOLOGICAL POLITICS IN THE NUCLEAR AGE

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INTRODUCTION

For the last two centuries, Western expectations of a more just and equitable society have been predicated on scientific and technological advance. Utopians and futurists from Saint-Simon to Herman Kahn have argued that contemporary social progress derives (or should) from the application of science and technology to the solution of social problems and the removal of physical constraints. Through their application, an era of material abundance, social opportunity and democratic participation can be secured. In this view technological society tends toward greater political and economic equality, by on the one hand, providing "the physical means of achieving democratic objectives" (Quoted in Ferguson, 1979:14); and, on the other, by "universaliz[ing] all the beautiful and glorious results of industry and skill . . . [making] them a common possession of the people" (Quoted in Ferguson, 1979:15).

Central to the fulfillment of the technological promise is an energy system capable of generating ever increasing amounts of cheap and widely available fuel. In a technological society, abundant energy represents the means to assure the continued production of all other commodities. Thus, a principal task confronting the society is the development of what has been referred to as an "abundant energy machine" (Byrne and Rich, 1986). For many contemporary writers, nuclear power is understood to be the technology capable of delivering the limitless quantities of energy necessary for the continuation of human progress. Nuclear advocates in countries as disparate as the Soviet Union, France, the United States and Japan, regard this technology as possessing attributes uniquely suited to meeting the demands of progress. Their promotion of nuclear power is rooted in a belief which links technology and energy with abundance and social equality.

This paper seeks to evaluate the relationship between social equality and technological expansion with particular emphasis on the context of nuclear power development. The first part of the paper discusses the theory and ideology of technological equality. In the second part, we develop a critical analysis of this view, arguing that the modern process of technological development is embedded within social structures which, rather than offering the opportunity for increasing degrees of equality, tend to produce and reproduce political and economic inequality.

THE PROMISE OF SOCIAL EQUALITY

The view that scientific and technological advance brings about a more equitable society rests upon three interrelated ideas: first, that science and technology furnish through systematic understanding and application, the means to overcome scarcity; second, by ushering in material abundance, a process of social emancipation is initiated which replaces the dominions of nature and social privilege with universal rules of reason; and finally, science and technology open the way for the objectification of social order in which all merely political and economic differences among social groups are (or can be) dissolved and replaced by rational equitability. These themes of abundance, emancipation and objectivity form a political vision, compelling to the modern mind, of scientifically and technologically established social equality.

At least since the 18th century, Western technology and science have been associated with the promise of abundance. The industrial revolution in the U.S. and Europe seemed to confirm the capacity of new technical methods and modes of thinking to yield a world of plenty. Expansion in the types and numbers of goods produced was beyond anything experienced before in the West, encouraging the idea that "technological development progressed not on an **arithmetic** scale... but that the process was **geometric** or even logarithmic in growth" (Pursell and Kranzberg, 1967: 3 -- italics in original). In the face of rapid and widespread development, traditional norms of self-sufficiency, balance and stability lost their meaning and were replaced by ideals of growth and change (Kumar, 1978). Western societies put their faith in the transformative power of science and technology and seemed to reap rewards in nearly every sector of life: "technological developments... increased man's control over his environment, ministered to his animal needs and creature comforts, rescued him from the ever-present fear of starvation, increased his mobility, lengthened his lifespan, and, in general, made work easier and life more comfortable" (Kranzberg, 1973:

62). Continued social support of science and technology would produce the level of affluence necessary to resolve the most vexing problems of Western civilization: "poverty would be abolished; technology's benefits would spread worldwide to do away with misery and insecurity and hence with class and international warfare" (Kranzberg, 1973: 63).

The abundance realized during industrialization, and the promise of still greater material growth, created a new optimism about the social condition and possibility. Science and technology seemed to offer the prospect for emancipation of the human body and spirit. By the close of the 19th century, science and technology had released human beings from "the drudgery of threshing wheat, digging dirt, carrying water, breaking rocks, sawing wood, washing clothes, and, indoors, spinning and weaving and sewing" (Ferguson, 1979: 16). We were now able to assume the role forecast by Descartes: "instead of the speculative philosophy now taught in the schools," we can by "knowing the nature and behavior of fire, water, air, stars, the heavens, and all the other bodies which surround us... make ourselves masters and possessors of nature" (1956: 40). In this master role, not only was the human frame disburdened, but the human imagination freed as well (Mishan, 1971:4):

> One has only to think with sublime credulity of the opportunities to be opened to us... universal adult education, free art and entertainment, frequent visits to the moon, a domesticated robot in every home and, therefore, woman forever freed from drudgery; for the common man, a lifetime of leisure to pursue culture and pleasure (or, rather, to absorb these from the TV screen); for the scientists... increasingly powerful

> and ingenious computers so that we may have yet more time for culture and pleasure and scientific discovery.

More than abundance, science and technology are conceived in the West to have emancipated the individual and society from destiny. Neither nature nor social privilege govern, at least rightfully, the human potential. In the modern era, it is possible, in the West at least, to choose the future guided only by the objective principles of science and the logic of technical application. In this respect, we are poised to implement Francis Bacon's ideal of a New Atlantis in which dominion issues not from force or scarcity, but from understanding.

To take advantage of this opportunity, traditional Western political organization must be revised to reflect the social realities wrought by science and technology. Specifically, political forms and values must undergo objectification so that they conform with scientific and technological reason. A 1978 essay by Daniel Boorstin provides a helpful illustration of the needed technicization of Western political life. In the piece, Boorstin proposes a special political term for Western industrial society--a "Republic of Technology." This republic is sharply differentiated from earlier political forms in the West which, he argues, were governed by tradition and in which "the most valued works were the oldest." In the new republic, the highest social value is reserved for the most recent; the future, rather than the past, "binds" society together. Boorstin traces this value reorientation in part to modern science and the ideal of progress resonant in its operations. Attributing the observation to mathematician David Hilbert, Boorstin notes that the contribution of a scientific work is "measured by the number of previous publications it makes superfluous to read." Similarly, this value reorientation reflects the process of "creative destruction" (Schumpeter, 1955) characteristic of technological innovation in which "old objects simply become second hand" (Boorstin, 1978: 4). In the technological era, societies are distinguished "not by their heritage or their stock of monuments (what was once called their civilization) but by their pace of change" (Boorstin, 1978: 4-5).

Scientific and technological ideals of progress embody a social principle of obsolescence. Prior **political** history is rendered obsolete by the successes of science and technology, allowing us to phase out traditional political forms and values. Buckminster Fuller may have overstated the point where he remarked (except in Teich, 1977: 141):

> Take away all the inventions from humanity and within six months half of humanity will die of starvation and disease. Take away all the politicians and all political ideologies and leave all the inventions in operation and more will eat and prosper than now while racing on to take care of 100% of humanity.

But the general principle is widely accepted in the Republic of Technology that scientific reason and technological application are usually superior to rule by political interest. And this applies not only to our political past: much of the present social order will eventually need to be abandoned as well. As Boorstin observes, technological progress depends upon "developing the need for the unnecessary; wants derive, not from "human nature... or century-old yearnings," but from "technology itself." Obsolescence is an integral and necessary part of scientific and technological change. It is the social parallel of our commitment to scientifically and technologically furnished material abundance and social emancipation.

This gives to science a special role of defining what is valuable, and what is not, over time. In this respect, both have normative rather than simply instrumental status in the republic. Public values and interests are fashioned within an environment produced by technology and science and are subject to change, even veto, by the abundance-obsolescence cycle of technical development. Because social options are routinely evaluated within a framework of scientific and technological feasibility, Langdon Winner has suggested that "the role of technological circumstances in the modern era does in fact supplant other ways of building, maintaining, choosing, acting and enforcing, which are more commonly considered political" (1977: 237).

With the technicization of political life, the Republic of Technology claims its most distinctive possibility--the attainment of democratic equality. Science and technology have been the "great levelers" in the modern era, bringing to everyone a common material experience (Boorstin, 1978: 3):

> ...developed in eighteenth-century England and spread over Europe and the New World... [p]ower-driven technology and mass production meant large-scale imports and exports--goods carried everywhere in steam-driven freighters, in railroad freight cars, on

> transcontinental railway systems. The ways of daily life, the carriages in which people rode, the foods they ate, the pots and pans in their kitchens, the clothes they wore, the nails that held together their houses, the glass for their windows--all these and thousands of other daily trivia became more alike than they had ever been before. The weapons and tools--the rifles and pistols, the screws and wrenches, the shovels and picks--had a new uniformity....

Eugene Ferguson offers a similar view of the democratization of ordinary life brought about by modern science and technology (1979: 16):

> The democratic ideal of American technology shone brightly, too, as countless low-priced pictures, books, lamps, rugs, chairs, cookstoves, and musical instruments served to lift hearts and reduce boredom and despair. The mail-order catalogs that appeared at the end of the 19th century epitomize the democratization of the amenities that has marked the rise of American technology. Rail, if you will, at the decline of taste; but look first at the real alternatives of bare walls, dirt floors, and minds untouched by the imaginative works of writers, poets, painters, and sculptors.

The democratizing impact of science and technology continues in the present. In the contemporary Republic of Technology, "anyone can be a citizen" precisely because science and technology are "ruthlessly egalitarian": in contrast to the pre-technological/pre-scientific Western ideal of democracy--the "Republic of Letters"--in which citizenship was functionally reserved for the select few "who shared **knowledge**," the modern-day resident "need not be learned, or even literate, to share the fruits of technology" since "Anybody can get the message from a television screen" (Boorstin, 1978: 3,5 and 10). Kranzberg and

Pursell present the argument with less flair, but with the same conclusion (1967: 702):

> Technology made possible modern industrial society, which provided the conditions for contemporary democracy. We can see the democratizing force of technology at work in many different ways. For example, the machine is color-blind: it does not care whether the hand that operates it is black, yellow, or white. Proof of this democratic impact of advancing technologies can be seen in the progress toward integration in the southern United States. The development of a new industrial South... is slowly but inexorably bringing an end to inequality. This situation is not peculiar to the United States; the demands of a modern industrialized society in India have breached the caste system in many places.

The last point is echoed throughout Western literature on science and technology. Jerome Wiesner, past president of the Massachusetts Institute of Technology, has observed (quoted in Borgmann, 1984: 38):

> More than any nation in the world, the United States has the opportunity to lead mankind toward a life of greater fulfillment. This opportunity is based on benefits from our continuing advances in science and technology. It is significant that people everywhere look to the United States to provide the science and technology which they need as they, too, seek to improve their condition.

And Boorstin suggests that "we see the experience of all peoples converging," and even proposes that "while it took centuries or even millennia to build a civilization, the transformation of an 'underdeveloped' nation can be accomplished in mere decades" with the adroit use of science and technology (1978: 5).

In sum, scientific and technological advance is conceived by many strands of Western thought to furnish society with an infrastructure of material abundance that frees the human body and spirit to choose and enjoy a self-determined future. With prudent use of scientific reason and adherence to technical principles, democratic equality can be realized, a goal that, until now, has eluded civilization. Ours is an era of "opportunities of opportunity" (Boorstin, 1978: 12).

THE NUCLEAR IDEA OF EQUALITY

The norms and aspirations of technological society are nowhere more evident than in the area of energy production and development. Since the days of early industrialization when coal and steam were first harnessed for power, energy consumption has been regarded as an essential facet of human prosperity. Underlying the ideology of technological abundance is the belief that the advance of civilization is fundamentally dependent upon an ever increasing supply of power for the production of material goods. George Basalla has labeled this relation the "energy-civilization" equation. He argues that each newly developed source of energy has been vested with utopian powers, "promising a golden land of the future" (1982: 28), while simultaneously forewarning of the impending doom awaiting civilizations resigned to lower rates of energy use (Basalla, 1980: 39,40).

> ... tractors paralyzed in the fields, abandoned automobiles rusting on weed-choked freeways, factories as quiet as tombs, and haggard descendants facing a life of everlasting drudgery.... As less energy is

> available per capita the nation is thought to lose its standing among the world's civilizations (Basalla, 1980: 39,40).

While the quest for technological abundance in general, and energy abundance in particular, spans across the last two hundred years, twentieth century articulation of the energy-civilization equation is distinctive. The modern day search for an "abundant energy machine" resides within an institutional context borne out of a military-science-industry alliance "dominated by large-scale programs that offer the promise of technological spectaculars, that involve billions of dollars in expenditures and casts of thousands, and that can only be managed effectively by large techno-bureaucracies" (Byrne and Rich, 1986: 145). It is out of this institutional framework that the contemporary energy promise of limitless power is fashioned.

Since its inception, nuclear energy has been promoted as the technology of energy abundance. Even before the first prototype nuclear power plant was in operation, Alvin Weinberg, a chief architect of the U.S. nuclear program, celebrated "the unborn technology" of atomic energy as the "solution to one of mankind's profoundest shortages" (Weinberg, 1956: 299). Exuberance for nuclear power among its scientific proponents has not been dampened in the thirty years since birth. According to Harold M. Agnew, former director of the Los Alamos National Laboratory, "nuclear is the only nonfossil fuel energy source that will be available to us in sufficient amounts to supply our current civilization and to fuel progress for the foreseeable future"

(1983: 1). Even this evaluation may understate the importance of nuclear power. As David Lilienthal, the first chairman of the U.S. Atomic Energy Commission, has observed:

> Energy is more than an impersonal statistic to be bandied about by computers and theoreticians. Energy is part of a historic process, a substitute for the labor of human beings. As human aspirations develop, so does the demand for and use of energy grow and develop. This is the basic lesson of history (Lilienthal, 1980: 10).

Seen in this context, development of nuclear power is a requirement for global progress (1980:10):

> For many other peoples [in the non-industrialized world] energy sources are scarce, and therefore their living standards are low. Their need for more energy is desperate. Inevitably they look to us and to other highly industrialized nations, needing to use our technology to develop more abundant supplies of energy.

It is perhaps **only** in this context that one could describe the harnessing of the most destructive force known to humanity as heralding a new age where life would acquire "a gentler, more abundant aspect" (Weinberg, 1956: 302).

The significance of nuclear power cannot be assessed solely in terms of its instrumental value or effectiveness. Through the discovery of the fundamental secrets of the universe, the scientific and technological community claims to possess the means to liberate humankind from the scarcities of nature, not by further exploitation or numerical increase, but through the use of scientific and technical knowledge. In this sense, nuclear power marks our passage from a social order limited by scarcity and the conflicts to which it gave rise, to a new Republic of Technology ruled not by political or military domination, but by scientific reason. In the nuclear vision, "social and political tradition become obsolete with the full flowering of the Scientific Era simply because all of the traditional doctrines were conceived in an economic and technological era which bears little relation to the age of abundance" (Weinberg, 1956: 302).

But if the past is obsolete, the future is uncertain until and unless society carries out the changes it must to realize the nuclear promise. Science and technology have provided the opportunity, but if the vision of nuclear abundance and emancipation is to be fulfilled, an abiding social commitment is needed to make nuclear power work. Presently, what stands in the way of nuclear power--and progress--has little if anything to do with practical or technical considerations, according to its advocates. With the appropriate knowledge and method at hand, "every large-scale scientific or technical problem is soluble," or will be, in due course (Weinberg, 1956: 301).

But as the accumulation of scientific knowledge continues to foster technological change through new discoveries, social institutions too often fail to keep pace. According to some, nuclear power has been saddled with the problem of social inertia almost from the outset. Thus, Lilienthal warned in 1949 that unless institutional changes were made, "The atomic adventure may be stifled in the throes of politics, of routine, of sluggishness and apathy" (1949: 146). For the scientifically informed, this is unacceptable; failure to respond to the new challenge is tantamount to social retrogression (Lilienthal, 1949: 145 and

147-148):

> Atomic energy is a force as fundamental to life as the force of the sun, the force of gravity, the forces of magnetism. It is an unfolding of new knowledge that goes to the very heart of all physical things. Perhaps the greatest single opportunity for new fundamental knowledge about the nature of the physical world lies in the development of atomic energy. Within the atomic nucleus are those deep forces, so terribly destructive if used for warfare, so beneficent if used to search out the cause and cure of disease, so almost magical in their ability to pierce the veil of life's secrets.... For the citizens of the world's leading democracy to be in the dark as to the nature of the fundamental structure and forces of the atom--and of the great good as well as evil this knowledge can bring--would be for them to live in a world in which they are, in elementary knowledge, quite blind and unseeing. It would be almost as if they did not know that fire is hot, that water is wet; as if they did not know there are seasons and gravity and magnetism and electricity.

How should society meet the challenge of nuclear power? Consistent with the modern tendency to seek technical responses to social and political questions, nuclear power promotion has generally focused on strategies to infuse greater technical discipline, order and organization into the social structure. For the technically minded, the greatest threats to progress in the Nuclear Project are human error and political interference and, therefore, attention has concentrated on systems with diminished human-political presence and activism, a greater reliance on machine autonomy (e.g., the inclusion of automatic shutdown and redundancy features), and the search for long-term solutions through scientific research and development. It is in this spirit that the nuclear science and technology community advocate "inherently safe" reactor designs, refined emergency systems, more and better machines to monitor machine behavior and to serve as back-ups in the event of malfunction, upgraded technical credentials and training of system personnel, the substitution of technical reviews for political oversight, regulatory decisionmaking by scientists and technologists instead of lawyers or politicians, and bigger nuclear R&D budgets.

Yet, even depoliticization efforts are unlikely to resolve the deeper issue which has most worried scientific proponents of nuclear power, namely, that (Lilienthal, 1949:151):

> In a democracy public thinking that is dominated by great fear, by phantasy, or by indifference to one of the central facts of our century provides a sorry foundation for the strains we may find it necessary to withstand, the hard decisions we must make, and the opportunities for a peaceful world we must develop.

Democratic forms and values must change to reflect the scientific and technological realities of nuclear power. Alvin Weinberg foresaw this dilemma in 1972 when he pointed out that, while the probability of life-threatening nuclear plant accidents is low, expanded use of the technology will lead to an increased frequency of accidents and enlarged risks and hazards. In this respect, the "strains" and "hard decisions" forecast by Lilienthal were inevitable and inescapable. Weinberg also recognized the conclusion to be drawn from right technical thinking of what needs to be done (1972: 33-34):

> We nuclear people have made a Faustian bargain with society. On the one hand, we offer--in the catalytic nuclear burner--an inexhaustible source of energy.... But the price that we demand of society... is both a vigilance and a longevity of our social institutions.... In a way, all of this was anticipated during the old debates over nuclear weapons.... In exchange for atomic peace, we have had to manage and control nuclear weapons.... [W]e have established a

military priesthood which guards against inadvertent use of nuclear weapons, which maintains... a precarious balance between readiness to go to war and vigilance against human errors that would precipitate war.... [P]eaceful nuclear energy probably will make demands of the same sort on our society, and possibly of even longer duration.

Secrecy and security considerations have always figured prominently in the case of nuclear technology, but their presence is typically assumed to derive from social demands for safety on the one hand, and protection against a military reversion of the peaceful atom on the other (ranging from "terrorist" sabotage to irresponsible state conversions of "civilian" programs). Weinberg's insight is to recognize the obverse purpose in garrisoning the Nuclear Project--to secure this technology from precipitous social abandonment. The fear within the technostructure is that ill-informed public officials, mass hysteria and contemporary Luddite orientations may combine in the aftermath of nuclear accidents to weaken social resolve and perhaps even foster irrational actions to dismantle the Project. By restructuring societies around an institutional complex managed by a technical and military priesthood, a reliable, stable social environment can be created in which 1,000 year nuclear security zones and 505,000 year social contracts, essential to the Nuclear Project, arise naturally to address the social and political challenges of the atomic adventure (Weinberg, 1979: 94-95; Anderson et al., 1980: 30).

The political outlines of the Weinberg proposal are not new. They were themselves foreseen by Henri Saint-Simon in the earliest stages of the Scientific Era (in Taylor, 1975:83-85):

> The nation's members vote each year, as individuals, to elect the five best physicists, mathematicians, astronomers, chemists, physiologists, and authors.
> These thirty scientists are joined by five artists and ten persons chosen from industry.
> The assembly of these forty-five men of genius will be called **Parliament of Improvement**...
> All enlightened peoples will adopt the view that men of genius should be given the highest social standing.

The regime of nuclear science and technology appears as the only sensible response to the challenge of atomic progress. After accidents at Windscale (UK), Three Mile Island (US), and Chernobyl (USSR), and after recent disclosures about the harm already done and the perils still to be avoided in the U.S. nuclear bomb-making complex of Savannah River-Hanford-Lawrence Livermore-Los Alamos-Oak Ridge-Sandia-Rocky Flats-Pantex-Fernald (Feed Materials Production Center), nuclear power remains one of the most important Western hopes for material abundance and social emancipation. Sobered by events in the 17 years since he termed nuclear power a "magical energy source" and 33 years since he encouraged its development as contributing to a "gentler" way of life, Weinberg is still hopeful that we may achieve a Nuclear Society, concluding that the "technical means to ending our dependence on fossil fuels" lies in "inherently safe fission reactors that are both economical and acceptable to the...public" (1989:85).

If society, especially Western society, adheres to its part of the Faustian bargain, nuclear development can complete the promise of worldwide social parity, according to its proponents.

Its first-order contribution is a "fabulous productiveness that has not exacted our essential freedom as its price, but indeed can be made to increase the sum total of freedom of choice for the individual" (Lilienthal, 1949:126). Provided that the necessary social commitment and support is forthcoming, an even greater contribution to equality is possible. In easily the most original comparison of conservation and nuclear power we have read, Lilienthal offers a glimpse of the technical vision of equality and the obstacles to its realization (1980:111,112):

> Conservation...isn't this nothing more than a kind of isolationism in a particularly heartless form, an elitist disguise to mask putting a limit on total energy production, thereby slowing economic growth for those who need growth the most?...The only escape from this sinister and destructive meanness is to frame policies that recognize our ethical responsibility toward other peoples on the planet as fellow members of a world community. This task cannot be dismissed as empty idealism; it is the only practical problem for the long run. Unless we make a major contribution toward easing the **world** energy shortage--instead of merely satisfying our own needs--we may be creating for our children's children a life of constant crises and chronic insecurity.

By this definition of the challenge, we can reject a nuclear future only at the risk of harming worldwide development. Nuclear power is an imperative for modern hopes of abundance, emancipation, and equality.

NUCLEAR REALITIES: ELITE POWER, CENTRALIZATION AND TECHNICAL INVASION

Contemporary ideas of technological equality, including the nuclear version, represent a basic distortion of political language and discourse. Self-contradictory notions of democratic elitism and benign authoritarianism are promoted while certain items in the political vocabulary--in particular, citizenship, participation, access and accountability--are trivialized. We are left with a stunted language which, not surprisingly, fails to alert us to the reductionism inherent in the treatment of social emancipation and equality as derivative states of materialist abundance.

Beyond the effect on language and discourse, the technicization of politics threatens to corrupt political understanding and analysis. In the specific case of the Nuclear Project, we are at risk of: (1.) failing to recognize the elite nature of the technology and the socio-technical system it spawns; (2.) failing to describe and explain the centralization of military, corporate, scientific and state power associated with the investigation and development of nuclear energy; and (3.) failing to address the real and imminent danger that this technology poses to autonomous social development throughout the world. Below we offer an analysis of each of these concerns.

Nuclear Elitism

Elite rule is a necessary requirement of Nuclear Society. An elite is needed to fulfill three interrelated functions. First, provision and extension of specialized knowledge and expertise is necessary to ensure safe and efficient operation of the system. Safety, however, requires additional contributions beyond the sphere of specialized knowledge. Because of nuclear energy's intimate relation with nuclear weapons, an elite is needed to maintain comprehensive security for the enterprise. Finally, a nuclear system depends upon an elite to manage the long-term threat posed by the routine operations of the system itself, including waste generation and the stockpiling of enriched fissionable material. In fulfilling these social functions, the Nuclear Project's rulers have no direct interest in democratic principles or social justice. Popular regard for these values may lead the elite to fashion industrial operations in a manner which recognizes such sentiment, but it is neither their objective nor their intent to democratize the technology or the technical system. Their interest in social engineering lies elsewhere, in the legitimation and maintenance of their elite rule.

Weinberg has pointed to a belief among utility executives that "a nuclear plant [is] just like another generating plant" (1979:105). This view is enormously mistaken: "[T]he responsibility borne by the nuclear operator is so great that he and his staff must be regarded--and trained--as an elite." A professionalized cadre is, according to Weinberg, "necessary to keep the nuclear enterprise out of trouble" (1979:105). Western societies are periodically reminded of the specialist nature of the enterprise by the occurrence of (in the special language of nuclear regulation) "technical incidents," "nuclear events" and "normal accidents". These phenomena are unique to nuclear power not only in the technical sense that coal plants (for example) and nuclear plants apply different engineering principles or designs and, as a result, can encounter different technical problems; there are many areas of design and operation which employ identical engineering know-how. The requirement of elite rule derives instead from the nature of nuclear mistakes. The complexity of nuclear accidents is so great that at least some have asserted the impossibility and inappropriateness of probability analysis to assess them (Perrow, 1984). Moreover, the catastrophic consequences of machine failure and human error in the nuclear enterprise lifts this industrial operation out of the ordinary safety vs. profits compromises of business-as-usual. Weinberg argues that recent incidents should serve as "powerful medicine for clearing one's brain" of any confusion regarding the special social status of nuclear operations. Galbraith's analysis of the modern corporate economy, in which a technostructure has far greater social significance than the owner class for maintaining efficient and reliable operations (1985), is especially applicable to the nuclear industry where "the pilot and operator bear a heavier burden of direct responsibility for people's lives than do their respective bosses" (1979:105).

Scientific and technological expertise is only one root of the elite ruler group. Alongside the cadre of technical specialists is a security apparatus formally charged with preventing "terrorists and saboteurs" from diverting fissionable material to non-peaceful uses. In fact this apparatus is an outgrowth of the military origin of nuclear energy development.

The technical possibility of nuclear power was an inherited one. Knowledge of how to control a nuclear reaction and utilize the heat energy given by it evolved from scientific understanding of the possibility of an atomic chain reaction. Although two options could be identified, namely, setting off a chain reaction or controlling one, from a technical point of view the developmental sequence and direction was predetermined. Given the state of scientific and technical knowledge and the institutional organization of Western research and engineering on the eve of World War II, the first option involved much simpler technical problems and logically preceded the second. Control methods necessary for bomb-making could be quickly attained, while control methods for nuclear-based electrical and heat generation were more complex and took longer to fashion. In this socio-technical sense, the atomic bomb heralded the nuclear plant (Ellul, 1964:98-99).

> Could not atomic engines and atomic power have been discovered without creating the bomb?...If atomic research is encouraged, it is obligatory to pass through the stages of the atomic bomb; the bomb represents by far the simplest utilization of atomic energy. The problems involved in the military use of atomic energy are infinitely more simple to resolve than are those involved in its industrial use.

And Joseph Camilleri points out, even societies which attempted "peaceful" nuclear development were ultimately incorporated into the military project (1984:8):

> Only a few small European nations anxious to capitalize

> on indigenous technology and independent access to uranium and heavy water--notably Norway, Sweden, Belgium and the Netherlands--were able to initiate a modest programme of nuclear research and development unrelated to any military objective. But even here the countries in question were dependent, at least in part, on access to fuels and technology which only the existing or aspiring nuclear weapons states could supply.

One of the architects of the U.S. Nuclear Project, J. Robert Oppenheimer, confirms that "the close technical parallelism and interrelation of the peaceful and the military applications of atomic energy" preclude separate development (1955:6-9).

> The science, the technology, the industrial development involved in the so-called beneficial uses ot atomic energy appear to be inextricably intertwined with those involved in making atomic weapons...The same raw material, uranium, is needed for the use of atomic energy for power as for atomic bombs...The same physics which must be learned and studied and extended in one field will help with the other.

Seen in this context, security considerations are unavoidable. Military interests, **regardless** of the political structure of the state, will be asserted in the operation of the nuclear enterprise of bomb and power production. Compromises of civil liberties and rights accompany the assertion of military interests as "security checks, covert surveillance, wiretapping, informers and even emergency measures under martial law" become legitimate components of system operation (Winner, 1986:37).

While non-proliferation is certainly part of the goal, interpretation of the security rationale for elite control should be made with care. There are numerous instances in which non-proliferation is disregarded in deference to other elite interests. For example, the U.S. recently completed negotiations with Japan to allow the latter to recycle U.S. spent fuel for the purpose of plutonium separation for the next thirty years. This agreement waives the long-standing consent requirement exercised by the U.S. in an effort to limit proliferation of plutonium supplies and supply locations (Spector, 1989:29-30). Elite maintenance, safety considerations and non-proliferation goals are sufficiently intertwined to preclude explanation of security needs on any one of these grounds alone. Monopoly power can be as important as social protection.

The third imperative of elite rule arises out of the unique properties of the nuclear system's principal ingredient. Unlike coal, gas, solar, and other fuel sources, the use of uranium requires the consideration of consequences far beyond the time-frames normally used by society in the evaluation of social and technological systems. As Carter has shown, every stage of the nuclear fuel cycle involves the release or creation of radioactive contamination, some of which will remain lethal to humans for thousands of years (1987). This fact requires both "a vigilance and longevity of our social institutions," as Weinberg has observed, which exceeds the governance capacities of traditional political society (1972:33).

While many in the nuclear community argue that deep-site geological storage will safely protect future generations from the worst of the hazards produced by 20th century, even the most optimistic recognize the potential dangers of the waste disposal process. As Weinberg points out, some small measure of permanent surveillance will be necessary "if only to prevent men in the future from drilling holes in the burial ground" (1972:34). In the case of high-level waste even a perfected system of geological disposal will require extraordinary care in the packaging, transportation, and site handling of the wastes. The same is true regarding low-level waste. Under present disposal regimes, for instance, a decommissioned reactor and its associated systems (pipes, robotic handling equipment, and so forth) will require a "cooling off" period of between 50 and 100 years. Thus, even if the as yet unproven disposal technologies function tolerably, an elite will be required to manage the waste stream over several generations to come. It is in this context that Weinberg proposed the institutionalization of a "nuclear priesthood". Not only must the present generation accept the priesthood as a condition of its survival, so long as wastes are active their security must be guaranteed. In this respect, the present generation of nuclear builders has set conditions for the survival not only of themselves but of many future generations as well.

Once more, however, the rationale or elite rule should be carefully interpreted. For it is in the self-interest of the Nuclear Project to expand and radioactively enrich the waste stream. Increased waste means increased use of nuclear power; and as the Committee for Economic Development has pointed out, "any nation that invests in nuclear power reactors... will be motivated to economize nuclear fuels and to consider the likelihood that facilities for plutonium separation, even if not now economic, may become so within the period of a nuclear power development plan" (1977:30). The consequence of expansion and enrichment are an endogenous stockpiling of bomb-grade material and highly toxic "feeder" waste. The plutonium economy which is at the center of the nuclear dream for an abundant and egalitarian future presumes, as well, a highly militaristic and authoritarian social system (Ayre, 1975:443):

> With the passage of time and the increase in the quantity of plutonium in existence will come pressure to eliminate the traditional checks the courts and legislatures place on the activities of the executive and to develop more powerful central authority better able to enforce strict safeguards.

The nuclear elite is part of a "technocratic image" which dominates contemporary ways of thinking and acting (Gunnell, 1982). This image relies upon a language which impoverishes traditional ideas of political leadership and equality. In a technological society, equality does not refer to the opportunity to participate in a process meant to determine the goals and purposes of social action. Rather, participation is a consumptive act unrelated to acts of a social or communal nature. The functions of political leadership is to assess the material wishes of the people and structure the production process in a way which will assure the efficient delivery of the desired goods and services. Politics becomes defined as the management of things best carried out by a qualified elite equipped with tools sufficient for the task. Society is told that the elite serves as a benign instrumentality necessary for the fulfillment of material abundance, social emancipation, and, eventually, social equality.

This portrayal of a technocratic elite resembles past elite justifications for regimes of dynastic and oligarchic rule. In these political systems, social chances were held to be necessarily unequal, since the majority of people were incapable of either creating or following rules of social conduct which required active or sustained participation in a political process. Only the noble and wealthy classes had the vision, foresight and skill required to make these decisions necessary to preserve social stability. Yet, stability was merely an intermediate goal: at the root of the quest for stability was the desire to preserve, protect and enhance the privileges and control of the elite.

Modern technological elites rule in much the same fashion. The existence of the elite is justified and rationalized on the basis of social necessity. Similarly, the elite motives of self-preservation and aggrandizement are present. In this respect, technological politics represents a step backwards into earlier regimes of political authority which sought to limit rather than expand the condition required for social equality. The one difference between these two elite styles is that earlier representatives were clear in their desire for the inequality; the nuclear elite is not as forthcoming.

The Nuclear Consortium

The history of electric power can hardly be understood as a stage in the development of a more democratic and egalitarian society. Quite the contrary, from its inception, the electric industry has sought to increase the profitability of integration and corporate control and to facilitate development of a "network of power" (Hughes, 1983) beyond political reach. The rise of the holding company, the creation of the state regulatory system, the development of industrial science and engineering and the elimination of local authority and institutions (such as the earlier municipal franchise system) was a necessary prelude to nuclear power and one in which "an increasing number of people have become increasingly dependent on a decreasing number of corporations" (Messing, et. al. 1979;62). This is the institutional setting into which nuclear power was introduced.

At the turn of the century, the U.S. electric industry was a highly competitive but fragmented business. In Chicago alone, over 30 utilities were serving the city "despite the fact that only five thousand persons out of a population of one million used electric lights" (Anderson, 1981:34). One of the first efforts to overcome the uncertainties of this risky economic environment was the formation of General Electric in 1892. GE became the first large-scale electrical power system for the manufacture and sale of power equipment as well as the generation, distribution and marketing of electricity. In addition, a Company laboratory was established in 1900 to serve as the basis for planned invention and long-term research and development. GE, along with Westinghouse (who also established a laboratory in 1903), became the model corporate enterprises for the development of the electric industry.

Organizational scale offered an effective and profitable solution to problems of risk, instability and competition which otherwise would have stymied expansion. The heavily capital-intensive nature of electricity production and distribution made the industry particularly vulnerable to financial and economic downturns. GE solved this problem by creating a holding company specifically for the purpose of leveraging additional capital. Electric Bond and Share assumed the utility bond and stock holdings of GE and utilized them to gather finance capital through the sale of EB&S bonds and shares. As part of the EB&S package, affiliated utilities accepted "service contracts" with the Company whereby energy and management expertise was provided. In this way EB&S achieved functional control of utility operations without the need (or expense) of acquiring a majority interest through the purchase of voting stock. The financial scheme and the service contract together heralded the arrival of the integrated corporate system, essential for the successful development of an integrated power planning and production system.

The remaining obstacle to the development of a fully integrated, centralized power system was political. The U.S. municipal franchise system, originally instituted at the encouragement of producers and distributors for the purpose of rationalizing competitive markets, had resulted in small service territories with correspondingly small utility profits. Led by Samuel Insull of Consolidated Edison, the National Electric LIght Association (the industry's trade association), lobbied for monopoly status and state regulation. This movement had the dual function of freeing the utilities from local control, and at the same time mounting an effective resistance to the growing threat of municipal utility ownership.

The combined impact of these organizational, financial and political innovations was to substantially expand the scale, size and quantity of power production in the U.S., as well as the magnitude of revenues and profits. The new regulatory environment and the integrated utility structure touched off a sustained period of mergers in the industry as small local companies were brought into the networks of holding companies. Even municipally owned plants were eventually taken over in this manner. In 1926 alone, over 1,000 mergers were undertaken, and by 1955 approximately 500 private companies controlled 80 percent of national sales. Since then, the number of companies has been halved while the percentage of total sales controlled by these companies has remained approximately the same (Messing, et. al., 1979:45-46; Hughes, 1983:201-226 and 391-394). An equally significant consequence of the revised social environment was the growth in the size of power plants. Generating capacities which averaged 7.5 kW in the 1880s increased to 200,000 KW in 1930 and by 1955 it was possible to construct 1,000 MWe plants (Messing, et. al., 1979:3). Thus, well before the introduction of nuclear technology, a common effort of organization, capital, technology and production method was in existence to produce large supplies of electricity. This vertically and horizontally integrated system replaced the haphazard, competitive basis of accumulation, with one rooted in principles of control.

If the "network of power" that characterizes the institutional structure of electric energy seems contradictory to the scientific and technological vision of opportunity, the institutional origins of nuclear power can only amplify the contradiction. With the demonstration in late 1938 of nuclear fission, physics and the new world entered a new and threatening era. With this newly discovered knowledge, the most prestigious physicists from all over the world in partnership with the U.S. government embarked on a research and development program for the creation of a bomb. Initially, the endeavor brought together and organized a scientific corps for research primarily located at the University of Chicago and the University of California at Berkeley. By the attack on Pearl Harbor, nearly 150 senior scientists with a budget of over $2.7 million, were involved in research projects investigating the feasibility of atomic weapons. When Enrico Fermi successfully produced a nuclear chain reaction in December 1942 (using a squash court under the west stands of Stagg Field, the University of Chicago's unused football stadium--Kevles, 1977:326), development of the most destructive weapon imaginable was assured.

Franklin Roosevelt's approval of an "all out effort" on December 28, 1942 brought together the nation's largest corporations to assist in the production of the bomb. The list included DuPont, General Electric, Westinghouse, Union Carbide and Carbon, Stone and Webster, Chrysler, Allis Chalmers, Republic Steel, International Nickel, and Eastman Kodak. To accomplish the task, a "giant industrial complex" was erected with three separate facilities in addition to those already in existence at various university laboratories. Oak Ridge in Tennessee, Hanford in the state of Washington and the Los Alamos Laboratory in New Mexico were built for the purpose of producing fissionable uranium, plutonium and eventually the bomb itself. But with as yet no firm knowledge about either the processes of attaining fissionable material or actual feasibility of an atomic weapon, principles of corporate efficiency and organization guided the project. In this respect, the Manhattan Project represents a prototype of contemporary technocratic order.

By the conclusion of World War II, the Manhattan Project consisted of thirty-seven installations in nineteen states and Canada; 254 military officers; approximately 4,000 scientific and technical personnel; and a $2.2 billion wartime expenditure (Hewlett and Anderson, 1962:2). The entire apparatus had been built without public consent, and most of it without public knowledge. The nuclear energy program arose out of a federal research development effort that has remained remarkably similar over the last forty years. Nuclear power continues to act as the centerpiece for the integration of the science, military, industry and state sectors. Camilleri characterizes the integration of nuclear power in the following manner (1984:5):

> The principle actors are the armed services, private industry and finance, the legislative and executive organs of government, intelligence organisations and to a lesser extent the atomic bureaucracy, sections of the scientific and technological community and even elements of the trade union movement. That is not to say that the constituents of the military-industrial complex [are] of one mind or always acted in unison. On the contrary, on many issues relating to the scope of the nuclear programme, the level of resource allocation, the degree and form of secrecy to be observed, the organisational arrangements to be enacted, the relationship to be maintained between the military and civil spheres of government, there [are] deep divisions and prolonged battles. On the other hand, it is also true to say that these groupings recognise one another as legitimate participants in the nuclear project and as sharing a common set of basic assumptions about its value and functions.

The electrical network as it developed in the 20th century was a force for technocratic rule, not democratic governance. The Nuclear Project reinforced this orientation, adding military secrecy and security to the institutional apparatus. The electrical network and the Manhattan Project have demonstrated high degrees of hierarchy and centralized control; both sought and obtained institutional autonomy; and both were able to accumulate power at the expense of other potentially more democratic social institutions. In this respect, nuclear power's integration into the electrical network served to extend and amplify institutional inequalities immanent in technological society. Atomic power plants and bombs are evidence of the power of a consortium of centralist institutions to shape modern social history. Both technologies depended for their development upon technocratic norms, secrecy and even exclusion of the public from most policy decisions.

The Universalization of Nuclear Technique

While the idea of technological equality serves to veil political realities in most instances, there is one area in which the Nuclear Project is demonstrating tendencies toward social parity, if not equality. The penetration of this technology into all parts of the world is both rapid and sustained despite very high capital requirements and numerous outstanding safety concerns. For many in the nuclear community, the question of expansionism is settled. LLewellyn King, editor of Energy Daily, recently declared that the "nuclear industry's place is secure; its present is difficult. By the mid-1990's alternative energy systems, such as solar, which have been found wanting, will not be suitable or adequate and we are going to go nuclear. The whole world is going to go nuclear" (Nuclear News, January 1987:90). No nation is likely to be exempt from the logic of nuclear necessity; the possibilities of not "going nuclear" are often beyond the realm of national choice. Even nations endowed with plentiful supplies of alternative fuel sources have invested substantially in nuclear technology. Angelo Giambusso, Chairman of the American Nuclear Society's International Committee, concludes in a study commissioned by oil-rich Indonesia that to meet its energy needs, this country must restart its nuclear development program which had been suspended in the early 1970s. Indonesia is portrayed as having to act on a foregone conclusion, common to the community of nations: "it is not a question of whether a nation should have nuclear power, but one of when it is needed, and how much" (Giambusso, 1986:128). And Remy Carle, director general of Electricite de France's Engineering and Construction Division, in a post-Chernobyl assessment of nuclear power warned that abandonment of the technology "would involve such great tensions on the energy market that [it] would endanger world peace, with all the resulting catastrophic consequences" (Nuclear News, January, 1987:84).

In spite of scattered instances of nuclear opposition, global production of electricity by nuclear power continues to grow steadily. Between 1984 and 1985 nuclear capacity increased 14 percent following a 19 percent increase from 1983 to 1984 (U.S. Department of Energy, 1987:183). Growth continued in 1987 after Chernobyl, as 21,076 MW of new nuclear capacity were connected to electrical grids for the first time (Nuclear News, March, 1988:86). According to the U.S. Department of Energy (DOE), the 416 reactors currently on-line will grown to 500 by the end of 1990 if current construction schedules are met (DOE, 1987:183). Construction orders from 118 plants remain for start-up by 1990 (Ramberg, 1986:318), including new orders by Japan, the Soviet Union and Great Britain.

Nuclear expansion has been particularly robust in the Third

World. China is currently completing the construction of two 900 MW pressurized water reactors (PWR) and is itself building a 300 MW PWR at Quinshan: the latter will be supplemented by two additional 600 MW PWRs in the near future (Nuclear News, November, 1987:98-99). India has contracted to purchase two 1000 MW reactors from the Soviet Union in the largest single foreign purchase it has ever made. The reactors are part of India's plan to add 10,000 MW of nuclear energy to its electrical network by the year 2000 (India Today, May 15, 1988:87). Korea has equally expansive nuclear ambitions recently agreeing to add two 1000 MW reactors to that country; these units will supplement the 10 units either operating or in the Korean pipeline (Power Engineering, April, 1988:10; Payne, 1987:59). Korea's prodigious investment in nuclear power is nearly matched by that of Taiwan, which has 6 units in place with a rated capacity of 4918 MW. Active nuclear programs are also in place in Pakistan, South Africa and in many countries of Eastern Europe (Borg, 1987). Countries of the western hemisphere are also pursuing active nuclear programs. Undeterred by the 1987 radiological accident at Goiania (Petterson, 1988), Brazil recently announced the privatization of its National Nuclear Energy Committee (CNEN) as a way of bolstering that country's long-standing commitment to the technology (Nuclear News, October, 1988:59). Also in 1988, Brazil opened an advanced uranium enrichment plant (The Economist, 1988:86) and signed a pact of co-operation with Argentina for purposes of exploring the joint development of a breeder reactor and other nuclear options (Perera, 1987:39). Currently, Brazil and Argentina both operate nuclear facilities capable of producing bomb-grade plutonium (Spector, 1989:31). Cuba is proceeding with the construction of a 4-unit complex (U.S. Senate, 1986) and Mexico has recently announced that it intends to begin activating the first of two 654 MW reactors located at Laguna Verde on the shores of the Gulf of Mexico (New York Times, 1988:7).

The attraction of nuclear technology to the South is rooted in the themes of technological equality promulgated in the West. India's energy planners for instance, regard nuclear power as an "ultimate dream," a kind of technology which can move its energy system from "infancy to adolescence" (India Today, 1988:87). Nuclear power, however, is valued not merely for its capacity to generate electricity. It is often discussed as an essential technology for rescuing the developing world "from the shackles of poverty and ignorance" (Indira Ghandi quoted in Pathak, 1980:24-25).

Through nuclear power, the South searches for the energy required to industrialize and thereby secure the material advantages currently possessed only by the West. Alder captures the full extent of the relationships among nuclear technology, development and equality in his description of the motive forces driving Brazil's and Argentina's quest for "nuclear autonomy" (Adler, 1988:18):

> Progress from the perspective [of the developing countries] means only going forward, and anyone in the

> rich countries who suggests that such movement should be slowed down or redefined is accused of wanting to prevent the developing countries from achieving a measure of equality. Thus progress is viewed by the developing countries not only as modernization and economic and technological development but as a matter of autonomy and equality as well. This is why their nationalist ideology is so strongly linked to development and equality. Liberation, cultural self-affirmation, development, science and technology: these are the core dimensions of the idea of progress in the Third World.

Although the aspirations that drive developing countries to accept this technique are the achievement of development autonomy and parity, in fact, they are undergoing a form of technical invasion. Far from breaking the cycle of dependency, the exploitation of nuclear power has only deepened reliance of the developing world on the capital and expertise of the industrialized world. French experts, with experience gained from efforts in South Africa and Pakistan, are supervising the Chinese nuclear projects; West German firms are serving as principal engineers and suppliers to both Brazil and Argentina; the Soviet Union is providing similar support to India, Cuba and the Eastern Bloc; and major U.S. firms such as Westinghouse, Bechtel, Combustion Engineering, and General Electric have marketed nuclear machines and expertise throughout the globe.

Nuclear power has become a new plank in nationalist ideology. As Poneman points out (1982:123-125):

> (T)he ability to harness the atom for scientific and ultimately commercial purposes . . . measures advancement and independence relative to the industrialized countries... Large projects [such as nuclear plants] often appeal to developing country

> governments as a means to demonstrate their ability. Because of its complexity, perhaps even its mystery, the mastery of nuclear technology can instill popular pride.

Ownership of a plant is being assumed by many in the South as an indication that they are on the road to achieving developmental parity with the West.

The attachment of value to the technique per se, rather than to a social end has been described by Jacques Ellul as part of a general process of technical invasion in which cultural resistance is rarely effective. Technical considerations overwhelm and displace alternative principles of social evaluation: "[T]echnique can leave nothing untouched in a civilization. Everything is its concern... It is a whole civilization unto itself" (Ellul, 1964:125-126). This logic of technical advance points out the precarious status of traditional social and political boundaries: "[U]ntil now, it was generally accepted that very similar social environments were necessary if propagation of techniques were to occur. This is no longer true. Today technique imposes itself whatever the environment" (Ellul, 1964:118).

Rather than mimicking Western technological institutions, developmental parity depends upon each society having the power to determine how best to meet its present and future needs given the historical cultural context in which it finds itself. The universalization of nuclear technique at the very least impedes parity, and most likely prevents it.

CONCLUSION

A central belief of contemporary Western culture is that social progress can be measured by material abundance. Nuclear power was proclaimed as the limitless energy source able to fulfill the culture's search for affluence. The costs of societal investment in this promise have been numerous. But perhaps the most significant and alarming cost is in the sublimation of our political being and aspirations. Lewis Mumford warned us 25 years ago of the generic problem, "the bargain ...that takes the form of a magnificent bribe" (Mumford, 1964:6):

> Under the democratic-authoritarian social contract, each member of the community may claim every material advantage, every intellectual and emotional stimulus he may desire, in quantities hardly available hitherto even for a restricted minority: food, housing, swift transportation, instantaneous communication, medical care, entertainment, education. But on one condition: that one must not merely ask for nothing the system does not provide, but likewise agree to take everything offered, duly porcessed and fabricated, harmonized and equalized, in the precise quantities that the system, rather than the person, requires.

The Nuclear Project requires that we accept a politics without substance in exchange for a promise of abundance. the challenge to contemporary society is to realize the hollowness of the bargain and to revitalize its politcal language and understanding.

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