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NUCLEAR POWER AND TECHNOLOGICAL AUTHORITARIANISM

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Nuclear Society and Technological Progress

When the lid blew off the Chernobyl No. 4 nuclear reactor on April 26, 1986, it released the largest quantity of radioactive material ever in one technological accident. The estimated 28 megacuries of escaping gases dwarfed the less than one megacurie released in the 1957 Windscale (U.K.) accident and the 17 curies from the 1979 Three Mile Island (U.S.) accident. One hundred thirty-thousand people within a 30 kilometer radius were evacuated, and 300-400 million people in 15 nations were put at risk of radiation exposure. Present forecasts of additional cancer deaths attributable to the Chernobyl accident range from 5,000 to 75,000 (Byrne and Rich, 1987: 4).

The Chernobyl explosion is the latest in a long series of technological "incidents" marking this era's commitment to what Alvin Weinberg has called a "magical energy source" (Weinberg, 1972: 33). Two workers died in accidents at the Los Alamos plutonium processing plant in 1945-46; a partial core meltdown occurred in 1952 at Canada's experimental Chalk River plant; the 1957 fire at Britain's Windscale plant contributed to making the Irish Sea the most radioactive body of water on the face of the earth; an explosion in 1961 at an experimental nuclear reactor facility in Idaho Falls, Idaho killed three operators; in 1966, the Fermi demonstration breeder reactor near Detroit experienced a partial core meltdown; a Soviet breeder reactor accident in 1973 took an unknown toll in human lives; an electrical cable fire in 1975 at the Browns Ferry, Alabama plant crippled the emergency core cooling system; the accident that couldn't happen did at Three Mile island in 1979; in 1984 a major accident was only narrowly averted at the La Bugey reactors in France; the Davis-Besse plant (Toledo, Ohio) in 1985 nearly repeated the TMI accident; and the Superphenix fast breeder reactor (Tricaste, France) was closed in early 1986 after radioactive gases were released and an unexplained leakage of 25 tons of a highly volatile coolant was discovered.

Recently, the nuclear industry has been plagued by severe financial problems. The French nuclear authority, the Electricite de France (EDF), has ordered "more plants than the country needs or can afford. EDF now has a debt of $32 billion -- exceeding that of most developing countries" (Flavin, 1987: 56). In the United States, a nuclear power project precipitated the largest default in the history of the municipal bond market when the Washington Public Power Supply System (WPPSS) declared its inability to honor financial obligations for $2.1 billion worth in bonds issued to finance two nuclear power plants. An additional $6.7 billion in principal and $23.8 billion in interest is still outstanding on these and three other WPPSS nuclear plants (Byrne and Hoffman, 1986). The promise of lower operating costs for nuclear power plants has not materialized according to a recent study by the Tennessee Valley Authority, the nation's second largest nuclear utility (1985: 5). Between 1970 and 1986, operating and maintenance costs for nuclear plants increased fourfold in real dollars, or 11.4 percent per year above the rate of inflation (Energy Systems Research Group, 1987:3). From 1981 to 1985 operating, maintenance and fuel costs increased 50 percent for nuclear plants compared to 10 percent for coal plants (NARUC Bulletin, 1987: 14-15).

There has been a tendency by some writers to point to the numerous accidents, disasters and financial problems as evidence of the nonviability of nuclear technology (Flavin, 1987; Stobaugh and Yergin, 1983; Komanoff, 1984 and 1981). In response, defenders of nuclear power have cited variously the accidents and death tolls on American highways, the radioactivity of coffee, and other risks of ordinary life, and conclude that elimination of the highway system and coffee drinking would be as rational as banning the use of nuclear power. Both positions seek to analyze the technology in its future tense, namely, its suitableness as a source of energy in the coming years apart from its past or present institutional context. Yet, it is precisely that context which explains how nuclear technology got to where it is. An understanding of the institutional underpinnings of nuclear power is essential to an analysis of its prospects. While plant closings, order cancellations, and financial boondoggles have recently become common phenomena in the Nuclear Project, its viability does not seem to have been damaged significantly. *After* Chernobyl, 118 nuclear plant construction orders remain for start-up by 1990 (Ramberg, 1986: 318).

The Characterology of Nuclear Necessity

Nuclear power is the unique possession of technological civilization. It represents a high-point in technical and scientific achievement. Through the Nuclear Project, the disparate scientific, intellectual, military and industrial communities have been melded into a single instrumentality to foster technological progress.

Following Jacques Ellul's advice that "we must assess, not the internal characteristics of the technique, but the actual situation of technique in human society" (1964: 64), we offer in this section an analysis of the social necessity of nuclear technology in the modern era. It is our position that there are compulsive forces operating in technological societies which make nuclear power development virtually unavoidable. While recognizing these deterministic elements, we do not believe that nuclear power development is beyond challenge. However, in our view for resistance efforts to be successful, the relation between technique and human society must be altered. We do not claim to know how this is to be done. But we hope that the analysis provided here can usefully serve, along with the significant contributions of other writers, to clarify the nature of the challenge.

The idea of nuclear power did not surface in response to pressing social need. There was no economic demand in 1946 for this "energy source" when the U.S. launched its research program. An energy shortage was not imminent. There had been no technical failure or breakdown in the energy system that required a new energy technique. In the face of a labor surplus after World War II, there was little need for a technology which would allow energy to be substituted for labor in the production system. In fact, suspicion and even resistance from utility owners and liability insurers was encountered during the initial stages of this technology's promotion. Nuclear power developed not to solve energy problems but because it was a necessary step in the progress of technology.

J. Robert Oppenheimer recognized in 1949 that the development of the nuclear technique had the status of an imperative for technological society: "When I saw how to do it, it was clear to me that one had to at least make the thing. The [hydrogen bomb] program . . . was technically so sweet that you could not argue about that" (quoted in Winner, 1977: 73). No social or economic criterion, only technical "sweetness" was necessary to justify the Nuclear Project.

The development of nuclear power occurred and continues to occur because: (1) it is technically logical within the existing ensemble of technique; (2) it advances a pattern of technical universalism; and (3) it contributes to an aesthetic of technique, a "best way" to appreciate the pure possibility of technological civilization. Together these characteristics represent a self-rationalizing institutional context for the development of the nuclear technique.

Technical Possibility and the Irrevocability of Technical Knowledge

At any moment, only some things are technically possible. Technical options depend for their development, at least in part, upon already existing techniques and ideas. Each advance in technology represents both an addition to the infrastructure of science, industry and government for solving technical problems, and a tool to confront the next generation of barriers. While technical understanding at any the moment cannot embody perfect foresight of problems-to-come, an heredity principle can be observed in the evolution of technology. This heredity principle both reflects and motivates new techniques in a manner akin to paradigm as described by Kuhn in his analysis of normal science (Kuhn, 1970). Conflicting ideas and techniques are not precluded by the operations of this principle; hypothetically, different, even contradictory, approaches can exist. But they are almost always practically unworkable because they lack a clear place in the technological chain. An uninherited approach is constantly under threat of self-contradiction – of what value is a means that cannot easily and readily be used?

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. Once this understanding was established, decisions hinged upon intrinsically technical matters. Although two options could be identified, namely, setting off a chain reaction or controlling a continuous 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: "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" (Ellul, 1964: 98-99). As Joseph Camilleri points out, even societies which attempted "peaceful" nuclear development were unavoidably incorporated into the military project (1984: 8).

> [A] few small European nations anxious to capitalize on indigenous technology or 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.

Finally, Oppenheimer observed that "the close technical parallelism and interrelation of the peaceful and military applications of atomic energy "precluded their separate development" (1955: 9).

Once this knowledge had proceeded to the point where it was only a "matter of time" before it could be used, the development of the nuclear technique was assured; its technical possibility had been realized. Stopping or reversing technological development at this point would have required erasure of the corresponding technical knowledge. For technological (or any) society, this is impossible; indeed it is unthinkable. While particular aspects of technical knowledge can become obsolete with the arrival of new ideas and methods, there is no meaning to the notion of returning society to a pre-existing state of knowledge. The heredity principle precludes going backward: each assembly of ideas includes earlier vintages of knowledge which enable thinking to move forward, to progress. The necessity of earlier ideas can be removed with technical advances, but technical advances cannot be reversed and can only be removed by *subsequent* innovations of ideas and means. In this sense, technological knowledge is irrevocable.

Yet, implementing a technical possibility very often raises issues of compatibility with existing technique. For nuclear power, there were few obstacles presented by the operating energy system. Tendencies toward centralized production and economic concentration have been in evidence in the electric supply system since at least the beginning of this century. When pressure-staging turbines were introduced in the 1880s, generating capacities averaged 7.5 kW. By 1930, the capacity of U.S. generating units had increased to 200,000 kW and by 1955, it was possible to build 1,000 MWe plants (Messing, et al., 1979: 3). Alongside the escalation of powerplant size, there was a pronounced trend toward increasing organizational scale as the utility industry underwent a process of merger and consolidation. Between 1900 and 1920, the number of investor-owned utilities in the U.S. grew from 2,800 to 6,500 to serve a rapidly expanding electricity market. Over the next twenty years, supply was "rationalized" and spatial monopolies created to maximize opportunities for selling large blocks of power produced by the new machines. The number of private utilities fell to under 1,000 as holding company pyramids were formed to link regional supply operations. By 1955, there were approximately 500 private companies controlling 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: 45-56; Hughes, 1983: 201-226 and 391-394).

Together these technical and economic orientations toward the supply of power represent, to use Ellul's term, an "ensemble of technique" – a common effort of capital, machinery, production methods, research and consumption in support of the best way of manufacturing and distributing electrical energy (Ellul, 1964: 90). This common effort fuses the worlds of the engineer and the economist: coordination, integration, control, order and system, the icons of engineering, are harmonized with efficiency, rationality, optimality and equilibrium, the canons of economics. From such an attuned world emerged a vertically and horizontally integrated "network of power" (Hughes, 1983). Only an integrated network could satisfy the requirements for large regional markets and therewith create the conditions for predictable demand. However, the thermal efficiencies and scale economies of centralized, linked power systems could only be realized with the assurance of reliable market demand; efficiencies and economies are the outcomes, rather than the causes, of an ensemble of technique. Without the integrated network, there could be no regional market and no justification for the development of large power plants.

The demands of the electrical ensemble of technique were (and are) centralized production, integrated operations and planning, and regionalized transmission networks and power pools. Nuclear power had no difficulty complying with these objectives. Indeed, this technology intensified electrical progress in the form of increases, often by several orders of magnitude, in steam pressure, boiler and turbine capacities and thermal efficiencies. But perhaps its most significant achievement was in megawattage. With government and utility commitment to nuclear power, growth in the scale of generating capacity entered an unparalleled stage in the history of electrical production. For a time, 3,000 MWe plants were contemplated by the U.S. nuclear industry, before a ceiling of 1,300 MWe was settled upon. As Messing et al. point out, the single-minded pursuit of large plants virtually eliminated commercial interest in and research on small- and medium-scale facilities (1979: 7-8). Nuclear power promised not only to accommodate the demands of prevailing technique, but to augment them.

This technology inaugurated a new "planning reality" for the utility industry which sought redefinition of political authorities between national and local governments, and in some cases, between two or more national governments in an effort to make room for nuclear power (Messing et al., 1979: 14-16). Grid interconnections, wheeling techniques and new transmission line technology (with carrying capacities of up to 765 kV) assumed prominent roles in industry thinking and have become adjuncts of the new reality stimulated by nuclear power. In this respect, whatever the extent of its eventual use, nuclear power has already so affected the technical environment as to constitute a new root for reticulating electrical technique. Specifically, the next generation of power technology will have to respond to the nuclear inheritance as a functional component of the electrical ensemble.

Nuclear Power and Technical Universalism

Nuclear power is grounded in and contributes to the universalism of technique in at least two ways. First, it fosters the spread of the technical orientation as a geographic phenomenon. And second, its development represents a key step in the integration of the dominant social institutions in technological society.

As Hughes points out, the electrical ensemble historically served to help universalize the geographical preeminence of technique. In his study of Germany, Great Britain and the United States during 1880-1930, a common technological history is adduced (Hughes, 1983: 405):

> The similarities can be . . . explained by the existence of an international pool of technology from which the industrial nations drew. Manufacturers engaged in international trade, patents were generally

> licensed for international use, scientific and technological literature circulated to all of the world's centers of learning, courses in engineering schools described and rationalized world experience in electrical technology, and engineers and inventors moved and consulted easily across national boundaries. Technology transfer was not so much from point to point or place to place as from place to pool to place.

This raises a question, though, as to whether the geography of technique is determined by the plasticity of technical means to fit social aims, or the plasticity of social institutions and aims to fit technical requirements. Hughes is persuaded by the variety he finds in "regional cultures" of technical systems that it is technique, rather than society, which bends: "The common technology of the [international] pool was shaped to suit the place" (1983: 405). However, he implies that this relation may have changed contemporarily as emphasis is placed upon "a superior, advanced technology — 'the one best way' — a way that transcends regional and national differences" (1983: 405). Even in the period of his study, though, he points out that cultural factors faded in importance when confronted with issues of technological progress. In the early part of the 20th century, Hugo Stinnes, chairman of the Rheinisch-Westfalisches Elektrizitatswerk AG, and Samuel Insull, chairman of Commonwealth Edison Company, adopted identical strategies to mass produce and market electricity and to "rationalize" utility operations and planning, notwithstanding the existence of significance regional differences (Hughes, 1983: 404-412).

In his development of the concept of technical universalism, Ellul argues that it is society which adapts and accommodates to technical advance, or as he terms it, "technical invasion" (1964: 116-133). Nontechnical culture "collapses" in the face of technical culture because technique is both indispensable and totalitarian. While each culture contains within it the essential technical means for achieving its existing goals, Ellul points out that the logic of technical possibility drives the culture to innovate beyond its present requirements. The instrumentality of technique becomes valued in and for itself, and eventually all aspects of social organization are subjected to the scrutiny of technical consideration: "Technique can leave nothing untouched in a civilization. Everything is its concern . . . [I]t is a whole civilization in itself" (Ellul, 1964: 125-126). The geography of technique displays the universal nature of technical advance: "Until now it was generally accepted that very similar social environments were necessary if propagation of techniques was to occur. This is no longer true. Today technique imposes itself, whatever the environment" (Ellul, 1964: 118).

In the case of nuclear energy systems, there are observable national and regional differences (e.g., between the systems of the U.S. and France), but these seem to be minor in comparison with the similarities. Nuclear power was delivered to societies as diverse as the Soviet Union, France, Great Britain and the United States via a "military transfer" and in each, the military and the state continue to play central roles in the articulation of this technology's development. The collaboration of science and the state was essential in all of these societies as was (and is) the organization of this collaboration outside the normal channels of government and industry. Much as with the earlier development of steam turbine technology, the spread of nuclear power has been dependent upon an international pool of technology and expertise, a research and educational infrastructure devoted to sharing information, findings and innovations (and beliefs) across national boundaries, a series of treaty agreements to aid promotion and regulation of this technology, and an oversight body — the International Atomic Energy Association (IAEA) – to facilitate communications, standardization of the technology, and the adoption of procedures to increase plant safety.

Beyond its geographic proliferation, nuclear power serves the interest of technical universalism as a centerpiece for the institutional integration of the science, military, industry and state sectors. Camilleri depicts this integration as follows (1984: 5):

> The principal actors [of the American nuclear programme] were the armed services, private industry and finance, the legislative and executive organs of government, intelligence organisations and to a lesser extent the emerging 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 were 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 were deep divisions and prolonged battles. On the other hand, it is also true to say that these groupings recognised one another as legitimate participants in the nuclear project and as sharing a common set of basic assumptions about its value and functions.

Camilleri documents a similar institutional congealing in Britain, France and West Germany. And socialist equivalents are found in the Soviet and Chinese development of nuclear power. This congealing is made possible in part because the relevant institutions in each society can communicate by means of a universal language.

Its conformity with and capacity to contribute to geographical and institutional tendencies toward technical universalism make nuclear power development a necessary step for technological civilization. It provides the means of technicizing the inorganic world of the atom and permits a shift in technical attention to the investigation of the sub-atomic sphere and to the technicization of the the organic ("death, procreation, birth and habitat") (Ellul, 1964: 128). Understood in these terms, nuclear power can hardly be rationalized as either a machine to substitute for human labor or a solution to an energy problem.

Modern Progress and the Nuclear Dream

The necessity of nuclear power derives not only from materialist characteristics of technical heredity, compatibility and universality but, in addition, from its importance to the aesthetic of technique. As Winner has argued, the appreciation of technique is not limited to a "cult of efficiency" or an "enthusiastic group of technophiles" (Winner, 1977: 277); nor is it confined to ideological purposes of justification, legitimation or rationalization. Through the technical aesthetic, societies learn the majesty of technological power, order and civilization (Mumford, 1934: 334):

> [P]ass through the waterfront of Hamburg, say, and review the line of gigantic steel birds with spread legs that preside over the filling and emptying of the vessels in the basin: that span of legs, that long

> neck, the play of movement in this vast mechanism, the peculiar pleasure derived from the apparent lightness combined with enormous strength in its working, never existed on this scale in any other environment: compared to these cranes the pyramids of Egypt belong to the order of mud-pies.

Imbued with the majesty of technological power, the technological personality realizes that a synchrony exists between material and spiritual progress. This realization has the status of undisputed belief and evidence for it is found everywhere. The technical esthete counterposes the life of misery, hunger, disease and despair of the "pre-technological" era to the present life of abundance, leisure, comfort and freedom. Langdon Winner depicts the belief as follows (1977: 102):

> Certain technical means stand at the very basis of human survival. Failure to provide for them is to invite discomfort, suffering, or even death . . .Any attempt to deny this . . .can only be an expression of malice, stupidity or madness.

From this perspective, as Winner notes, technique represents far more than a functional requirement; "it is also a moral standard, a way of distinguishing the good from the bad, the rational from the irrational, the sane from the insane" (1977: 102). The clearest (and most dangerous) implication of the aesthetic, in this regard, is that civilizations can be distinguished as "advanced" or "backwards" depending upon their technological possessions and commitments.

In this regard, nuclear power has become the preeminent symbol of advanced civilization in this era. At the September 24, 1986, meeting of the International Atomic Energy Agency *after* the Chernobyl disaster, the head of the Soviet delegation declared: "The exploitation of the atom's energy has become a realistic requirement, and is preconditioned by interests of human civilization progress." Chancellor Helmut Kohl delivered a similar message to West Germany's citizens: "Abandoning nuclear power could spell the end of the Federal Republic as an industrialized nation." And Great Britain's Energy Secretary Peter Walker concluded: "if we care about the standard of living of generations yet to come, we must meet the challenge of the nuclear age and not retreat into the irresponsible course of leaving our children and grandchildren a world in deep and probably irreversible decline" (all quotes in Flavin, 1987: 62). Finally, three weeks after Chernobyl, Soviet General Secretary Mikhail Gorbachev assessed the international importance of nuclear power for social progress: "The future of the world economy can hardly be imagined without the development of nuclear power . . .[H]umankind derives a considerable benefit from atoms for peace" (Vital Speeches of the Day, 1986: 516).

The commitment to nuclear modernism is not limited to the West. Many countries of the South have either developed substantial nuclear programs or taken steps to integrate nuclear technology into their electrical networks. This commitment has not been shaken by the Chernobyl explosion. In August 1987, Egypt's electricity minister stated that "Egypt needs nuclear generation to meet the demands for power;" an opinion shared by Cuba's Executive Director of its Atomic Energy Commission, who has committed the country to a nuclear project capable of generating 25 percent of the nation's electric needs by the year 2000. Indonesia is planning construction of two nuclear units in the 1,000 MWe range by 1999. August 1987 also saw a ground laying ceremony for the Quangdong nuclear facility in the People's Republic of China, and Taiwan, with six generating plants, envisions the need for ten new plants to supply 12,600-16,600 MWe of additional generating capacity by the year 2000. India has announced a goal of 10,000 MWe of new nuclear capacity by the same year. According to the Minister of State for Atomic Energy, the main impediment to this effort will be money; "There are no technical obstacles." Brazil and Argentina have agreed to explore joint development of a breeder reactor which would close the technology loop in their nuclear systems. Finally, the recently retired president of South Korea chose the dedication ceremony of the nation's fifth nuclear power plant as the occasion to address his country's political crisis (*Nuclear News*, 1986 and 1987).

While opposition movements to nuclear power (plants and bombs) have grown over the past twenty years and in some countries represent potent political forces, worldwide appreciation of the nuclear dream has been steady. The promise that this technology will deliver an endless source of power, a comprehensive knowledge of the underlying order of all matter, and global security based on limitless material abundance has captured the soul of technological societies. William Laurence, one of the early American nuclear propagandists, communicated why a sense of enthrallment accompanies this technological vision. In the nuclear dream, technology delivers "wealth and leisure and spiritual satisfaction in such abundance as to eliminate forever any reason for one nation to covet the wealth of another" (1959: 240), and can be compared to a "veritable Prometheus bringing to man a new form of Olympic fire" (1940: 12-13). Indeed, nuclear advocacy has frequently presented nuclear power as analogous to the discovery of fire. In his 1914 novel, *The World Set Free,* H. G. Wells has Professor Rufus summarize the modern situation (1914: 24-25):

> We stand today towards radioactivity exactly as our ancestor stood towards fire before he had learned to make it . . .just when it is becoming apparent that our ever-increasing needs cannot be borne indefinitely by our present sources of energy, we discover suddenly the possibility of an entirely new civilisation.

Alvin Weinberg continues this tradition in our time characterizing nuclear power as a "marvelous new kind of fire," and declaring that civilization finds "an inexhaustible source of energy" in "the catalytic nuclear burner" (1972: 28 and 33). Whether and in what technical forms nuclear power will be further harnessed is, in a basic sense, irrelevant. Henceforth, any generation of technique will be measured against the nuclear aesthetic and its promise of a culture of abundance (Byrne and Rich, 1986: 141-159).

The Future Tense of Nuclear Power

If the above analysis is correct, the evaluation of nuclear power's future cannot be conducted apart from the institutional context of technological civilization. Within that context, nuclear power is a necessary development. Through this technology, cooperation among the military, state, scientific and economic sectors has been facilitated and a social form has emerged in which technical, political, economic and aesthetic aspects have melded to constitute a single, integrated reality.

The future of nuclear power will be determined by the extent to which conditions for expansion of this technological orientation in societies are realized or effectively resisted. So far, there is little evidence of sustained social resistance.

Rather than challenging the values and commitments of technological societies, the Chernobyl explosion has become a focal point for identifying new political, economic and ideological measures needed to ensure the spread of the technological grid. Diagnoses by the socio-technical mainstream generally have reflected and reinforced institutional tendencies already firmly resident in technological culture. Chernobyl has been (and will likely continue to be) analyzed as an instance of human-political failure which can be avoided in the future by the infusion of greater technical discipline, order and organization into the social structure. For the technically minded, the Nuclear Project is not jeopardized by accidents such as Chernobyl since machine failure can usually be traced to human mistake, political interference, or both. Machine operation and function is still largely governed by humans either as machine designers or as handlers and users, but the hope for the future is that the role and significance of the "human element" can be reduced. The ground for such optimism is found in the belief that technological improvement is achieved by the application of logical, objective laws which are impervious to human error and political interest. Indeed, science has become the essential instrument for detecting human-political failures. From a scientific standpoint, the sensible solution to accidents in technical systems is a diminished human-political presence and activism, a greater reliance on machine autonomy (with automatic shutdown and safeguard routines incorporated into systems), and steady social investment in technical innovation. In the case of nuclear power systems, solutions take the form of "inherently safe" reactor designs, increased emergency system redundancy, 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, and bigger nuclear R&D budgets (Weinberg, et al., 1985).

Alongside efforts to depoliticize the technology have been and will be actions to assemble cultural support for nuclear power as an imperative of progress. This ideological tendency is rooted in the equation, commonly made in technological societies, that associates the quantity of energy produced and used with the advance of civilization (Basalla, 1980; Kash and Rycroft, 1985). However, an event such as the Chernobyl explosion and the resulting radioactive plume are a frightening reminder of the threat to all of human existence posed by the possession of the atomic secret. In the wake of this and other "accidents," it is not easy to package nuclear power in a commercial language that can convincingly portray the continued spread of the technology as unalarming, much less rational. 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. He 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 precipi-

tate 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 (the latter from concerns about "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 "nuisances" of atomic wastes and nuclear protest (Weinberg, 1979: 94-95; Anderson, et al., 1980: 30).

In sum, Chernobyl can conceivably facilitate the arrival of a Second Nuclear Era by serving as a means for eliciting consensus to tighten the hold of technocratic order. It may well bring forward actions which continue the process of replacing political with technical authority, strengthen the power of the national security apparatus, reassert an ideology of progress which devalues human autonomy, and prepare the way to the next stage of technological authoritarianism.

The reflexivity of technological value – that technology is evaluated within its own technical environment – poses a significant dilemma for social resistance to nuclear authoritarianism. Social values cannot be depended upon to threaten the Nuclear Project since they constitute literally alien sources of meaning and assessment. Technique's capacity to dominate other forms of social valuation stems from the Grundnorm of technological civilization: "Efficiency is a fact and justice a slogan" (Ellul, 1964: 282).

Conclusion

Technological progress in the contemporary situation is founded upon the prioritization of technical value over social value. If this ordering is not observed, progress either ceases, is set adrift, or becomes retrograde. As Ellul has succinctly put it, attempts at "moral conversion" of technicians or "moral intrusion" in technical processes only produce poor technicians and inferior techniques (Ellul, 1964: 97). For technological societies, at least as they have emerged to date, observance of the Grundnorm of technical valuation is essential. For such societies, the Grundnorm is not a theoretical abstraction or hypothesis awaiting empirical testing. It is a social truth which is itself subject to reflexive evaluation only. Indeed, members of a technological society do not know what it means to be technological and not observe the Grundnorm. How can we realistically investigate the future of nuclear power under the constraint of prior social considerations? Nothing will be *solved* so long as laymen's concerns are treated as authoritative in the design and assessment of nuclear research. Laymen may recognize problems with the use of a technology, but from the vantage point of the technological-military priesthood, ordinary citizens cannot know and cannot be relied upon to appreciate the solution to such problems. Social values can have little meaning apart from the technical in a technological society.

The ideology of technological progress "presupposes, normatively, that behaving in accordance with technical recommendations is not only desirable, but also 'rational'" (Habermas, 1974: 269). Neither the technical object nor the individual who fabricates it can be evaluated in autonomous moral terms as, the making of the atomic bomb illustrates. When asked if he or other scientists should feel guilty about the horror brought to Hiroshima and Nagasaki by the atomic bomb, Werner Heisenberg responded (quoted in Winner, 1977: 69):

> The word 'guilt' does not really apply, even though all of us were links in the causal chain that led to this great tragedy . . .[A]ll of us have merely played our part in the development of modern science. This development is a vital process, on which mankind, or at least European man, embarked centuries ago — or, if you prefer to put it less strongly, which he accepted.

Traditional sources of social evaluation are failing to challenge effectively the determinism of technological development. Rather than questioning the value of technology, modern thinking is preoccupied with whether society — its organizations, processes, structures, values, and its individuals — is adequate to the task of successfully accommodating technological possibilities. Literally, the value of technology is taken to be socially unassailable. Problems of value exclusively concern the evaluation of society. With regard to nuclear power, John Kemeny (chairman of the U.S. commission charged with investigating the Three Mile Island accident) accurately portrayed the modernist understanding: "The plants are safe: it's the people who aren't" (quoted in Hawkes, et al., 1986: 97).

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