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NUCLEAR OPTIMISM AND THE TECHNOLOGICAL IMPERATIVE:

A Study of the Pacific Northwest Electrical Network

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Introduction

Many in the policy and research communities project the imminent demise of nuclear power (Flavin, 1989; Campbell, 1988). Inefficient, costly, and unable to resolve the problems of plant decommissioning and waste disposal, nuclear power is portrayed as a technological failure. Yet, a close examination of the current energy and environmental policy debates suggests that eulogies for the industry may be premature. With international concern over global warming trends, there has been renewed advocacy for this technology as a "clean solution" to the greenhouse and other environmental problems associated with a carbon-based economy. Indeed, in a recent issue of one science magazine some proposals were described as strategies to "nuke the greenhouse" (New Scientist, 1988). Some countries which lack domestic energy sources regard the utilization of this technology as essential to industrial development. Thus, the Republic of Korea is considering a proposal by a national panel of eminent scientists to build 55 new nuclear plants by the year 2030 to satisfy the country's growth needs (Choson Daily News, 1989). Such environmental and economic factors have led a pioneer of this technology, Dr. Alvin M. Weinberg, to urge worldwide commitment to the construction of 2,000 to 6,000 additional nuclear reactors over the next 40-60 years (1989). Finally, a new generation of what is termed "inherently safe" reactor technology is being heralded as providing a solution to the perennial problems of health and safety which have plagued nuclear power (New York Times, 1989; see also Weinberg, 1989-90).

The resurgence of optimism toward nuclear power has been bolstered in the U.S. with the release of a study prepared by MIT's Center for Energy Policy Research (Hansen et al., 1989). The spotty performance record of the nation's nuclear system is traced in the study to a cross-industry pattern of poor management which can be corrected by the adoption of certain reforms. The study advocates the adoption of "internal mechanisms for improvement" including: "closer ties between utilities and suppliers;" the creation of industry-wide personnel training centers; the development of clearinghouses to foster information sharing, especially with foreign utilities; maintenance of "high-quality components, thorough spare-parts inventories, up-to-date instruments for testing and diagnosis, and extensive contacts within the industry;" and, most important, the establishment of "a constructive vehicle for candid self-criticism" which would allow the industry to "pressure operators of the weakest plants to improve their performance" (Hansen et al., 1989, p. 40). Several of these reforms are being implemented by the industry with the expectation that the U.S. nuclear program will finally achieve standards of performance rivalling those of West Germany, Japan and Sweden. In combination with recent actions taken by the U.S. Nuclear Regulatory Commission to streamline the regulatory process, there are some who now believe that the country is ready to enter a "Second Nuclear Era" (Weinberg et al., 1985).

What is striking about the debate over the second nuclear era is its unbroken continuity with that of the first era. In both, the focus has been on the "future tense" of what is promised by and what can be believed about nuclear power. In our view, this orientation misdirects the efforts of social evaluation and criticism by concentrating analysis on the relative costs and benefits of the technology's projected performance. Left out of such analysis is a "present tense" understanding (this phrase is borrowed from David Noble, 1983) of the politics, economics and technics of nuclear power. This omission results in the actual social interests and values of nuclear power being made abstract, while its possibilities are treated as though they were concrete. Society as a whole, but especially those who are most immediately threatened by the advance of the technology -- plant neighbors and workers, are placed in the untenable position of having to argue against progress.

The study of specific case histories of nuclear power offer one important method for developing a present-tense understanding of the technology. In this article, we examine the origins, evolution and impacts of the largest nuclear power project undertaken in the Pacific Northwest. The history of the Washington Public Power Supply System (WPPSS) and its endeavor to build five nuclear plants with a total rated capacity of over 6,000 MW is particularly useful for identifying those social forces and structures which engineered the first phase of U.S. nuclear power development and which sustain the drive toward a resurgent nuclear political economy.

Our analysis is presented in three parts. In the first section, we provide a brief overview of the history of energy policy regionalization since 1937 in the Pacific

On January 22, 1982, construction was terminated on two of five WPPSS nuclear power projects, setting in motion the largest municipal bond default in the history of the United States. WPPSS declared that it was unable to honor financial obligations for $2.1 billion in bonds issued to finance the two plants (Falk, 1985). By 1983, two other plants had been mothballed, one at 65 percent and a second at 75 percent of completion. Estimated completion costs have been put at $2.758 billion (in 1988 dollars -- see Northwest Power Planning Council, 1988a, pp. 6-41). Only one plant has been successfully operated. Brought on line in 1984, the facility has a rated capacity of 1,154 MW. Additional debt amounting to $6.7 billion in principal and an estimated $23.8 billion in interest was accumulated to underwrite the five-plant project (Morrison, 1981; Loeb, 1982). For utility districts which invested in all five plants, the median debt per household (for construction costs alone) at the time of default was figured to be between $27,000 and $30,000 (Loeb, 1982, p. 13). Since 1975, wholesale power rates have increased 700 percent and electric rates have increased over 250 percent. These increases are mainly attributable to the WPPSS nuclear projects (Loeb, 1982, p. 13; Gleckman, 1984, p. 23; Comptroller General, 1984, p. 7; Northwest Power Planning Council, 1988b, p. 2).

Early Tendencies Toward Regionalization

The WPPSS default can be located within the context of the centralizing tendencies historically present in the region. As early as 1937, when the federal government established the Bonneville Power Administration (BPA), steps were taken to organize the production, distribution and marketing of electricity on a regional basis. The trend toward regionwide cooperation accelerated during World War II as U.S. military planners sought to take advantage of the surplus of low cost electricity in the area for the manufacture of military aircraft. At the urging of BPA, the War Production Board in 1942 ordered the interconnection of utility operations and the creation of the Northwest Power Pool (Blumm, 1983, p. 204). The federal government also built aluminum plants in the region to supply military needs, further adding to the demand for electricity (Balmer, 1983, p. 646). By 1942, 92 percent of BPA's load was committed to industrial producers of military hardware (Bluum, 1983, p. 203).

After the war these plants were privatized and the region's aluminum and aircraft manufacturers returned to civilian production. BPA responded to the burgeoning needs of its industrial customers by adopting a sales policy which offered large blocks of power at discount rates (Blumm, 1983, p. 206). It also initiated efforts to bring electricity users and providers together to plan for

Northwest. This history is marked by the convergence of public and private sector decisionmaking around the "single utility" concept. We then locate the movement toward regionalization within an institutional and ideological context which equates social progress with increased energy production and consumption (the idea of "megapower") and with technical advance (the "abundant energy machine" ideal). In a section entitled "Autonomous Technology," we document the resulting transfer of autonomy over the specification of ends and the criteria for public policy decisions from the political to the technocratic sphere. The article closes with our assessment of the future of the, nuclear political economy.

Toward the Single Utility

Over the past 50 years, electric supply in the Pacific Northwest has evolved from a fragmented patchwork of federal, regional and local providers to an integrated electrical network. The Army Corps of Engineers, the Bonneville Power Administration (BPA), WPPSS, over 100 public and private utilities, the Canadian government, municipal power authorities, the region's aluminum and aircraft industries, at least two power pools and several coordinating bodies have joined together to rationalize the growth and interconnection of the Northwest power system. The supply and demand for electrical energy are now constituted within a regionwide "hydrologic, electric, economic an legal" framework (Balmer, 1983, p. 653).

A major step towards this integration was taken in 1956, when the State of Washington authorized the creation of a municipal corporation initially composed of 17 public utility districts and four municipal authorities, known as Washington Public Power Supply System (WPPSS). The purpose of the organization was to "tackle the big projects" necessary to energize the state's economy (Gleckman, 1984, p. 2). Twelve years later, the adoption of the Hydro-Thermal Power Program (HTPP) by 108 utilities in six Pacific Northwest states expanded the scale of electrical projects to levels not seen in the area since the great dams were built in the 1930s. The Program proposed to add 41,400 megawatts (MW) of hydro- and thermal power (involving 20 nuclear plants) with WPPSS assigned a central role in its implementation (Gleckman, 1984, p. 5). It was a spectacular vision of energy abundance justified in appropriately fervid term: "Increased use of electricity has contributed importantly to the emancipation of peoples from poverty and drudgery and to expansion in human capacity to live the good life ... [T]o expand these benefits to a larger segment of our society will require more electricity" (quoted in Olsen, 1982, p. 19).

the post-war energy needs of the region. The Pacific Northwest Utilities Conference Committee (PNUCC) was organized by BPA in 1948 and included public utility districts, municipal authorities, investor owned utilities (IOUs), and industries that received electricity directly from BPA via dedicated transmission lines, the so-called Direct Service Industries (DSIs). The PNUCC was charged with "the development of analytical tools to determine, on a rational basis, the relative costs and benefits of the various resources available to meet the Northwest's energy loads" (PNUCC, 1985).

The activities of the War Department, BPA and the PNUCC put the Pacific Northwest on a clear course toward regionalizing power supplies. However, these activities, by themselves, could not realize the full possibilities of regionalization. The historic antagonism between public and private power on the one hand, and populist resentment of federal "intrusion" in local affairs on the other, meant that BPA could not command sufficient trust to serve as the coordinating agent for the region. Additionally, BPA was restricted by law from constructing or directly financing generation facilities. This latter problem was especially significant because the region was experiencing power shortages as early as 1948 (Blumm, 1983, p. 206) and was, as a result, soon to require additional generating capacity.

Creation of the Washington Public Power Supply System

In the early 1950s many IOUs in the region had previously depended heavily upon BPA for power supplies undertook joint projects to build and operate large-scale plants (Balmer, 1983, p. 649). These joint projects, together with efforts by the Eisenhower administration to weaken the preference clause in the BPA charter (which favored public power), were interpreted by public power providers as threats to their market share (Blumm, 1983, p. 210). In response to this situation, Washington public utilities and municipal authorities banded together as WPPSS to protect their collective interests. This consolidation was a key step in overcoming the obstacles to full-scale regionalization. WPPSS neutralized traditional opposition of public power to regionwide cooperation while enabling public authorities to pool resources for the purpose of financing and constructing new plants. This meant that public power could compete on an equal footing with the IOUs (Gleckman, 1984, p. 2).

In 1964, the System demonstrated the technical and economic efficacy of regionalization with the completion of the Packwood Lake hydroelectric facility, a 27.5 MW plant. While the project ran 25 percent over budget and was seven months behind schedule (Leigland and Lamb, 1986, pp. 4-5), it was viewed as a success because public power had established its capacity as an independent source of regional generation projects. Encouraged by this success, WPPSS sought to establish the ability of public power to operate at a scale and with technologies as sophisticated as those employed by IOUs. Planning was begun in 1962 to purchase and convert to electricity the excess heat from an 860 MW military reactor to be built at the Hanford Nuclear Reservation in northeastern Washington State (commonly known as the N-reactor). The project, which went into commercial operation in November 1966, was significant for several reasons. It established WPPSS as an effective manager of large-scale construction projects and offered proof that public power was up to the technical challenges posed by nuclear generation. Perhaps most important, the project demonstrated the viability of civilian nuclear power as a seemingly cheap and reliable source of electricity for the region. The Washington legislature captured the rising euphoria toward nuclear power when it declared, with the heels completion of the WPPSS conversion facility, that the region "should turn to nuclear power plants to supply [the] growing needs for industry, jobs and an increased standard of living" (Olsen, 1982, p. 16).

WPPS, BPA and the Hydro-Thermal Power Program

By the mid-1960s, the Pacific Northwest had in place two major organizational means for advancing the regionalization of power supplies. In BPA, a thirty year legacy of technical coordination in regional power planning and distribution had been established. In WPPSS, public power had a model of its own for managing and financing power plant construction. The next step was to bring these bodies together with the IOUs to complete the electrical network. The Hydro-Thermal Power Program (HTPP) served this end. Initially discussed in a 1958 Corps of Engineers report, the Program was predicated upon two assumptions. First, it assumed that electrical demand projections issued by the PNUCC of a steady 5 to 7 percent annual increase were accurate. Second, it assumed that the remaining hydropower capacity in the region would be exploited by 1975 and that power shortages would ensue unless new plants were built (Lee, 1980, p. 66). Indeed, BPA warned that after 1975 the region would face annual increases in demand averaging 1,000 MW which could not be satisfied by available hydropower capacity (Gleckman, 1984, p. 6). The HTPP was offered as the means of solving the supply problem by harnessing the remaining hydropower capacity and undertaking construction of several thermal power plants.

The ideas of the HTPP were not pursued until 1968 when a way was found to establish joint participation and control by public and private producers over the

Program. At BPA's initiative, a Joint Power Planning Council (JPPC) was created. Consisting of 108 public and private utilities in the region, the JPPC integrated the load planning and forecasting activities of these organizations to produce a single plan for responding to the area's energy needs. The document incorporated the Army Corps plan to add 20,000 MW of hydropower by completing the Columbia River system, while simultaneously calling for public and private utilities to build a combination of 22 coal and nuclear thermal power plants with an output of 21,400 MW over the following twenty years.

In the following year, the Council program was refined into a Phase 1 plan to build seven plants by 1980 with a capacity of 7,930 MW. Carrying out even this scaled-down version, however, still required a substantial commitment to new plant construction. BPA proposed that WPPSS act as construction manager for three nuclear plants with a total rated output of 3,580 MW; the other 4,630 MW would come from IOU projects already planned or underway. BPA drafted participation agreements which were circulated among the area's public and private utilities. According to the agreements, WPPSS would be owner-operator of WPPSS Nuclear Projects (WNP) 1, 2 and 3; BPA was to market the power generated by the plants; and the cooperating utilities would purchase shares of the nuclear plant output through BPA. This tripartite arrangement among the utilities, BPA and WPPSS was based on a "net billing" formula in which participating utilities would purchase nuclear power at a price equal to the net difference between the cost of a utility's normal hydropower purchase from BPA and the cost of its share of output from the new plants. The agreement promised a handsome subsidy to the utilities who would be able to buy thermal power at a "melded" price which included the cost of older and cheaper hydropower (see Appendix A in Sugai, 1987, pp. 423-443). Utilities were insulated from the immediate effects of cost overruns and construction delays because their costs were based on projected output expenses from the new plants. Until cost projections were revised and reflected in higher BPA wholesale rates, a utility could reap the benefits of regional cooperation without experiencing its full costs. A managing director of WPPSS succinctly stated the organizational advantages of Phase 1: "The [HTPP] is a realistic plan. Public power interests as well as those of private utilities are well protected" (in Olsen, 1982, p. 19).

Almost immediately, Phase I of the HTPP was diagnosed as insufficient. In 1970, the PNUCC forecasted electricity demand at almost 18,000 MW by 1979-80 (Gleckman, 1984, p. 10), which if true, would absorb all of the new capacity proposed under Phase I. By 1972 BPA was forecasting power shortages for the decade under low water conditions (Blumm, 1983, p.

225). Moreover, significant cost overruns and construction delays on the WPPSS plants were rapidly exhausting the net billing capacity of BPA. The final blow to Phase I was a 1972 Internal Revenue Service ruling declaring net billing in violation of BPS's charter proscription against the direct purchase of electricity.

In late 1973 BPA and the utilities agreed upon Phase 2 of the HTPP. Eleven plants with 11,300 MW of capacity would be added by 1987, of which 5,800 MW would come from nuclear facilities. These plants were in addition to the three Phase 1 projects. WPPSS agreed to build two nuclear plants with a rated output of 2,500 MW, while IOUs would construct six coal-fired and three nuclear units. Although the utilities could no longer depend upon net billing, Phase 2 was accepted in the belief that scale economies would result from the construction of large plants and that the new capacity would complete the integration of the region's electrical network thereby creating the potential for supplying new and more lucrative markets beyond the Northwest (Gleckman, 1984, p. 8). Thus, by 1976 WPPSS was simultaneously building five nuclear plants with a combined rated output of 6,080 MW at a projected cost of $4.265 billion. The last plant was to come on-line in September 1987 (Heutte, 1982, p. 3).

Through the HTPP, a political milestone of regionwide cooperation in planning, forecasting, plant construction and power distribution and transmission was achieved. The Program joined rivals such as public and private power, BPA and the region's major electricity-using industries in a synergistic relationship. Interests which for 50 years had been perceived as conflicting, were now seen as complementary. Cooperation between BPA, WPPSS and the IOU's was essential: BPA to develop and sustain regional markets; and WPPSS and the IOUs, to build the plants which would complete the electrical network. In the HTPP disparate interests were combined to function as a single utility.

The Institutionalization of Megapower

The single utility framework that emerged in the Northwest in the 1960s and 1970s was dictated by the developmental requirements of a technological system. Distinguishing between the technical and the technological is necessary for understanding the evolution of the region's electrical system: "Technical refers primarily to tools, machines, structures and other devices ... [F]actors embedded in technology besides the technical are the economic, political, scientific, sociological, psychological and ideological" (Hughes, 1980, p. 142). The problem for the Northwest was not whether and how to build large-scale power facilities. There already existed in the region knowledge, capital and organizations that could be combined to build and operate power plants. Moreover, BPA and the utilities had fashioned rate policies and distribution networks that could effectively market the power generated by their machines. If the HTPP is seen simply as a statement of technical need, it could have been implemented as a series of individual projects.

The HTPP was not a plan to build 22 or 7 or 11 power plants. Instead, the Program was part of a developmental sequence which was guided by the assumption that regional growth required the expansion of the electrical network. The HTPP represented a logical response to the region's energy needs within a technological system predicated upon the axiom that "civilization = k(energy);" or as Aldous Huxley once remarked, "because we use a hundred and ten times as much coal as our ancestors, we believe ourselves a hundred and ten times better, intellectually, morally and spiritually" (for both see Basalla, 1980, p. 40). This energy-civilization equation impelled the region's almost single-minded pursuit of the ideal of megapower.

The Ideology of Megapower

In 1972, on the eve of the first bond sale to finance WPPSS's Phase 1 nuclear projects, BPA alerted the region to its central challenge: "Failure to meet regional power requirements as they develop will result in economic and social penalties. Significant growth and power requirements cannot be stopped without compromising the future well-being of people" (Olsen, 1982, p. 19). In 1975, as a series of Phase 2 projects were being finalized, BPA was even more blunt about the matter. "Notices of Insufficiency" were issued by then BPA Administrator Donald P. Hodel which declared that hydropower deliveries would have to be restricted to "preference customers" (the public utilities) unless new plant construction was undertaken soon (Gleckman, 1984, p. 12). BPA was holding forth on a familiar theme for the region. Indeed, the enabling legislation which created the Administration was based on a "gospel of growth" (Blumm, 1983, p. 207), namely, that expansion should be the foremost social goal of electrical planning (Lee, 1980, p. 188). A pro-growth orientation had guided hydropower development since the 1940s, and by the 1960s had mobilized a variety or organizational interests behind the theme that "electric power, the region's only indigenous energy resource, would continue to be the key element in the region's economic health" (Balmer, 1983, p. 637). The region consistently responded to the challenge of economic development with investment in large-scale power technologies, seeking social progress through megapower.

The attraction of megapower is deeply rooted in American myth and values. Throughout its industrial history, the society has equated national wealth with energy use, so much so that the two are often seen as synonymous (Ward, 1977). Electric power plants have occupied a special status in this ideological attitude, representing the technical archetype for the realization of cheap and abundant energy; the ideal "abundant energy machine" (Byrne and Rich, 1986). For seven decades, experience with electrical technology seemed to confirm the ideal. Average thermal efficiency of plants increased nearly eightfold from 1900 to 1970 while the size of facilities grew by a factor of eleven (Ross and Williams, 1977, pp. 12-14). These technical achievements were matched by steady declines in the average price per kW from 1899 to 1969 (Bergman, 1982, p. 65).

The Northwest had for a long time experienced the advantages of megapower. Home to the largest hydroelectric system in the world, several of the world's largest dams, and the cheapest electricity in the United States, the region has routinely supported large-scale, centralized electrical generation. A BPA administrator reflected this regional consensus in a 1966 speech: "I am sure that I don't need to convince this group [of area utility executives] of the economies of scale. I don't think anyone here would urge the route of small, less efficient plants" (in Gleckman, 1984, p. 5). The region's adoption of nuclear power was a natural extension of the megapower ethos. It is fully consistent with a technological regime based on large-scale, centralized power production and it meets the requirement of connectivity with existing institutional arrangements and satisfies the technical criterion of system efficiency.

But nuclear power's institutional importance goes still deeper. A U.S. Department of Energy official spelled out the general rationale for the promotion of nuclear power in Western societies: "nuclear is the only nonfossil energy source that will be available to us in sufficient amounts to support our civilization and to fuel progress for the foreseeable future" (Agnew, 1983, p. 1). By this standard, even cost, the crucial capitalist measure of worth, cannot alone halt the pursuit of megapower. Enthusiasm for nuclear power is not primarily rooted in its purportedly superior engineering or economic properties. Indeed, these advantages of the technology were virtually undemonstrated at the time that WPPSS made commitments to build five plants. As Bupp and Derian have noted, the nuclear industry has consistently made claims about safety and economy which reflect self-interested promotion and advertisement rather than analysis (1978, p. 84). Leigland and Lamb make the same point regarding the WPPSS projects: "In sections that read more like a sales pitch than analysis, the [John Nuveen and Company financial] report recites arguments why ratepayers should accept rate hikes, and why they should recognize that the risks of nuclear accidents, nuclear waste disposal problems, and damage to the environment are very low" (2986, p. 123).

The appeal of nuclear power is explained by its compatibility with a particular technological system. Within the megapower paradigm, nuclear power, and possibly only nuclear power, can be understood as capable of meeting the region's "civilization needs." Seen in this light, the operant question is not whether or why but how the nuclear energy machine can be made to work. A technological society accepts the necessity of nuclear power and its inherent risks. In fact, it may seek to dismiss the risks, as when The Economist, one month before the Chernobyl accident, judged a nuclear plant to be "as safe as a chocolate factory" (1986, p. 11). A Soviet official similarly tried to minimize the risk after the Chernobyl accident: "[T]here is bound to be a technical incident ... We can say that this is a normal incident, and there is nothing abnormal" (Associated Press, May 12, 1986). The New York Times in an August 25, 1986 editorial agreed: "Chernobyl is a lesson to improve safety, not throw in the towel ... More accidents are certain."

The Electrical Technostructure

Langdon Winner has observed that, "technological society tends to arrange all situations of choice, judgement and decisions in such a way that only instrumental concerns have any true impact. In these situations, questions of 'how' tend to overpower and retailor questions of 'why' so that the two matters become, for all practical purposes, indistinguishable" (1977, pp. 232-233). Northwest power development has adhered to this technocratic principle.

Historic divisions of political and economic interest such as those underlying public versus private power and sagebrush resentment of federal control have regularly been superseded by the requirements of megapower. Despite deep suspicions and mistrust among electric generators, marketers and distributors, the region has witnessed an extraordinary proliferation of cooperative technocratic ventures. The Northwest Power Pool, the Pacific Northwest Coordination Agreement, the Western Systems Coordinating Council, the Mid-Columbia Hourly Coordination Agreements, as well as the alphabet organizations already discussed (the PNUCC, JPPC, WPPSS, and the HTPP), were all created to elevate regional discussion and action above the merely political so that the higher concerns of technological coordination could be met. The energy problem was framed by these ventures around issues of adequate and reliable supplies, transmission and distribution, and the capacity of the region to finance and manage a growing and more complex electrical network. These are questions of science, engineering and business management best handled by those with technical training. As Balmer suggests, the region has come to rely heavily upon its technical experts in policy matters. "We have seen the shift over time from a decidedly hostile coexistence of public and private power to a growing technological interdependence which ... [has] led to an era of policymaking by relatively autonomous technocrats" (Balmer, 1983, p. 659).

The pervasive belief not only in megapower but in the efficacy of technocratic organization is traceable to a general predisposition to regard means as ends. The commitment to megapower, as noted above, is based on the idea that large-scale power production constitutes social progress. The commitment to technocratic organization is an extension of this logic: deciding among social ends is seen as equivalent to exercising technical judgement about what is best. Both reflect the basis of thinking and acting in technological society. As Galbraith has argued, advanced technology presumes technocratic organization: "technology requires specialized manpower;" "the inevitable counterpart of specialization is organization;" and "from ... the needs of large organization ... comes the necessity for planning" (1967, pp. 14-15). The structure of decision making in such a society is based upon principles of specialization, organization and planning. They guide the definition of the problem, establish criteria for an appropriate solution and steer decision makers toward the optimal decision. In this sense, technocratic principles become the means and the ends of decisions. Organizations predicated on this manner of decision making evolve into what Galbraith refers to as a "technostructure" (1967, p. 65).

Northwest power planning under the HTPP emphasized "technical virtuosity as a style" (Lee, 1980, p. 90). Managers at BPA and WPPSS tended to have engineering or other scientific backgrounds, adopted "scientific approaches" toward management matters, emphasized formal control in the organization of work and, above all, did not "play politics" (Leigland and Lamb, 1986, p. 75). To plan and manage the construction of five nuclear projects, several of the largest and most prestigious technology and investment firms were relied upon for technical counsel and management services (Leigland and Lamb, 1986, pp. 60-67). Merrill Lynch, Paine Webber, Salomon Brothers and Blythe Eastman Dillon worked for WPPSS, as did Bechtel and the "big four" reactor vendors -- General Electric, Westinghouse, Babcock and Wilcox and Combustion Engineering. Undergirding WPPSS was a transnational complex of corporations, interlocked with the largest U.S. banks, insurance companies and law firms (Leigland and Lamb, 1986, p. 183). The energy problem, as these organizations defined it, required specialized knowledge, planning and coordination to be solved.

This technocratic orientation largely precluded assessment of alternatives to large-scale centralized production. "By training and by tradition, all the utilities were growth oriented, concerned with meeting needs before they arose, and unreceptive to the idea that conservation ... might be substituted for increased supplies of power" (Balmer, 1983, p. 651). The technocratic bias neglected two possibilities. First, it was assumed that the WPPSS projects would continue the pattern of low power prices for the region. In fact, the Pacific Northwest has discovered that megapower can be a major cause of spiraling prices.

Second, the treatment of conservation as curtailment rather than as a supply option meant that the greatest advantages of the conservation strategy were ignored. In particular, the possibility that conservation investments might result in lower costs per kW saved than investments to supply a kW was overlooked. Estimates of regional levelized added-capacity costs (construction only) range from $395 to $489 per kW for combustion turbine (peaker) units; for base-load pulverized coal plants, unit costs in the region are thought to be in the range of $1,211 to $1,749 (Northwest Power Planning Council, 1988a; Tables 6-6 and 6-7). Nuclear unit construction costs vary widely, especially by country. Thus, levelized per kW costs in France are as low as $1,000; while the U.K. average is $2,000 and that of the U.S. is $3,000 (Keepin and Kats, 1988, p. 541). Unit costs to complete WNP 1 and 3 (ignoring already sunk costs of $3.99 billion) are estimated to be $1,140-$1,303 (Northwest Power Planning Council, 1989b, p. 9). All of these figures are well above the typical unit costs of utility conservation programs. For example, funding a residential conservation program aimed at reducing space conditioning requirements has been calculated at $7 per kW saved (Weil, 1985). A survey of national utility experience during 1979-1985 with commercial/industrial sector energy efficiency programs revealed a cost per saved kW of $9-$535 (New York State Energy Office, 1986).

However, the proponents of megapower were able to ignore these economic issues due to the strength of the region's conviction in large-scale technology. When the city council of Seattle voted in 1976 against further participation out of a fear that "the nuclear proposal would lead to higher cost power," WPPSS had already tallied over $1 billion in cost overruns (Narver and Stewart, 1984, p. 5). Nonetheless, membership on the WPPSS governing board expanded in that year as 88 utilities agreed to underwrite WNP 4 and 5 without net billing.

Despite decade-long experience with significant construction delays, rising costs, and increasing electric rates (averaging over 86 percent in December 1979 - see

Sugai, 1987, p. 351), it was not until the approval of Initiative 394 in November 1981 that WPPSS bond sales were subjected to ratepayer referendum. Citizen protests were few and unorganized before late 1980 -- "any direct attack upon the Supply System would fail to elicit majority public support" (Sugai, 1987, p. 8) -- and reached their peak in January 1982 with the termination of WNP 4 and 5. By that time, ratepayers had mobilized into a series of organizations, including "Irate Ratepayers" chapters, the "Don't Bankrupt Washington" coalition, and the "Progress Under Democracy" committee. But with the cancellation of two projects and mothballing of two others, activism quickly waned and in September 1982 efforts to form an umbrella coalition were dropped (Sugai, 1987, p. 363). This is not meant to diminish citizen activism in the Northwest. Rather, the short life of mass protest in the region and its limited accomplishments underscore the considerable problem faced by citizen groups in affecting, much less controlling, the activities and direction of a technocratic regime such as that ruling Northwest energy policy.

WPPSS, BPA and the HTPP together constitute a technostructure predicated upon the belief that the decision to create a regional electric power system represents the rational solution to the energy problem. This belief assumed the status of an imperative by the mid-1970s. Faith in nuclear power and in technocratic judgement, resigned acceptance of significant cost overruns and project delays, and an abiding belief in the energy-civilization equation express some of the requirements of this technological imperative. Jacques Ellul has emphasized the specific role of electrical systems in the spread of the technological imperative:

> Electrical networks may remain for some time independent of one another. But this situation cannot last when it is found that independence gives rise to general costs of no inconsiderable magnitude, difficulties in arranging the courses of the wires, and even practical difficulties in electrical technique. The interconnection of electrical networks is demanded by all technical men. (1964, p. 237)

Autonomous Technology

Arguments of technocratic ideology and technological imperatives are at variance with most social science frameworks of explanation which tend to reply upon rationality models (Byrne, 1987). In the latter, social choice about technology is conceived as being exercised through institutions such as markets or governments independently of existing technological systems. Explanations of this type preclude the possibility of a compulsive or deterministic quality in technology choice. The contrast between conventional social science and the approach taken here can be sharply drawn through an analysis of the economic relationships underlying the WPPSS episode.

Conventional economic analysis assumes that markets act as independent arbiters of the relative worth of alternative economic activities. Through the price mechanism, competition for resources is weighed and the most efficient mix, purportedly, is accepted. The trading of current versus future goods is not supposed to affect the "independence" or the efficiency of markets (Hahn, 1981). In this view, markets are self-governed by internal rules (the laws of supply and demand) and act upon social life rather than the other way around; that is, markets are seen as autonomous institutions.

A stylized account of energy decisions in the Northwest as market-determined hardly squares with the realities of megapower. The attempt to create such an account for the WPPSS projects unavoidably devolves to a series of explanations on why market processes didn't or couldn't work. After all, the WPPSS projects represent more than $30 billion in investments (with interest) made over ten years with the only tangible result to date being several nuclear plants "left to sit out in the rain" (Gleckman, 1984, p. 35). But it is not simply the magnitude of the economic "mistake" that challenges the validity of conventional market doctrine. A regression analysis of bond sales during 1973-82 (the period during which the WPPSS bonds were issued) indicates that at no time did the municipal bond market, the source of capital for all five nuclear projects, assign a measurable risk premium to the WPPSS securities compared to other revenue bonds floated in the same time period. That is, the market which was responsible for financing the projects never judged them a higher risk than competing users, much less a mistake. (See Appendix A for a description of the data, variables and estimation procedures.)

Tables 1 and 2 summarizes the results of the analysis. Our equations were successful in accounting for a large percent of the variance in interest costs paid by bond issuers generally (Table 1) and by electric utilities as a subclass of borrowers (Table 2). All variables used in the equation had the expected signs. While the Durbin-Watson statistics indicate that homoscedasticity cannot be assumed (and therefore that the standard errors for the equations are underestimated), this is of little relevance to our analysis. The central issue is whether a statistically distinguishable interest cost premium can be found between WPPSS and non-WPPSS issues, not whether the estimates of individuals variable effects are efficient. Using the Chow test (Table 3), it can be shown that the WPPSS and non-WPPSS equations can be pooled at 0.01 confidence level for both the quadratic and logarithm size models. Differences in interest costs are not statistically significant and can be attributed to issue size (see the intercept tests -- WPPSS averaged $197 million per float while the average for revenue bonds was $85 million and the average for electric-only revenue bonds was $100 million).

(insert Tables 1, 2 & 3)

These results are surprising only if a theory of autonomous markets is maintained. There are ample reasons for assuming the reverse; namely, that market activity with respect to WPPSS was conditioned by and subsumed within a political economy of megapower. Markets cannot perform a general evaluation of megapower versus other energy options because this requires an assessment of what Amory Lovins has termed institutional "architectures" which are, by their nature, mutually exclusive and antagonistic (Lovins, 1977, p. 59). As he has argued, it is not possible to pursue simultaneously a centralized system of power production and exploit fully the economics of conservation and renewables. System rationality and efficiency depend upon sustained commitment to one or the other, but not both. Economic analyses of nuclear power versus other "energy paths," such as those performed by Hohmeyer (1988), Keepin and Kats (1988) and Flavin (1983 and 1989), tend not to address this point. Based on comprehensive studies of the relative social benefits and costs of full scale nuclear and conservation alternatives, these researchers conclude that nuclear power fails the market test. However, these analyses presuppose the complete replacement of one system with a different one. This would involve a comparison not only of advantages at the margin, but of mutually exclusive and antagonistic technological infrastructures. These infrastructures cannot be reduced to their "sunk costs" and, for this reason, are economic incomparables. Only one infrastructure is reflected in current investments and it is dedicated to the support of megapower. Simply put, there is a functioning system for the delivery of "parts" -- from nuts and bolts to laws, financing and public policies (e.g., the Price-Anderson Act) -- to service the megapower machine. There is no equivalent to service conservation and renewables.

From a megapower perspective, conservation and renewables represent enormous costs, regardless of their relative energy economy after adoption. There are the investment costs in a new infrastructure, the losses to be suffered by the old energy regime and the transition costs in smoothing and changeover. Arguments that energy is more cheaply and efficiently provided and the environment more readily protected under a conservation-renewables regime are hardly persuasive under the logic of megapower. The beneficiaries of this logic understand this all too well. That is why the U.S.

Committee on Energy Awareness, a lobby for the utility industry, represents nuclear power in its media campaigns as the long-term market choice. It is, so long as the elimination of the institutional apparatus of megapower is counted as a cost (Byrne and Rich, 1983, pp. 176-181).

Whatever judgement is made about the possibility and adequacy of a market test, nuclear power passed the limited but real test of profitability to the primary institutional interests having the most to gain from the spread of a political economy of megapower: the regional electric technostructure established through the HPP; the major electricity-using industries of the region; the transnational nuclear construction and engineering companies; and the investment and banking sector which supplied capital for the megapower projects. Several of these interests are active not only in the region, but nationally and internationally. They participate in and shape an expanding technological system of which the Pacific Northwest electric network is only a part. Markets, such as the municipal bond market, function within the parameters and logic of this technological system. They do not independently assess its efficacy. Instead, market evaluations concern the far narrower but more tangible question of profit.

When financial advisors such as Merrill Lynch and John Nuveen and Company sought to weigh the performance of WPPSS, their first concern was not with the creditworthiness of the organization, but with the potential profit in "helping WPPSS to sell ... bond" (Leigland and Lamb, 1986, p. 104). In preparing a September 1981 bond sale for the Supply System, Merrill Lynch advised that the market had become saturated and forecast difficulties if the organization sought to offer an issue of more than $450 million. However, the company felt that these problems could be overcome if the bonds were bid on a negotiated basis and a vigorous sales campaign undertaken. The System followed this advice and was able to increase the offering to $750 million. Included as part of the promotional campaign were blue buttons reading "I'm bullish on the Supply System" (Leigland and Lamb, 1986, p. 112). When an internal report by Sitzer and Karvelis (1981) for Merrill Lynch warned of financial problems being experienced by WPPSS and of the slowdown in regional energy demand, it was ignored in light of the firm's responsibility as managing underwriter for an upcoming February 1982 bond sale of $850 million, one of the largest municipal bond sales in U.S. history.

It was not the judgement of Merrill Lynch alone that WPPSS bonds were profitable. In fact, bond ratings by Moody's Investors Service and Standard and Poor's were uniformly high during the entire 10 year sales period. "Throughout the 1970s national investment banking and brokerage house were enthusiastic marketers of the [WPPSS] bonds ... Supply System bonds were rated AAA, the highest rating which can be assigned to debt" (Comptroller General, 1984, p. 10). Even after termination of WNP 4 and 5 and the declaration of default in January 1982, WPPSS bonds continued to receive a AAA rating, were bought readily by retail traders and investors, and underwriters were able to increase offerings and cut interest costs on subsequent sales (Moody's Bond Survey, 1982, p. 2707). Not only did the market fail to asses an interest cost premium during the sales period, investor judgement about the value of the nuclear projects remained positive after termination and default. In fact, WNP 1, 2 and 3 bonds were rated A1 and WNP 4 and 5 bonds received a BAA1 rating as late as May 1983. John Nuveen even found "good news" in the 1982 termination of the two nuclear plants "because it ended uncertainty concerning WPPSS plans" (see Leighland and Lamb, 1986, p. 25). The projects did not lose investment grade ratings until June 7, 1983, eighteen months after default, "too late to benefit the bond buying public" (Leigland and Lamb, 1986, p. 116).

Throughout the 1970s, direct service industries steadfastly supported WPPSS building plans, actively lobbying for capacity additions through the PNUCC. The projections issued by that committee substantially overstated regional energy demand but neither the method nor the purpose for these projections was altered. High demand projections reinforced the conviction that greater supplies of electricity would be needed. When issues of cost regarding the added supplies were raised, the nuclear construction firms encouraged the view that Supply System cost overruns and project delays were "typical of the industry" (Leigland and Lamb, 1986, p. 45).

With this sort of institutional support, the electrical technostructure in the Pacific Northwest found capital easy to obtain, political backing at their ready disposal, and a general ideological climate favorable to the promotion of megapower. As a consequence, the market test of profitability was passed despite cost overruns of 600 percent, combined project delays of 28 years (to date), and the occasion of the largest default in the history of the municipal bond market (Heutte, 1982, p. 1). A Wall Street banker underscored WPPSS's market success in remarking that: "Nothing went wrong. We all made money, didn't we?" (Gleckman, 1984, p. 37) Autonomy, politically and economically, is located in the technological system of megapower and the organizational interests which profit from its operation.

Conclusion

With the WPPSS default on two plants and construction postponement of two others, it might appear that the regional autonomy of megapower has been seriously shaken. In our view, however, a negative prognosis about the future of megapower in the Pacific Northwest would be premature. Notwithstanding passage of the 1980 Pacific Northwest Power Planning and Conservation Act, which required the region to exhaust cost-effective conservation and renewable options before building additional power plants, utility commitment to megapower remains strong. Shortly after the WPPSS default, several utilities proposed construction of eight new coal and nuclear plants "while seeking to retain the option of completing ... WPPSS Nuclear Units 4 and 5" (Northwest Conservation Act Coalition, 1982, p. 3). The 1986 Northwest Conservation and Electric Power Plan sought to extend the commitment to WNP 1 and 3 through the year 2006. Advocating a continuation of the regional cooperation pioneered under the HTPP, the Plan forecasted $2.2 billion in energy savings over the next twenty years through coordinated power development and conservation. Thirty percent of these energy savings were contingent upon the completion of WNP1 and 3. Net benefits of $630 million were projected if the region would commit an additional $2.8 billion (not including debt service) to the WPPSS nuclear program (Northwest Power Planning Council, 1986, pp. 2-1 and 7-12). The 1986 Plan remains the controlling energy policy document for the Northwest and its objective of retaining the nuclear option was recently reaffirmed by the Northwest Power Planning Council which found that "problems precluding further financing of these plants [WNP 1 and 3] apparently have been resolved" (1989a).

The Council's optimism appears well-founded. In a move reminiscent of the heyday of nuclear power in the Pacific Northwest, WPPSS recently sought to refinance WNP 1 and 3 bonds by entering the municipal bond market in September 1989 with a $721 million offering, and again in December 1989 with a $600 million offering. History repeated itself: both issues received investment grade ratings -- A and AA- by Moody's and Standard & Poor's, respectively; the September issue traded at an interest rate of 7.58 percent by the conclusion of the sale; the December issue at 7.42 percent (interest rates comparable to those of other large sales in the market at those times); the underwriters, led by Goldman-Sachs and Smith Barney made a substantial profit on the sales. Nuclear power continues as a future-tense idea for progress in the region. In spite of its practical problems, megapower still represents an imperative for all technical people.

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Appendix A

A database was created consisting of all municipal revenue bond issues amounting to $50 million or more sold between June 1973 and June 1982. The database was comprised of 627 issues with a mean value of $105 million per issue. Two hundred electric utility bonds are included in this universe. Both sales populations are compared against the complete history of 42 WPPSS offerings. Pooled regression analysis was used to evaluate the presence of an interest cost differential between WPPSS and other revenue bonds sold in the municipal bond market. Separate equations were estimated for each population. An equation including all sales was also estimated to determine whether the two series could be statistically pooled. Chow tests were performed to evaluate the structural characteristics of these equations.

The specification of the equations and the selection of independent variables was based on previous research on the municipal bond market. Followng Kessel (1971), Tanner (1975) and Rubinfeld (1981), an issue amoung variable was included in the equations to reflect the effect of issue size on bond interest rates. Logarithmic and quadratic size expressions were tested (Bierwag and Kaufman, 1981). An integer variable was created to reflect the Moody's Investor Service rating class assigned to each issue. A major factor affecting interest costs during the study period was the secular increase in interest rates. A trend variable identifying the quarter and year in which an issue was sold was included to account for this growth. The analysis also considered a pre- and post-Three Mile Island variable since some evidence suggests that a price differential was imposed on nuclear securities soon after the accident (Hewlett, 1984; Brooks and D'Souza, 1984). Finally, a variable distinguishing securities for WNP 2, 2 and 3 from those for WNP 4 and 5 was tested. Several models were specified with two yielding the best statistical results. These are:

$$I = a + b_1S + b_2S_2 + b_3R + b_4T + e$$

and

$$I = a + b_1 \ln S + b_2R + b_3T + e;$$

where

I = interest cost

S, S^2 and lnS = the simple, quadratic adn logarithmic expressions of issues size

R = bond rating assigned by Moddy's Investor Service at the time of issue

T = quarter of observation (with April-May-June 1973 = 1 and April-May-June 1982 = 41)

e = error term

Table 1
All Revenue Issues

Quadralic Model

		C	S	S^1	R	T	R^3 (Adjusted)	Chow Test	Durbin-Watson Statistics
Non-WPPSS	B	2.0163	-.1874E-5	0.6046E-11	0.4553	0.1756	0.5160		
Issues	F-value		0.966	3.435*	59.819*	573.02*			0.4666
(n=585)	S_c		0.0000	0.0000	0.0589	0.00734			
WPPSS	B	5.5782	-.1554E-4	0.2449E-10	0.2346	0.1368	0.7268		
only	F-value		5.831*	11.302*	0.962	27.741*			1.1689
(n=42)	S_c		0.0000	0.0000	0.2392	0.0260			
All	B	2.2412	-.2288E-5	0.8294E-11	0.4163	0.1731	0.5241	F=2.271	
Issues	F-value		1.780	10.534*	55.720*	603.32*		p=0.046	0.4720
(n=627)	S_c		0.0000	0.0000	0.5578	0.0071			

Logarithm Model

		C	LnSize	R	T	R3 (Adjusted)	Chow Test	Durbin-Watson Statistics
Non-WPPSS	B	1.1748	0.7054E-1	0.4555	0.1748	0.5119		
Issues	F-value		0.284	59.254*	565.977*			0.4452
(n=585)	S_c		0.1323	0.0073	0.0073			
WPPSS	B	-4.9822	0.6516	0.4017	0.1760	0.5541		
only	F-value		2.006	1.832	32.664*			0.6224
(n=42)	S_c		0.4600	0.2968	0.0308			
All	B	-0.3911	0.2205	0.4161	0.1743	0.5089	F=2.092	
Issues	F-value		3.290*	53.991*	595.034*		p=0.082	0.4046

* Significant at the .01 level of confidence

Table 2
Electric Revenue Issues Only

Quadralic Model

		C	S	S^1	R	T	R^3 (Adjusted)	Chow Test	Durbin Watson Statistics
Non-WPPSS	B	1.9184	-.7866E-05	0.1334E-10	0.5110	0.1746			
Issues	F-value		0.757	2.132	15.165*	148.206*	0.5543		0.4348
(n=158)	S_c		0.0000	0.0000	0.1312	0.0143			
WPPSS	B	5.5782	-.1554E-04	.2449E-10	0.2346	0.1368			
only	F-value		5.831*	11.302*	0.962	27.741*	0.7268		1.1619
(n=42	S_c		0.0000	0.0000	0.2392	0.0258			
All	B	2.4438	-0.2190E-05	0.1007E-10	0.3858	0.1670		F=1.950	
Electric	F-value		0.653	6.949*	13.391*	173.343*		p=0.086	0.4534
(n=200)	S_c		0.0000	0.0000	0.1054	0.0127	0.5765		

Logarithm Model

		C	LnSize	R	T	R^3 (Adjusted)	Chow Test	Durbin-Watson Statistics
Non-WPPSS	B	-0.3378	0.1795	0.4981	0.1765			
Issues	F-value		0.519	14.108*	149.516*	0.5442		0.4247
(n=158	S_c		0.2491	0.1326	0.0144			
WPPSS	B	-4.9822	0.6516	0.4017	0.1760	0.5541		
Issues	F-value		2.006	1.832	32.664*			0.62243
(n=42)	S_c		0.4600	0.2968	0.0308			
All	B	-3.1932	0.4746	0.3580	0.1751			
Issues	F-value		5.506*	10.664*	180.199*	0.5372	F=1.418	0.35821
(n=200)	S_c		0.203	0.1096	0.01305		p=0.230	

* Significant at the .01 level of confidence

Table 3
Chow Tests for Intercept/Slope Differences

	Intercept	Slope
	All Revenue Issues (n=627)	
Quadratic Model	F=5.430 p=0.029	F-1.498 p=0.213
Logarithm Model	F=7.076 p=0.008	F=0.624 p=0.650
	Electric Revenue Issues (n-200)	
Quadratic Model	F=4.401 p=0.038	F=1.331 p=0.259
Logarithm Model	F=4.713 p=0.032	F=0.336 p=0.852