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ENERGY, TECHNICS AND POSTINDUSTRIAL SOCIETY:

THE POLITICAL ECONOMY OF INEQUALITY

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by

Cecilia R. Martinez

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PREFACE

Throughout my university life, I often pondered the value of my contribution to the intellectual tradition, and at times even questioned the value of the tradition itself. After all, my pursuit of this vocation has been based on a position of privilege. In my early years as an undergraduate and graduate student I was taught about the necessity to separate knowledge and theory from action in order to preserve the ideals of objectivity. This was not to say that society was to proceed uninformed, but rather that knowledge was not to be impelled by any preconceived notions about appropriate social actions. Such a posture would only serve to prejudice the vocation and lead to biased outcomes. While uncomfortable with these notions of a truly scientific social discipline, it became incumbent upon me and others to engage research and analysis in a manner consistent with this interpretation. Learning and our pursuit of knowledge were understood to stand apart from the consciousness of our individual and collective experiences. This seemed particularly difficult for "nontraditional" students, those of us who had only recently gained access to elite institutions of higher learning, and who were consistently reminded of the "special" process by which we had gained entry. Most of us nevertheless strove to perform according to the ideal.

It was only later, under the guidance of my friend and colleague, that I came to understand the possibility of a much richer meaning for our privilege. I was offered a new understanding of theory and theorizing that embodied a commitment to and a responsibility for the human condition. The dissertation, I was told, was a craft in which the author endeavors to gain his or her intellectual voice for the construction of possible worlds. The long and arduous struggle to complete this dissertation has been my effort at gaining that voice. I was relieved to find that my participation in the intellectual vocation did not require that I aspire to shed my sense of self or culture. I was nevertheless overwhelmed by the responsibility with which I perceived my task. It was then that I learned of another aspect to this vocation, and one that was contrary to all the usual conceptions about how it was practiced. Generally, the fruits of our work are seen as individual accomplishments, with the ideal purpose of entering into a dialogue with other members of our community. While that purpose is certainly the intention here, this dissertation is far from being an individual endeavor. This work reflects a true intellectual sharing of ideas. In our undertaking, my friend and colleague and I have tried to follow the counsel of Lewis Mumford on the futility of a methodist vision of social inquiry (1970:418):

> The effort to eliminate the formative role of the mind, making the artifact more important than the artificer, reduces mystery to absurdity; and the affirmation of absurdity is the life-heresy of the present generation. This in itself is a sardonic final commentary on the mechanical world picture...

My friend and I have learned that in practice this form of learning is not well understood or accepted. Nor is it easy. It has required tolerance and mutual trust in an institutional setting which is often hostile to the notions of a shared community. But without this struggle, the meaning of our vocation would ring hollow. I offer my thanks to my friend John Byrne for this lesson.

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Many people have provided me with the support and encouragement needed to finish this project. I would like to thank my committee, Dr. Paul Durbin, Professor Barry Cullingworth, Dr. Daniel Rich and, of course, Dr. John Byrne, for their time, patience and tolerance, and the constructive comments and criticisms which they offered. I would also like to thank Dr. Rich for showing me the enthusiasm and excitement with which one can approach learning. My friends and colleagues that make up the Center for Energy and Urban Policy Research have been an intimate part of this project. The ideas embodied in this dissertation reflect the countless discussions we have all had. Patricia Grimes and Beth Byrne offered me a home away from home and have always been there to support and encourage me when my work seemed to overwhelm.

My deepest gratitude goes to my family. My mother, through her hard work and unending self-sacrifice to provide me with a home and an education, has shown me the beauty of love and devotion. As my work has carried me

away from home, Seres has been a source of strength and courage, providing the candle which lights the path back to Taos again and again. Together with my grandfather, Richard's humor and patience have made me realize the true meaning of family. Lastly, I would like to thank Steve, Daniel and Michael for their love. It was *only* because of their dedication that any of this could have been possible.

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* Parts of Chapters 8 and 9 draw upon "Technolgical Politics in the Nuclear Age" (1989) coauthored with John Byrne and Steven Hoffman and "The Post-Industrial Imperative: Energy, Cities and the Featureless Plain" (1985) coauthored with John Byrne and Daniel Rich.

CHAPTER 1

INTRODUCTION

In 1968 the National Advisory Commission on Civil Disorders concluded that urban America was in a state of crisis brought on by white racism, the concentration and isolation of the poor, and the growing disparity between rich and poor, white and black. The Commission specifically noted that poverty was concentrated among black and female-headed families; that black family income was only 58 percent of the white median; that 81 percent of female-headed non-white families with children under six years of age lived in poverty. And for the Commission, the most disturbing finding was that things were getting worse with the gap in income between black and white steadily widening from 1947 to 1965 (1968:123-128). Worsening inequality had bifurcated American society into two societies, "separate and unequal." Large cities contained the most extreme problems of poverty, racism and alienation, and their future as communities was threatened.

A period of national policy activism followed to address the problems of the urban crisis. But soon enough this activism became the object of political attack as national policy itself was viewed as the problem. Policy abandonment was counseled in recognition of the larger transformative forces of technology and economics at work on the national and, increasingly, international levels (Baumol, 1981:12-13):

> A rebuilt South Bronx can only lure the jobless into remaining longer where they have no economic prospects. One can be fairly confident that the reconstructed homes will be transformed into slums soon enough, and that the torch will be back at the task of destroying them soon enough...The basic point is that at least some historical forces cannot be resisted for long...It is within the limits imposed by [technological and economic] constraints that we are free to act in a way that contributes to social welfare.

Twenty years after the Kerner Commission report, U.S. urban reality is little changed. The national poverty rate is virtually the same--13.5 percent in 1987 versus 12.8 percent in 1968 (U.S. Bureau of the Census, 1989:7). Black median family income stands at 56 percent of the white median; nearly 70 percent of female-headed minority households with children under six years of age live in poverty; the gap between black and white family income continues to widen--from 1967 to 1987 it grew in constant

1987 dollars from $11,434 to $14,176; and income inequality has reached its highest level since 1947 (Mishal and Simon, 1988:iii and 2; and U.S. House of Representatives Select Committee on Children, Youth and Families, 1989:113).

Less than ten years after the urban crisis, the United States officially recognized another state of national crisis. The second concerned the role of energy in the national economy. In 1973 then U.S. President Richard Nixon declared that the society had suffered an "energy crisis" brought on by an embargo of Middle Eastern oil. The embargo had exposed the dependence of the U.S. economy upon low-cost imported oil with over 36 percent of petroleum consumption supplied by foreign sources (Energy Information Administration, 1989b:41,119). Real U.S. GNP fell for the first time in 17 years while unemployment doubled (Bureau of Economic Analysis, 1986:7; and Dohner, 1982:6). In the wake of a 300 percent increase in oil prices, the proportion of GNP absorbed by energy payments jumped from 8 percent in 1970 to 11 percent in 1975. Five years later, a second "oil shock" increased world oil prices by another 300 percent (Stobaugh and Yergin, 1983a:6). Again U.S. GNP declined, unemployment rose, and double-digit inflation returned (IMF, 1981:65, 114). By the close of the decade, the national energy bill had climbed to 14 percent of GNP.

The two energy crises brought into sharp relief a dual U.S. reality of exceptional growth in corporate wealth amid national economic turmoil. While in 1974-75 the society suffered one of the deepest recessions of this century and over the decade of the 1970s had lost well in excess of $100 billion in economic growth due to the oil shocks (Stobaugh and Yergin, 1983b:356-357, footnote 59), the U.S. oil majors profited handsomely. Exxon's annual net income nearly quadrupled during the decade of the 1970s from $1.5 billion to $5.7 billion; Mobil's net income increased sixfold from $0.5 billion to $2.8 billion; the net income of Standard Oil of California (Chevron) grew 470 percent from $0.5 billion to $2.4 billion; and Standard Oil of Indiana (Amoco) increased its annual net income by 560 percent from $0.3 billion to $1.9 billion (National Petroleum News Factbook, 1977-1980).

The energy sector became a contributor in its own right to social inequality as energy costs increased three times faster than food and other necessities in the budgets of the lowest income quintile. The poor experienced a 47 percent increase in their energy bills, compared to 18 percent or less for the middle and upper income classes. By 1981, the poorest fifth of the population traded 27 percent of their income for energy services, twice the national average (Byrne, et al., 1985:84-90).

Again, a period of policy activism ensued as the society grappled with the conditions of inequality and poverty amid national and international economic restructuring. Even more apparent than in the case of the urban crisis, the energy crisis revealed a world political economy based upon an institutional reality of giantism, centralism and technicism. Yet policy efforts to ameliorate social impacts became quick targets, as national energy problems were blamed on government interference in technological and economic processes of change and renewal. Calls for deregulation of everything from prices of domestic energy products to nuclear plant siting issued forth as policy retrenchment and inaction assumed the status of *answers* to social problems. There were even demands for the suspension of emergency response planning in the energy sector (see Byrne and Rich, 1983). Likewise, regional economic disparities were to be accepted quietly, without resistance (Downs and Bradbury, 1984:2):

> *In the long run, entire energy-importing regions may also suffer adverse income effects from higher energy prices that are not felt in energy-exporting regions.* Large increases in

> energy prices have shifted the terms of trade between energy-importing and energy-exporting states in favor of the latter. In addition, large state revenues from severance taxes and other energy-related sources may permit energy-exporting states to reduce their other taxes to relatively low levels. Low general taxes plus high energy accessibility will make these states attractive locations for economic activity. Such regional income effects will probably accelerate long-run migration into energy-exporting regions from energy-importing regions. It would be unwise, however, to try to offset these long-run effects through public policies to redistribute incomes among regions deliberately.

Constraints on social action had again been detected, although the sense of irreversibility of direction was now even greater; the promise of eventual benefits was withdrawn and optimism was seen to rest only in the prospect of staying the course, wherever it might lead. A former energy official and economist of the Ford administration captured the new spirit with the prescription: "let the forces start turning; we're not going to be able to stop them" (Sant, 1982:117).

By 1988, the portion of U.S. oil consumption supplied by imports (43 percent) actually exceeded the 1973 level (Energy Information Administration, 1989b:119). The proportion of GNP needed to pay the society's energy bill remained high through 1985 despite declines in energy use. Then, with dramatic reductions in world oil prices, the energy ratio of GNP fell to 9 percent in 1987, close to the 1973 level. Some argue that the return to a single-digit ratio confirms the effectiveness of market deregulation. But the heightened state of inequality that coincides with this apparent market renewal poses an even more serious dilemma. For as pre-crisis energy-GNP relations have resumed, they are based upon a substantially higher degree of energy-based inequality. The poor in the United States had to devote in excess of 20 percent of their income in 1988 to pay their heating bills, with the energy costs of utility services and transportation still to be paid (National Consumer Law Center, 1989:17). Such a burden had not been borne before the energy crises of the 1970s and is a persisting legacy of the period.

In addition to social inequality, the defining attributes of the U.S. energy economy continue to be giantism, centralism and technicism. One of the best illustrations of this is the case of nuclear power. Fifteen years after the last U.S. plant order was filled (all plants ordered after 1974 have been cancelled), nuclear power's share of electrical generation steadily increases and will do so into the 21st century, even if no additional plants are built. The enormous size of the units and the central-station ideology of the U.S. electrical system ensure this result. Nuclear technology also commands the largest share of government energy R&D expenditure in spite of the absence of plant orders (American Association for the Advancement of Science, 1989:120-129). It has held this position since the embargo, a tribute to the faith of the scientific establishment in the peaceful atom, and to its political ability to regularly overcome public opposition (Nelkin, 1981). In this regard, the Nuclear Project testifies to the extraordinary insularity of the energy system from social influence. As the society hesitates on the question of further use, the logic of technicism, centralism and giantism controls the actual course of energy development.

While the United States had experienced massive change as a result of the urban and energy crises, practically nothing had changed in the institutional fabric. Everything seemed different, yet nothing was different.

1.1 Transition or Social Rigidity

Two decades of social crisis bring into sharp focus the problem of understanding order and change in the contemporary context. On the one hand, there is the objective condition of rapid, large-scale, and often painful change. And on the other, there is the absence of significant change in the objective conditions of order underlying social development. Immense urban and energy change not only restructure these sectors, but spill out into virtually every other sector of the modern system. At the same time, patterns of inequality and racism and operating system principles such as technicism, centralism and giantism not only fail to change, but in many respects intensify.

A prevalent view of this circumstance is that modernity has or is entering a new phase of development and these paradoxes of order and change are reflections of the transitional nature of the present. With time, the paradoxes will be resolved and a coherent developmental system will emerge. Most often, this transition is conceived as the passage from industrialism to postindustrialism. A "reconvergence" thesis is asserted in which the necessity of change out of well-worn industrial patterns is accepted, but the new order is seen as evolutionary, especially in technological terms (Kumar, 1988;77):

> [Postindustrialists] accept that the nineteenth-century scheme in its strict form will no longer do. 'Industrial Society' as it has been known hitherto cannot be taken as the fulfillment and final end of social evolution; but all one has to do is to add another stage to the sequence. The old story is given a new chapter with a new ending, rather as Marx had tried to do, and after him, James Burnham. But formally the pattern remains the same. The present is once more

> seen as transitional, as metamorphosis: not now from feudal agrarianism to industrialism, but from the industrial society to the 'postindustrial society'. The driving force of this transformation is also of the same character as in the past. It is technology, 'the great, growling engine of change' as futurologist Alvin Toffler puts it. Instead of the power loom, the steam engine and the railway, we have computers and the electronic media of communications.

This theoretical orientation projects order and change in largely economic and technological terms: the movement from manufacturing to services; the rise of professional and technical cadres; the displacement of mechanical and hydraulic tasks with electrical "information"; the increasing scientization of society; the dispersal of population out of machine-organized metropolises and into electronic villages, "ecumenopolises," and "daily urban systems"; and the eventual globalization of the economy, technology and even culture (see, e.g., Bell, 1973; Kahn, 1967, 1976; Toffler, 1970; Drucker, 1971; McLuhan, 1964; Baumol, 1981; Boulding, 1964; Doxiadis 1974; and Berry, 1981). Technology and economics are conceived in instrumental terms--utilitarian, socially responsive, elastic--and free of values and politics in themselves. They represent social processes for discovering methods of highest efficiency for satisfying human needs. The most common prescription for social problems is to produce more--postindustrialism "justifies itself in the end by producing the goods, and ever more of them" (Kumar, 1988:66).

From this perspective, resilience is the hallmark of social order and change. Those institutions of society which are able to adapt to change become the most influential in the new system. Contemporary Western economies and technologies are seen in this vein as among the most resilient (Kumar, 1988:105):

> [T]he oil crisis...is a good example of how capitalism can weather even the roughest storm...the post-1973 period saw the capitalist countries in the worst recessions since the 1930s...[Some] proclaimed 'the end of an era'...The days of neo-capitalism are numbered...In the upshot the prophecies of collapse seemed wide of the mark. The West rallied under the leadership of the United States and brought about a remarkable re-stabilization--or at least 'normalization'--of the international economic order.

However, modern Western resilience is peculiar. All but lacking are the qualities of flexibility and adaptiveness assumed in postindustrial thinking. Instead, Western societies, and certainly the United States, exhibit an increasingly compulsive character. Their resilience seems more an outgrowth of *forces* of technology and production which define rather than reflect social choice. To have weathered a decade of urban and energy crises with little or no change in the structure of the political economy is a testament not to regenerative capacity, but to social inertia and the preemption of significant choice.

As disturbing is the persistence and even worsening of inequality within the society. A return to normalcy which includes, as it has in the United States, a widening of the economic gap between white and black, rich and poor, and which renders basic social needs for housing, food and energy incompatible options, hardly suggests social progress. In what sense is the structure of social inequality operating in the urban and energy spheres of the United States *normal?*

Finally, the interpretation of what it means to have restored international economic order after this recent period of crisis depends upon perspective. While the U.S. economy grows again (although still lopsidedly), the same cannot be said of the Third World, especially the poorest countries. Energy restructuring did not produce oil "shocks," but economic devastation in the development periphery where the majority of the world's population lives. Net oil import expenditures were increased tenfold for those developing countries without their own fossil resources, as a result of the crises of the 1970s. This increase in turn doubled their current account deficit (Duersten and von Lazar, 1982:267-269). But this was only the most immediate effect on the poor. As well, the accompanying economic restructuring instituted by the industrialized orbit decreased export opportunities for the Third World oil importers. The combined result was "a stunning rise in indebtedness" of nearly $0.5 trillion by 1981 (Yergin, 1982:6). International restabilization after the oil crises of the 1970s left the global poor near bankruptcy and, with what the World Bank has characterized as "unsustainable trade deficits" (quoted in Yergin, 1982:6). From the perspective of the Third World, the resilience of the United States and other industrial economies is synonymous with continued hegemony of the rich over the poor.

This study seeks to challenge the postindustrialist view of transitional development and technological-economic evolution. Instead, modern order and change are argued to be predicated on an institutional system of exceptional rigidity and inflexibility. An alliance of centralized power, corporatism, "big science" (Price, 1963) and the technocratic state (each to be defined and documented in the ensuing chapters) is traced through the twentieth century and shown to have channeled social choice and action along a narrow range of alliance-reinforcing development paths. The postindustrial phase represents a matured state of integration among these institutional phenomena. The energy complex, often ignored by social theorists, is found to have been a major source of organizational, technological and political initiatives vital to the operations of postindustrial order. The cross-fertilization of science and industry, yielding what David Noble has called "science-based industrialization," is also identified as an essential precursor process to the emergence of the modern order (Noble, 1977:5). Together with corporatism and technocracy, these institutional developments are argued to organize and guide postindustrial society.

Contemporary theory assumes that postindustrial development is the outcome of 'autonomous' technical and economic processes. While autonomous, these technical and economic processes are understood as governed by a system rationality which continuously calls forward individual and organizational adjustments to insure a steady tendency toward an optimal social arrangement. This theoretical posture is unsatisfactory on at least three grounds. First, the theory's presumption of a system rationality leading to optimal outcomes is taken to be beyond dispute. The theory is exclusively concerned with a social order which is always either at or tending toward a state of "efficiency." Non-efficient states cannot be examined from this perspective except as transitional phenomena along a path of efficiency. Furthermore, the evolving order cannot be understood as anything other than it is. The theory presumes that the status quo is the only analytically available social reality.

Second, this theoretical posture prejudges the desirability of a system of efficiency adjustments. In this sense, technical and economic process are seen as not only autonomous, but necessarily beneficial. The unchallengeable normative status of markets and technology reduces the problem of social value to one of accommodation. So long as efficiency is taken to be desirable, the need for, indeed the relevance of, choice is removed. The *only* significant theoretical questions remaining concern the pace of adjustment and the particular direction it will take; that is, how fast should certain corporations leave certain urban areas and where should they relocate; and correlatively, how fast should the energy system centralize and how extensively should energy grids be interconnected.

Under this framework, postindustrial change is not understood as intentional as the concept of autonomy implies. But postindustrialists counsel that we shall not be concerned by this because economic and technical processes deliver social optimality. This combination of process autonomy and normative unassailability leads to a third problem, namely, that this posture must yield ahistorical accounts of social possibilities. According to this perspective, we cannot learn from history; we can only reinterpret it in light of more precise ideas about the character of technological and economic processes. The social represents little more than an accommodating factor in the determination of social history. In this regard, the disturbing implication of this theoretical posture is that social determinism, in this instance represented by the accommodation of economic and technological processes, displaces the idea of social responsibility in social theory. A new theory of postindustrial change is needed.

Before an alternative theory of postindustrialism can be written, a new way of theorizing is needed. In contrast to the timeless and deterministic orientation of contemporary thinking, a theoretical attitude which leaves history open-ended is desired. By this is meant an understanding of history as yielding multiple possibilities for social explanation. At the same time, the possibilities of theory must also remain open-ended. Fixing history denies learning; fixing theoretical alternatives precludes social choice.

Under this mode of theorizing, the relation between theory and history is conceived as interactive. History provides the opportunity for the discovery of a number of alternative explanations about social order and change, while theory interprets social relations in historical context. Social truths can change according to this perspective; indeed they must change--otherwise history is reduced to a static condition. In this regard, the interactive relationship between theory and history is of a special type. Not only does history act on theory, and theory act on history; but history can contradict theory, and social action informed by theory can alter history. Theory and history are dialectically related.

The theory-history dialectic is a manifestation of a proposed general dialectical relation between social action and social structure. Theorizing is one of several elements constituting the realm of social action. It and its companions are identified by the presence of human intention, choice, will and value which underlie and motivate individual and collective actions. Social structures on the other hand, represent organized patterns of interdependent social actions (e.g., political structures are organized political actions, economic structures are organized economic action, etc.), and bear the imprint of their historical development. These structures both promote and constrain social action. Seen in this way, the relation between social action and social structure can be alternatively complementary or conflicting. Social conflicts emerge when desired actions are incongruent with established norms expressed in the prevailing social structure; insofar as desired actions are consistent with these norms, conflict is avoided and there is a sense that the values and intentions underlying these actions are socially encouraged. But there is an even more fundamental aspect to this dialectical relation: to the extent that an existing structure is able to resolve conflict by effectively resisting the demands for change resident in social action, social structure becomes an instrument for the maintenance of order; while in those instances in which change overwhelms structure we can recognize the appearance of new modes of structure and action.

Given the dialectical character of social reality, the challenge to theory is at once to understand the organizing principles that sustain social order and to state possibilities for social change; to provide a basis for explaining patterns of social history *and* a basis for altering those patterns. The approach taken here to this challenge is to conceive the organizing principles of postindustrial order and change in terms of social institutions that provide legitimacy to certain modes of social action and structure. Through an analysis of certain institutions that have been central to past industrial development, and through an investigation of the possibilities for new institutions which may establish a different social order, an historically grounded account of postindustrial order can be provided. In so doing, it is possible to expose the compulsive structures underlying postindustrialism so that strategies may be devised to restore social control of social development.

1.2 Outline of Chapters

Before undertaking a critical analysis of postindustrialism, a theoretical framework is set forth to understand contemporary social order and change as historical and institutional phenomena. This approach breaks with the transitional and evolutionary theories of postindustrialism over the question of the progressivity of modern technology and development tendencies. Chapter 2 outlines such an alternative, borrowing heavily from the work of Lewis Mumford. The chapter reviews Mumford's analysis of social transformation from Eotechnicism to Paleotechnicism and presents his basic concepts and strategies for the study of industrial change. Four institutions are identified as essential for understanding the rise of postindustrial societies. These are the power complex, the dominant technic, economic organization and the pattern of urban settlement. This study utilizes these four institutions for examining twentieth-century postindustrial developments in the United States.

Chapters 3 through 7 provide a historical accounting of the process by which three of these institutions--the power complex, science and technology, and the corporate economy--coordinated their actions to produce an integrated system of political economy. Chapter 3 studies the changes in the power complex emanating from the transition to a petroleum- and electricity-based system of energy use. This complex is seen as the prototype for other sectors of postindustrial society, serving as a major institutional locus for technical change, and political and social centralization. Chapter 4 outlines the interactions of science and industry which have played such a vital part in transmitting the values of postindustrialism. The aims of this chapter are to outline the system character of the corporate form of economy and industrial science, and to examine the coalescence of the ideals of science and industry. Chapters 5 through 7 discuss the emergence of an institutional ensemble of large corporate organizations, technological systems, "big science" and the technocratic state. Borrowing from the organizational, technical and political achievements of the power complex, this ensemble produces a technocratic image that has come to dominate our way of thinking, acting, and valuing.

In Chapter 8, the role of the urban system in postindustrial development is addressed. Unlike its energy, scientific/technological and corporate counterparts, the significance of the urban system lies in its decline into relative powerlessness. A distinctive achievement of postindustrialism, in this regard, is the fragmentation of place-based communities, rendering largely irrelevant the political, economic and social values associated with them. It is against the background of an integrated institutional reality that the urban and energy conflicts of the 1960s and 1970s are analyzed. Chapter 8 and Chapter 9 argue that postindustrialism threatens the very capacity of societies to act as agents of order and change. Social choice during the energy and urban crises is shown to have been virtually preempted by a postindustrial ideology of technology and economic compulsion. A series of development imperatives are identified which serve to technicize the social milieu and render human action largely passive and automatic in the postindustrial era. These imperatives include the acceptance of a permanent underclass as a price of progress; the globalization of a process of "placeless development" (Byrne, 1985); the spread of a technocratic order involving society's dependence on highly centralized forms of production and development (including corporate oil, electric utility monopolies and the nuclear consortium); the existence and perpetuation of conditions of unequal national and international development; and an alienation of humanity from nature through the "commodification of the environment" (Byrne, 1990).

The present course of technological and economic development challenges those interested in the possibility of a humane social order to state their objections to the existing scheme of things. There is little reason to believe that a position "in-between" postindustrialism and democratic society exists. As Kumar has observed, the postindustrial development path is predicated on an exclusionary vision of social progress which has no tolerance for social values beyond those embodied in modern technology (1988:33):

> To modernize is to take everything, the bad with the good. Not to modernize is to play no part in the life of contemporary humanity. One of the unusual, and historically unprecedented, aspects of modernization is that it leaves no choice in the matter.

The final chapter assesses the challenge to creative social action that would address the conditions of technocratic compulsion and inequality in postindustrial society. An outline of strategies is offered to give a sense of the needed political emphasis in the struggle with postindustrial order.

CHAPTER 2

TOWARD AN INSTITUTIONAL ANALYSIS OF POSTINDUSTRIALISM

Fortunately, there already exist several well-developed theories and histories upon which an institutional analysis of postindustrial order and change can be based. These range from Karl Marx's analysis of mechanization under capitalist development in *Capital* (originally published in 1867), Patrick Geddes' critique of industrial "conurbations" in *Cities in Evolution* (1915), Sidney and Beatrice Webb's studies of deskilling and worker alienation in *Problems of Modern Industry* (originally published in 1902), and E.P. Thompson's monumental account of class conflict in *The Making of the English Working Class* (1964), to the contemporary work of Herbert Marcuse's *One Dimensional Man* (1964), David Noble's *America By Design* (1977) and *Forces of Production* (1984), and Maxine Berg's *The Age of Manufactures* (1985), among others. It would be a valuable task in itself to synthesize this body of thought for the purpose of shedding light on the process of the industrialization of social life (of which postindustrialization is a phase).

The objective here, however, is different. It is to focus on the phenomenon of postindustrialism as a compulsive, deterministic institutional force in modern society. While the writers and works referred to above have been vital influences on this study, there is one theorist and historian who has been the most influential--Lewis Mumford. Through his considerable study of the energy-urban basis of social development documented in *Technics and Civilization* (1934), *City in History* (1961), *The Human Prospect* (1956), and *Myth of the Machine, Volumes I and II* (1967) (1970), Lewis Mumford offers an institutional theory that is felicitous to both dimensions of theorizing sought here, namely, an account that is historically grounded and dialectically attentive to the always immanent conflict between technological determinism and the human prospect. Mumford's collective work establishes the salience of four institutions in the investigation of the transformation from pre-industrial to industrial to post-industrial societies. These are: the power complex, the dominant technic, the system of economic production and consumption, and urban settlement (social, political and spatial). He conceives these institutions as working together to support an integrated pattern of social structure and action. Thus for example, pre-industrial history is characterized as an Eotechnic order, predicated on an energy "commons" composed of wood, wind and water power; a handicrafts technic organized to serve local requirements; a somewhat segmented economy of self-reliant agriculture and modest cottage-scale production; and an urban spatial order centered on the townsquare and governed by cooperative guilds. By contrast the Paleotechnic order runs on a privatized, fossilized fuel system; a technic characterized by scale, quantity and mechanized logic; a similarly quantitative and agglomerative economy organized according to the principles of capitalist profit; and an urban chaos in which nearly every dimension of space is commercialized. Through an analysis of the contrasting institutional underpinnings of Eotechnics and Paleotechnics, Mumford achieved an explanation of the causes of industrial transformation and was able to identify the emergent threat to human autonomy and freedom posed by the modern phase of social progress.

2.1 Eotechnic Dialectics

Mumford considered the Eotechnic phase as the "dawn-age of modern technics" (Mumford, 1934:109). Roughly encompassing the period from the eleventh century to the mid-eighteenth century, Eotechnic civilization took root in Western Europe, although much of the mechanical and cultural inventions upon which it depended were imports from Egypt, the Arab world, Persia, China, India and Pre-Christian Greece.

In this phase, the power complex relied on three energy sources beyond what was available in the "human engine," namely wood, water and wind. Through the eighteenth century, Europe was largely dependent on wood for everyday living needs such as cooking and heating. However, wood as fuel had to compete with wood as building material as well as material from which tools, utensils, machines, ships, harbors and canals were fashioned. This competition eventually led to a condition of scarcity; as the process of forest clearing outpaced the natural abilities of forests to renew themselves, "wood became rarer everyday, even in the richly endowed countries" (Braudel, 1973:270). This situation was not easily resolved and wood shortages were a frequent occurrence. Commercial practices in wood-dependent manufacturing did little to obviate the difficulties (Braudel, 1973:270):

> As soon as the radius from which a wood burning factory drew its supplies became too large and costs increased, the most they did was to try and shift it somewhere else. Or else, they simply cut down on the amount of work it produced.

The effect of these shortages on the population was dramatic and often the most basic of human needs were denied as when "the poor were forced to do without fires" to warm themselves or cook their food (Braudel,1973:270). Indeed, an expert of the time expressed concern over the intense use of wood and the future of this natural resource: "trade in wood has become the trade of all the inhabitants: it is a case of who can fell more trees, and in a short time the forests will be completely destroyed" (in Braudel,1973:270). Moreover, while other sources of non-animal energy such as wind and water power were more plentiful, their use was dependent upon the tides and currents of nature. Waterwheels and windmills complemented wood, but were mainly used for the millstones to grind corn and grain. Only later was the power from these sources extended to serve the many purposes of medieval life: "pounding devices for crushing minerals, heavy tilt hammers, bellows, pumps, millstones to grind knives, tanning mills, and paper mills" (Braudel, 1973:261).

Significantly, energy sources of the Eotechnic period were irregular and diffuse. None could be relied upon as continuous sources of power. This energy condition particularly suited a mode of self-sufficient production that was predominantly agricultural with some cottage scale industry. Eotechnic industry was concentrated in glass, paper production, printing and textiles, emphasized craft skills and knowledge, and was more concerned with workmanship and quality than surplus production. It was not until late in the period that intermediate production activity was in evidence.

These two features--the irregularity of energy and the self-sufficiency scale of economy--ensured for much of the Eotechnic period, a locally oriented and controlled social organization. The two paramount local institutions were the guild monopoly and the medieval town chartered under the the authority of the feudal count or the church bishop. Together they brought regularity and stability to social life and the local economy, and established an efficient means of protecting, controlling and transferring local knowledge, skill and experience. The town served the direct needs of its members and was the center of economic and technical activity. Town guilds largely governed economic life elevating human skill, invention, and cooperation above mere mechanical improvement or economic gain. The medieval town was based upon a "social contract" (Mumford, 1961:261-262):

> [A contract existed] between the landed proprietor and the settlers or inhabitants: it came as a result of a bargain, for value given and received on both sides, not primarily as the

> result of military conquest, as in the most ancient examples.

At least through the fourteenth century, the energy, technical, economic and urban facets of Eotechnic existence were mutually reinforcing. For the most part local life was pervaded by a sense of security and stability brought about by the medieval system of regulation and protection. Indeed, this system had so successfully produced a sense of stabilization that as Mumford noted, it had become difficult to conceive "how life, growth and movement were to take place in a world governed by the ideas of fixed custom and inherited privilege" (Mumford, 1961:335). The disruption of Eotechnic regularity began with the alliance of technics and economics. Mumford points to Francis Bacon's proposal in 1601 that patents be granted for original inventions (this was passed into law in England in 1624), and the Royal practice of chartering companies with special monopoly advantages as early manifestations of this alliance. Patents and charters acted as "special inducements...to those whose mechanical ingenuity" could supplant "the social and economic regulations of the guilds" (Mumford, 1934:132). Here were the means to place growth over stability as a social orientation; a way to overcome the constraints of a protected economy.

The chartered company and patent monopolies were Eotechnic innovations intended to respond to the problem of social stagnation. With them came a flow of mechanical invention which "broke the caste lines" of medieval society and prepared Europe for industrialization and concomitantly, proletarianization (Mumford, 1934:132). As Mumford makes clear, these innovations had nothing to do with "natural laws" of economic or technical development. The impetus for their creation was an effort to replace one type of monopoly advantage with another. In contrasting the guild with the patent system, Mumford observed: "From this time on it *was not past heritage that was effectively monopolized but the new departure from it*" (Mumford, 1934:132).

The Eotechnic period produced a second, equally powerful response to the contradiction of feudal stability (Mumford, 1934:132):

> [T]he most important invention of all had no direct industrial connection whatever: namely, the invention of the experimental method in science. This was without doubt the greatest achievement of the eotechnic phase.

The attraction of scientific method to the Eotechnic mind was its promise to identify the "factual, impersonal order...under the dominion of *natural law*," that is, an order beyond the control and manipulation of the monarch, the guild and the church (Mumford, 1934:133). Through the practice of science, feudal authority upon which social stability rested could be brought into question. At the same time the factuality and precision of science could be used to compliment the quest for economic advantage (Mumford, 1934:133):

> It was on the model of this external physical order that men began systematically to reorganize their minds and their practical activities: this carried further, and into every department, the precepts and the practices empirically fostered by bourgeois finance.

In this respect, science became a partner to the alliance of technics and economics in permanently disrupting the balance of medieval society.

The undoing of Eotechnic order was set in motion by innovations indigenous to the period. In the space of 150 years or so Eotechnic life was utterly transformed. The mechanical clock was invented and took over the governance of economic work *and* social life *and* future technical developments. Economics and technics were most fully affected by this invention. As Mumford notes, the clock "set the pattern in accuracy and finish for all further instruments...the clock was the most influential of machines, mechanically as well as socially;...To this day, it is the pattern of fine automatism" (Mumford, 1934:134).

The clock directed social thought and action to the task of discovering how to save time. A simple but radical equation would henceforth rule economic and technical development: labor-saving = time-saving = profit. The clock served, and serves, as the scientific means for measuring achievements in saving time, labor and money.

The value of mechanical invention began to be determined by its labor-displacing capacities and its own creative possibilities. With the former, machinery reduced labor requirements and therewith time and cost of production; with the latter, machinery promised production without labor and therewith minimized absolutely time and cost of production. The introduction of power-driven machinery during the Eotechnic period in the paper, textiles and printing industries spawned the mechanization of human machines; specialization and division of labor replaced craftsmanship; the goal of surplus production replaced self-sufficiency; and quantity replaced quality as the objective in production (Mumford, 1934:146):

> Here was both the process and the result which came about through the increased use of power and machinery in the eotechnic period. It marked the end of the guild system and the beginning of the wage worker. It marked the end of internal workshop discipline, administered by masters and journeymen through a system of apprenticeship, traditional teaching, and the corporate inspection of the product; while it indicated the beginning of an external discipline imposed

> by the worker and manufacturer in the interest of private profit--a system which lent itself to adulteration and to deteriorated standards of production almost as much as it lent itself to technical improvements. All this was a large step downward. In the textile industries the descent was rapid and violent during the eighteenth century...In sum: as industry became more advanced from a mechanical point of view it at first became more backward from a human standpoint.

The emergence of science, technics and economics as the dominant institutions certainly answered the medieval problem of stagnation. At the same time, their dominance had a destructive effect on community and the sense of locale. Mumford argues that while these institutions "released people from the domination of the immediate and the local," they simultaneously put severe pressures on the sense of social being and relation so that "people lost that balance between the sensuous and the intellectual, between image and sound, between the concrete and the abstract" (Mumford, 1934:136).

The release of the individual from the domination of the local order without relocation in a social equivalent to the village left the individual isolated. Technic was substituted for social and "the impersonal order and brute facts" of the experimental method of science became the new world view (Mumford, 1934:132-133):

> [T]he relative impersonality of the new instruments and machines, particularly the automata,

> must have helped to build up the belief in an equally impersonal world of irreducible and brute facts, operating as independently as clockwork and removed from the wishes of the observer; the reorganization of experience in terms of mechanical causality... *this was a gigantic labor-saving device.*

Thus, the Eotechnic phase encompassed both the self-contained, self-sufficient medieval guild life and its eventual antithesis. A new world was emerging, a world of science, automatic machines and humanity without the "garden" promise of "an auxiliary supply of food and a touch of independence" (Mumford, 1961:451). Mumford pointed out that the demise of the Eotechnic regime was inevitable because of its "dependence on strong, steady winds and upon the regular flow of water" which "limited the spread and universalization of this economy" (Mumford, 1934:142). The vain hope of Eotechnicism was that science and the alliance of economics and technics would observe the limits of medieval social structure. They did not. But it was not until basic changes in energy conditions occurred that full-scale industrial development could proceed. Indeed Braudel suggests that European development had reached a plateau from the 15th to the 18th centuries (Braudel, 1973:274):

> To all intents and purposes, therefore, the economy was trapped in the old inflexible solutions, and it was this that hampered the development of mechanisation most of all, not any

> delay in the inventive urge. Many elaborate machines were working but still in slow motion. Mechanisation required large sources of power: they were not available until after the eighteenth century.

The appearance of a surplus of easily mobilized power was essential to the industrialization process. "It was from this crisis," Braudel asserts, "that in the course of time the coal revolution emerged" (Braudel, 1973:270). Without the capacity to prevent industrial modes of production and an industrial way of life, Eotechnic society was prone to the intrusions of "capitalist monopolies" and to machines which "tended by reason of [their] 'progressive' character to the more naked forms of human exploitation" (Mumford, 1934:144).

2.2 The Paleotechnic Cloud

In the passage from Eotechnics to Paleotechnics the power complex underwent significant transformation. The turning point, as Sombart expressed at the time, was "the transfer of the center of gravity from the organic textile industries to the inorganic mining industries" (quoted in Mumford, 1934:145). Coal, the newly acquired energy source, had its own distinctive attributes and relationships. The universalization of machine technology and the synchronization of human activity which had begun in Eotechnic times with the mechanical clock and automatism, reached full realization in terms of regularity, consistency and quantity with the fossilization of energy. The main attribute of coal (and later oil) was that it could be accumulated and stored for future use to be transferred upon demand. In this manner it was relatively unhindered by seasonal or other environmental influences (Mumford, 134:196):

> [T]he changes that were manifested in every department of technics rested for the most part on one central fact: the increase of energy. Size, speed, quantity, the multiplication of machines, were all reflections of the new means of utilizing fuel and the enlargement of the available stock of fuel itself. Power was dissociated from its natural human and geographic limitations: from the caprices of the weather, from the irregularities which definitely restricts the output of men and animals.

With this quality, the scarcities of the Eotechnic regime for all intents and purposes were overcome. Machine technology could have a power base at its disposal that reliably sustained large scale operations for extended periods of time without the threat of stoppage. The energy base was no longer a constraint on technological performance, nor on economic production. At this point, "once the new scale, the new magnitudes, the new regularities were established, wind and water power could not...compete with steam" (Mumford, 1934:161).

In contrast to the dispersed pattern of development exhibited in the Eotechnic period, coal and later oil promoted a highly concentrated and consumptive technical and economic system. Technological improvements by their nature served to replace human labor and expand the use of energy and machines in work and production. Even to the extent improvements resulted in greater efficiencies, such as in the development of Watt's steam engine (which nearly halved the energy requirements of its predecessor engine) these only served to hasten the almost universal use of fossil fuel as the primary energy source.

The viability of the Paleotechnic complex rested directly on the "characteristic inventions and improvements" of the mine (Mumford, 1934:158). Techniques for extraction and transport were developed and the impetus to continually improve the efficiency in their performance governed nearly every aspect of Paleotechnic society. As a result, industry increased in size and concentrated itself around energy supply areas, for "to be cut off from the mine was to be cut off from the source of Paleotechnic civilization" (Mumford, 1934:159). Increase in the scale of the power complex was the essential step in the process of diffusion to higher, more complex scales.

This tendency toward enlargement continued without question, until Mumford notes, "[b]igger was simply another way of saying better" (Mumford, 1934:162). Everything was measured in terms of its size--the size of mines, the size of factories, the size of cities, and the size of the population devoted to manufactured production. In addition, the energy advantages of coal made it possible to fabricate iron, a material that could withstand enormous stress in order to support large physical structures--bridges steamships, and multi-story buildings. Mumford tagged this new age "carboniferous capitalism" because wealth had its source in an accumulation of potential energy derived "from the ferns of the carboniferous period instead of upon current [energy] income" (Mumford, 1934:157). This explosion in potential energy and iron led to the rapid proliferation of the machine into all manner of industry.

By the nineteenth century the world had become divided into two parts: areas of machine production and areas of food and raw material production. The "advanced" countries quickly sought to use their coal agglomerations and machine culture to dominate those not directly a part of the Paleotechnic complex. Coal and iron gave societies the capacity to mass produce destruction: "war became a department of large-scale mass production" (Mumford, 1934:165). Turning war into industry had direct economic consequences as production and sale of armaments became a profitable preoccupation of Paleotechnic capitalism. A period of what Mumford called "panicky imperialism and armament competition" set in during the late nineteenth century (Mumford, 1934:193). But while nationalist tensions continued throughout the Paleotechnic period the division of the world into machine and non-machine areas was ultimately untenable. The new machine system, Mumford observed, "was a universal one" and it would be in the interests of Paleotects in the advanced countries to spread the machine everywhere (Mumford, 1934:133). Ruled by a "policy of blood and iron," the motives of carboniferous capitalism assured that Paleotechnic production would become global.

Even the most basic elements of everyday life succumbed to this universalization. In Eotechnic society, daily activities had conformed and cooperated with nature's order. But with continuous power, society substituted the rigor of the machine for the laws of nature. Twenty-four hour non-stop operations were not only made possible, but necessary. Machine technology could not be efficient otherwise. "Spurts and stoppages" bore heavy costs in the form of lost production time. Time was money in this world (Mumford, 1934:197):

> Time...was a commodity...Time as pure duration, time dedicated to contemplation and reverie, time divorced from mechanical operations, was treated as a heinous waste. The paleotechnic world...had no mind to sit upon an old gray stone and dream its time away.

Every effort was made to reduce the temporal content in every stage of industry such that "[t]ime-saving now became an important part of labor-saving." Eotechnic efforts in this direction paled by comparison (Mumford, 1934:197):

> From now on filling time and killing time became important considerations: the early paleotechnic employers even stole time from their workers by blowing the factory whistle a quarter of an hour earlier in the morning, or by moving the hands of the clock around more swiftly during the lunch period: where the occupation permitted, the worker often reciprocated when the employer's back was turned...[Time was] accumulated and put by, it was reinvested like money capital in new forms of exploitation.

With the commercialization of time came also the commercialization of space. Transport of resources to and from production altered the nature of movement and space; "[t]o quicken movement through space was looked upon as a significant end in itself" (Mumford, 1934:198). The development of the railroad epitomized these Paleotechnic transformations. Its operation required synchronized time-keeping, and its purpose was to move both people and resources more quickly, thereby promoting maximum mobility between supply areas and places of production. But this capacity was valued not only with respect to the pecuniary benefits of reducing time and space. Perpetual motion became a technical ideal.

Paleotechnicism manifested an unmistakable scale principle: "monopoly and concentration" (Mumford, 1934:161). Not so much as descriptions of the tendencies of individual wealth and capital, rather monopoly represented a condition of civilization being overwhelmed by and literally reconstructed according to the new values of a new technic (Mumford, 1934:184, 185):

> The machine was displacing every other source of value partly because the machine was by its nature the most progressive element in the new economy...What paleotect dared to ask himself whether labor-saving, money grubbing, power-acquiring, space annihilating, thing-producing devices were in fact producing an equivalent expansion and enrichment of life.

Paleotechnic development promoted uneven economic growth patterns both within the "advanced" nations as well as between them and their supply areas. Notwithstanding the highly uneven development pattern of this period though, economic progress was measured by a single criterion--quantity. It was the achievement of large production capacities and surpluses that became Paleotechnic's unrepudiated symbol of achievement. In Paleotechnic logic, progress was measured in quantitative dimensions of bulk, size and number. The underlying logic was circular (Mumford, 1934:185):

> For Progress was possible only through increased production: production grew in volume only through larger sales: these in turn were an incentive to mechanical improvements and fresh inventions which ministered to new desires and made people conscious of new necessities.

Indeed the whole economic scheme was based on quantitative relations: supply and demand; production and consumption; income and expenditure; cost and profit. These relations were evaluated by a quantity variant of the Paleotechnic size principle: not only bigger, but more was better (Mumford, 1961:570):

> Quantitative production has become, for our mass-minded contemporaries, the only imperative goal: they value quantification without qualification. In physical energy, in industrial productivity, in invention, in knowledge, in population the same vacuous expansions and explosions prevail. As these activities increase in volume and in tempo, they move further and further away from any humanly desirable objectives.

Even economic accountancy could be overruled by this principle. Growth, increase, expansion were *assumed* to have long-term value even if the short-term economics was negative (Mumford, 1938:160):

> In short: numbers begot numbers; and concentration, once well started, tended to pile up in ever-increasing ratios, claiming increase by inertia where it could no longer promise more effective economic performance.

Paleotechnic society valued numerical growth as much out of fear of what it would mean to be without it, as out of appreciation for what it would bring. Growth was good to a significant extent, because the absence of growth was not good; once on the Paleotechnic treadmill society could only retrogress if it failed to keep up.

Whereas the technician was absorbed with time-saving, the businessman in Paleotechnic society was absorbed with labor-saving. Mumford approvingly cited Marx's thesis that the exploitation of labor is the source of production surpluses. By labor cheapening (that is paying laborers less) and labor-saving strategies (that is unemploying labor), production surpluses were maximized. Capitalist competition focused on "improvements" in such strategies, with the most ablest capitalist being the one that could produce with the least quantity and cost of labor. The reward for being the most efficient labor-saver was monopoly. The capitalist had numerous tactics he could use in seeking to win out in the competition. These included: deskilling through routinization and mechanization of work, which reduced the economic power of labor; the substitution of machines for labor which imposed mechanical rule over the workmen that remained and reduced work, in Marx's words, "to watching the machine with [one's] eyes and correcting its mistakes with [one's] hands...In the factory we have a lifeless mechanism independent of the workman who becomes its mere living appendage" (Marx, 1912:409, 461-462); the automation of production, as labor was wholly replaced by a system of machinery thereby inflating the supply of idle workers and depressing the average wage; the enlistment of science and technics to discipline and subordinate workers--as the 19th century engineer Andrew Ure put it, new inventions "confirmed the great doctrine already propounded that when capital enlists science into its service the refractory hand of labor will be taught docility" (quoted in Mumford, 1934:174).

While labor-saving was perhaps the most visibly dehumanizing aspect of Paleotechnic economy, the challenge to human dignity was all pervasive. The capital-controlled, machine-driven, labor-obsolescing economy provided concrete expression of the means-ends reversal that underlies Paleotechnicism. No Paleotect dared ask about the enrichment of life because it was beyond his mental grasp (Mumford, 1934:176-177):

> The gospel of work [was] the positive side of art, play, amusement, or pure craftsmanship which attended the shriveling up of the cultural and religious values of the past...[T]he iron-masters and textile masters drove themselves almost as hard as they drove their workers...The lust for power made [them] despise a humane life...[A] new type of personality had emerged, a walking abstraction: the Economic Man. Living men imitate this penny-in-the-slot automaton, this creature of bare rationalism...These successful neurotics looked upon the arts as unmanly forms of escape from work and business enterprise.

Paleotechnic society lived according to the doctrine that the perfection of economic and technical means *is* the end. A philosophy that sought human dignity in the expression of ends and purposes was foreign to this society. In fact, Paleotechnicism turned the whole matter on its head (Mumford, 1934:185):

> [L]ife was judged by the extent to which it ministered to progress, progress was not judged by the extent to which it ministered to life...[T]he struggle for the market became the dominant motive in a progressive existence.

With the maturation of Paleotechnicism in the latter part of the nineteenth century, the power complex, technics, and economy had combined to establish an entirely new social order. Its most advanced forms appeared in the United States and Europe, but via colonialism the institutional structure of Paleotechnicism spread world-wide. As nearly three hundred years of trends in these three sectors reached fruition, two consequences for society became clear. In the new order the traditional organic relation between nature and humanity was broken; henceforth nature must be regarded purely as a commodity, a source of profit. In the social sphere, the very meaning of community and association was transformed; now commercial relations replaced social ones and cities as "storehouses of civilization" lost significance altogether. Neither the symbiosis of nature and humanity nor the culture of cities could survive the age.

The emblems of Paleotechnic society were pollution and waste. The energy, technic and economic achievements of this era presupposed a foul environment; in fact, the latter was a signal of success in the former. As Mumford remarked, "the reek of coal [is] the very incense of the new industrialism. A clear sky in an industrial district [is] the sign of a strike, or a lockout or an industrial depression" (Mumford, 1934:169). The environment as Nature lost all meaning. The dependence of human posterity on a livable environment seemed to have been forgotten. Mumford sarcastically queried (Mumford, 1934:255):

> What had posterity done for [the new exploiters]? In their haste they over-reached themselves: they threw money into rivers, let it escape in smoke in the air, handicapped themselves with their own litter and filth, prematurely exhausted the agricultural lands upon which they depended for food and fabrics.

Unless the elimination of pollution and waste could be shown to have profit-making potential, there was nothing technically, economically, logically that needed to be done from a Paleotechnic point of view. Instead environmental violation was transmuted into "side-effects," "spill-overs," "externalities"; in essence, phenomena to be residually "treated" after the all-important production operations had been permitted to reach their conclusion. The quantities of energy, technical operation and economic production were real; the environment was not (Mumford, 1934:168):

> In this paleotechnic world the realities were money, prices, capital, shares: the environment itself, like most of human existence, was treated as an abstraction. Air and sunlight, because of their deplorable lack of value in exchange, had no reality at all.

With cities representing the massing areas for industrialization they were unavoidably drawn into the process of degrading the environment. Cities had traditionally been located along waterways for advantages of transportation and trade. Urban rivers came to serve a new function with the Paleotechnic advance (Hugh Miller, quoted in Mumford, 1961:459-460):

> Nothing seems more characteristic of the great manufacturing city [of Manchester]...than the river Irwell, which runs through the place...The hapless river--a pretty enough stream a few miles up, with trees overhanging its bank and fringes of green sedge set thick along its

> edges--loses caste as it gets among the mills and print works. There are myriads of dirty things given it to wash, and whole wagonloads of poisons from dye houses and bleachyards thrown into it to carry away; steam boilers discharge into it their seething contents, and drains and sewers their fetid impurities; till length it rolls on--here between tall dingy walls, there under precipices of red sand-stone--considerably less a river than a flood of liquid manure.

Cities not located near water also contributed to the despoliation of nature. Mining towns which were the distinctive invention of Paleotechnicism, specialized in a new kind of pollution (Mumford, 1961:459):

> [G]reat mounds of ashes, slag, rubbish, rusty iron, and even garbage...[a] vision of misplaced and unusable matter...In the Black Country of England, indeed, the huge slag heaps still look like geological formations.

The new conurbations thrived throughout the nineteenth century on an economy of heavy industry. "Factory agglomerations" yielded surpluses not only of commodities but of smoke and industrial fog. The Paleotechnic cloud was composed of "atmospheric sewage" contributed to, in varying measures, by the steel mills, iron works, chemical industries, gas plants, soda works, and cement plants that prospered in the period (Mumford, 1934:169; see also Mumford, 1961:471-472).

Coketowns, the name given to these agglomerations by Charles Dickens, were an essential building block of early industrialism but lost their economic purpose as advances in transportation and communication eliminated the need for locating near the mine. Improvements in energy technique, including the invention of electricity, eliminated the need to burn coal in order to power machines. Installation of public sanitation systems in the late nineteenth century also served to slow the near geometric growth of filth and disease. The raw industrialism of Coketown was replaced by a new urban order. The dominant principle of this new order remained quantification, but instead of the earlier spatial aggregations, the new urban order exhibited an undifferentiated commercialization of space. By the early twentieth century, the age of Megalopolis had arrived (Mumford, 1961:544):

> The form of the metropolis, then, is its formlessness, even as its aim is its own aimless expansion. Those who work within the ideological limits of this regime have only a quantitative conception of improvement: they seek to make its buildings higher, its streets broader, its parking lots more ample: they would multiply bridges, highways, tunnels, making it ever easier to get in and out of the city, but constricting the amount of space available for any other purpose than transportation itself...An expanding economy, dedicated to profit, not to the satisfaction of life-needs, necessarily creates a new image of the city, that of a perpetual and ever-widening maw, consuming output of expanding industrial and agricultural production...

While the transition from Coketown to Megalopolis provided some relief to urban inhabitants, cities continued to be governed under the energy-technic-economic complex. If anything, "the province of the marketplace" intensified as "every part of the city [was turned] into a negotiable commodity" (Mumford, 1961:446). An imbalance of economic activity ruled as the "tendency toward settlement" was replaced by a universalizing "tendency toward movement" (Mumford, 1945:10). Mumford coined the resulting urban sprawls "metropolises of motordom" (Mumford, 1961:474). Social heritage which imbued place with its special meaning and nourished a sense of community among members, did not fit in the new value scheme which instead emphasized temporary living quarters, temporary economic structures, and temporary social relations. Megalopolis emerged as the urban type best suited to the commercial phase of Paleotechnicism. Cities had all but lost their distinctive spatiality and with it their social basis. They were borderless, a "formless urban exudation" (Mumford, 1961:505).

There was no internal mechanism to halt the spatial homogenization of megalopolitan development. As Mumford noted, "congestion and expansion...are in fact complementary movements" under this urbanizing pattern

(Mumford, 1961:551). Expansion was dictated by the energy-technic-economic complex and its glorification of size and quantity. The consequence of continuous expansion was that modes and scales of social organization other than mass organization could not survive; "the organic tissue of neighborhoods and smaller communities" was under constant threat (Mumford, 1961:552). Unregulated expansion led to congestion on a correspondingly mass scale. There was no way out of the expansion-congestion cycle; movement away from megalopolis simply added to its reach. Mumford summarized this condition as "the bursting container" (Mumford, 1961:551).

In the nineteenth century the congestion-expansion cycle was fed by a stream of landless, traditionless proletarians. Cities served as collectors for the "[drifting] raw materials, unemployed workers, and unemployed capital" that were the corollates of the Paleotechnic ethos of free trade, free invention, free enterprise and free access. Industrial buildings were the anchors of the urban landscape with railroads and streets providing the radii to deliver the "inputs" and "outputs" of production. Workers housing was largely a spatial afterthought built as cheaply as possible in accordance with the discipline of low wages necessary for capitalist progress.

With the pecuniary motives at the apex of the Paleotechnic value hierarchy, city life lost any semblance of "balance" of activity. There was no significant role to be played by cultural, religious or artistic associations; even play became a luxury as the clock-regulated workday dominated. As Mumford observed, "none of these towns heeded the old saw, 'All work and no play makes Jack a dull boy.' Coketown specialized in producing dull boys" (Mumford, 1961:446).

The helter skelter of urban congestion spatially expressed the expansionist motives of the power complex, technics and economics of the era. The helter skelter had a specific name--the slum, the prevailing spatial order of nineteenth century cities. Indeed, Patrick Geddes, Mumford's teacher, summed up nineteenth-century English urban-industrial development with the characterization, "Slum, semi-slum, and super-slum--to this has come the evolution of cities" (quoted in Mumford, 1961:464).

By the twentieth century, a second dynamic had been added to the congestion-expansion cycle. While the magnetic draw by city industries of landless labor and capital continued, some elements of the society tried to escape. In their rush out of the city two things became clear. First, the slum nature of urban life proved to transcend class; it turned out to be a general condition of urban Paleotechnicism. When workers occupied the vacant housing of the bourgeoisie, the veneer of upper class elegance was exposed as a Paleotechnic deception. Certainly, the extreme inequalities of wealth and income were a necessary, functional part of this social order, but all rungs of the economic latter exhibited a cultural dullness. Aptly illustrated in the housing designs of the period, those that were better off lived in similar dark, enclosed, and congested quarters: "like the dwellings of the poor they occupied the larger part of the plot, and instead of providing the amenity of collective open spaces and gardens, they offered, for most of the rooms, a mere air-shaft..." (Mumford, 1961:433). The second thing that became clear was that efforts to escape were fruitless. Suburban tendencies financed by income and wealth inequalities accomplished only temporary segregation of the well-to-do from the feared proletarian rabble. Each ring of suburbanization simply extended the helter skelter of Paleotechnic urbanization. The city and suburb were dialectically linked within the congestion-expansion cycle.

Urban existence in Paleotechnic society had lost its social coherence. Energy-economic-technical complexes had replaced cities as the primary instruments of social organization. Cities as institutions were functionless, formless, socialless. Modern economics had been one of the first to realize this in redefining the city as a form of agglomerative economy. More recent thinking in the discipline suggests that the city has undergone a further transition to a museum and tourist economy (see Baumol, 1981). Mumford, too had projected the demise of the city as a social institution when he mourned the passing of the great cities: "Only the sects, the fragments, the social debris of old institutions remained, left like the muddied debris scattered by a great river after the flood has subsided: a no-man's land of social life" (Mumford, 1961:470). But whereas economics reached this conclusion from an understanding of the rational requirements of economic and technical efficiency, Mumford had shown that it was the anointing of a cult of efficiency and greed which had transformed the great cities into cultural pseudomorphs. Paleotechnicism had suffused the urban process with self-contradictory and self-destructive elements such that the advance of urbanism actually became antithetical to civilization. While contemporary theories describe this transition in the neutral tones of regionalization, suburbanization, exurbanization and multinucleation, Mumford had concluded oppositely: "[This] is not in fact a new sort of city, but an anti-city. As in the concept of anti-matter the anti-city annihilates the city whenever it collides with it" (Mumford, 1961:505).

The shift from Eotechnic to Paleotechnic order was, by Mumford's analysis, a social retrogression. The institutionalization of the power complex, the machine economy and the technical system as ultimate social authorities threatened humanity. If the Paleotechnic description were carried to its finish, a shift from life values to pecuniary values was forecast (Mumford, 1934:153). The dismantling of Paleotechnic order was essential; the agenda for social theory and social action was clear (Mumford, 1961:263, 248):

> [A]n orgy of uncontrolled production and equally uncontrolled reproduction: machine-fodder and cannon-fodder: surplus values and surplus populations...The dirty crowded houses, the dank airless courts and alleys, the bleak pavements, the sulphurous atmosphere, the over-routinized and dehumanized factory, the drill schools, the second-hand experiences, the starvation of the senses, the remoteness from nature and animal activity--here are the enemies. The living organism demands a life-sustaining environment.

2.3 Mumford's Institutional Framework

The institutional analysis developed by Mumford to examine industrial change yields empirical and conceptual findings which alternately contradict the mainstream analysis of contemporary social science and reveal theoretical issues unavailable for investigation from the conventional vantage point.

While recognizing that the energy complex was shaped by economic and technical developments, Mumford disagreed that it was merely an artifact of these two forces. Instead he conceived energy as a distinct institution which directly influences the pace and diffusion of technology and industrialization in societies. Its organization, politics and economics were as central to the study of contemporary society as the corporation, the state, and the prevailing technic. In the case of the Eotechnic-Paleotechnic shift, the change from renewable to carboniferous fuels was seen as central to redefining the "laws" of social development. While development was limited to self-sufficiency in the Eotechnic period and was locally based, the Paleotechnic phase powered by fossilized energy abolished the ceiling on development, replacing sufficiency with surplus, local needs with international markets and more generally quality with quantity. In this scheme, energy prices, energy demand and energy sales are artifacts of the particular social order in which they are found. They connote neither natural nor rational social adjustments for equilibrium, but the epiphenomena of a power complex and its relation to the extant social order. The cheap and abundant energy that fueled development for much of the Paleotechnic period does not reflect, by Mumford's account, the relative availability of fossil energy over other "factors of production"; but an essential institutional requirement of a social order built on a logic of surplus.

Technology and technical thinking are similarly conceived by Mumford as constituting a social institution. The craft technic of the Eotechnic period suited the focus in self-sufficiency and local needs. The technical requirements of the Paleotechnic period were quite different. To promote surplus, technical means must be standardized, universalized and centralized. These tendencies were not the product of scale in organizational efficiencies, but instead were motivated by the search for process control and uniformity each of which was necessary for different mechanical systems to link. These tendencies were also dictated by the search for monopoly by economic agents who can best realize the "efficiency," that is profit potential, of alternative production methods by restricting competition and the Schumpeterian "creative destruction" it portends.

Paleotechnic economy was predicated upon similar tendencies toward centralization, standardization and universalization. With the promise of cheap and abundant fuel, industries formed to simultaneously maximize production and profit. Surplus quantity required the creation of surplus value which was achieved by establishing control over production by the owners of capital. They alone made the decisions as to the scale and quantity of output in the economy. Work was transformed into a competing means of production alongside the machine and money (which could make money directly by financial speculations). Such a system is hardly in equilibrium with human needs, nor is it socially stable. The "laws" of development require endless progress, "number piled upon number." This ideology of progress leads to a permanent boom-bust economy with individual fates determined by one's position in the economic hierarchy. Each phase of boom and bust at once streamlined and concentrated the hierarchy. Regions were assigned specialized roles as supply areas, production areas or market areas, while economic organizations engaged in capitalist combat to determine who controls the technology and the markets. These processes of regionalization, specialization and concentration, all within an environment of corporate competition, necessarily bring about highly uneven patterns of growth and change: economic winners and losers. The social good is thereby defined by those who survive.

The economic pattern of development in the energy, technic and economic sectors assured an integration of institutional aims and value tendencies, and accorded the social complex they represented exceptional political power. They became the new social artifice replacing the dynastic state, cooperative economy, and locally-scaled technology of Eotechnicism. Whereas the latter attempted self-sufficiency within the constraints imposed by nature, the new order proposed existence autonomous from nature. The environment represented for Paleotects a waste repository. Ample use of the repository was made. Environmental degradation became an important part of a strategy of efficient Paleotechnic development. In itself nature had no value, it was worthless. Society was alienated from nature by economic and technical design. No longer would life be understood as being with or in nature, but with or in the machine-produced "environment" of carboniferous capitalism.

The very nature of community was transformed by the passage from Eotechnicism to Paleotechnicism. Instead of a social settlement, community became a social means of economic production. Social life was organized around industrial needs and in fact found itself in direct competition for living space with those seeking business space. Space was marketed and traded as a commodity. The superior "bargaining power" of capital meant that its needs outweighed those of community. Patterns of mobility everywhere replaced tendencies toward settlement. In the wake of this competition between capital and community, cities literally fell apart. Where once they represented an integrating institution, bringing together the social essences of culture, art, play, economy, technic, nature, and mutual aid and association, they were now reduced to competitors in the new market of spatial organization and location. Agglomerative advantages determined their fate not their contribution to the enrichment of life. Cities lost their autonomy, meaning and value, and their demise records the replacement of life values with pecuniary values. The corporation and the machine became the new symbols of civilization.

2.4 Paleotechnicism and Postindustrialism

The study of the transformation of society from an Eotechnic to a Paleotechnic base underscores the institutional character of social order and change. The collision of these two social paradigms demonstrates the undetermined nature of social transformation. The confrontation of self-sufficiency and surplus, stability and progress, quality and quantity, craft and efficiency, aesthetics and rationality, cannot be reduced to the playing out of a natural, evolutionary process of deciding what is superior. The revisionist history of Paleotects may declare the present situation a victory for society, but its optimality depends upon a particular institutional way of seeing things: atmospheric sewage and externalities may describe the same phenomenon, but obviously do not agree on its meaning.

Moreover, it is clear that social transformation cannot be examined as a set of single isolated changes. The integrative nature of social institutions requires a study of the parts in the context of the whole. The Eotechnic individual *and* the Eotechnic society differ fundamentally from their Paleotechnic counterparts. Individually and collectively, humanity thinks, acts and values in incomparable ways under these two systems. It is necessary therefore, to study the individual, the organization and the institution with reference to the underlying paradigm of social order which gives meaning and value to all three. In this respect, a paradigmatic rather than a linear theory of social transformation is needed if we are to reach beyond the marginalisms of contemporary thinking and understand the holism of social existence.

If the general relations between individual and society are radically redefined in a social transformation such as that between Eotechnicism and Paleotechnicism, then social order and social change are at bottom, political phenomena. Existing social institutions are the consolidated, legitimate facts of the prevailing social order and their factuality hinges upon the maintenance of their authority. Social change in the form of resistance to such authority, to the facts as they are, is likewise political. It is shaped by the circumstances of the institutional system which it seeks to alter. Eotechnic politics was governed by a class and status hierarchy based on patriarchy and the dynastic state. By challenging the dynastic state and the land basis of class, Paleotechnic politics was able to change the facts. Patriarchy was extended, but the new dimension of capital as the basis for ownership and control of production permanently altered society. The combination of a new energy complex and a new technic eradicated the stability and protection of the Eotechnic order. Governance was shifted from the cities and their alliance with the state, to the energy-technic-economic complex and its alliance with a newly constituted technocratic state.

Mumford's analysis of Eotechnic and Paleotechnic societies provides a guide for the study of the modern order. By focusing on the institutional fabric and principles of integration of social institutions, it is possible to both locate postindustrial society in its historical context and to identify the distinctive structures and values which are embodied in it. Mumford's specific institutional choices--the power complex, economic organization, the dominant technic, and the prevailing forms of community--are likewise instructive for the task of an analysis of postindustrialism. The emergence of the energy-technic-economy complex in the twentieth century continues to anchor social order and change, while the urban system has become a battleground for sorting out the conflicts of postindustrialism. The study which follows seeks to build from Mumford's analysis of Paleotechnicism to identify the institutional attributes and social dilemmas of postindustrialism.

CHAPTER 3

POSTINDUSTRIAL INTEGRATION IN THE POWER COMPLEX

3.1 Introduction

From the beginning of the twentieth century until the 1960s, the power complex experienced a second transition, this time from coal as the primary energy fuel to petroleum and electricity. While even to this day, coal remains an important source of energy in most technological societies, its position in the power complex during this period was severely eroded. Yet, the transition from coal to petroleum and electricity seems to have been more a continuation of the tendencies already evident in the power complex rather than a disruption. Petroleum's relatively easy rise to energy dominance occurred because it was well suited to the economics-energy-technics alliance. In many respects petroleum performed better than coal in the very complex which coal had helped to create. While the early development of electricity under public control appeared to challenge economic and machine values, later tendencies toward increase in scale and universalization of technology actually strengthened the position of the alliance and served to infuse technocracy into the political system itself. Thus, the displacement of coal did little to challenge the surplus, quantification and rationality ideals of Paleotechnicism. The power of the alliance not only remained intact, but was expanded.

New elements reinforced and expanded the inherited Paleotechnic order: the integration and control of the entire energy system under a corporate structure; the installation of a system rationality in which the "value and performance" of energy alternatives was based on their "fit" with the existing power complex; the sublimation of the political within the scientific/technocratic; and the appearance of a synergistic relationship between the military, the state and the power complex. These four developments have culminated in what Byrne and Rich have characterized as the "search for the abundant energy machine" whereby the power complex "is dominated by economic and political institutions which are militaristic, highly centralized, technocratic, and dedicated to the preservation of a culture of energy abundance" (1986:156).

3.2 The Petroleum Consortium and State Cooperation

The coal-based power complex had introduced regionalization and privatization as important developmental characteristics of Paleotechnic energy. Petroleum grew from the same roots. Originally oil exploration was carried out by an unorganized group of small-sized speculators, but this fuel's relative ease of transport and higher BTU content eventually attracted large capital interests, in particular the railroads. By the turn of the twentieth century coal had become fragmented as an industry, and two distinct regional supply systems had appeared: the anthracite and other hard coals which had to be deep mined at increasing costs and were found mostly east of the Mississippi; and the softer bituminous coals found throughout the United States which allowed less expensive techniques of strip mining but which "had one serious drawback--highly toxic smoke" (Melosi 1985:31). Periodic coal supply disruptions caused by labor-management battles for control, the spiralling cost of anthracite, and the success of smoke abatement leagues in major cities to establish strict antismoke laws led to a weakening in coal demand. To replace the coal business the railroads looked to oil as a new freight commodity. While oil moved by rail as early as the 1860s, it was not until the end of the nineteenth century that oil movement (particularly over long distances) became a major market for the railroads. Rebates ranging from 11 percent to 47 percent (Melosi, 1985:41) were part of the promotional effort by the railroads to maintain this market.

The early investment of the railroads in oil development was soon replaced by that of the Standard Oil Trust organized and run by John D. Rockefeller, Sr. Standard Oil had sought to form a cartel in 1871 consisting of several eastern railroads and the company's oil well operations in order to gain control of the refinery business. While the charter for this cartel (South Improvement Co.) was revoked after only three months, it forecast the business strategy that Rockefeller would pursue to dominate the oil industry. The decade of the 1870s had begun with Standard controlling 10 percent of the refining market; by the close of the decade it had captured 95 precent of that market. Standard Oil was able to establish vertical integration through its refinery operations and rail and pipeline linkages to such an extent that it "became a self-contained corporation with control of oil from wellhead to market" (Melosi 1985:42). Its "trust" business structure became a model for the development of other industries including sugar, steel, tobacco and whiskey

(Melosi, 1985:42). Numerous attempts to halt and even dismantle this corporate giant met with little success. When the Ohio courts threatened the "trust," the company was reincorporated in New Jersey. When oil strikes in Ohio, Indiana, Illinois, Kentucky, Virginia, but especially Texas, Oklahoma and California, threatened to bring new competitors to Standard Oil, the company was successful in obtaining substantial and often controlling interests in the oil operations in these states. Finally, with the appearance of Texaco, Gulf and Shell Oil companies, a competition of sorts was established in the industry. However the model in all cases followed Standard Oil's strategy of vertical integration and regional monopoly. By the outbreak of World War I, the petroleum industry manifested several of the new characteristics of the energy-economics-technics alliance--bigness, integration and system rationality.

The oil market experienced growth throughout the early twentieth century as new applications in lubrication, illumination and some industrial processes developed. But its greatest potential was as a transport fuel where it had three distinct advantages over coal: it was easier to store and transport as a vehicular fuel; it was easier to handle and deliver; and it burned more efficiently. For this reason the United States navy adopted oil in 1912 as a major transport fuel. The demand from the military expanded quickly into aircraft and tanks. And with its growing demand for rubber tires, the military also represented a major consumer of petroleum-derived products. Not surprisingly therefore, when the United States entered World War I, a Petroleum Advisory Committee was formed to "insure the delivery of oil and recommend allocation of supplies" (Melosi 1985:98). This committee (later renamed the National Petroleum War Services Committee or NPWSC) was composed entirely of oil industry members. Under their leadership, the supply of oil to the military was expanded and stabilized. This committee also provided the oil companies with a means to fix national prices during wartime. The national government not only endorsed the NPWSC's supply and price stabilization policy proposals but actually encouraged greater industry integration in recognition of this fuel's strategic importance to mechanized war making. As Melosi notes (Melosi, 1985:97-98):

> World War I was the first major conflict in which belligerents were heavily dependent on motorized transportation on the sea, on land, and in the air. Before the war, the major naval powers adapted their vessels to use fuel oil rather than coal. Submarines employed diesel engines. Gasoline-powered land vehicles moved personnel and equipment. Tanks and aircraft were fitted with internal-combustion engines.

> Efforts by both the allies and Central Powers to control oil supplies became standard war strategy.

Thus by 1920, a fourth element of the contemporary power complex had begun to emerge--the close linkage between energy and military systems development.

The dismantling of the war agencies in the postwar reconversion had several implications for the petroleum industry. First, without the NPWSC the industry's position in directing oil policy would be severely undermined. In response, the NPWSC was converted into the American Petroleum Institute (API) in 1919. The API retained essentially the same membership and became the mechanism by which the oil industry could cooperate and "speak with one voice in Washington and in the countryside,...resist government interference...[and] hostility to antitrust action" (Engler 1961:271). From the national government's perspective, continued integration and consolidation within the industry was seen as necessary for the postwar stabilization effort. Donald R. Richberg, General Counsel for President Franklin Delano Roosevelt's National Recovery Administration expressed this public sentiment when he stated, "[o]ur legislative, administrative and judicial efforts to enforce the principles of the antitrust laws have been a deceitful failure and a continuing public injury for 45 years" (quoted in Engler, 1961:272). Thus, while the military/power complex connection was more tenuous during postwar years, a policy structure which located the public interest in highly centralized and vertically integrated oil corporations remained. Rockefeller's early proclamations about the virtues of his corporate strategy which had attracted criticism before the war, had achieved a certain legitimacy (quoted in Melosi, 1985:40):

> It is a common thing to hear people say that this company has crushed out its competitors. Only the uninformed could make such an assertion. It has and always has had, and always will have, hundreds of active competitors; it has lived only because it has managed its affairs well and economically and with great vigour.

Rockefeller's strategies of "good management," "rationalization of production," and "efficiency" became a model for all industrial organization. Particularly important for Standard Oil and other petroleum companies were the similar strategies employed by Henry Ford and the automobile industry. Henry Ford's technique of mass production and Alfred Sloan's pursuit of mass marketing approaches to develop the General Motors empire accomplished for the automobile industry what Rockefeller had been able to do for the petroleum industry. Approximately 4,200 automobiles were produced by Ford in 1900, by 1921 this figure reached one million and in 1929 a total of 5.6 million automobiles were being produced in the United States. Gasoline consumption likewise rose from 3 billion gallons annually in 1919 to 15 billion gallons in 1929, an increase of 400 percent in ten years. The symbiotic relationship between automobile sales and gasoline consumption was a fact recognized by both industries. In a system predicated upon integration and control, the cooperation of these two industrial giants became both rational and profitable. Several expressions of this cooperative interest were pursued during the 1920-1941 period.

In 1925, General Motors (GM) entered into the production of motorbuses. Seeking a market for its product in an urban mass transportation system dominated by electric streetcars and railways, GM assisted in forming a number of subsidiary transportation companies. As GM General Counsel Henry Hogan observed, "the only way this new market for buses could be created was for it to finance the conversion from streetcars to buses" (quoted in Morris 1982:20). Thus, Greyhound Corporation and United Cities Motor Transit were formed in 1932, as were Omnibus Corporation and National City Lines, Inc. (along with Standard Oil of California and Firestone Tire) in 1936--all with the express intent of replacing electric streetcars and rail transit with the petroleum-fueled motorbus. These holding companies acquired electric streetcar companies, converted the local transportation system to motorbuses and then resold them to local buyers (public and private). This scheme insured a market for both industries in the near term, but GM, Standard Oil and Firestone were forward looking as well. Included in the resale contracts was a clause which "prohibited the purchase of any new equipment using any fuel or means of propulsion other than gas" (Morris 1982:22).

Converting the transportation system required more than substituting the motorbus for electric streetcars in the mass transit system. If the gas-powered vehicles were to emerge as the dominant transportation alternative, an infrastructure for the car and bus was also necessary. Highways and roads needed to be built and maintained, a substantially large investment which the automobile-petroleum-rubber consortium was unwilling to provide on their own. The consortium turned to the public sector. Their first effort was to encourage the national government to invest in a federal assistance program. The Federal Road Aid Act of 1916 served this purpose by committing federal funds to state and local road construction and, at the same time, committing the country to a national highway system (Melosi, 1985:109). Twenty-five years later a more ambitious program was launched. In 1932 the National Highway Users Conference was organized with membership from the Motor Vehicles Association, the American Petroleum Institute, the American Trucking Association, the Rubber Manufacturers Association, and the American Automobile Association. This powerful umbrella association controlled 2,800 lobbying groups and was instrumental in convincing 41 state legislatures to establish a tax on gasoline consumption and then to allocate local tax revenues exclusively to highway construction (Morris, 1982:23). In this manner, the Conference was able to satisfy the mutual needs of its members for increased demand of their various products. The joint demand for cars, rubber and gasoline was effectively advanced through the establishment of a highway and road transportation system bought and maintained by consumers.

A series of steps were taken by consortium members to cooperate in the regulation of competitive pressures within and between the industries. In 1922 several oil majors formed a cooperative pool termed "the patent club" to limit competition for superior refining techniques and better performing gasolines which, until then, had brought on a spate of litigations, lawsuits, and had pitted one oil company against another. The patent club provided the means for intra-industry cooperative research and development, standardization of fuel quality and refining procedures, and the adoption of common strategies with regard to business-government relations (Giebelhaus, 1982: 99-103). An inter-industry version of efforts to regulate competition was applied in the late 1920s and early 1930s to resolve the competition over "knockless" gasolines. Standard Oil (New Jersey) and General Motors had together patented an anti-knock fluid which could be added to gasoline to improve octane and eliminate engine knocking. A two-tier price structure was created to market gasoline with the anti-knock additive as a "premium" fuel and untreated gasoline as "regular" fuel. Through the Ethyl Corporation, Standard Oil and General Motors sought to capitalize on their patent by selling the anti-knock additive to other oil companies. A problem occurred, however, when the Sun Oil Company discovered a refining procedure which could achieve a "high-powered knockless fuel at no extra price," and at a below industry standard octane level. Termed "Blue Sunoco," this fuel could be sold at a lower price than premium conventional gasolines thereby undercutting into Ethyl's market position. Such competition could unsettle markets, and corporate profits. A more "rational" and "orderly" market was restored when General Motors agreed at the request of Standard Oil, to build engines with at least a 78-octane requirement (Giebelhaus, 1982:103).

Despite these industry efforts to regulate competition, an oversupply of oil occurred during the Depression years. Public sector assistance was once again required. In order to bolster their failing oil industries, the states of Texas and Oklahoma sought to ration production by establishing an overall cap on well-head output and then allocating specific ceilings to individual wells. This effort to control production and thereby raise oil prices was generally welcomed by the oil majors. However, independent producers who stood to lose the most because of their small production levels and holdings, rebelled. Governors of both states sent National Guard troops into the oil fields to enforce the rationing system. The national government assisted in their enforcement of the stabilization policies of the states by prohibiting interstate shipment of "hot oil"--oil produced above the state-set ceilings (Melosi, 1985:152-158). The Buy American Act, passed by the U.S. Congress appeased the independents to some degree by requiring the national government to give first priority to the purchase of domestically produced raw materials, including oil. It also assured profits since state ceilings lowered supplies while the Act raised demand.

3.3 Global Integration and the Private Government of Oil

The advent of World War II brought new challenges and opportunities for the petroleum complex. Led by Standard Oil (New Jersey), American firms sought to supply all sides including the Axis powers. As late as October 1941, Jersey Standard was supplying oil to Germany and Italy via its Brazilian and Argentinian subsidiaries. The company cited "financial loss and possible suits" in support of its activities (Engler, 1961:103). It was later discovered in documents of the I.G. Farbenindustrie, Germany's chemical giant, that Standard Oil had not only provided petroleum but also secret experimental knowledge on the production of lead-tetraethyl (a high-octane gas), and had formed two joint companies with I.G. Farben to share patents and research on petrochemical processes (Engler, 1961:100-104). While refusing to share information on synthetic rubber research with American firms, Standard Oil actively sought I.G. Farben as a partner in this area. When the Goodyear, Goodrich, Du Pont and Dow Chemical companies decided to move ahead in the early 1940s with their own synthetic rubber programs, Standard Oil sued to block such U.S. based research on the basis of infringement of patents held with I.G. Farben (Engler, 1961:107-109). When asked to explain the company's "full marriage" with I.G. Farben during a time of war before U.S. Senate hearings in 1942, the president of the subsidiary Standard Oil Development Company stated: "Technology has to carry on--war or no war." A U.S. assistant attorney general translated the company president's assessment (quoted in Engler, 1961:107-108).

> What these people were trying to do was to look at the war as a transitory phenomena and at business as a kind of permanent thing: The war is bound to be over in a couple of years and let's not have it interfere anymore than necessary with the commercial relationships which in the long run are bound to exist.

While Standard Oil was reluctant to "take sides" in the war, the U.S. military obviously had to. The navy, and mechanized units of the army, including its aircraft, as well as support services had become heavily dependent upon fuel oil. As Melosi points out, "military demands for oil had grown astonishingly since World War I" (1985:181). Once more, the national government mobilized to protect the domestic oil system and to control the production, distribution and pricing of this resource. The

Petroleum Administration for War was formed to re-establish direct linkages between the military and corporate oil organizations. The national government partially financed the construction and interconnection of domestic oil pipelines through the "Big Inch" and "Little Big Inch" projects.

The military importance of oil extended beyond its "strategic resource" status of World War I. Literally, war could not be conducted without ample petroleum supplies. In the span of 35 years, the relative power of the military-oil relationship had been nearly reversed: whereas Corporate oil needed the military market in the early part of the century to flourish; by mid-century, the military needed oil to function at all. This reversal is perhaps best illustrated in the military-government response to the rubber shortage during World War II. With the Japanese occupation of the Dutch East Indies and Malaya, the United States was deprived of sources for 90 percent of its crude rubber. In 1942, a national effort to establish synthetic rubber production was begun. The first step in this effort was to force Jersey Standard to release its joint patents with I.G. Farben so that government plant production could get underway (Melosi, 1985:185). An important decision remained, however:

whether to produce the synthetic rubber by a petroleum or alcohol-based process. On the surface the choice seemed an easy one. Since oil was now a scarce material and needed as a direct fuel for many military operations, using it for synthetic rubber manufacture would be foolish when a grain surplus existed (due to the U.S. farm price support program) from which more than sufficient supplies of alcohol could be derived. However, Corporate oil seeking to maintain its link to the rubber industry, resisted this conclusion and successfully lobbied the national government to finance a $650 million petroleum-based synthetics program (to be operated, not surprisingly by the petroleum, rubber and chemical giants); only approximately $50 million was devoted to alcohol-derived synthetics production (Engler, 1961:110-111). But production levels from the two processes were mirror opposites of the government subsidy distribution. Melosi observes that "[i]n 1944, about 362,000 of the 558,000 tons of [synthetic rubber] was made from alcohol" (1985:187). In sum, Corporate oil and its allies had been able to dictate government support for a commercially untested production process of a strategic military material (synthetic rubber). For their "assistance" in solving this military need, the petroleum, rubber and chemical companies were paid $127 million in "management fees above all costs which were the equivalent of profits" (Engler, 1961:110). The ascendance of Corporate oil during World War II had direct implications for postwar national policy. Hereafter, Corporate oil development policy would intermingle with American foreign policy, making the two at times indistinguishable.

The U.S. petroleum industry developed foreign production operations as early as 1888 when Standard Oil established its first foreign affiliate in Latin America, the Anglo-American Oil Company. From the perspective of the petroleum companies, foreign exploration meant greater profits. It provided the corporations freedom from troublesome domestic economic policies such as antitrust legislation and substantially higher profit margins because of the willingness of foreign governments to grant favorable concessions. By 1907 Jersey Standard "was a giant multinational business with fifty-five foreign enterprises, and, by 1911, it had sixty-seven affiliates in foreign trade" (Melosi, 1985:161). Before 1911, U.S. controlled foreign oil operations had facilities in Canada, Latin America, Asia and Africa.

While the U.S. government did little to actively support these "corporate diplomats" in the early years, it also did little to discourage their activities. Such a policy was interpreted by the oil industry as tacit approval of their foreign investment. Moreover as the strategic military importance of petroleum was realized, direct government support for foreign exploration was forthcoming. An early example of a proactive national policy posture occurred when the U.S. State Department represented American oil company interests and negotiated for their entrance into the British and French controlled Middle East in 1922. Advocating an "Open Door Policy" to commercial matters, the U.S. government lobbied to gain an American presence in Middle Eastern oil production and thereby establish a basis for U.S. influence over the disposition of one of the largest supplies of this strategic resource in the world.

Each partner in the government-petroleum alliance had its own ideas of what constituted the national interest. The petroleum companies saw the European stronghold in the Middle East as posing a challenge to their own design for market hegemony; in this regard national security to the oil companies meant control over markets. The U.S. government on the other hand, feared that lack of access to this oil rich area placed the nation's defense in a state of vulnerability. Thus, the mutuality of interest that guided the Middle East effort masked underlying conflicts (such as the rubber research programs later exposed). Tensions in the alliance intensified as oil corporations not only became powerful domestic institutions, but international ones as well. An interesting result of this tension was that the partnership between the oil industry and U.S. economic and foreign policy succeeded in installing U.S. oil companies as major producers of foreign oil, and thereby promoted the nation's dependence on imported oil. One era's national security would later become another era's insecurity.

The low cost/high profit character of foreign operations provided the major petroleum corporations with new economic opportunities. However, in order to exploit the profit potential of foreign oil, two things needed to occur. First, an increase in demand for their product was necessary. Second, domestic production had to be slowed, over the objection of independent domestic producers who competed in the same market. The petroleum giants were able to achieve both requirements shortly after World War II.

To increase demand for oil, the industry returned to a strategy, along with its natural allies (the automobile companies and the rubber producers), to persuade the national government to make a new and substantially greater commitment to highway construction. Two World Wars had already convinced the government that oil was a strategic and vital military resource. The oil-automobile rubber consortium now set out to convince the government that the highway system was also a significant factor in national security. An extensive interconnected national interstate highway system was rationalized through the National Highway Defense Act of 1956 as an investment in the nation's security because it facilitated movement of military forces and equipment. To pay the huge costs for such a system, the consortium, as it had in 1916 and 1932, sought a consumption tax earmarked almost entirely for highway construction. In this case however, the funds from consumers in different areas of the country would be pooled into one common source--the National Highway Trust Fund. These two federal policies were enormously successful in providing the conditions for increased oil demand while shifting the burden for highway investments to consumers. Between 1945 and 1970, the federal government spent $70 billion for highways, and states and localities spent an additional $156 billion while rail transit received approximately one percent of that amount (Morris, 1982:23; Judd, 1984:293).

The automobile-rubber-petroleum consortium succeeded in their effort to convert the entire U.S. transportation system to one dependent upon petroleum--and to one under the control of a vertically integrated, centralized corporate complex.

To diffuse the competitive challenge posed by independent oil producers, and thereby provide Corporate oil with control over domestic supply levels, a national security argument was once again employed. The large companies resisted efforts to set national quotas on the amount of oil imported by the country. When the Eisenhower administration signed the Reciprocal Trade Agreement Extension of 1955 enabling the President to reduce oil imports to 10 percent of domestic demand in the interest of national security, the oil majors countered that domestic oil production during peacetime should not exceed levels which might threaten this supply option in periods of military conflict, i.e., a reverse national security argument. At the same time, they defended states' rights to cap domestic well production (a leftover from the Depression era) on the grounds that such restrictions improved domestic production efficiency (Engler, 1961:24):

> The avowed purpose was to give the state[s] the necessary power to protect the oil fields from rapacious drilling and production that would dissipate the underground gas pressures essen-

> tial for driving out the petroleum and thus lose much of the oil.

In other words, domestic restrictions were to be seen as in the interest of reducing waste and improving engineering performance; but international restrictions were to be opposed because they adversely affected market efficiency.

While the argument was convoluted, it was nevertheless successful in establishing at least part of the conditions necessary to slow the rate of domestic supply relative to foreign supply into the American oil market. The other key element was Corporate oil's successful use of the oil depletion allowance and a provision of a 1918 U.S. tax law which was designed to avoid double taxation on foreign investments. Through the former, oil companies were allowed to shelter 27.5 percent of their income from American taxes as an incentive for investing in supposedly risky oil exploration (the purported logic was that some part of the revenues earned from a paying well should be sheltered from taxes as compensation for the costs associated with the many dry wells that would be drilled before finding oil). The depletion allowance was ruled to apply to domestic *and* foreign oil. Because foreign oil could be obtained at lower costs (and therefore earned higher income) than it could from domestic operations, the depletion allowance was especially beneficial to the former. The magnitude of the benefit could be staggering. The experience of the American oil consortium operating in Saudia Arabia--the Arabian-American Oil Company (ARAMCO)--illustrates (Engler, 1961:225):

> ARAMCO received $148 million in 1955 and $152 million in 1956 from the depletion allowance. This loophole deprived the United States treasury of $124 million for the two years...it wiped out all [ARAMCO] income-tax obligations to the American government.

This allowance also encouraged Corporate oil to minimize exploration activities and instead promote drilling ventures by independents. When the independents were successful in finding oil, the oil majors then moved in and bought up the wells obtaining in the process the depletion allowance rights. Thus, the depletion allowance worked to the disproportionate advantage of corporate over independent producers and foreign over domestic production.

But the tax benefits to foreign oil did not end there. American Corporate oil feared that its lucrative foreign field operations would become the target for nationalist sentiments to demand indigenous ownership. The nationalization of oil operations in 1938 by Mexico indicated that this fear was not altogether without basis. To head off future take-overs American oil developed the

"50-50" plan" which was first applied to Venezuela and then used throughout Latin America. Under this plan, the oil majors agreed to split their profits 50-50 with the Latin governments in return for their tacit agreement not to nationalize American holdings. Because of a provision in the 1918 tax law which allows American companies to deduct foreign taxes, dollar for dollar, from their domestic tax bill, Corporate oil's "generosity" was actually paid for by American tax payers who lost tax revenues on a grand scale as a result of these agreements. This procedure was so lucrative that ARAMCO quickly moved to apply the 50-50 plan to its concession in Saudi Arabia, with the result that between 1950 and 1951 ARAMCO's tax payment to the United States fell from $50 million to $6 million. The arrangement was dubbed "the golden gimmick" (Melosi, 1985:244-245).

Considered together, these various strategies--the support of states' rights to cap oil production, the resistance of national import quotas, the utilization of the depletion allowance to favor foreign production operations, and the design and implementation of the golden gimmick--brought about a rapid and substantial increase in American consumption of foreign oil. Between 1945 and 1970, the percentage of domestic consumption supplied mostly by American companies from foreign oil sources rose from 4.2 to 24 percent (American Petroleum Institute, 1959:213; Stobaugh, 1983:19). In creating an American dependence on foreign oil, Standard Oil and its companions also achieved a globalization of the oil production-consumption system. While American governments would later worry about the country's dependency on "foreign oil" such a characterization of the dependence in many ways is a misnomer. After all, both ends of the pipeline were and are owned and operated by American corporate capital.

The organization of a world petroleum-based energy system can hardly be attributed to free market forces. Nor can it be traced to American business genius. After World War II, the American government was repeatedly called upon to resolve conflicts in this world system in ways that would preserve the status and authority of corporate oil. When the Premier of Iran was assassinated in a populist rebellion in 1951 and the Shah was forced to flee into exile, the American government in league with Great Britain, sanctioned a boycott of Iranian oil. The boycott was a warning to the new Premier, Dr. Mohammed Mossadegh, against nationalization of British oil holdings. But even more important, the American-British alliance intended to use Iran as an object lesson against nationalist efforts to interrupt "the private government of oil" (Engler, 1961:34). When the new premier showed signs of failing to learn this lesson, and other countries in the region began to express support for Iran's move to put Iranian oil fields in Iranian hands, the Central Intelligence Agency was directed to engineer his overthrow. It did so in August 1953, whereupon a new entity, the National Iranian Oil Company was established to manage the oil fields; British Petroleum was given a 40 percent interest, five American companies were also given a 40 percent interest, the Dutch-Shell company was allocated 14 percent, and a French firm was allocated the remaining six percent. And a 50-50 plan was drawn up in which profits would be shared equally between the companies and the Iranian government (Engler, 1961:202-209; 1977:242-243; Melosi, 1985:246-248).

The 1956 Suez Crisis is another illustration of demands upon American foreign policy by Corporate oil. When Egypt nationalized the Suez Canal company in that year in order to establish control over its own national borders, fears arose within the private government of oil that its own authority might eventually be threatened. Two-thirds of daily tonnage passing through the canal was oil, most of which was destined to serve Europe's needs.

In the fall of 1966, Israel attacked the Sinai peninsula and with British and French forces entered the canal zone. Egypt retaliated by sinking ships in the canal thereby halting nearly all water-borne traffic, including tankers carrying 1.5 million barrels of oil daily. The American government set up the Middle East Emergency Committee composed of governmental officials and representatives of the major oil companies to work with European governments in reorienting world oil shipments, defining new pipeline schedules, and seeking increased production at other points in the world petroleum network. As noted earlier, a 1955 law had given the American president the authority to limit oil imports to ten percent of total demand. Yet throughout the crisis and despite European oil shortages this authority was never invoked. Indeed, an assistant secretary in the Department of Interior argued that employing such authority would be against "the customary United States policy of interfering as little as possible with the operations of our commercial enterprises" (quoted in Engler, 1961:240). Nor was the level of domestic American production increased substantially during the period. The Middle East Emergency Committee concluded that doing so would harm the competitive advantage of American oil importing companies and would damage the stability of the market. Furthermore, no effort was made to restrict price increases even after first quarter profits in 1957 of the large oil companies increased by 18 percent. Instead the major actions taken by the American government were to relax antitrust restrictions on the oil companies during the crisis period so that they could collaborate on production, planning and pricing, and *simultaneously* to publicly defend the right of these companies to operate without interference in the free market. When shipping began to flow through the Suez canal once again in 1967, a crisis had been weathered by the world oil system with no noticeable change in its structure, thanks to the actions of the U.S. and European governments. In the process, the meaning of national security had been clarified: American society depended upon a private government of international oil, and the rights and authorities of that private government were to be defended when and however necessary (Engler, 1961:235, 246; Melosi, 1985:250-251).

3.4 Electricity and the Utility Monopoly

Electricity, the other distinctively twentieth-century fuel, exhibits a parallel pattern of development to that of petroleum. Large scale production systems, expansive spatial markets, and extensive public sector cooperation are shared features of the two fuel system. Most important though, oil and electricity have in common the dominance of prior organizational, financial, and political considerations in shaping, directing and even, in some instances, dictating technical development. In the case of electricity, technical problems, in particular the significant losses associated with the use of direct current (DC) in early power production, needed to be resolved. Very soon the alternating current (AC) developed as a competitor to the DC system. The AC-DC engineering battles that ensued certainly played a role in slowing the movement to a national power system. But even this debate was not exclusively technical in nature. Primary on Thomas Edison's mind was to develop strategies that would protect markets for his DC system. One such attempt to forestall the use of AC powered systems was the staging of "grizzly experiments for the press in the West Orange Lab, notably electrocuting stray cats and dogs with high tension currents" (Melosi, 1985:61). This and other "engineering" debates about the safety of alternating current underscore the supra-technical nature of system choice. As Thomas P. Hughes argued, the strength of the "Edison method" of research and invention was its emphasis on "ordered desiderata--[by] ordering priorities, Edison defined the problem and insisted, as many other inventors, engineers, and scientists have, that to define the problem is to take the major step toward its solution" (1979:18). In the case of lighting, Edison defined the goal as "an incandescent light economically competitive with gas" (Hughes, 1979:18), which is surely not a technical problem only.

In addition, as Melosi points out, there were identifiable strengths and weaknesses in both systems (AC and DC); and therefore technical criteria alone could not determine the superior one. While both presupposed a fully integrated and planned system of electrical generation, each would yield a different integration, would adhere to a different plan, and ultimately would result in a different system. Under the Edison DC system, for example, "[a] city like New York would require hundreds of separate power companies to serve it. Edison assumed this would be the case, and he intended to profit from it" (Novick, 1975:11). In contrast, an AC system such as that first tested by Westinghouse in Pittsburgh in 1886 would have greater efficiency in electrical transmission, permit longer lines and require fewer stations. Where transmission distances were short however, the advantages of AC were not compelling, especially with Edison's successful adaptation of his DC system to the production and distribution networks employed by gas companies in large densely populated cities (Melosi, 1985:60-61).

The determining factors in the development of the U.S. electricity system were political, organizational and financial, not technical. Indeed, technical options and opportunities were conceived within a particular political-organizational-financial framework. It is the conjunction of these various pieces that gave meaning and possibilities to what Messing, et al. have termed Centralized Power. As Hughes' 1983 cross-national study *Networks of Power* convincingly demonstrates, centralized power proceeded in Europe as well as the United States only when and insofar as the technical was melded with distinct social forms, specifically: a system of state monopoly; a science and engineering based corporate organization capable of integrating power production and delivery; and the holding company as financier.

The American electricity market grew out of the sale of generation equipment, originally to large office buildings and retail stores. This on-site power-generation approach was popular until the late 1880s.

Initial efforts to market power rather than power equipment were uncompetitive. Thus, the most celebrated early (but not the first) venture launched by Thomas Edison in 1882 at the Pearl Street Central Power Station (located in New York's financial district explicitly to attract business attention) was commercially marginal. Its market was limited largely to lighting and to those who could afford its high price. But, "[v]ery few found any reason to buy power from the power companies: In the late 1880s, electricity for lighting cost 20 or 25 cents per kilowatt-hour...far more than gas lighting" (Novick, 1975:12). Even after the first electric streetcars were installed in 1885, these companies were reluctant to purchase power from Edison's central stations, preferring instead to buy their own power plants. Moreover, technical development in the electricity field was greatly affected by the financial requirement of significant capital needed to underwrite research and the purchase of related equipment. Additionally, there was strong financial interest in controlling patents and royalties to be derived from them. For these reasons, as well as the high cost of purchased power, the first phase of commercial growth occurred in the manufacture of electrical equipment.

Edison sought to overcome the financial problem by structuring his electrical power and equipment companies so that some portion of the royalties from the latter were funneled to the former. This strategy enabled Edison and his financial backers to diffuse his inventions and simultaneously to secure a lead position in the electric utility business. Westinghouse pursued a similar strategy using profits from his Air Brake Company and gas businesses to finance research and development of electric power. However, his system was based on alternating current. This set in motion the competition between AC and DC power systems and the parallel competition in electrical equipment to produce and consume power from these systems. In one direction this competition was spatial in form with AC systems capturing markets in the urban periphery while DC systems dominated the urban core. Coincidentally, the competition was over patent rights and royalties from equipment developed to service AC versus DC systems. And a financial dimension to this competition continued because under either system high levels of capital were required for expansion. The multi-dimensional character of the competition meant that participants in the electric industry found themselves in a risky and often unstable financial and economic environment (Electric Power Research Institute, 1979:44).

The formation of the General Electric Company (GE) in 1892 was one step in addressing the problem of expansion under multiple competitive pressures. GE was formed from the Thomson-Houston company which had bought up many of Edison's businesses and represented an early organizational effort to combine AC and DC systems. The General Electric Company constituted the first large-scale integration of power systems on the one hand, and power and equipment enterprises on the other. By this organizational device, it was possible to regulate spatial and patent competitions within the company's service territory. As with Corporate oil, organizational scale offered an effective and profitable solution to problems of risk, instability and competition which otherwise would have stymied expansion. Few utilities could afford to purchase central power station facilities on their own even when demand for electricity in their area was expanding. GE responded to this constraint by accepting utility stock in lieu of cash payments for the sale of central station equipment. In this way, General Electric benefitted from expanded sales of its electrical equipment, the utilities were able to expand their operations and both were rewarded by the increased value of utility stock as the power market grew. As one of the industry-authored histories points out, "it was to the advantage (indeed, it was part of the strategy) of the electrical manufacturers to see the [utility] companies established and prospering" (Electric Power Research Institute, 1979:44).

Financial constraints still loomed over the electricity business, however. The capital-intensive nature of the power and equipment enterprises left the electricity industry, including those members of the scale of GE, vulnerable in times of tight finances. Indeed, their vulnerability was displayed in the financial crises of 1893 (Lauck, 1907:106-107):

> With the...resultant stringency in the money market during the spring and summer of 1893, the difficulty of conducting business was intensified, and only the strongest corporations and mercantile houses were able to continue operations. As it was, many of these were forced to suspend, and the smaller establishments which had already been weakened by the depressed conditions prevailing during the previous year were forced to close their doors.

Resolving the financial problem required an increase in the amount of capital *regularly* available to utilities and a reduction in its cost. The model for overcoming the financial constraint was provided in 1905 with the creation of the Electric Bond & Share Company (EB&S) as a subsidiary of the General Electric Company. Electric Bond & Share assumed the utility bond and stock holdings of GE and utilized these holdings to leverage additional capital through the sale of EB&S bonds and shares in the financial markets (Hughes, 1979:157):

> The essential financial structure evolved by Electric Bond & Share for the operating utility companies...called for 60 percent capitalization by the sale of bonds to the public, 20-25 percent by preferred stock sold to the public, and the remaining 20-25 percent in common stock to be taken by the holding company.

As part of the EB&S package, affiliated utilities accepted "service contracts" with the Company for which engineering and management expertise was provided. In this way EB&S achieved functional control of utility operations without the need (or expense) of acquiring a majority interest through the purchase of voting stock. The financial scheme and the service contract together heralded the arrival of the holding company and the inter-locking directorate, essential social inventions for the development of an integrated power planning and production system. In effect, a single utility had been created from many with its headquarters in New York (Hughes, 1979:156):

> Bond & Share recommended that the directors of the client company elect a Bond & Share executive as a nonsalaried officer. This officer--like Bond & Share executives serving other companies in a similar capacity--remained in its New York offices to facilitate coordination, communication, and the transaction of business. From its large staff of men experienced in managing and advising utilities, Bond & Share also designated one to act as "sponsor" manager of the client. The sponsor kept informed of the

> company by visits, observation, inspection, and correspondence. He applied Bond & Share's general knowledge of the utility company. Further, he had at his disposal the large Bond & Share staff of specialists in insurance, taxes, rates, public relations, statistics, and other management functions. The contract also called for a "sponsor engineer." A senior engineer drawing upon his own and Bond & Share's long and generalized experience, he advised the client utility about engineering practices. By visits and correspondence, he too kept informed about the client. Besides the management and engineering specialists, there was a "sponsor acccuntant" from the New York office.

The GE-EB&S model continued the dependence of the electric industry on a parent-subsidiary relationship for its growth, with the electric equipment manufacturers as the parent and the power company as the subsidiary. Thus, for two decades (1905-1924) over 90 percent of the generators sold to utilities in the EB&S system were manufactured by General Electric (Walton and Cleveland, 1964:24). One of the major reasons that the parent-subsidiary relationship remained into the 1920s was political--the municipal franchise system.

The franchising of electric utilities imitated the municipal model for water and gas service. The purpose of the franchise system was to ensure that owners would furnish customers service "at a fair price and make adequate investments to serve public as well as private needs" (Jacobson, 1989:16). This system clearly did not develop in response to scale economies of production or distribution. The results of municipal franchises were more nearly the opposite: the encouragement of numerous producers and distributors. In 1892 for example, there were over 30 utilities serving Chicago, "despite the fact that only five thousand persons out of a population of one million used electric lights" (Anderson, 1981:34). The political logic underlying the municipal franchise system--to expand the availability of service in a manner profitable to city government--has often been maligned for the corruption it bred. But it can hardly be blamed as the obstacle to technological advance of the industry. In fact, the technical constraints of the Edison system favored a municipal franchise approach. What this system retarded was the expansion of the economic organization rather than the technical system. Specifically the municipal franchise system kept the utilities small in economic terms, thereby exacerbating the financial problem of securing large flows of capital. The municipal system had a two-fold impact on utility finances. Through the fixed-term of the franchise (typically twenty years), the system presented a serious obstacle to the sale of long term bonds once the utility had passed the halfway point in its franchise tenure. The second problem for utilities was that the system openly courted competition and thereby limited the revenue pool available to individual companies. Since it was on the strength of their revenues that utilities could attract capital, franchise competition was widely regarded by utility owners as a threat to the long-term profits of the industry.

Relief from the competitive pressures of municipal franchises were sought by private utility owners in the form of monopoly grants and state regulation. As Douglas Anderson has pointed out, it is a common misperception that state regulation was adopted over the objections of the utilities. In fact, the reverse was true--"the utilities sought to preserve their autonomy...not by opposing state regulation, but by seeking it" (Anderson, 1981:33). For a brief period, from 1890 to 1902, there were scattered efforts by private utilities to create monopolies without the assistance of the state. One of the most celebrated efforts in this direction was mounted by Samuel Insull, who in 1892 undertook a strategy of buying out competitors in the Chicago service area and then retiring their power production operations. In addition, he obtained the exclusive rights for the Chicago area to buy electrical equipment from every American manufacturer (Anderson, 1981:34). This direct approach to the establishment of monopoly proved to be a fragile and ultimately ineffective one. The city of Chicago could break his control merely by franchising a new company, which a group of city councilmen known as the Gray Wolves promptly sought to do in 1897. They formed the Commonwealth Electric Company, a paper organization whose primary purpose was to extort a buy-out proposal from Insull. While the threat eventually backfired (the Gray Wolves belatedly learned of Insull's complete control over the purchase of electrical equipment), the lesson was not lost on Insull and other private utility owners (Anderson, 1981:35-36):

> Insull's experience with the Gray Wolves must certainly have affected his attitude toward local control of utilities, for the following year (1898), as president of the National Electric Light Association (NELA), the electric industry's trade association, he advocated the elimination of competitive franchises and the establishment of a system of legislative controls of rates and service. Competition, he argued, had not lowered the price of electricity but had only made investments riskier and costs higher. He further asserted that to acquire capital at low interest rates utilities needed to be protected from competition, but in return for exclusive franchises they must be willing to accept public control.

Insull and the NELA's proposal for state regulation drew a quick response from several large municipalities who saw the issue as not only one of franchise revenues, but also one of local control. If monopoly was to be granted in the area of electric service some argued, why shouldn't it be a city-regulated or owned enterprise? Several city authorities had already established municipally-owned electric utilities regarding them as necessary infrastructure much like water and sewer services. With just four municipal systems in 1882, growth in city ownership was quite rapid; by 1892 there were 235 and by 1902 the number had increased to 851 (Melosi, 1985:66). Municipal regulation and ownership of electric utilities became bound up in the "home rule" movement as cities sought greater control of their own political and economic affairs.

But the prospect of local control or ownership was anathema to the private utilities (usually referred to by their owners as the "public" utilities). Insull bluntly enunciated the ideological position of the private owners (Keily, 1924:233-234):

> Efforts to cripple the public utilities under cover of the seductive term "home rule" are self-condemned; the arguments most employed are of no merit and are of questionable sincerity...Sincere advocates of utility regulation by local municipal authority (if such there be) must be simply classed with the reactionaries and the opponents of progress in all ages--with the smashers of weaving machinery in the earliest of textile mills; with the mobs that stoned railroad trains when the steam locomotive was new. All of you here can remember restrictions upon automobiles, as to speed and otherwise, that now appear utterly ridiculous; in many cit-

> ies they were barred from the driveways in public parks.

In his 1932 *Confessions of the Power Trust,* Carl D. Thompson, then Secretary of the Public Ownership League of America, detailed another tactic to halt municipal control of utilities, namely to characterize public ownership of electric service as "the Bolshevik idea," and "communism's stepping stone" (1932:586,588). Quoting from a speech of one utility executive, Thompson illustrates this common smear tactic prevalent in the industry during the debate over regulation and ownership. "Government ownership is the masked advance agent of communism--not merely socialization...for the common good as the 'pinks' have it, but the communism of the reds as the dictionary has it" (Thompson, 1932:587).

The utility group won the regulatory arrangement they desired although many attribute the triumph to their ability to characterize cities as the instruments of corrupt political machines rather than as hotbeds of communism. The process of replacing the municipal franchise system with a state regulatory mechanism took approximately 20 years (1907-1922). Insull was a leader in the utility lobby throughout the period and his efforts earned him the title of the "inventor of the electric monopoly."

The rise of the state regulated utility system had extraordinary impacts on the scale of organization, power plant size, the quantity of power production, and the magnitude of revenues and profits. In the socio-political environment of the municipal franchise, the utility system was a mosaic of small to medium sized companies. With the arrival of state regulation the limits on size, scale and quantity were dramatically lifted. The political invention of state regulation was the final piece necessary in the development of the modern electrical network. It literally created the economic space for Giant Power to emerge as the predominant mode of power production and distribution. By far one of the most successful examples of Giant Power made possible by state regulation, was Samuel Insull's Middle West Utilities. Over a period of approximately 30 years Insull assembled an electric utility empire worth three billion dollars in utility properties, and which operated in 32 states, serving 4.5 million customers, and supplying eight percent of the commercial kilowatt-hours in the United States (McDonald, 1962:275; Hyman, 1985:78; Melosi, 1985:120; and Hughes, 1979:153).

State regulation made the electric holding company immensely profitable by assuring large regional markets and providing a means for inaugurating promotional rates which lowered the marginal price of electricity as consumption increased. The new regulatory environment touched off a sustained period of mergers in the industry as small local companies were brought into the networks of the holding companies. Even municipally owned plants were eventually taken over in this manner. One measure of the importance of state regulation to the rise of the electrical network is the pace at which mergers were undertaken. In 1926 utility companies were involved in over 1,000 mergers (Melosi, 1985:119). A second measure is the growth in the size of plants. Between 1903 and 1930 generating units grew in size from 5,000 kW to 200,000 kW (Messing, et al., 1979:3). But perhaps the most significant measure was the economic dominance achieved by the utility holding company: by 1930, ten holding companies controlled 72 percent of the electric market (Melosi, 1985:120).

In sum, three inventions had together ushered in a new technological era. Yet none of these inventions was technical in nature. State regulation (a political creation), combined with the science and engineering based enterprise (a new organizational from), and the holding company (a financial innovation), to make the large power plant and an expanding grid technically and economically practical. As Novick has pointed out, "the power company which has a monopoly of power supply was an invention, not an inevitable development" (1975:13). Together these inventions also contributed to the utter transformation of local social institutions. Samuel Insull had accurately foreseen this transformation (Keily, 1924:234):

> Proposals to regulate public utilities by local municipal authority become more of an absurdity day by day. These companies are no longer local institutions. They cannot be local if they are to be fully useful. Economic necessity does not recognize parochial boundary lines.

The displacement of local organizations with regional and national ones was not to be feared, though. Indeed, in the mind of Insull the system-builder, large-scale deserved society's endorsement; so long as scale was to be governed by a systems logic, an era of social abundance was promised. More than that, some social ills may be cured.

> Only a beginning has been made in serving the vast territory of the United States with electric energy, and we can have only a dim idea of what it will mean to humanity when cheap power, conveniently usable in the form of electricity, is available in every hamlet and along at least the more important country highways.
>
> Industries grow up, usually, where power is cheap--where coal or oil or gas is abundant or where waterpower may be utilized economically. If power is made cheap everywhere, or nearly everywhere, by means of the co-operation of the scientist, the inventor, the capitalist, the enterpriser and the engineer, then it may be possible perhaps to do away in great measure

> with the overcrowding--or one may say with the slums--of great industrial cities (Keily, 1924:30).

If large-scale had been essential to economic success, it was also its greatest threat. Again the Insull empire is instructive. Hyman has estimated the asset value of Insull's pyramid of holding companies to be at least half a billion dollars by 1930, but this asset value had been capitalized through an investment of less than $30 million. As he notes, "one could argue, in fact, that Insull controlled the lowest level operating companies by means of an investment equivalent to less than 0.01% of the securities issued by those subsidiaries" (1985:78). This scheme was well suited to a business strategy of rapid and large market expansion. But it was also highly vulnerable to fluctuations in subsidiary income. With the American stock market crash in 1929 and the ensuing worldwide depression, the vulnerability of Insull's techno-economic organization was exposed. Profit depended upon a broadly based pattern of economic development; under such conditions an intra-empire multiplier could be observed in which the increased business of subsidiaries improved the stock values and, therewith, the profit margins of the holding companies whose positive economic situations advanced and multiplied wealth up the pyramid. However, the reverse was also true. "Lacking the movement of constant growth in the economy, the whole structure fell into disarray" (Melosi, 1985:126). The Insull failure cost investors approximately one billion dollars and precipitated "the largest corporate failure in American history" (Melosi, 1985:126).

3.5 The Electrical Network

Insull's downfall brought forward public policy initiatives at the state and federal levels designed to reduce communities' dependency on the holding company pyramids. The 1935 amendments to the Federal Power Act established partial federal oversight of the interstate activities of electric utilities. An annual electric rate survey was undertaken by the Federal Power Commission which resulted in the publication of "typical electric bills" in several hundred communities. Publishing the wide variation in electric bills had the effect of stimulating local pressure on state commissions to justify high rates, especially those paid by residential customers. These and other policies reduced the discretion available to utilities and thereby dampened some of the more speculative tendencies in the utility industry. But the most important regulatory reform came with the passage of the

Public Utility Holding Act in 1935. This act abolished holding company pyramids with more than three tiers; required all utility holding companies to register with the Security Exchange Commission (SEC) and register details of their financial holdings; and empowered the SEC to restrict holding companies in some instances to a "single, integrated utility system of one tier" (Melosi, 1985:129).

Public policy initiatives helped to ameliorate the magnitude of social and community risks associated with the expansion of the electrical network. However, they did not answer the more pressing concern of what to do to revitalize the utility sector in a time of national economic stagnation. The governmental response to this issue was the pursuit of "public power." Government-owned power generating stations and distribution systems represented one of the most significant program elements in Franklin D. Roosevelt's strategy for national economic renewal. In one formulation advocated by FDR's lieutenant, David Lilienthal, public power was to challenge the conventions of industrial capitalism by providing a citizen-based organization for the determination of rates, production levels and distribution policies. A power authority accountable to the public interest and will, and controlled at the grass roots level, would restore the localist character to this institution. The advantages of large-scale power production would be preserved by designing the production facilities according to engineering criteria and principles of technocratic administration. This centralist-decentralist approach would deliver the best of both worlds, while at the same time offering competition to private utilities in setting the national "yardstick" for reasonable electric rates. For Senator George Norris, a leading proponent of public power; Arthur E. Morgan, first chairman of the board; and David Lilienthal, the Tennessee Valley Authority was intended to implement the ideal. Established in 1933 by President Roosevelt, TVA was a multi-use, multi-purpose project involving "flood control, fertilizer production, soil conservation and reforestation, inland waterway construction, promotion of regional economic growth, *and* the generation of hydroelectric power" (Melosi, 1985:130). In his 1933 address at the dedication of the TVA David Lilienthal articulated what was to be expected in the electric future (quoted in Carey and Quirk, 1970:235):

> This valley will be the first to enjoy the full fruits of this new age, the Age of Electricity. Those who have its blessing in abundance will come into a new kind of civilization. New standards of living, new and interesting kinds of jobs, totally new industrial processes, an end to drudgery, congestion, waste...such things are in store for us.

While TVA was successful in the areas of flood control, development of recreational facilities, and the supply of cheap electricity ("residential rates in 1933 ranged from $.1 to $.3 per kWh, as compared to $.55 nationally"--see Melosi, 1985:132-133), its status as an alternative to private power never materialized. This was due only in part to the heated political criticism which it attracted as a "socialist" experiment (as its private power detractors sought to portray it). When the projected "competition" got underway, TVA turned out to be, not a grass roots alternative for democratic power (Selznick, 1979), but rather a technocratic public imitation of Giant Power.

The actuality of public power as Giant Power had been presaged in the developments surrounding the 1925 *Report of Giant Power Survey Board*. The report was the product of the "power progressives," including Governor Pinchot of Pennsylvania, Senator George Norris, then-Governor Franklin D. Roosevelt and mechanical engineer Morris L. Cooke, who had sought for years to establish an alternative to private power monopoly (Melosi, 1985:120-121). The report sought to reorganize the power system in the Commonwealth of Pennsylvania by calling for the interconnection of all private utility grids, the construction of nine mine-mouth power plants with capacities in the range of 300 MW, and the establishment of an administrative authority to oversee and plan the integrated operations of private, municipal and cooperative utilities (Hughes, 1976). The report attracted its share of political denunciation, with *Electrical World* publishing an engineer's charge that the proposals were "communistic" (Hughes, 1976:1369). In the end the report was not implemented, but this failure was not due to any technical dilemmas or constraints. Instead, Giant Power as private power continued to be implemented; that is, large-scale organization, expanding grids and big power plants--key elements of the Pennsylvania Power proposal--were pursued, although only as the hardware of privately owned electricity enterprises.

TVA and the Pennsylvania proposal shared a vision of public power as imitative of private power--both subscribed to the model of Giant Power. Furthermore, public power accepted the planning and scientific management orientations that had come to dominate the large corporate organizations (indeed Morris Cooke was an associate of Frederick Taylor's--see Hughes, 1976:1363). In this respect, the most significant outcome of the public power-private power controversy of the 1920s and 1930s was the loss of institutional meaning in the choice between the two. Much as public policy and private wealth had been joined in the petroleum complex, institutional differences in the electrical network faded by comparison to the common predisposition of public and private power to seek development through the instruments of bigness (organizational and financial) and technocracy.

World War II encouraged the tendency toward bigness and technocracy in two ways. Armaments production for global war dramatically increased the requirements for electricity. Modern warfare is fought with machines whose materials (most notably aluminum and steel) and fabrication processes are electrically intensive. These facts combined with the enormous number of machines required, meant that electricity would be an essential energy source. Giant Power fulfilled U.S. war needs particularly by means of the huge hydro-electric projects financed by the federal government, mainly in the northwestern United States. Government-owned aluminum plants to manufacture land vehicles, airplanes, ships and weapons were constructed near the hydro-electric power pool in order to take advantage of these cheap and abundant electricity supplies.

While some war production could be mobilized in the northwest, it was not possible to satisfy the full range of war-making needs in this manner. A second requirement was that the loci of power pools be more fully interconnected so that a national power system would exist to facilitate and support armaments production. The first power pool was established in 1927 to link the Pennsylvania-New Jersey generating facilities. The Federal Power Act of 1935 gave the national government the authority to oversee and set rates for interstate electricity sales, but by wartime there were only a few power pools serving such needs. During World War II this authority and the power pool model were relied upon to fashion the beginnings of a national electric network.

3.6 Electricity: The Postindustrial Fuel

Forty-five years of extension of the electric network--and the absence of war waged on U.S. soil--had prepared the way for a distinctively modern social order predicated on the ideals of energy abundance, mass consumption and high technology. Having escaped the devastation of World War II, the United States was poised to become the first technological society in the modern sense. Electricity would constitute both the fuel of choice for the high-tech economy and the status symbol of consumerist society. The alliance of energy and technics promised a postindustrial order of material abundance gained without significant toil. Indeed leisure would replace work as the focus in individual lives. A special twentieth-century feature of this long anticipated world was the appearance of an energy source that would halt the harm of nature and brighten (literally) daily life, and bring a new standard of cleanliness, even sparkle, to the workplace and the household. Mumford's mentor, Patrick Geddes, was among the early enthusiasts of an electrified social order (1971:129):

> [T]he fairy godmother is coming, nay is even here year by year she stands waving her fairy electric wand as the herald of the new era in the domestic labour and consequent life of woman, ready and waiting to free her from all the old elements of dirt and drudgery, and this henceforth for good and all. Her future in the adequate neotechnic home, characterized by electricity and its labour-saving, by hygiene, and by art, is thus as true princess, that is lady commanding assured wealth, effective service, adequate leisure, and thus with no limit to her refinement and her influence.

The "electronic revolution," indeed, seemed to confirm the arrival of a new society based on the ideals of technological and scientific progress: energy-based materialism, technological positivism and a sense of unlimited social opportunity would be realized with the rise of an interconnected service and high-technology economy. In this new society, electricity was not merely a fuel, but a medium of information and communication. As McLuhan observed, "in all forms of electric circuit and appliance, whether telegraphy, radar, or guided missile, we are confronted with the give and take of dialogue" (quoted in Carey and Quirk, 1970:401). Indeed it was the unique characteristic of electricity to furnish a medium without its own content (McLuhan, 1964:52):

> The electric light ended the regime of night and day, of indoors and out-of-doors. But it is when the light encounters already existing patterns of human organization that the hybrid energy is released. Cars can travel all night, ball players can play all night, windows can be left out of buildings. In a word, the message of the electric light is total change. It is pure information without any content to restrict its transforming and informing power.

This characteristic had an enormous importance when electricity took technological form in communications and transportation. As McLuhan observed, electronic technologies in these areas had the capacity to "abolish space and time alike" (quoted in Carey and Quirk, 1970:222)--to erase social barriers and boundaries--by instantaneous transmission of messages, thereby delivering the possibility of a universal culture. Electric society would be a world society with all language groups participating equally as computers translated and transmitted information at "approximately the speed of light" (quoted in Carey and Quirk, 1970:401). Similarly, Buckminster Fuller forecast a golden electronic age, "a dynamic, electronically articulate, constant world democracy referendum whose computer integrated voice and evolutionary wisdom will be stunning" (quoted in Carey and Quirk, 1970:420). For many, electricity seemed to correct the negative relation between energy, industry and society that had surfaced in the nineteenth century. Now it seemed possible to have development without smoke and filth; progress without inequality. As Carey and Quirk have suggested, "in electricity was...seen the power to redeem all the dreams betrayed by the machine" (1970:226).

To support the growth of technological society, the power system underwent a transformation. Scale of market operations remained a necessary condition of modern economic development, but there were the additional requirements of increased scale of technical operation and technical coordination. The era of Giant Power gave way to an era of Centralized Power (Messing, et al., 1979). As Melosi has observed, "the electric utility industry became even more monolithic in almost every phase of business after the war: ownership, planning, coordination, decision-making, and economic influence" (1985:200). Virtually every technical measure of scale and size in the power business increased substantially between 1945 and 1965. Boiler and turbine capacities increased dramatically, leading to growth in the size of generating units from a 30 Megawattage (MWe) average in 1947 to a 400 MWe average in 1965, with an upper limit of 1,000 MWe. An industry trend toward multiple-unit power plant sites was also set in motion during this period. By the 1960s utility planning called for the construction of power plant sites with total capacities of more than 2,000 MWe. Transmission voltage nearly doubled between 1945 and 1965. In one decade alone (1950 to 1960) the largest current transmission lines went from 230 kV to 345 kV. Power pools and regional reliability councils were introduced in the late 1950s and early 1960s to facilitate utility coordination and planning of regional electricity supplies. Nearly 50 percent of the nation's generating capacity was incorporated, formally or informally, into these regional planning systems. In two instances--those of the New York Power Pool and the PJM Interconnection (which includes the utilities operating in the states of Pennsylvania, New Jersey, Maryland and Delaware)--a central dispatching authority was created to regulate generation and transmission of all plants operating within the boundaries of the power pool (see Messing, et al., 1979:1-62). Finally, the period saw the electric utility industry emerge as the most capital intensive in the country: based on 1973 figures, "the [electric utility] industry required more than $4 in plant, property and equipment costs for every dollar of sales revenue." By comparison, the oil industry required $1.15, the steel industry $0.86, and the auto industry $0.57 (Messing, et al., 1979:19, 62).

Early in this period, thermal efficiency reached a plateau as design and engineering innovations brought thermal performance near the upper limits set by the laws of thermodynamics. Yet the acceleration in engineering scale continued as described above. Notwithstanding the popular assumption of a positive relationship between scale and technical efficiency, Messing, et al., indicate that there is "virtually no correlation...between unit size and thermal efficiency for the most efficient units in operation or between the year of introduction and thermal efficiency" (1979:10).

Another anomaly for the scale economy-efficiency thesis concerns the trend in utility reserve margins in the 1945-1965 period. As noted above, the continuous growth in electricity consumption and generating capacity transpired within an environment of greater utility coordination, planning and interconnection. If efficiency and scale logics determined the organization of power supply, we would expect utility reserve margins to have decreased over the period as utilities shared generating capacity to meet peak loads. However, the contrary trend is found as reserve margins increased nearly 300 percent. Messing, et al., summarize the situation (1979:53):

> Large-scale plants have proliferated, but purported economies of scale have not been realized. Power pools have proliferated, but utility coordination has remained limited, and power pool reserve margins have increased. Regional power planning has proliferated, but has only made the planning less accessible to state and local governments...Unless new institutional mechanisms are created to coordinate these planning functions, it would appear that local governments will remain unable to respond to planning options considered by regional utility planners and that an increasing amount of utility planning will be conducted through regional power pools or other interstate coordinating agreements with minimal consideration to options of local and even state governments.

The conventional argument that scale economies were an outgrowth of social engineering and technical considerations fails to recognize the essentially social character of Centralized Power. Without expanding consumer demand for electricity, large-scale is not only uneconomical but irrational as well. Of what value is idle electricity capacity? The obverse argument (also conventionally espoused), that electricity demand is a derived demand, likewise provides an incomplete explanation of the events of 1945 to 1965. While it is obvious that electricity is generally not desired for its own sake, the derived demand thesis presupposes that the growth rate of electricity lagged that of mass consumption. Yet nearly the reverse is true of the period, as kilowatt-hour sales increased annually at an average of 1.5 to 2.0 times that of the rate of growth in real GNP. It was only at the close of this twenty year period that real GNP and kilowatt-hour sales growth rates approximated a pattern consistent with the derived demand thesis (Hyman, 1985:94). Centralized Power grew in the postwar period not by an internal logic of efficiency, scale economy or productivity, but by an environmental logic of mass-increase.

As well, the economies of Centralized Power are not self-evident. A condition of sustained mutual growth in a wide array of economic enterprises must be presupposed as the social background in order for Centralized Power to be economically rational. Said another way, the social prerequisites of Centralized Power--mass consumption, high technology and large-scale organization--must be assumed to already exist in order for such an energy system to be a "rational economic response." What needs explanation of course (and what is lacking in standard economic analysis), is the sources of these social developments. To explain the push toward mass consumption in 1945 to 1965, we need to examine culture and ideology.

The belief that energy consumption is a necessary facet of civilization has been a pervasive one throughout the history of the United States. The belief arises in part from nineteenth century experience with industrialization. Relative labor and capital shortages were compensated for with intensive use of domestically abundant energy sources, with the result that "abundant energy turned labor-intensive jobs into capital-intensive ones" (Melosi, 1985:9; see also Rosenberg, 1972). However, the "energy-civilization equation" has, as well, a mythic component. George Basalla has described the American energy myth as follows: "[A]ny newly discovered source of energy is assumed to be without faults, infinitely abundant, and to have the potential to affect utopian changes in society" (1982:27).

Not until the postwar period has the United States fully realized the culture of energy abundance. Guided by the precept that "the more energy we use, the better off we are" (Lovins 1977:4), the most pressing problems immediately after the war centered around issues of growth. The labor surplus and housing shortages created by returning soldiers could be mutually solved by rapid economic growth. Similarly, the civilianization of production and the re-establishment of mass markets required a development leap of national proportions. Federal policies in the fields of housing, transportation, education and urban development provided the stimulus (See Judd, 1984). A political coalition was fashioned between the local and national parties around a pro-growth strategy (See Mollenkopf, 1983). European reconstruction and the demise of that continent's colonial empires provided additional impetus and outlet for American commodities production.

The role of energy generally, and electricity specifically, in this rapid growth process has been well documented. Energy consumption nearly doubled between 1945 and 1965 with electricity growth outpacing all other fuels throughout the period. Accelerated electricity use is, in turn, attributed to the mass-marketing of appliances, electric heating and air conditioning, and the rise of a commercial-service economy. In what represented a repeat of the 1920s mutual growth pattern, GE and Westinghouse raised appliance saturation rates and their own revenues by successfully spreading the micro-electronic revolution to virtually all sectors of society. The utilities in their turn, widened the equipment markets by the sale of power on a declining block basis, rewarding large users of electricity with lower marginal prices. The result was a 34 percent decrease in residential electricity prices between 1945 and 1965 (a 9 percent decrease for all electricity consumers), with a simultaneous increase in electricity consumption per resident of 301 percent. By the close of the period, the average residential customer consumed 4,933 kWh annually compared to the 1229 kWh of their 1945 counterpart; while average use per customer grew from 5,762 kWh in 1945 to 14,694 kWh in 1965 (Hyman, 1985:95).

While these trends *can* be explained in terms of the price elasticity of electricity demand, such an explanation hardly instructs the observer about the institutional prerequisites which were necessary to establish the very possibility of elastic demand--the rise of the holding company, the creation of the state regulatory system, the development of corporate science and engineering, the elimination of local authority and institutions such as the earlier municipal franchise system, and a world war which caused massive destruction on virtually every continent except North America. This social history was the necessary prelude to Centralized Power as the dominant energy system in which "an increasing number of people have become increasingly dependent on a decreasing number of corporations" (Messing, et al., 1979:62).

The utilities were (and are) planning a power system which would not simply meet the needs of mass consumption, but would facilitate its rapid and continuous growth. Similarly, the intent of utility plans was not merely to accommodate a high-technology economy, but to promote high-technology development and growth. From its inception, the electric industry had entailed a complementary relation between equipment and power production. The General Electric and Westinghouse empires built in the early part of this century demonstrated not only the feasibility, but profitability of integrating operations in these two markets. When the two operations were organizationally separated later in the century, it did not disturb the functional complementarity of the two. Innovations in electronic communications, the electrification of household technology, and the arrival of computers, at once depended upon the availability of cheap and abundant electricity and reinforced the spread of the electrical network. If conceived in isolation, these components would not have been practical; but conceived together they represented the foundation for the development of a postindustrial technological order.

3.7 Conclusion

Mumford had forecast that a culture of quanitification, in which bigger and more were regarded as better, would dominate Paleotechnic society. The energy roots of this society were both the source and sustenance of this culture. As Paleotechnic society's industrial base was transformed, its cultural structure likewise changed. Quantification subtly but significantly gave way to an ideal of abundance. Increase was still highly valued, but the prospect of quantity with little or no human effort--a machine-produced endless supply--captivated the social imagination. This is the dream of postindustrial society. Here too, the energy sector is both a source and means of sustenance for the requisite cultural attitude.

Twentieth-century U.S. petroleum and electricity development showcased institutional innovations which have come to define postindustrial society generally. The alliance of the state, capital and technology in a common economic effort; the centralization of operating and economic systems in each sector; the creation of a corporate private government to oversee these systems; and the spread of a "production ideology" of organizational gigantism and a "consumption ideology" of material abundance (which rationalized mass production for mass consumption), all characterized the rise of Corporate Oil and Centralized Power. In time, these same characteristics would be recognized as the foundation not only of economic restructuring in the United States but, eventually, as the basis for the rise of a world political economy. The institutionalization of postindustrialism, first evident in the energy sector, *committed* modern societies to a form of social order in which political and social choice are displaced by technocratic considerations.

CHAPTER 4

A CHARACTEROLOGY OF CORPORATISM AND INDUSTRIAL SCIENCE

The achievements of technical and economic centralization first witnessed in the Power Complex, have since been repeated in several production sectors (e.g., steel, transportation, electronics), and have come to pervade nearly every layer of the state and society. A primary method for the diffusion of centralization has been what David Noble terms *science-based industrialization* (1977:3). This and the next three chapters examine this phenomenon as part of the theoretical effort to explain the institutional basis of postindustrialism.

4.1 A Characterology of the Corporate System

The transformation of "science into gold" (Noble, 1977:3) has characterized much of twentieth century technical invention. But as in the case of electricity, the origin of invention was seldom the tinker or free-lance entrepreneur. The folk image of Thomas Edison as bootstrap inventor of the technologies that spawned an industry is far from accurate. Indeed, Edison's early success in obtaining financial backing from J.P. Morgan, and partner Egisto P. Fabbri and others, and his conception of the research-and-development process in commercial terms were important organizational steps in the industrialization of the laboratory. The simultaneous and rapid growth of the modern corporation and the science-engineering-technology sector is no mere coincidence. Each served the organizational and resource needs of the other; each depended upon a similar mode of authority; and each eventually assumed the other's existence as a condition of mutual stability.

The spread of the corporation as an organizational type can be attributed to a host of factors, including cultural development (Weber, 1947), legal innovation (Frug, 1980), and the logic of capitalist production (Galbraith, 1985). But for purposes of this analysis, causes are less important than the norms and capacities associated with the corporation. John Kenneth Galbraith identifies four such capacities: first, the modern corporation has demonstrated an ability to become large in size, not so much as a function of economies of scale, but to satisfy the requirements of industrial planning; second, it has successfully replaced individual with group decision-making and based the latter on specialized (expert and technical) knowledge; third, it has achieved autonomy for organizational authority both from internal "threats" (e.g., stockholders and employees) and external ones (especially state intervention)--what Weber and others have referred to as the bureaucratization of authority; fourth, it has promoted economic stability for the organization ideally in both its horizontal and vertical business relations (1985:75-90).

The significance of the corporation lies not only in its organizational characteristics, but in the system that results from the proliferation of this type of organization. This point can be illustrated through an examination of three characteristics common to the corporation *and* the corporate system. One such characteristic is the integration of industrial processes. Corporations as single entities impose a consistent and comprehensive logic on production which ties labor, capital and materials into a single economic effort. This single effort can embody many outputs, and in this respect at least, the integration achieved by a corporation lies beyond the manufacture of a product or products. Entrepreneurs produce goods; corporations produce rationalized production systems. Of course, the integration characteristic is based upon and reflects the economic and technical capacities of the organization, but it also defines the interrelationship of one corporation to another. That is, as the corporate form takes root in a particular production sector, the rationalized production system of any one corporation influences the design and development of related production processes undertaken by other corporations in the industry. With time, one corporation comes to assume as part of its own production process the rational structure of production existing in other corporations with which it does business. When the industry is dominated by this organizational form, a rationalized production system is an industry-wide phenomenon with the production structures of individual corporations having the status of subsystems. In this way, integration passes from the individual corporation to the industrial system.

A similar tendency can be observed with regard to market control. Individual corporations increase their size, in part to internalize and regulate market competition. The internalization of competitive forces has two advantages. It facilitates integration of production and contributes to the stabilization of markets. Increasing size and economic stability eventually provide the individual corporation with monopoly status within a competitive economic environment. Joan Robinson has termed such economic niche finding, "monopoly competition" (1938). Her analysis of selling tactics and product differentiation strategies pursued by different corporations led her to conclude that monopoly competition was descriptive not only of the relation between an individual corporation and its environment, but also of the system of economic relations operating in an industry dominated by large differentiated firms. Thus, as with integration, market control becomes a feature of the corporate system as well as of single corporations.

A third individual-system characteristic in a corporate order is the emergence of bureaucratic structures to plan organizational activity (present and future). Galbraith points out the prevalence of group decision-making in the corporation (1985:63):

> [T]he circumstance that in modern industry a large number of decisions, and *all* that are important, draw on information posessed by more than one man...the final decision will be informed only as it draws systematically on all those whose information is relevant.

For the assembly of such information to be reliable and complete it must be routinized. Specialties within the organization must be tied into a common information supply system; managers of one part of the organization must be able to call upon other parts for information; and those departments in the organization which are responsible for pricing and product strategies must be able to know what other parts of the organization are doing. The hallmark of bureaucracy is the routinization of complex organizational tasks. The very complexity of organization in the modern corporation makes planning "endemic" (1985:65). Planning replaces the marketplace in the growing corporation (Galbraith, 1985:65):

> [T]he manufacturer...must foresee the requirement for specialized plant, specialized manpower, exotic materials and intricate components, and take steps to ensure their availability when they are needed. For procuring such things, we have seen, the market is either unreliable or unavailable.

What is true of the individual organization is also true of the corporate system. Planning is an essential activity if production is to be rationalized and market stability is to be achieved as industrial traits. Ultimately, planning by one corporation depends upon the assumption that its organizational partners likewise act according to plan. In this sense, while no common plan need be formally devised, a common transorganizational plan nonetheless is experienced. John Maynard Keynes long ago demonstrated the necessity of this outcome (and the dilemma it raises). The recognition by modern corporations of the requirement not only to develop an internal plan but to anticipate a transorganizational plan results in the spread of bureaucracy and planning throughout the corporate system.

4.2 A Characterology of Modern Science

Modern science has organizational and normative capacities similar to those of the modern corporation and it has manifested equivalent individual-system symmetries. At least since the Newtonian revolution, science's organizational home had been the academy or university. But with the rise of industrial society, both the role of the academy and the individual scientist changed. Science as the activity of scientists was replaced by an organizational approach in which principles of division of labor and specialization became dominant. Simultaneously, the academy was transformed from an individualistic institution to a bureaucratic one, and found itself interacting increasingly with the state and industry. Science diversified in terms of its "clients" and correspondingly multiplied its organizational addresses: science was no longer confined only to the academy, but became a sponsored activity of industry and the state (especially the military).

With its organizational diversification, science became a part of and contributed to the gigantism of the

Paleotechnic era. Progressive science and big science, like progressive business and big business, became synonymous. In addition to the norm of size, science contributed to the displacement of the individual by the group. Decision-making by committee became as prevalent in the scientific arena as in the corporate arena, and for the same reason: the advance of specialist knowledge presumed the elevation of the group over the individual. Scientific validity resided contemporaneously in the organized methods of science; scientific results were the product of science organizations rather than scientists; and neither the individual scientist nor the layperson could conclusively determine truth. Science as an important source of social authority had been in evidence at least since the time of Saint Simon, but implementation of his idea of a Parliament of Improvement in which scientific authority supercede all other, was not achieved until the twentieth century. Autonomy for scientific authority passed from the individual to the organization.

While science adopted the norms of size, group and organization, the adoption of these norms *in themselves* did not ensure that science's contributions to economic life would reinforce social stability and control. Indeed, the non-necessity of science as a stabilizing force was what made theories of development such as those of Joseph Schumpeter plausible. His thesis of industrial development as a process of creative destruction enshrined science's creative capacities as a positive force for social progress, destroying the old, the less efficient, the hackneyed, and replacing them with the modern and superior. Such an idealized vision was hardly descriptive of, or compatible with, Paleotechnic quantification. Corporations were well aware of this and took steps in the early twentieth century to integrate innovation and invention within their own organizational spheres of influence. Research and development were combined into a single organized process governed by corporate bureaucracies called "R&D" departments.

In addition to replicating the organizational normative capacities of corporatism, science reproduced its own counterparts of integrative process, internalization of competition, and bureaucratization of complex tasks. Science entered into the industrial process via the electronics field where both academic and corporate sponsors sought to turn scientific research into the source of commercially successful technologies. Patent law had created the opportunity, but it was largely unexploited before science was harnessed by the electronics industry. Once a partner in the production process, the utilization of science quickly spread. Related industries found a science partnership both attractive and necessary to maintain profitable relations with the growing electronics organizations. Science sponsored in one production area became useful to another which, in turn, spurred greater involvement of science in industry. Industrial organizations were linked by the generalizability of scientific results and methods: a finding in one area could have multiple applications and a variety of commercial expressions. Science-based industrialization extended beyond an organizational level and characterized the industrial system generally. Science's own integrative tendencies mixed with those of corporate industrialism to define a new system.

The interior logic of science which emphasizes generalization and cumulativeness encouraged industrial tendencies toward diversification. Only through such a strategy could an industrial organization fully internalize the potential profits from its science investments. The large diversified organization was equally attractive to science in its own terms. This organization fostered cooperation across disciplines and research specialties, as well as permitting an "internalization" of the benefits of cumulative science. By sharing information and facilities, large diversified science organizations could progress more rapidly and efficiently. Competition could play a useful role but only if it was pursued within a general organizational framework; science of the creative destruction variety was likely to slow the accretive process of discovery in which "normal research" was promoted (Kuhn, 1960). In this regard, scientific and industrial organizations shared a common interest in the regulation of competitive tendencies. And as with the industrial sector, this interest soon expanded beyond the organizational level to include the science-industry partnership generally.

Finally, science has grown out of an earlier model in which disciplines were relatively isolated. This has created both more complexity and connectivity among scientific tasks with the familiar consequence of the rise of bureaucratic organization. Science in the academy *and* industry *and* the state is pursued through a regime of planning structures and group decision-making processes. Science agendas and funding are set by means of these bureaucratic planning routines. This is both consistent and probably unavoidable so long as generalization and cumulativeness are emphasized in scientific inquiry. In the context of the normal research paradigm, bureaucracy and planning serve as essential mechanisms for controlling scientific labor in the interest of "systematic discovery." They are the attributes not only of successful scientific organizations but of successful science itself.

The convergence of science and industry at the organizational and system levels and their adoption of similar norms to guide development were key factors in the rise of technological society. Building upon the earlier achievements of the Power Complex, science-based industrialization brought rational discipline to an otherwise chaotic condition of Paleotechnicism. The destructive impulses of this socio-technic order remain, but the science-industry alliance (and frequently science-industry-state alliance--to be discussed shortly) has been effective in fostering the view that objective knowledge is being applied to solve problems.

4.3 The Transformation of the Ideals and Aims of Science

The realization of Big Science in the twentieth century could not have been possible without the formation of a science-technology partnership that began during the nineteenth century. In turn, this partnership would not have been possible without a similar evolution in understanding of the nature of scientific inquiry, from the classical pursuit of knowledge as philosophy to the industrial period's redefinition of knowledge as methodology. In this epistemological transition, both the scope and purpose of Western inquiry were fundamentally altered.

Several accounts of transformations in the epistemological and methodological foundations of Western science have been written over the past several years. These include: Alfred North Whitehead's *An Enquiry Concerning the Principles of Natural Knowledge* (1925), Bertrand Russell's *A History of Western Philosophy* (1945), John D. Bernal's *Science in History* (1954), Thomas Kuhn's *Structure of Scientific Revolutions* (1962), Karl Popper's *Conjectures and Refutations* (1963), Joseph J. Kockelman's *Philosophy of Science* (1968), and John Ziman's *The Force of Knowledge* (1976), among others. No attempt will be made here to synthesize this considerable work or the controversies raised by its contributors. Instead, a more modest purpose is set, namely, to draw out the distinction between science as philosophy and as methodology by reference to selected works on theories of science. For this purpose, the work of Thomas Hobbes, Immanuel Kant, John F.W. Herschel, William Stanley Jevons, Henri Poincare and Percy Williams Bridgman is consulted below. Each author was selected to represent a particular region of thought which contributed to the transition from the ideal of scientific philosophy to one of scientific method. Thus Hobbes and Kant are employed to describe the political and rational traditions of scientific philosophy; while Herschel, in his account of a sensate method of scientific discovery, Jevons, in his formulation of a probabilistic idea of objective reality, Poincare, in his relational model of science, and Bridgman, in his account of objective reality as a system of mathematically specifiable operations, are used to depict the evolution of the ideal of science as objective method. These selections were made from a large number of alternative candidates, and there is no presumption that a different complement of theorists could have effectively accomplished the aim of this section.

Until the nineteenth century, Western inquiry sought explanation which encompassed both physical *and* social relationships. Knowledge was assumed to be inherently social because phenomena were understood to be comprised jointly of physical and social dimensions. Humanity itself was the manifestation of this integration of physical and social. The search for truth involved the determination of the meaning of the phenomenal world with knowledge (including scientific knowledge) constituting a scheme of truths which took us beyond the facts. Of central concern to inquiry generally was the role of human intention and will in a universe simultaneously physical and social. Science represented one response to this dilemma. In challenging religious doctrines of divine inspiration and intervention in human affairs, science proceeded from a philosophy in which knowledge about the natural order of things was seen to empower human intention and action. While the academy was often deeply divided over this issue of science and religion, the need to explain a coincidentally physical and social order was recognized and shared by nearly all parties. This demand on inquiry represents a core assumption in what David Noble has called the "classicist" tradition (1977:25).

Two notable examples of this classicist tradition are exhibited in the work of Thomas Hobbes in *Leviathan* (originally published 1651), and Immanuel Kant in *Kant's Metaphysical Foundations of Natural Science* (originally published in 1786). Separated by more than a century, the major philosophic concerns were somewhat different for the two. Human will versus divine intervention was a prominent debate in the philosophy of Hobbes' time. But by the early nineteenth century naturalism had been largely successful in displacing religious doctrine as an appropriate source of knowledge. Inquiry then turned to examine the nature and character of "objective" knowledge in a social world, providing the setting for Kant's inquiry.

For Hobbes, the universe consisted of facts of both a physical and social order. Physical facts, or *"natural history"* he defined as "the effects of nature" which had "no dependence on man's *will."* Social facts consisted of the "voluntary actions of men in commonwealths" and he called them, *"civil history"* (Hobbes, 1967:69). In Hobbes conceptualization, neither the existence of history (natural or civil), nor individualistic understanding of history was a sufficient basis for the creation of knowledge. In the former case, histories could and did exist independently of human knowledge about them. Similarly, understanding of isolated events as in the case of a dog that "will understand the call, or rating of his master" do not constitute the basis for knowledge (Hobbes, 1967:27). For Hobbes, the possibility of a *shared understanding* which invested meaning beyond present circumstance and particular events was the essence of human knowledge. Only human intention and will offered this possibility through the use of speech or language. Absent speech and the basis for social discourse, there could be no science and no knowledge. "For true and false are attributes of speech, not of things. And where speech there is not, there is neither truth nor falsehood" (Hobbes, 1967:36).

A century later, Western philosophic tradition had accepted Hobbes' insights and turned its focus to the growing concern over "objective" knowledge independent from the individual philosopher/scientist or civil society and its institutions. In addressing this problem, Kant's philosophy continued the classicist integration of the physical and the social, or in his language, the "doctrine of body" (*extended* Nature) and the "doctrine of soul" (*thinking* Nature). Scientific expression of this duality of natural order was manifested in the *empirical* and *rational* components of knowledge. Empirical knowledge derived exclusively from experience while rational knowledge originated in the conscious reasoning being as it sought to conceive (Kant, 1970:4):

> Only that whose certainty is apodeictic can be called science proper; cognition that can contain merely empirical certainty is only improperly called science. The whole of cognition which is systematic can therefore be called science, and, when the connection of the cognition in this system is a coherence of grounds and consequents, rational science. But when these grounds or principles are ultimately merely empirical, as, for example, in chemistry, and when the laws from which reason explains the given facts are merely laws of experience, then

> they carry with themselves no consciousness of their necessity (are not apodeictically certain), and thus the whole does not in a strict sense deserve the name of science. Therefore, chemistry should be called systematic art rather than science.
>
> A rational doctrine of nature, then, deserves the name of natural science only when the natural laws that underlies it are cognized a priori and are not mere laws of experience.

For Kant, to speak of a purely empirical investigation independent of human conception was to speak of a science which divorced the soul from the body of knowledge. From a classicist perspective, such an account was entirely meaningless.

A priori conception was, in Kant's view, essential to the development of scientific knowledge: "natural science properly so called presupposes metaphysics of nature" (1970:5-6). Laws of nature presupposed concepts of law, and of nature, which in turn must be cognizable by human intuition. Science's a priori origins meant that the pursuit of such knowledge engaged both the actual and determinant, and the possible and indeterminate. The actual within the possible, the determinate within the indeterminate, constituted the whole of the cognitive enterprise with science serving as one system of metaphysics for apprehending the whole. For Kant, the promise of objective knowledge via science was to be appreciated not primarily in terms of determinacy, predictability and precision, but in general metaphysical terms--"standing astonished" by the possibilities of objective understanding. Such an understanding was not reducible to either mathematics or empirical study. Only by the investigation of concrete aspects of nature could a priori concepts be given sense and meaning; and only through a priori concepts could the investigation of concrete aspects be meaningful and sensible. The engagement of consciousness *with* nature's possibilities, rather than "pure reason" or "pure experience," was the basis for scientific understanding.

The advent of industrialization challenged the classicist tradition on two fronts. The evident success of the machine became a standard by which a great range of human activity was to be judged. Inquiry generally, and science specifically, had to prove its value through mechanical expressions. Furthermore, the industrial apparatus shattered the classicist view of physical and social union. Emergence of the machine showed that physical laws could be separately and independently discovered and applied. Many wondered whether any equivalent social laws actually existed, and in any event, the industrialization of society raised strong doubts as to the relevance and efficacy of the classical philosophy of human will and action. Science steadily disinvested in the social and moral, placing focus instead on the gathering and analyzing of concrete things, that is, concentrating the enterprise on the discovery and manipulation of facts. The "facts" designated the boundaries of truth; the truth was now understood to be limited to what the facts had to say. On a broader scale, inquiry fragmented as philosophy was defined as a speculative activity; ethics and morals were regarded as subjectively bounded; and religion was relegated to the private domain of the faithful.

Science in the machine age proceeded on an entirely new concept of natural order. The physical and social integration which had formed the basis of classicist philosophy gave way to a purely physically determined natural order. Under this perspective, the laws of nature existed and operated independently of human conception. Method assumed the role earlier accorded human conception. Knowledge of the laws of nature was to be *discovered* in the workings of nature itself. The fundamental question for the new science was "how," that is, by what method could natural operations be reliably discovered.

An initial response to the problem of method was to ground discovery in sense impressions. Herschel's

"Principles On Which Physical Science Relies For Its Successful Prosecution" (written in 1831) illustrates the sense theory of the emergent methodical science. Herschel's goal was to find access to nature without interference from the mind. He argued that direct sensation provided a vehicle for uninterrupted contact with the physical order (Herschel, 1987:83-84):

> As the mind exists not in the place of sensible objects, and is not brought into immediate relation with them, we can only regard sensible impressions as signals conveyed from them by a wonderful, and, to us, inexplicable mechanism, to our minds, which receives and reviews them, and, by habit and association, connects them with corresponding qualities or affections in the objects; just as a person writing down and comparing the signals of a telegraph might interpret their meaning. As, for instance, if he had constantly observed that the exhibition of a certain signal was sure to be followed next day by the announcement of the arrival of a ship at Portsmouth, he would connect the two facts by a link of the very same nature with that which connects the notion of a large wooden building, filled with sailors, with the impression of her outline on the retina...

Herschel outlined the steps in what is now conventionally taken to constitute scientific method. Science, he argued, begins with the act of induction in which a multitude of sense impressions are organized by thought into a hypothesis of general relations or patterns. The hypothetical generality is then employed as a prediction of particulars which either repeat the initially hypothesized relationship, or represent logical deductions from the first hypothesis. Finally, these repeated or deduced relationships are tested against sense experience for their validity. Human thought and will were by no means absent from scientific procedures, but the potential for human prejudice was abated by the continual return to the record of sense experience. Understood in this way, the human mind did indeed provide a priori concepts for science, but, in direct contradiction with Kant, a prioristic explanation was formed *after* sense-delivered signals (Herschel, 1987:97):

> [T]he analysis of phenomena, philosophically speaking, is principally useful, as it enables us to recognise, and mark for special investigation, those which appear to us simple; to set methodically about determining their laws, and thus to facilitate the work of raising up general axioms, or forms of words, which shall include the whole of them; which shall, as it were, transplant them out of the external into the intellectual world, render them creatures of pure thought, and enable us to reason them out *a priori*. And what renders the power of doing this so eminently desirable is, that, in thus reasoning back from generals to particulars, the propositions at which we arrive apply to an immense multitude of combinations and cases, which were never individually contemplated in the mental process by which our axioms were first discovered; and that, consequently, when our reasonings are pushed to the utmost limit of particularity, their results appear in the form of *individual facts,* of which we might have had no knowledge from immediate experience; and thus we are not only furnished with the explanation of all known facts, but with the actual discovery of such as were before unknown.

The chief advantage of sense theory was that it placed scientific method (hypothesis-prediction-validation routines) at the center of inquiry without the intrusion of the prejudices of the human mind. Its chief drawback was that it seemed to restrict the application of scientific method to only those phenomena which could be verified by sense experience. Jevons, among others overcame this limitation via the concept of probability. Revisiting the problem of induction in *The Principles of Science: A Treatise on Logic and Scientific Method* (originally published in 1873), Jevons pointed out that empirical science at the time assumed that for every event there was a cause and that through the study of the conjunction of events (i.e., observations) these causes would be discovered. This assumption implied that scientific knowledge obtained only when cause was definitively established; yet the means of establishing certain cause, namely induction, necessarily produced only partial, incomplete knowledge. The incompleteness of inductive knowledge derived from the fact that "we deal with events which follow from previous events, or with existences which succeed existences...[N]ature is a progressive existence, ever moving and changing as time, the great independent variable, proceeds" (Jevons, 1924:220-221). While the future is unobservable and not available to sense experience, Jevons pointed out that it is nonetheless essential to the production of scientific knowledge. For it is about the future that prediction is made and validation is anticipated. In this respect, sense theory with its emphasis on observation of events to establish cause, was not simply restrictive of science's reach, it actually cast doubt on the possibility of prediction and validation which were so central to the scientific enterprise. Instead of seeking a means for establishing a single cause for every event (i.e., establishing an absolute relation grounded in observation), he argued that science would proceed more effectively if it sought to distinguish the conditions which "with more or less probability, precede an event" (Jevons, 1924:226). Probability in this formulation attempted to define a specific quantitative relation between the observed and the unobserved (Jevons, 1924:224):

> By induction we gain no certain knowledge; but by observation, and the inverse use of deductive reasoning, we estimate the probability that an event which has occurred was preceded by conditions of specified character, or that such conditions will be followed by the event.

For Jevons, science proceeds by the invention of hypotheses which state the probability of an as yet unobserved event on the basis of prior observed conditions. These inventions are then checked with experience (as the future becomes the present) to determine their actual possibility (Jevons, 1924:228):

> [W]e must invent hypotheses, until we fall upon some hypothesis which yields deductive results in accordance with experience. Such accordance renders the chosen hypothesis more or less probable, and we may then deduce, with some degree of likelihood, the nature of our future experience, on the assumption that no arbitrary change takes place in the conditions of nature.

Jevons insisted that his probability theory retained the idea of science rooted in empirical observation and that "the theory of probability shows how far we go beyond our data in assuming that new specimens will resemble the old ones" (1924:219). He apparently failed to recognize that probability actually implied a method of scientific discovery which no longer depended upon experience, direct or indirect. Poincare grasped this point in *The Value of Science* (originally published 1905), when he declared, "all that is objective is devoid of all quality and is only pure relation" (Poincare, 1968:274).

The shift from sensation to relation as the focus of scientific inquiry had profound implications. Jevons' probability theory hinted at the nature of change in human thinking represented by this shift through the probability "discovery." Jevons and scientists generally, could impute a precise relation between observed and unobserved, and between scientific hypothesis and error. Experience--sensation--was removed from the role of scientific arbiter, thus ending the subjective source of science; neither the human mind nor human experience was needed to validate scientific knowledge. Instead, objective relations were cast in the role of scientific arbiter, that is physical reality was recognized to be composed of "pure" relations among objects and the task of science was to discover them (Poincare, 1968:275):

> Now what is science?...It is before all a classification, a manner of bringing together facts which appearances separate, though they were bound together by some natural and hidden kinship. Science, in other words, is a system of relations...it is in the relations alone that objectivity must be sought; it would be vain to seek it in beings considered isolated from one another.

Once freed of the problem of induction, the task of scientific method is to model the "natural and hidden kinship" among objects and to deploy such models in the prediction and validation of hypothesized objective relations. From here on science would emphasize quantity and order, as the two hallmarks of objective relations (Poincare, 1968:274, 275):

> I shall not go so far as to say that objectivity is only pure quantity (this would be to particularize too far the nature of the relations in question), but we understand how some one could have been carried away into saying that the world is only a differential equation.

and,

> Nothing is objective except what is identical for all; now we can only speak of such an identity if a comparison is possible, and can be translated into a 'money of exchange' capable of transmission from one mind to another. Nothing...will have objective value except what is transmissible by 'discourse,' that is, intelligible...An absolutely disordered aggregate could not have objective value since it would be unintelligible.

Henceforth, human beings would have to discipline their thinking in a manner which corresponded with the objective thinking of physical reality. "Whether we take the moral, the esthetic or the scientific point of view, it is always the same thing" (Poincare, 1968:275).

Poincare's relational philosophy, while representative of new directions in physical inquiry, maintained a steadfast commitment to ideals of order and precision. With Albert Einstein, a theory of relativity in space-time relations was conceived without appeal to traditional norms of physical order. But for some in the scientific community, Einstein's theory represented a threat to the very possibility of science. Definiteness and exactness were being sacrificed for the dubious achievement of an abstract definition of physicalness--the relativity of simultaneity--which was alien to the human experience of simultaneity. If relativity was accepted, wouldn't science repeal experience?

In his *Logic of Modern Physics* (originally published in 1927), Percy Williams Bridgman diffused the criticisms against relativity, but most importantly for purposes of this inquiry, he clarified the modernist idea of science as 'Principles of Design'--the authoritative method for determining the organization of reality. Objections to relativity were dispatched through his argument on the correspondence between physical and measurement operations. Whereas classical physics had defined physical reality in terms of the properties of objects and the location of objects in fixed space and absolute time, relativity physics doubted the idea of properties of objects (indeed, Bridgman regarded this idea as "beyond the verge of meaning"--1968:72), and directly challenged the assumption of absolute time and fixed space. In place of classical thinking, Bridgman called for a physical understanding which defined reality in terms of physical operations (e.g., the motion of objects), and defined science in terms of the measurement operations corresponding to the physical operation under investigation (e.g., the measurement of distance and speed to describe the motion of objects). The implications of this correspondence theorem can be illustrated with Bridgman's challenge to prerelativistic concepts of space and time which, he claimed, assumed space and time to be physically empty. In the instance of space, he argued the following (Bridgman, 1968:465-466):

> [W]e can think of [space] as the aggregate of all those concepts which have to do with position...The position of things is determined by some system of measurement...We cannot measure the distance between two points in empty space, because if space were empty there would be nothing to identify the position of the ends of the measuring rod when we move it from one position to the next. We see, then, from the point of view of operations that the framework of Caresian geometry, often imagined in an ideal mathematical sense, is really a physical framework, and that what we mean by spatial properties is nothing but the properties of this framework.

By a similar argument applied to the problem of time he concluded that, "the concept of time is determined by the operations by which it is measured" (Bridgman, 1968:467). Physics, and science generally, are to be constructed from this fundamental design principle: "In general, we mean by any concept nothing more than a set of operations...if the concept is physical, as of length, the operations are actual physical operations, namely, those by which length is measured" (Bridgman, 1968:462).

More than the human mind or experience, consciousness itself was to be subsumed within a reality of physical operations according to modernist thinking (Bridgman, 1968:471):

> It is difficult to inhibit [a] habit of thought, but we learn to do it...we do not appreciate until we make further analysis that our present consciousness of the existence of the moon or a star is due to light signals, and that therefore the apparently simple immediate consciousness of events distant in space involves complicated physical operations.

In this understanding, sense experience communicates relations among objects (light signals); these relations are composed of physical operations, which correspond to measurements (light signals involve length which is measured in units of time and space). Earlier habits of thought which assumed an independence of human consciousness from physical order in the determination of meaning had to be discarded. For modern science the only meaningful thoughts are those which describe operations of measurement corresponding to actual physical operations. Thoughts which cannot meet this standard are meaningless.

The modern scientific view typified by Poincare and Bridgman steadily gained social acceptance throughout the twentieth century. Indeed something like Bridgman's correspondence theorem for physics has tended to be adopted as the appropriate model of science to be imitated by social inquiry. In his study of the emergence of Western social science, Maurice Natanson argues that two schools, the "phenomenological" and the "naturalistic," vied for the right to define the meaning of science as it was to be applied to social inquiry. Under the former, social science would entail the study of social phenomena (Natanson: 1963:209):

> [Phenomenological inquiry] takes into primary account the intentional structure of human consciousness, and [which] accordingly places major emphasis on the meaning social acts have for the actors who perform them and who live in a reality built out of their subjective interpretation.

Under the latter, social science would imitate physical science, searching for methods which would yield correspondence between social operations and their measurement; social science would strive for theories, which as Ernest Nagel put it, would be "continuous with the theories of the natural sciences" (Nagel, 1963:209). While the debate between these two schools continues to this day, the dominance of the "naturalistic" view is clear. Every social discipline has accepted the need to justify its chosen path with reference to a naturalistic standard. By contrast the phenomenological approach usually constitutes an intellectual outpost or fringe movement largely consumed by the task of criticizing the naturalistic standard bearer (See for example, Schutz, 1967; Gunnell, 1973; Merleau-Ponty, 1973; and O'Neill, 1973). The sublimation of the social within the naturalistic has meant the rejection of the idea that society can be studied in terms of the intentional meanings ascribed to objects by consciousness. Rather, the meanings ascribed by social operations, and modelled by corresponding measurement operations of social science, represent the only acceptable objective of social study.

With this epistemological transformation, science--physical and social--has become the authoritative basis for the production of knowledge in Western society. Western thought and institutions are no longer shaped by the Hobbesian problem of order, but instead by "principles of design" gathered from Bridgman's empirical science. In the new intellectual order science is the means of access to truth, and facts are its raw material. Empiricist conceptions of science which emphasize the importance of method replace classicist ideas of integration and unity. Science has been methodized to such an extent that it now pursues the goal of objective truth in a manner which implicitly and often explicitly extracts human intentionality from the world. Under this new methodist conception of knowledge a distinct physical world is conceived which imposes its laws and will upon humankind. In the ideal, science will conquer nature, overcome its natural limitations, and provide the means for its exploitation. With nature usually or typically regarded in Western inquiry as feminine, science constituted an expression of masculine triumph, not simply in metaphorical terms, but culturally and politically as well (Rothschild, 1983; Merchant, 1983; Keller, 1985; Mumford, 1967).

4.4 Conclusion

Together, the spread of corporate ideals of administration and management, and recent scientific ideals of methodical analysis and empiricist inquiry serve as "ideological preparations," to use Mumford's phrase, for postindustrialism. Social order and change, from both the corporate and modern scientific perspectives, are predicated upon the logic/laws of an autonomous, "natural" reality. This ideal view of the social scheme rationalizes the operations of the corporate economy and the science-technology complex as *objective* components or processes of the natural order of things. In this ideology, both the reality to which science and corporate organization contribute, and the practical activities of each sector, are removed from direct social criticism. Corporate and scientific/technological operations inherently represent solutions to society's problems. Any other view threatens progress. Indeed, in the postindustrialist view, reality can be objectively evaluated only under the premise that science/technology and economics are rational, progressive forces.

CHAPTER 5

SCIENCE-BASED INDUSTRIALIZATION

As methodological science gained influence, institutional tensions from the conflict with classicist values arose. These were particularly evident in the academy. Early attempts at inclusion of the new science in traditional schools were met with firm resistance. Home to the classicist tradition of science, few in the academy regarded the "new empiricism" and "methodism" (Noble, 1977; Wolin, 1969) and their corollary, "practicality," a legitimate aim (officials of Williams College, quoted in Noble, 1977:24-25):

> [T]his is a college and not a technical school. The students who come here are not to be trained as chemists or geologists or physicists. They are to be taught the great fundamental truths of all sciences. The object aimed at is culture, not practical knowledge.

Despite such attitudes methodist science *was* able to effectively challenge the old school especially through the fruits of its practical orientation. Still dependent to a large extent on European technical knowledge (Germany, in particular) and industrial technology (British imports dominated over U.S. production), the accomplishments of practical science were becoming more and more evident--in both research--America's first Nobel prize was received by A.A. Michelson for his work in optical measurements in 1907 (de V. Heathcote, 1965)--and industry--illustrated by the birth of both the electrical and chemical industries (Kevles, 1987; Noble, 1977).

This practical orientation spurred the introduction of engineering as a new discipline within the academy. Initially, engineering appeared only on polytechnic campuses which were specifically devoted to technical education. One of the earliest engineering departments in the United States was instituted at the Renssalaer School in 1823. The school was created and financed by Stephen van Renssalaer, a wealthy landowner, for the express purpose of training professional engineers. Military schools also experimented early in the organization of engineering programs, with West Point graduating its first civil engineers in 1849. Thereafter the engineering movement spread rapidly in the academy, with liberal arts schools establishing programs as well. Between 1845 and the 1870s, engineering departments were created at the University of Michigan, Cornell, Johns Hopkins, Union College, Brown, Dartmouth, Harvard and Yale (Noble, 1977:23). But even this pace was too slow for the most ardent proponents of what was increasingly becoming accepted as industrial science. When Harvard was slow in developing programs for training in engineering, mining, and manufacturing, some scientific and civic leaders of Boston helped found the Massachusetts Institute of Technology, which was to become the American model of scientific and technical instruction. As Noble points out, the word technology was included in the title of the new school to signal that "the study of science...rather than being a form of polite learning, would be directed toward practical ends" (1977:23).

5.1 The Rise of Industrial Engineering

As the method-based scientific attitude was becoming institutionalized in American universities, members of the science and engineering departments were seeking to professionalize their vocation. A private scientific consultancy to the government on technical and military matters was created in 1863 and named the National Academy of Science (NAS). Specialty societies were organized shortly after the NAS in the areas of mechanical engineering (the American Society of Mechanical Engineering in 1880); electrical engineering (the American Institute of Electrical Engineers in 1884); and chemical engineering (the American Institute of Chemical Engineers in 1908--offshoot of the American Chemical Society and focusing its energies specifically on the promotion of industrial chemistry). An umbrella group for the development of engineering generally was established in 1884 called the Society for Promotion of Engineering Education (SPEE) (Noble, 1977:36, 45). Thus, by the close of the nineteenth century, methodist science with its practical orientation had penetrated into the academy, introducing specialization and disciplinary differentiation in the intellectual organization of universities. The professionalization of scientists and engineers complimented the new intellectual organization and set the academy on the path of industrialization. While corporate leaders, especially by use of their capital, heavily influenced the development of science and the academy, the industrialization of both was to a significant extent an internally led movement. The industrial focus of modern science was not at all an alien one, and it certainly was not imposed upon an unwilling, resisting university system.

As the academy imitated industrial processes of specialization and differentiation, the enterprise system began to employ scientific ideas and structures in the organization of production. The energy sector took the lead in merging the two, and between 1890 and 1910 corporate schools were developed at General Electric and Westinghouse, as well as American Telephone and Telegraph. These early school experiments served as models for the incorporation of science and engineering into the electrical, chemical, communications and other high technology industries. One of the most successful of these schools was GE's Test Course program. Begun by Charles Steinmetz, director of educational activities at General Electric and early president of the National Association of Corporation Schools, the Test Course was intended to complete the training of engineers whose university instruction was largely restricted to "blackboard fundamentals." Corporate schools which could afford the equipment for laboratory and hands on technical experience were able to provide "state of the art" instruction (Noble, 1977:171). While emphasizing application and serving to socialize young engineers into the corporate culture, instruction in basic research was also provided: the Test Course "originated from the experience that in the work of an electrical manufacturing company to secure efficiency to carry out operations, a theoretical knowledge is necessary" (quoted in Noble, 1977:171). The inclusion of scientific theory and engineering practice *within* the corporate organization was by design: the Test Course was "not a philanthropic question...it is merely a necessary part of the work of the corporation...it is part of the corporation" (quoted in Noble, 1977:171). The aim of these schools was to internalize research within business organization so that it might more directly serve the economic goals of enterprise.

A second approach to the development of a science-industry alliance was the establishment of university-industry partnerships. Robert Kennedy Duncan from the University of Kansas pioneered the idea, creating the Industrial Fellowship program in 1907. Duncan intended the program to correct what he saw as a serious shortcoming of factory research, namely that business management did not know "how to treat a man of science in his factory in giving him either power or trust" (quoted in Noble, 1977:123). But by this, Duncan did *not* mean that industry should learn how to support scientists' research agendas. As conceived by Duncan, scientific autonomy referred only to the organizational and analytical aspects of research; in the Industrial Fellowship Program, decisions on research topics were exclusively the domain of those supporting the program. Indeed, Duncan regarded the partnership as a purchase of scientific expertise by a commercial interest. Under the program, a university scientist would be contracted by the company for a specified period (Noble, 1977:123):

> [The scientist] was appointed for a two-year period to work exclusively on a problem defined by the sponsoring company, which would underwrite the cost. Any discoveries made during the fellowship period became the property of the company, and all patents were assigned to it. The fellow...was permitted to publish his work in a manner which did not, 'in the opinion of the company injure its interests'.

Several universities adopted this partnership approach, among them the University of Pittsburgh, which created the Mellon Institute of Industrial Research in 1913; the Purdue Research Foundation created in 1930 at the university's West Lafayette campus; the University of Chicago; and the regional partnership developed at Batelle Memorial Institute in 1929 which linked several midwestern university scientists with area manufacturers. Perhaps the most active corporate promoter was the Du Pont Company which funded several university partnership programs (Noble, 1977:122-124).

The creation of a basic research apparatus within the industrial organization represents a further extension of the science-industry partnership. Edison had pioneered the idea of profitably synthesizing science and industry, bringing together scientists, engineers, lawyers and financiers. While Menlo Park had an avowed entrepreneurial purpose, it was also the beginning of organized science applied to the task of invention. Edison's creation, as Frank B. Jewett (an official of AT&T and future president of the National Academy of Sciences) later reminisced, had arisen out of the recognition that industry had "outgrown its ability to progress wholly on the basis of random invention" (quoted in Noble, 1977:115). However, planned invention lacked an industrial organization for long-term research and development. As U.S. business took on a corporate form and scale, it "had reached a stage," Jewett declared, "in which it was clear that some other kind of attack on problems had to be made" (quoted in Noble, 1977:116). Large-scale industrial laboratories were an important response to the problem. The electrical industry led the way in this regard once again, but soon industries in a variety of areas followed suit, including chemicals, rubber, automobiles, and petroleum. The GE Laboratory was established in 1900; Dow in 1901; Du Pont in 1902; Westinghouse in 1903; AT&T in 1907 (incorporated as Bell Labs in 1916); Goodyear in 1908; American Cyanamid in 1909; General Motors in 1911; and Eastman Laboratories of Kodak in 1912. Major oil companies such as Standard

Oil (New Jersey), Shell, Gulf, and the Universal Oil Products Corporation established labs in the 1920s (Noble, 1977:112-118).

For the scientists who entered industrial laboratories instead of staying in the university, the distinctions between their work and that of academic researchers had to do with organization, motive and resources. A "product" approach to science, a more economically oriented and business-like organizational structure, and the large-scale capital investments available for research and equipment were strong attractions to newly graduated scientists. Development and research expenditures in the Bell system alone amounted to over $2.2 million in 1916, and with substantial annual increases this figure reached over $23 million in 1930, "far bigger...for scientific research than any single university in the country" (Maclaurin, 1949:156,159).

While the comprehensive integration of science and industry was to await World War II, the prospect of organized industrial laboratories was hailed for its contribution to science by both communities for society (Gifford, 1925:91-93):

> So large a laboratory staff, adequately supplied with the best equipment, provides an exceptionally powerful instrument of research...The large

> laboratory, working to a single end, as contrasted with the individual worker, seems to present a definite stage in an evolutionary sequence. In it the many highly trained individual minds are fused into one composite mind...Some day it will be possible to state the gain in effectiveness which such a closely knit association provides but in the meantime there can be no doubt that the gain exists.
>
> The present day complexity of the telephone plant is such that very few problems involve experts in but a single field...the investment of more than a million dollars, and an improvement contemplated in one element may echo back and forth through the plant to such an extent that hundreds of experts in different departments are needed to decide the best procedure.

Other attempts at integrating science, engineering and industry popular at this time included schools supported by trade associations and the cooperative course movement. As to the former, several industries sought to create a common facility for member businesses such as the National Foundrymen's Association in Indianapolis; the Railway Education Bureau; and the National Metal Trades Association which established an apprentice school for machinists in Cincinnati (Noble, 1977:178). The cooperative courses movement began at the University of Cincinnati and sought a utilitarian expression for the increasing overlap in interests of industry and science. Originally focusing on the electrical and machinery industries in the metropolitan area, it was so successful that it established extension programs as far east as Boston. The courses focused on a specific industrial need and often were tailored to meet the demands of a specific business organization. One purpose of the cooperative course plan was to insure that the eventual industrial engineer would acquire "valuable knowledge of the labor problem, and of time as being the very essence of commercial production" (quoted in Noble, 1977:186). According to Noble, over twenty universities had developed cooperative courses by 1929, among them Northeastern University, the Universities of Akron, Georgia, Louisville, Georgia Institute of Technology and Antioch College (1977:187).

As science, industry and engineering cooperated closely in the assembly of a socio-technological system, it was clear to all concerned that certain rules were needed to govern the most practical expression of this cooperation, namely the manufacture of the technology. Early on, the national government saw the need for common rules, particularly in the manufacture of military armaments. To standardize the "product" and the "inputs" from various suppliers, the government created an Office of Weights and Measures in 1836 to give a uniform definition to the elementary quantities of technological production. The need for interchangeable parts and standard issue in the military had its civilian counterparts by the late nineteenth century. To address this need, the National Academy of Science recommended that the Office of Weights and Measures spearhead a development of national manufacturing standards. This recommendation was realized with the creation of the National Bureau of Standards (NBS) in 1902. The establishment of NBS was hailed by science as well as industry as a fundamental step toward technological progress. The National Academy of Sciences, the American Association for the Advancement of Science, the American Physical Society, the American Chemical Society, and the American Institute of Electrical Engineers were all strong supporters of the Bureau. There were a variety of other contributors to the standardization movement. Most trade associations established standards committees in the latter part of the nineteenth century to encourage mass production of machinery. Thus, the American Society of Mechanical Engineering in 1884 created the Committee on Testing to coordinate standards for measurement and terminology; in 1898 an American section of the International Association for Testing Materials was formed (later renamed as the American Society for Testing Materials); and in the same period, the American Institute of Electrical Engineers and the American Chemical Society organized standards committees charged with the responsibility of defining electrical and chemical standards for manufacturing. Henry S. Pritchett, one-time president of MIT captured the sociological meaning of the standardization movement (quoted in Noble, 1977:75):

> We are the victims of looseness in our methods; of too much looseness in our ideas; of too much of that sort of spirit, born out of our rapid development, perhaps, of a disregard or a lack of comprehension of the binding sanction of accuracy in every relation of life...Nothing can dignify this government more than to be the patron of and the establisher of absolutely correct scientific standards and such legislation as will hold our people to faithfully regard and absolutely obey the requirements of law in adhesion to those true and correct standards.

The integration of science and industrial concepts and practices was not confined to technical matters alone. The development of "scientific management" principles proved to be at least as significant. Importantly, scientific management emerged as an academic and industrial discipline at nearly the same time that engineering found its way into the two institutions. The first Masters of Business Administration programs appeared in the 1890s and Harvard opened its Graduate School of Business Administration in 1908 (Chandler, 1977:467). Industry associations borrowed the cooperative course idea, developing shared training programs in management, accountancy, and operations. The American Institute of Banking, the Insurance Institute of America and the American Management Association (originally the National Association of Corporation Schools) all sought to promote a management orientation which would increase "the efficiency of the human machine" (E.A. Deeds, an official of the National Cash Register Company, quoted in Noble, 1977:179). Engineering and management combined to reform industrial organization in the image of efficiency (in fact a new field was christened--efficiency engineering). One of the strongest and most successful advocates for this one-dimensional organization was Frederick Taylor, whose time and motion studies provided the means for management to usurp the role of expert from those who had direct knowledge about how the work was done. While industrialization had stimulated routinization of work and had divided the workplace into a hierarchical system of owners and workers, it was still the case that the most accurate knowledge about work resided with those who carried it out. Taylor's genius was to discover how management could take control of the definition of work by breaking it down to its most elemental non-specialized forms, namely, the motions required to complete a task and the time it took. Thus, with the support of science, analytically and ideologically, industrial organization assumed the role of producer not only of things but of "man-stuff": "[corporations] no longer expect to find satisfactory help ready-made, but are now applying themselves to the task of making men as well as commodities" (F.C. Henderschott, Educational Director of Consolidated Edison of New York quoted in Noble, 1977:178-179).

By 1910 a common social agenda existed for science, industry and engineering. All three were dedicated to the promotion of technological progress as the necessary prerequisite for social development. A de facto St. Simonian Parliament of Improvement had evolved with commitments to standardization, scientific management, professionalization, industrialization of science, and scientific organization of industry. But while linked by a common ideology and world view, science, engineering and industry maintained a degree of organizational autonomy. University science continued to perceive its function as long-term non-commercial research, while industry stressed the utilitarian aspects of science in the production system. Engineering acted as the mediator between the two organizations. With the breakout of World War I, important weaknesses in this pattern of relative organizational autonomy were soon exposed.

5.2 Science-Industry-State Wartime Cooperation

World War I partly represented an extension, although at a more rapid rate, of earlier technological tendencies. But this period also demonstrated the need for a greater level of cooperation among the institutions of science, industry and engineering. The war provided opportunities for tackling problems of fragmentation and segmentation that resulted from the state of relative organizational autonomy existing among these institutions. In this regard, the military emerged as a new partner able to better ally the interests of science, engineering and industry toward a common technological effort.

As has been well documented, World War I changed the nature and methods of war-making. War was no longer battles among armies, but a "total war" involving all social and economic sectors. War now required the complete militarization of industrial production, education and training, science and research. Dupree argues that two trends were set in motion by the events of World War I (1986:302):

> The first was the tendency to large-scale mechanized industry which geared the whole economic and social life into a common effort of total war. The second was the application of scientific knowledge and methods to the technology both of weapons and industry.

Social capacities to organize and centrally direct industrial production, schooling and training, research and technological development were all successful components for a successful military effort. An industrialist underscored the importance of organization and control direction with the following analogy (quoted in Cuff, 1972:235):

> Whether we go out to mobilize American industry or to sell forty million dollars worth of Hudson Motor Cars, the general principles of procedure must be much the same. We must work fast and we must over-ride obstacles quickly and perhaps ruthlessly.

To achieve a common effort in war, society needed to accept the challenge to, as one writer put it (quoted in Noble, 1977:207):

> [E]nvision an entire community as a single working plant...The war is opening many hitherto blind eyes to see that each gains more than he loses when he merges his strength with the might of all in an organization that is constructed for the purpose of releasing creative energy by giving each the work he is best qualified to do.

A special responsibility fell to scientists and engineers in reorganizing society to this end. As both "masters of the mechanic arts and moulders of men" (in Noble, 1977:207), this class was called upon to provide leadership in the mobilization of social and economic activity.

Inroads at universities in the standardization of curricula and admissions policies, and personnel classification of scientists and engineers had prepared the way for such leadership to be supplied. Dating from as early as 1902, universities had investigated student rating, testing and classification schemes. Cornell's engineering program was an early pioneer in developing student profiles which could be used to match graduates to different jobs. Purdue expanded the information collected on its students to include not only indices of scholastic performance but of character traits such as loyalty, efficiency and adaptability (Noble, 1977:198). These placement schemes represented first efforts at developing classification systems for scientific and technical personnel.

In the early twentieth century, universities also became interested in methods to evaluate scientific departments and curricula. The Society for the Promotion of Engineering Education created the Joint Committee on Engineering Education in 1906 to coordinate accreditation activities and procedures. In 1911, the Joint Committee acquired funds from the Carnegie Foundation for the Advancement of Teaching to conduct a comprehensive study of engineering education (Noble, 1977:203). An outgrowth of this study was the definition of national guidelines for accreditation of university departments and the development of admission standards.

Taken together, these efforts constituted a system of personnel standardization and classification. Through admissions, accreditation and testing policies, universities sought to mass produce scientists and engineers in the same manner as a factory produces cars or other desirable things. With the outbreak of World War I, the military value of mass produced technical personnel became obvious. But a series of organizational barriers and peculiarities stood in the way of effective utilization of science and engineering talent. The industrial sector and its leaders were not easily integrated into this common social effort.

The guiding principle throughout the war was the consolidation of effort among university, industry and government sectors. Consolidation required suspending or revising legal and economic distinctions between "private" and "public" organizations, and relaxing restrictions against "monopolistic" strategies. In this direction, specific steps were taken during World War I to exempt science-based industries from anti-trust provisions of the

Clayton Act. By design, corporate cooperation in research was encouraged, including activities which would strengthen the postwar market positions of a few companies. Bell Telephone, General Electric, Westinghouse and other science-based businesses had already successfully used the patent system to create corporate monopolies. The success of these organizations was cited as justification for government action to consolidate industrial activities in radio development. At the encouragement of the U.S. Navy, which sought a radio-based system of submarine detection, President Woodrow Wilson met with executives of General Electric to design a strategy for securing an American monopoly on radio technology. GE was given federal approval to exercise patent rights over certain radio technologies that would prevent progress in development of this field by other U.S companies and, most importantly, by the British Marconi Company. Further, GE was given clearance to set up the Radio Corporation of America (RCA) and to transfer GE-owned radio patents to this enterprise (Noble, 1977:88-94). Just as in the case of the petroleum industry, the coordination of the electricity industry was regarded as necessary to meet the needs of a nation at war.

Ideological resistance to this consolidated system of science, industry, government and the military was dispatched by a new doctrine of national security which emphasized standardization and simplification in the industrial sphere in order to reduce "inefficiency." The Council of National Defense (CND), consisting of the Secretaries of Navy, Interior, Agriculture, Commerce and Labor was formed in 1916 to "coordinate industries and resources for the national security and welfare" (quoted in Dupree, 1986:305); an advisory committee to the CND was also formed which included Daniel Willard, president of the Baltimore Ohio Railroad; Julius Rosenwald, president of Sears Roebuck; Franklin Martin of the American College of Surgeons; Samuel Gompers of the AFL; Hollis Godrey, president of Drexel; Howard Coffin, vice-president of Hudson Motor Car Company; and Walter Gifford of AT&T (Dupree, 1986:305). Replaced by the War Industries Board, this organization was responsible for "establishing uniformity in the manufacture of materials, machinery and parts" (Noble, 1977:81). To implement this responsibility, the Board organized a technical and consulting staff at the Mellon Institute at Pittsburgh to identify means of simplifying and standardizing the production process. Engineering organizations were similarly mobilized to promote standardization and simplification. In 1918, the American Engineering Standards Committee was organized by the mechanical, electrical and mining engineering societies and the American Society for Testing Materials. The representatives of the U.S. Departments of Commerce, War and the Navy were invited onto the committee and officials from numerous trade associations, private companies and professional societies also joined. The Committee held a quasi-governmental status focusing originally on the promotion of engineering standards, but its chairman soon judged this to be "too narrow and impractical in view of the growing need for national standards in nearly all spheres of economic activity" (quoted in Noble, 1977:80). Moreover, consolidation initiatives were not limited to governmentally inspired ones. In 1916, Magnus Alexander of General Electric, with colleagues from Westinghouse, AT&T and the National City Bank of New York, formed the National Industrial Conference Board. The Board was designed to serve as "the research arm" of U.S. industry and represented "the largest cooperative undertaking of American employers up to that time" (Noble, 1977:52). Together, these wartime structures implemented the "single working plant" concept of society.

Still, a nationwide single working plant staffed by scientists and engineers drawn from industry and universities needed a director. War preparedness presented an unassailable rationale for close industry, science and government collaboration, but as late as 1916 the United States still had no central agency to direct this collaboration. The closest approximation was the Naval Consulting Board (NCB). Created in response to Thomas Edison's call for a national facility for gathering and coordinating technical research in support of military needs, the NCB was intended to supply the machinery appropriate for modern warfare (Noble, 1977:148). The membership of the NCB was drawn from the engineering, invention, technology and military communities and was intended to provide a mechanism for "practical" men to contribute to the war effort. The NCB was chaired by Edison, with representatives from the eleven largest engineering societies and industrial leaders such as Willis R. Whitney of General Electric; Leo H. Baekeland, inventor of Baekeland Plastics; Frank J. Sprague, the developer of the electric trolleys; and Elmer Sperry of Sperry Gyroscope (Dupree, 1986:306). Notwithstanding its professed practical orientation, the NCB achieved little. While it received over 100,000 invention proposals in its capacity as the national clearinghouse for war-related technical innovations, it considered only about 100 to be worthy of investigation, and guided only one into production (Noble, 1977:149). Its attempt to tackle a major technology project in the submarine detection field met with no better results. Although the NCB was able to successfully lobby for the first national laboratory (to study sound detection of submarines), this facility was to be shared with General Electric and the Submarine Signal Company and managed by its corporate partners. Civilian government, military and industrial research were coordinated through a government research station at Nahant, Massachusetts.

This arrangement created two problems. First, the corporate partners were keen to reserve patent rights for themselves on any invention that might be forthcoming; therefore, they were reluctant to cooperate with scientists not affiliated with this effort. Indeed, Admiral Griffin explained the exclusion of academic scientists from the project as necessary to avoid patent complications (Kevles, 1987:120). This led to a second *political* problem as excluded science groups challenged the legitimacy of the NCB project. Eventual Nobel Laureate in physics, Robert A. Millikan, doubted that the NCB would find the best and quickest solution since some of the brightest minds were not involved. In the end though, the most important dilemma for the NCB research effort was its lack of progress and the growing belief among scientists that the "wrong" research path had been chosen. A different institutional effort was needed, one which recognized the problems of technology development as problems of basic research.

5.3 The National Research Council Initiative

Such an alternative, grounded in a philosophy of basic research, was being advanced by George Ellery Hale, MIT graduate, Foreign Secretary of the National Academy of Sciences and director of the Mount Wilson Observatory. Hale looked to the prestigious and influential European scientific societies, particularly the French L'Academies des Sciences and the Royal Society of London, as symbols of scientific preeminence. Since his election into the National Academy of Sciences in 1902, he had been actively promoting an agenda for scientific reform that also preserved the individual scientist's autonomy from external domination. Less enchanted with the French approach in which control and direction over science was shared with the government, Hale believed that the Royal Society and its "tradition of individualism" provided a more suitable model. Without such centralized coordination, American science had fragmented. Its focus of inquiry had become "too interested in the details and the merely technical elements of investigation" and consequently unable "to see the woods for the trees" (Kevles, 1976:280).

Hale's vision for the advancement of U.S. science was to emulate the Royal Society. The American effort at imitation through the formation of the National Academy of Sciences (created during the Civil War) had failed to elevate American science to the prestigious level it occupied in Europe. The NAS was little used and had no role in influencing government policy. Between its inception in 1863 and World War I, the national government had requested its assistance on 51 occasions, but as Kevles observes, "only four of them had been in the twentieth century, the last in 1908" (Kevles, 1976:281). Its function was largely honorific (one observer characterized it as a "blue ribbon society") and its advice was usually treated as "theoretical" (Kevles, 1976:281). As the United States prepared for War, NAS appeared moribund (Noble, 1977; Kevles, 1987), hardly the sort of institution that would provide leadership in forging the science government partnership.

Hale recognized the problem and became an advocate for the creation of a national research agency which would receive governmental support. "Great results," in national research, he believed, would hinge upon the organization enjoying "the active cooperation of the leaders of the state" (Kevles, 1976:280-281). However, in Hale's view, the individualist ideology of American society generally, and of scientists in particular, precluded a directive governmental role. Instead, as Hale saw it, government would provide coordination while the research agenda and research directions would be defined by scientists themselves. Acting as the "J.P. Morgan of American science" Hale launched a political campaign for the creation of a National Research Council. World War I presented a nearly ideal circumstance for implementing his vision. Science and technology were instrumental to the success of modern war. As Hale declared, "War should mean research" (Kevles, 1987:116). Although cooly received initially, Hale eventually persuaded President Woodrow Wilson to establish the National Research Council (NRC). In his announcement creating the NRC in July 1916, President Wilson declared: "Preparedness, to be sound and complete, must be solidly based on science" (Kevles, 1987:115). His Republican challenger in the 1916 campaign, Charles Evans Hughes agreed: military readiness, Hughes argued, depended upon "promoting research and utilizing science" (Kevles, 1987:115). To avoid being ignored, as had occurred with NAS, Hale linked NRC's activities directly to governmental needs. Through the NRC, science and technology would abandon "the passive and pristine" intellectual world of the "academic state" and would become involved first hand in the defense of the nation. Wilson's emergency order specifically directed the NRC to mobilize science to serve "the national security and welfare" (Kevles, 1987:112).

The NRC was not without its detractors. Some in the scientific community charged that the Council was militaristic, but Hale countered that science "should give our soldiers and sailors every legitimate and every means of protection (Kevles, 1987:113). But the real challenge to the NRC was the Naval Consulting Board. Although the Council of National Defense had designated the NCB as the "board of inventions" and the NRC as the organization for research coordination and mobilization of scientific resources, conflicts between the two agencies were manifold (Noble, 1977:153). It was only with the poor performance of the NCB in developing a submarine detection system that the NRC was finally able to implement its responsibilities. The NRC was authorized to set up its own research laboratory in New London, Connecticut to investigate submarine detection technologies. The key difference between the New London and Nahant operations was the existence of substantial university personnel at the former. Yale, University of Chicago, Rice, Cornell, University of Wisconsin Harvard were all represented in the NRC project. While conventional means such as depth charge mines and convoy systems were far more effective than radar in actually neutralizing submarine attacks, the New London research program inaugurated a new era of science-government collaboration. As Dupree observes, the common research effort at New London, centrally directed by the military, signalled a new way of thinking about science and technology and a new model for its national promotion (Dupree, 1986:319):

> The very approach to the [submarine detection] problem as one that could be solved only by massed and coordinated scientific resources demonstrated clearly that a new era of warfare had arrived and that science had an essential place in it.

Anticipated tensions between academic freedom and scientific "individualism" on the one hand, and military requirements of secrecy and central direction on the other, proved to be tractable. One particularly successful approach for resolving the apparent conflict was to eliminate the civilian-military distinction. Hale was assisted in his promotion of the NRC by Robert A. Millikan, a physicist at the University of Chicago and eventual Nobel Laureate. When University physicists were slow to join the NRC effort, Millikan, who was then serving as the chief administrative officer of the Council, was persuaded to take an officer's commission in the U.S. Army with the intended result that "soon many of the nation's scientists and engineers also donned military uniforms" (Noble, 1977:153). The NRC spearheaded the military-science collaborations in several other fields including aviation, photography and communications, and gas masks. Because it was responsible for the mobilization of all science resources, the NRC tapped industrial as well as university personnel and facilities to serve the national defense. Again its achievements in these fields were relatively minor, but its significance was in the demonstration of how to effectively organize a military-science-industry partnership. As Kevles observes (Kevles, 1987:282):

> The Council had persuaded many government agencies, traditionally jealous rivals, to cooperate. University and industrial laboratories, historically remote from the government's needs, were working on military problems. The bureaus of the Army and Navy, normally hostile to advice from non-military sources, were now paying attention to the ideas of academic and industrial scientists. The NRC's results reinforced the

> value of cooperation. The Council's scientists were developing myriad weapons, devices, and techniques for the military. Physicists could point to instruments for the detection of submarines; chemists to apparatus for gas warfare; psychologists to methods for the efficient assignment of personnel. Scientists from many disciplines were making their contributions. The Research Council, in short, had brought about an unprecedented and fruitful collaboration of university and industrial scientists with the military.

5.4 Mental Engineering

The NRC focused scientific thinking not only on war technology, but also on war management. One of its few accomplishments was the creation of a personnel classification system to identify and route scientific and engineering personnel. Building upon the personnel infrastructure created at universities and by professional societies, the NRC, NCB and CND worked together to devise personnel indices of available scientific manpower. In 1917, the Intercollegiate Intelligence Bureau (IIB) was established under the direction of Dean William McLellan of the Wharton School; CND Director Walter S. Gifford (later president of AT&T); Surgeon General William Gorgas; and the Secretaries of War and Navy. The purpose of the IIB was to "facilitate the ready placement of college men in the government service" (quoted in Noble, 1977:207).

To university and industry leaders, the military draft represented a serious threat to the effective use of scientific resources. To avoid depletion of this precious resource, the CND with the help of the NRC and others successfully lobbied for the creation of the Student Officers Reserve Corp which permitted students in engineering, medicine and agriculture to complete their studies as part of their officer training. With the expansion of the U.S. military's role in World War I, the War Department sought a more comprehensive mechanism for mobilizing "grades" of technically trained personnel in support of the war effort. To develop training courses and programs, the War Department enlisted educational directors of AT&T, Western Electric and Westinghouse (Noble, 1977:215). The Student Army Training Corp (SATC) was created in 1918 and, when the draft age was lowered to 18, the Corps program became a requirement on university campuses. The compulsory SATC program placed the entire American university system under War Department direction (Noble, 1977:220, 221):

> The colleges became cantonments and the students became soldiers...[a War Department agency] now actually took charge of all colleges of liberal arts, technology, business, agriculture, medicine, law, pharmacy, dentistry, veterinary medicine, all graduate schools, and all technical institutes in the United States. American education was placed under military authority of the educational and personnel directors of corporate industry and the leaders of the new corporate brand of engineering education.

Principles of scientific management were applied not only to the classification of technically trained personnel, but broadly to personnel of every kind required by the war effort. The challenge was succinctly defined by an historian of the period (quoted in Noble, 1977:208):

> Under war conditions, men were received by the hundred thousand...the new system had to be like a great factory where each process is separated and volume production is assured through rigid functionalization and organization. Men had to be sorted, recorded, and assigned as goods in some great warehouse and received, checked, sorted, and shipped on order.

Prior to the war, the rating systems conducted by the Carnegie Institute of Technology's Bureau of Salesmanship Research, with the cooperation of the National Association of Corporate Schools (NACS), resulted in a general-purpose rating system which was then developed and implemented by several companies including United States Rubber, Metropolitan Life Insurance, Cheyney Brothers Silk Mills and Winchester Repeating Arms. In the summer of 1917, the Committee on the Classification of Personnel (CCP) was established in the War Department for the purpose of classifying army personnel "according to their industrial abilities" (Walter Dill Scott, Carnegie Institute of Technology quoted in Noble, 1977:208). Building upon the CIT-NACS work, the CCP developed a comprehensive personnel rating system, identifying 84 separate trades, defining training needs by trade, and preparing testing procedures to match army personnel with the most appropriate position classification. The NRC assisted the CCP in the development of the Army classification system, perhaps its most interesting contribution coming from the work of its Psychology Committee which prepared psychological and personality tests to screen recruits. Research in behavioral psychology was employed to develop a new technology of "mental engineering" (quoted in Noble, 1977:228-229):

> The service of psychological examining in the Army has conspicuously advanced mental engineering and has assured the immediate application of methods of mental rating to the problems of [personnel] classification and assignment...

5.5 Conclusion

The war provided an unparalleled opportunity for science and technology, industry and the military to cooperate in the organization, classification and standardization of American society. Psychological and material, industrial, scientific and technological, public and private--all had blended if not merged in the "single working plant" environment of the war. As Dupree has argued, World War I utterly transformed science and its relation to society (1986:323):

> Although the entire period of the upheaval lasted no more than three years and hostilities less than twenty months, World War I had profound

> effects on every part of American science, whether supported by the government, by the universities, or by the foundations. The first major result was the infusion of research into the economy, especially into production, so thoroughly that industrial research as a branch of the country's scientific establishment dates its rise to eminence almost entirely from the war period.
>
> The second major result was the use of cooperative research on a large scale. American scientists became accustomed to working together for the quick solution of an immediate problem. Not only did specialists learn to work with others like themselves, but they rubbed shoulders across the lines of the accustomed disciplines, often much to their own enlightenment...[I]t became the common experience of a whole generation of scientists--the ones who shaped institutions not only in the 1920's and 1930's but during the second World War as well.

While much of the organizational framework would unravel with the end of the war, the validity of the model remained for most of its principals. When given a second opportunity with the arrival of World War II, the leadership of the science, corporate and state sectors were able to quickly assemble a "single working plant" and coordinate efforts for the prompt delivery of the most advanced technology in the world--the atomic bomb.

CHAPTER 6

THE ALLIANCE OF TECHNOCRACY, CORPORATISM AND THE STATE

The conclusion of World War I brought mixed results for the military-science-industry partnership. Direct support of research by the military ended. A war preparedness ideology, which had initiated military funds and directed research, was no longer applicable and public sentiment turned to the civilianization of these activities. Relatedly, the university-military cooperation of the war period also diminished as higher education returned to its traditional roles. Post-war criticism of the military discouraged scientists from adapting "warfare as a field for the application of their knowledge" (Dupree, 1986:333). In this regard, neither the military nor the university found postwar collaboration very attractive.

At the same time, substantial portions of the partnership infrastructure remained and were even expanded. Technical standardization and personnel classification were continued as vigorously after the war as before. Much had been learned through military experiments in these fields that could be easily applied to industry. The U.S. Army accelerated its use of these techniques of organization. Moreover, the importance of national research laboratories was established by the war, and their development continued apace afterward. The submarine detection facility in Connecticut became the model for the Naval Research Laboratory established in 1923. Although at a reduced scale, other research facilities were also maintained. As Dupree notes though, the armed services remained reluctant to become significantly involved in research.

6.1 Between the Wars

Most research on the period between the world wars concludes that science and technology made few inroads at the national policy level, and that a degree of institutional fragmentation resumed (see for example, Dupree, 1986; Auerbach, 1965; and Kargon and Hodes, 1985). Even so, important progress did occur in two technocratic areas. First, an ideology of national science was sustained in part by the installment of the NRC as a permanent arm of the National Academy of Sciences with a full-time salaried chairman "equivalent...in rank to a university president" (Kargon and Hodes, 1985:307). The institutionalization of the NRC facilitated "a web of relationships linking major American power centers: financial and corporate giants, the leading private philanthropies, the great universities and technical institutions, and, to a much lesser extent, the federal government" (Kargon and Hodes, 1985:303). Second, an emphasis on management and planning which had been so central to the war effort, received widespread support in the technocratic order throughout 1919 to 1939. The stagnation of western capitalism and the social crisis of the Great Depression attenuated interest in national planning and provided political pressure for the displacement of entrepreneurial economics with a managerial one.

Science had played a valuable role in the war effort, and its leaders now sought to apply its methods and ideas of science to peace and social reconstruction. The science-industry linkage established in the early part of the twentieth century was identified as the starting point for reconstruction and Germany, America's recently vanquished foe, became a model for science-industry cooperation. As Henry Pritchett, president of the Carnegie Foundation for the Advancement of Teaching observed (quoted in Noble, 1977:157):

> In the United States, the relations between research men in the university and institutes of of research and those operating industrial plants have not yet come to a stage as intimate and fruitful as that which has existed for many years in Germany. It is today a part of our plan of progress for the future to establish such relations that the investigator and the manufacturer shall understand each other and shall cooperate for the promotion of science and industry.

Accomplishing such an intimate relationship would require some alterations in the U.S. political system. Hale noted in a May 1919 memorandum to the NRC's executive council, that a certain level of "resource coordination" would be necessary "for the sake of enabling the United States, in spite of its democratic, individualistic organization to bend its energies effectively toward a common purpose" (quoted in Noble, 1977:154). Noble argues that the NRC's "extrapolitical" yet "official" status enabled it to perform the role of bringing together "management-minded engineers and business executives who were used to coordinating and directing the affairs of men from the top, without inefficient democratic mediation" (Noble, 1977:154).

Two other factors facilitated the development of a national science in support of a national industrial system. First, science itself has always been exempted from traditional "democratic" controls in industrial societies.

The pursuit of truth and excellence, the supposed ideals of science, have traditionally been regarded by a wide array of political interests as in some fashion *above* those of democratic consensus and accountability. If the effectiveness of science, therefore, depended upon special organizational relationships and structures, it was unlikely that political obstacles would long stand in the way. While the special political status of science smoothed the way for a national science-industry linkage, the common interest of each institution in efficiency cemented the relationship at a substantive and ideological level. Science and industry shared a vision in which the "one best way" represented both an institutional goal and a measure of institutional achievement.

Not surprising, the first order of business for the NRC after World War I was the improvement of industrial productivity. It undertook this goal by focusing its coordinating efforts on the fields of personnel classification and standardization of vocational terminology. The NRC's work in the personnel field reflected a Taylorite view of industrial harmony predicated upon elimination of waste and the maximization of production. Postwar dislocations and industrial reconstruction were seen by the NRC's divisions as raising problems of "scientific selection, assignment, and promotion of employees." The Council created a Committee on Industrial Research to investigate the "causes of labor unrest and resultant excessive high turnover, low production and high costs" and "the psychological and pathological aspects of labor problems relative to health, efficiency, and productiveness in industry," and "the analysis, classification, and specification of industrial employments" (quoted in Noble, 1977:229). The Committee's efforts led to the establishment of two national organizations. First, a Personnel Research Federation was created to standardize "human material" so that more efficient industrial organization was possible. Through the creation of the Federation, the NRC successfully coordinated the personnel researches of an extraordinarily wide array of organizations: the American Federation of Labor, the Bureau of Industrial Research, the Industrial Relations Association of America, the Taylor Society, the National Bureau of Economic Research, Carnegie Tech Bureau of Personnel Research, the National Industrial Conference Board, and the U.S. Bureau of Labor Statistics (Noble, 1977:230). In addition, the NRC was instrumental in establishing a National Board of Personnel Classification with responsibilities for standardizing job specifications. The Board's classifications provided universities and vocational schools with clearly defined job objectives thereby allowing them to develop precise training courses and curricula. With the creation of these cooperative personnel research organizations, a major step was taken toward resolving the problem of, as one writer put it, "the weeding out of the unfit and the adjustment of the pegs" (Dean Walker, University of Kansas, quoted in Noble, 1977:234).

The NRC was able to solidify its position as the national promotional organization of science. But its organizational status did not lead to the powerful role envisioned by its architects. Throughout the postwar period, the NRC was forced to rely on foundation funding of modest amounts for its projects and found itself in constant competition with research programs scattered throughout government agencies. Until World War II, the U.S. government was unwilling to accord the scientific establishment a visible leadership role. The national Science Advisory Board, for example, was allowed to languish as permanent funding was withheld (Kargon and Hodes, 1985). Similarly, efforts to create a federally funded "National Program for Putting Science to Work" during the Depression floundered (Auerbach, 1965:471-476), in part because science was suspected by some elements of the government as responsible for overproduction in the years immediately preceding this economic collapse (Dupree, 1986:344-350). Despite the failure to secure governmental recognition, the idea of a national science had been legitimated and an organizational precedent for its pursuit had been established.

6.2 The Managerial Economy

Since the beginning of the twentieth century, a new organizational form has asserted itself in the U.S. production system. Characterized by Berle and Means as a form of economic empire without geographic limit, the distinctive attributes of this organizational form are: separation of ownership and management, centralization of control, diversification of functions, and technicization of decision-making. The "private corporation" first appeared in the United States in 1813 with the formation of the Boston Manufacturing Company. By the end of the century, the U.S. Census reported that this organizational form had spread to such an extent that it accounted for nearly two-thirds of the production of all manufactured goods. By 1919 that figure had grown to 87 percent (Berle and Means, 1933:14).

The private corporation achieved its dominance by exploding the "atom of prosperity" (Berle and Means, 1932:8). For three centuries economic life was organized by the principle of private property, that is, the ownership of instruments of production with complete authority exercised by the owner over the direction and use of those instruments. Power was vested in ownership and the central economic questions for societies dwelled upon the definition of ownership and the enforcement of property rights associated with it. The corporation is predicated on an entirely different logic. The intent of this organizational form is to disperse ownership as far as possible--"to split [it] into ever smaller units"--while simultaneously concentrating control over the organization in the hands of a central management. As Berle and Means put it, management constitutes a "centripetal" force, ownership a "centrifugal" force, and the objective of the corporate system is to maximize both forces (Berle and Means, 1932:9). The cardinal advantage of the corporate system is that it maintains an organizational rather than an entrepreneurial interest in the aggregation of wealth. Early capitalism was predicated on individually owned business, was motivated by profit, and accumulated wealth through speculative activity. The corporate system replaced this haphazard basis of accumulation with one rooted in principles of centralized control. Where the owner-entrepreneur sought to anticipate supply and demand and to marshal property and capital in ways that would beat competitors to a pool of profit, the corporate-manager plans strategies that adjust supply and demand according to the requirements of organizational stability and expansion. Competitors are absorbed or bankrupted; when neither is feasible, competition is to be avoided.

By 1920, corporations in the food, oil, electrical, rubber, chemicals, primary metals and machinery industries had integrated production and distribution (Chandler, 1977:370-371). The concentration of capital facilitated by integrated organization, enabled enterprises in these industries to manufacture and market their goods on a regional, national and even international basis. Organizationally, the energy industries had taken the lead but, by 1914, 41 American firms had two or more plants abroad. In addition to Standard Oil of New Jersey, Westinghouse, General Electric, and Western Electric, other U.S. firms such as DuPont, U.S. Rubber, Ford and International Harvester were operating or managing plants on foreign soil. Direct foreign investment equalled seven percent of GNP in that year (Chandler, 1977:368-369). The corporate mode of organization had exceeded the spatial and functional boundaries traditionally associated with markets. In fact, the geography of corporate power in many industries far outpaced that of market competition, to the point that markets themselves became territorial divisions *within* the larger economic space controlled by particular corporations.

In principle, this provided these organizations with the means for shaping market demand and thereby of integrating consumer/consumption into an organization's planning. However, corporate capacities in this latter area were neither widely nor well developed by 1920. Sharp reductions in market demand brought on by the post-war recession of 1920-1922 left many of the industrial majors with sizable inventories. Many corporations were forced to drop prices in order to stimulate demand and few avoided significant reductions in profits during the period. These events reflected the poor state of demand forecasting, marketing and planning in the corporate sector. Most firms had only begun to seriously investigate these techniques. Few had achieved a level of sophistication necessary to balance the supply potential of integrated production and distribution with the potential to manipulate demand.

Beyond these weaknesses the inventory crisis had also exposed the danger of a relatively undiversified large-scale organization. Concentrating on the marketing of only one or a few products created the risk of sizable economic losses if the corporation only moderately misjudged the market situation or general economic trends. In response, several corporations adopted a multidivisional structure in which several relatively autonomous divisions of integrated production and distribution were created for a diverse number of markets. DuPont and General Motors were pioneers of this organizational strategy in which a general office of management, financial, and technical staff coordinated activities among the divisions and determined the allocation of corporate resources to each of them. Corporations were slow to adopt this structure relying instead on mergers and holding company formations to provide them with market diversity (Chandler, 1977:456-463).

The comparatively underdeveloped capacity to control supply in relation to demand and the lack of market diversity in many corporate organizations predisposed the corporate system to overproduction. The typical response of corporations to this situation, namely, efforts to reduce wage costs through the substitution of technology for labor, brought only short-term benefits. While such a strategy enabled a firm to sell goods at lower prices and still maintain profit levels, it did nothing to correct the bias toward overproduction and at the same time it reduced aggregate purchasing power. What was rational for individual firms turned out to be irrational for the corporate order as a whole. The worldwide Depression in the late 1920s and 1930s vividly demonstrated the contradiction. The rise of the corporation, and more generally, national and even international economic stability depended upon the decisions of a smaller and smaller number of corporate executives. If their production intentions were not mutually consistent, the capacity to produce would overwhelm the capacity to consume what was being produced. When only a few corporations decided to withhold capital in the face of declining prices, a self-destructive process of underinvestment was set in motion. And there was no endogenous mechanism in the decision-making corporations to halt the economic crisis before massive unemployment set in. The Depression revealed the contradictory nature of corporate economics in manifold ways as is displayed in the following newspaper accounts (quoted in Routh, 1989:285-286):

> 200,000 unemployed in Philadelphia on verge of starvation. Relief committee dissolves owing to lack of funds...140,000 families destitute in

> New York...Chicago school teachers unpaid...unemployed man tell court of eating wild birds.
>
> American farmers first great slaughter includes 2,000,000 sows and 4,000,000 pigs...milk poured down drain...USA farmers throw away milk.

The contradiction between overproduction and widespread poverty and unemployment was addressed in the United States in two ways. First, the corporate system accelerated the development of management-based economic organization; the interior reforms of the corporate system emphasized the professionalization of management and the technicization of decision-making. Second, a national governmental role in economic planning was institutionalized. New Deal policies established an essential role for the national government in the coordination of the economic sphere. As to the former, most managers were drawn from the ranks of industrial engineers. Indeed, the first national professional organization of managers--the American Association of Industrial Management--evolved from the American Society of Mechanical Engineering. These engineer-managers were easily persuaded of the value of scientific approaches to management, planning and marketing, and an infrastructure had already been put in place prior to World War I to supply scientific-managers to industry.

The addition of business schools to universities was an important step in creating a management elite. These schools also helped to rationalize the managerial division of corporate organization. As illustrated in the preamble of a 1912 Business Policy course syllabus offered in the Graduate School of Business Administration at Harvard University, its purpose was the development of "an approach to business problems from the top management point of view" (Chandler, 1977:467). Business schools now took up the challenge of improving managerial abilities to forecast, plan and analyze demand. Two new fields were developed in the 1930s at the business schools: marketing and advertising. Training in these fields allowed managers to exploit the potential to manipulate demand as part of a general corporate strategy. These newly found skills were essential in stimulating demand for new products developed by in-house research and development staffs and were officially termed "demand activation" by the Harvard Business School (Chandler, 1977:467). In both of these ways business education supported corporate growth strategies predicated upon internalizing developmental activities and market operations (Chandler, 1977:469). Successful demand management strategies were rapidly diffused via training courses, journals and consultants, all of which were direct or indirect outgrowths of business schools. Finally, business schools were instrumental in spreading the latest techniques of decision-making. Henry Dennison, a promoter and innovator in the field of business management instruction, pointed exuberantly to the "research and experimentation progressing in the fields of scientific management, scientific merchandising, scientific selling, scientific organization," all of which depended upon continued development of the "auxiliary sciences" of economics, statistics and industrial psychology (Alchon, 1985:127).

The Depression of the 1930s speeded the management transition from the classroom to the corporate order. The largest industrials quickly implemented a strategy of diversification in which growth was sought through internal expansion. New markets and new products were developed using plant, production know-how and managerial talent, and financing of these new initiatives was accomplished from retained earnings. The most successful diversifier during the 1930s was the chemical industry, followed by electrical machinery, transportation, metals and rubber (Chandler, 1977:473-474). In each of these industries marketing and advertising were combined with industrial R&D to identify and capture markets which best employed existing production processes and organizational structures. Despite the Depression, Du Pont was able to maintain profits by selling paints, film and fibers; General Motors, by selling diesel locomotives, tractors and airplanes; Alcoa, by selling kitchenware and household appliances and radio and x-ray equipment (Chandler, 1977:473-475). By focusing on economic stability for themselves during a period of international instability, these companies proved the efficacy of the new managerialism. By the time the United States entered World War II, the economic power of these industrials had expanded beyond the reach of even the national government.

In a sense, the Depression had forced federal government leaders to realize their comparatively modest power. While governmental policies immediately before the stock market crash had certainly exacerbated the economic crisis, they represented only one source of the problem. The basic cause rested with something outside the sphere of governmental control: the extraordinary productive capacity of science and knowledge-based industry which was not being balanced by sufficient "effective demand." To address this structural condition, industry and government would need to cooperate in a very special manner. Specifically, national authorities would need to develop macroeconomic plans which were consistent with those of the corporate sector. In effect, the national government would need to adopt the perspective of the industrials to take the appropriate actions that were needed to fulfill corporate expectations. This was the gist of the "Keynesian Revolution" (Klein, 1961), even if J.M. Keynes himself was more concerned about the inherent inequality of capitalism (Keynes, 1935). For at least two generations, many macroeconomists and federal policy makers would accept the premise that the state, through fiscal policy, had to rescue capitalism from itself.

6.3 World War II: Creation of a Technology Shiva

World War II provided the setting for industry, science and government to collaborate in a manner and on a scale that is so extensive as to have blurred any remaining distinctions among these institutions. Planning became a common tool for the three sectors, not only to define their individual objectives, but to adjust interior methods and goals to meet common needs and expectations. The military played a central role in the synthesis of the technocratic system, serving as a major client of industry, a major sponsor of scientific research, and a principal source of technology transfer within the U.S. system *and* in the emerging world system. It is arguable whether this technocratic synthesis, and the military's central role in it would have occurred without developments in atomic physics and the fabrication of the atomic bomb which came together during this period. It is not arguable that atomic theory and the atomic bomb have served as the focus of technicization in such a comprehensive and fundamental a manner that no sphere of social life can escape their effect or impact.

Wilhelm Contrad Rontgen's discovery of x-rays in 1895, Henri Becquerel's experiments with uranium in 1896 and Marie and Pierre Curie's detection of radioactivity from radium in 1898 together initiated a branch of physics concerned with the development of the theory of atomic particles, structures and behaviors. European universities and research centers were the sources of most of the important investigations in atomic theory. Through the 1930s, U.S. physics research focused largely on "narrow, pedestrian experiments" and "the gathering of insignificant facts." As Kevles observes, "one out of five American publications in the discipline reported upon mere observations of natural phenomena or objects" (Kevles, 1987:36). American physics built up slowly by relying on the import of British and European scientists who were promised laboratories and funds; and by industrial sponsorship of "impractical research" (Kevles, 1987:99). Johns Hopkins, Cornell, Yale, Harvard and the University of Chicago were the principal centers of graduate training in physics, supplemented by the Universities of Wisconsin, California, Michigan, Pennsylvania, Illinois and Columbia. Industrial benefactors included the Rockefeller family, AT&T, Du Pont, Standard Oil, Westinghouse and General Electric (Kevles, 1987:79,99). Initially the American program in atomic physics was exclusively based upon a university-industry partnership. When Ernest O. Lawrence, an experimental physicist at the University of California at Berkeley, sought in 1930 to build the first cyclotron in the United States (in order to study the properties of charged particles, an early step in understanding nuclear fission), support in the amount of $1.5 million came from the Rockefeller Foundation and the University of California. Another means of funding were grants from the Research Corporation, a non-profit organization which dispensed proceeds from the sale of patents developed by university professors to support basic research in university laboratories. This feedback relationship gave industries commercial technologies and participating universities a continuing source of research funds.

With the demonstration of nuclear fission in late 1938 by Otto Hahn and Fritz Strassan from Germany, and Lise Meitner and Otto R. Frisch in Austria (Meitner had fled Germany under fear of Nazi persecution), physics and the world entered a new and threatening era (Hewlett and Anderson, 1962:11):

> The discovery of fission was stimulating enough from a purely scientific standpoint, but the finding had such a galvanic impact because it pointed to the possiblity of a chain, or self-sustaining, reaction. Physicists thought it highly probable that fission released secondary neutrons. Should these be effective in splitting other uranium nuclei, which in turn would liberate neutrons, it might be possible to generate a large amount of energy. If the process could be controlled, a new source of heat and power would be available. If it were allowed to progress unchecked, an explosive of tremendous force might be possible.

Replication of the Hahn-Strassman result in the United States was conducted at Columbia University by Enrico Fermi (who had left Italy shortly after receiving the Nobel Prize in physics), Leo Szilard (a Hungarian physicist who emigrated expressly for the purpose of working with Fermi), and John R. Dunning. George B. Pegram, a physicist and Dean of Graduate Studies at Columbia, informed his colleague Admiral Stanford C. Hooper of the results of the fission experiments and suggested that a meeting be arranged with Fermi to discuss its implications. A meeting was arranged with the Naval Research Laboratory (NRL) and the Army's Bureau of Ordnance at which time the NRL expressed an interest in additional research of the energy potential of uranium. However, the national government was ill-organized to undertake or support such research because of the decision to de-fund and civilianize research after World War I. Reliance on industrial support would mean slow progress in this area and would fail to address the concern by some that Nazi Germany, which had its national science apparatus working on atomic physics, would discover an atomic explosive. While few in the American physics community believed that such a bomb was feasible, Szilard and Fermi concluded with the support of colleagues, that President Roosevelt should be informed of the possiblity. With the assistance of Alexander Sachs, an economist with the Lehman Corporation and a confidant of the President, Szilard drafted a letter informing Roosevelt of the new discoveries of atomic physics and encouraged him to identify a means for continuing this research under national government supervision. To assure the President's attention, it was decided to seek Albert Einstein's signature and to have Sachs personally deliver the letter. Upon reading the letter in October 1939, shortly after war broke out in Europe, Roosevelt commented to Sachs, "Alex, what you are after is to see that the Nazis don't blow us up" (Hewlett and Anderson, 1962:17). The Advisory Committee on Uranium was formed to investigate whether and how government atomic research should proceed. Initial members of the Committee were Lyman Briggs, director of the National Bureau of Standards, Commander Gilbert C. Hoover (U.S. Navy), and Colonel Keith C. Adamson (U.S. Army). The Committee informed Roosevelt in November 1939 that the chain reaction idea was a plausible but as yet unproven one. By May 1940, Briggs was convinced of the need for military supervision of atomic research; however, he did not seek to impose secrecy controls.

Fermi and Szilard's experiments with graphite as a moderator for containing, without absorbing, neutrons released in the fission process were recognized by Briggs and Admiral Harold G. Bowen (director of the NRL) as justifying laboratory-scale investigation. The organizational basis for such research was provided with the creation by Executive Order in June 1940 of the National Defense Research Council (NDRC). Support for the Council emanated from scientific as well as military leaders. Vannevar Bush (then president of the Carnegie Institution) and a participant in the submarine detection research of World

War I, Karl Compton (president of MIT), James B. Conant (president of Harvard), and Frank B. Jewett (vice-president of AT&T and president of the National Academy of Sciences) had all advocated the formation of the NDRC as an independent entity from either the National Research Council or the National Academy of Sciences. Each had backgrounds in weapons research from World War I, had encouraged the incorporation of science into military planning, and were utilized during World War I to promote a science-military partnership. Bush was appointed Chairman of the NDRC and Compton, Jewett and Conant were included as members along with military representatives of the Army and Navy.

In his order, Roosevelt defined the Council as an organization of *science* rather than of invention (Kevles, 1987:297). The distinction was fundamental for it meant that the national government would be directly engaged for the first time in defining and funding research in support of military requirements outside of a war context. Indeed, with his order Roosevelt created a new field, "defense science." This work was to be conducted under contract to the military by universities and industrial laboratories. Using emergency funds available to the President, the NDRC had in just six months authorized 126 projects in 32 academic institutions and in 19 corporations (Kevles, 1987:298). The uranium program envisioned by Fermi, Szilard, Briggs and Bowen was incorporated into the NDRC agenda with the Committee on Uranium placed under its jurisdiction. Isotope separation research was allotted $100,000 in July of 1940 and $40,000 was made available for chain reaction investigations. Columbia and the University of Virginia, Westinghouse, U.S. Graphite and the NRL were among the recipients of the initial allocations (Hewlett and Anderson, 1962:26-27).

The priority given to atomic research increased with the Nazi invasion of Belgium in the summer of 1940. Fears were voiced by scientists such as Szilard and Eugene P. Wigner (another continental physicist who emigrated to the United States to become part of the atomic research group at Princeton), as well as the military, that the summer 1940 invasion of Belgium by the Nazis might threaten access to one of the largest sources of uranium located in the Belgian Congo. National control of science in the atomic field became paramount. On the one hand this meant greater government financial support; but it also meant governmental oversight and control of research and information. Members of the scientific community as early as February 1939 advised that restrictions be placed on publication of uranium research, and the National Research Council in the spring of 1940 created a reference committee to control publication of research with military significance. The impetus for the NRC action was control over information relating to uranium and fission phenomena. The NDRC added to the security definition of this research by formally excluding foreign-born scientists from membership on the Committee on Uranium (Hewlett and Anderson, 1962:25-26).

Two separate committees of scientists appointed by Bush recommended an immediate government program in fission research. To mount such an effort, a much larger and more certain funding source was required than the emergency funds underwriting the NDRC. The problem was solved in May 1941 with the issuance of a new Executive Order creating the Office of Scientific Research and Development (OSRD). The new agency received its own budget from direct Congressional appropriation and its director was given the authority to "advance ideas for weapons from the germinal to the production stage" (Kevles, 1987:300). Bush was promoted to the directorship and Conant replaced him as head of the NDRC which was itself located within the OSRD. The Committee on Uranium became the OSRD Section on Uranium, or S-1. Under the new arrangement Bush continued to enjoy direct access to the President and now had relative autonomy from military direction, although the express purpose of the OSRD was still to provide the military with advanced weapons research capability. The OSRD operated "out of the limelight" with little public knowledge and practically no public access to its activities. With the creation of the OSRD, leaders dropped any pretense of a rigid separation between science and the state. Hale's earlier ideas of a national but "privately" based science appeared naive and outdated. The relevant question now turned on whether science as an institution would actually command and control certain spheres of state activity. A basic implication of developments in the atomic field by the summer of 1941 *before* the United States had entered World War II was that science would redefine war, national security, and even the very nature of the nation-state.

Through the fall of 1941, Bush mobilized the OSRD to examine two questions: Could a bomb be made? At what price? (Hewlett and Anderson, 1962:46) Bush had earlier commissioned the NAS to review the uranium program. Its Chairman, Arthur C. Compton, a physicist from the University of Chicago, submitted a report in November 1941 estimating the cost of assembling an atomic bomb at $80 million to $130 million. With the President's assent, Bush took action to accelerate atomic research and to investigate pilot plant operations. With respect to research, OSRD was already simultaneously sponsoring programs in the theoretical physics of an atomic weapon, power production, isotope separation (including centrifuge, gaseous diffusion, electromagnetic and thermal diffusion methods), heavy water and graphic moderators, and nuclear fission (using Uranium 235 or 238, and plutonium). As to the pilot plant consideration, a Planning Board was created to investigate the engineering and manufacturing questions related to the production of an atomic bomb. For expertise on these questions Bush turned to an engineer with industry experience, Warren K. Lewis of Standard Oil, to chair the Board. Corporate representatives from the Kellogg Company, Union Carbide and Carbon, and Westinghouse joined Lewis on the Board. Thus, *before* Pearl Harbor, the United States had already assembled an institutional structure to investigate the science and technology of atomic weapons. This structure had integrated university, industrial and military research and engineering, and had devised supply lines to insure delivery of everything from uranium to flow meters and thermometers; approximately 1,700 physicists were engaged in government-sponsored defense research by December 1941 (Kevles, 1987:320). Moreover, the organizational and research experience of leading energy industries such as Standard Oil, Westinghouse and General Electric would prove invaluable to the bomb effort.

A process of institutional integration continued despite the fact that no one in or out of the OSRD knew if the concept of a chain reaction was valid; at least four major isotope separation methods competed to demonstrate the feasibility of producing fissionable materials; three different materials were under active investigation; and two moderator techniques were being researched. The science and engineering *unknowns* were extensive. At the same time, science as public knowledge had been fundamentally challenged, while hierarchy and centralization pervaded the politics and economics of this new institution. The commitment to involve science with industry in military strategy went beyond the specific objective of building an atomic bomb. There was an institutional logic guiding cooperation among the three partners.

The Pearl Harbor attack drew the entire country into World War II, but its only significance for the atomic bomb project was to speed up OSRD planning and budget-ing. The week after the attack Bush divided the bomb project into two parts: engineering issues to be investigated by the Planning Board; and physics and chemistry questions to be researched at the universities. He consolidated and centralized the research phase by moving the Princeton and Columbia groups to the University of Chicago and forming the Metallurgical Laboratory. Nearly 150 senior scientists were involved in Laboratory projects on chain reaction theory, gaseous diffusion technology, isotope separation, and exploration of the properties of an exponential pile (Fermi had developed a theory on the critical mass of a nuclear chain reaction and was now investigating the requirements of a pile which would contain and return escaping neutrons of the fission process). To accomplish this research, an initial budget of over $1.1 million was established. Simultaneously, Lawrence's investigation of electromagnetic diffusion and plutonium were funded at $650,000. Included in the Berkeley Laboratory program were studies on fast-neutron reaction headed by Robert J. Oppenheimer.

The Planning Board focused attention on four tasks: 1) building pilot isotope separation plants for each of the major separation methods; 2) building experimental separation units of industrial size for the centrifuge and gaseous diffusion methods; 3) securing sufficient supplies of uranium oxide metal and hexaflouride (required by all separation approaches); and 4) producing a small supply of heavy water in the event that graphite proved to be a poor moderator. Engineering and construction for the plants was to be supervised by personnel from Kellogg, Westinghouse and Standard Oil; and heavy-water production was the responsibility of Standard Oil and Du Pont. Construction of a gaseous diffusion pilot plant and engineering work on a production plant was estimated to cost $2 million. An electromagnetic pilot plant would cost $12 million. The heavy-water project, involving a conversion of the Standard Oil plant in Trail, British Columbia would require $2.8 million. Conant and the S-1 estimated in May 1942 that the total construction costs to produce atomic bombs would be $80 million with an annual operating budget of $30 million (Hewlett and Anderson, 1962:71).

6.4 The Military and Science Alignment

In June 1942, Roosevelt authorized Bush to go forward with a full-scale effort to build the atomic bomb. Bush in turn authorized the newly created Manhattan District of the Army Corps of Engineers to assume management responsibilities in selecting plant sites, developing engineering designs and establishing a procurement process for materials, instruments and so on. Brigadier General Leslie R. Groves (who had built the Pentagon) was given command of what became termed as the Manhattan Project (Lauren, 1988:60). By the end of the year Fermi had produced a nuclear chain reaction using a graphite pile built "in a squash court under the west stands of Stagg Field, the (University of Chicago's) unused football stadium (Kevles, 1987:326). Fermi's experiment assured that the realization of the most destructive weapon imaginable was possible. Yet, atomic physics had advanced to such a state of thinking with its contributors accepting the legitimacy of this thinking, that few in the community regarded Fermi's demonstration as extraordinary" (Hewlett and Anderson, 1962:113):

> Unlike the discovery of fission, the first demonstration of the chain reaction did not come as an unexpected burst of knowledge which staggered man's comprehension. It was rather the capstone of a structure which Fermi and others had been patiently building since the first weeks of 1939. To those most closely related to the work at Chicago, the final experiment verged on the anticlimactic...Strictly speaking, the decision did not await the event; the event confirmed the decision already made.

Scientific-technical possibility overruled what might, on other grounds, be regarded as unthinkable.

Heretofore, the military-science-industry partnership had relied upon a somewhat fragmented organizational structure. University laboratories, industry representatives and military generals had been loosely organized in "committees," "planning boards," and so on. After December 1942, this was no longer acceptable. With Roosevelt's approval of an "all-out effort" on December 28, Groves was put in charge of a half-billion dollar budget and a "giant industrial complex" (Hewlett and Anderson, 1962:115). To build a bomb Groves would require the assistance of some of the nation's largest corporations, including energy industries such as GE and Westinghouse, as well as Union Carbide and Carbon, Stone and Webster, Chrysler, Allis-Chalmers, Republic Steel, International Nickel, and Eastman Kodak. The Du Pont Company was selected as industrial manager for the Project because of "its size and experience" and its internal organizational structure which was designed "so that all the complex activities of the company were oriented around the manufacture of products" (Hewlett and Anderson, 1962:187-188). Moreover, Du Pont was a veteran of military production. The War Department had already assigned to it the construction and operation of several explosive plants. Personnel from the Explosives, Ammonia, Chemicals and Engineering Departments were assembled to supervise manufacturing and engineering operations. On these matters the company had insisted, and had received, complete control in order to avoid "the many headaches of co-ordination and administration which plagued most joint enterprises between university research groups and industry (Hewlett and Anderson, 1962:188). Overall decision-making would be exercised by three individuals: General Groves, Professor Compton and the Du Pont company's Roger Williams. In this way, the Manhattan Project merged two modes of "efficient" organization: the multidivisional, horizontally and vertically integrated production structure of the modern corporation, and the command and control structure of the military system.

It is important to recognize that emphasis on organization was absolutely necessary since many of the components of atomic bomb manufacture had not yet been decided. Questions remained about the right fissionable materials, the best method of their production, the amount required, the detonation method, the mode of delivery and the destructive potential. Efficiency and organization would have to guide the project until the technical, military and political "ends" were resolved. In this respect the Manhattan Project represents a prototype of contemporary technocratic order. Groves simultaneously authorized construction of testing, pilot and full-scale production plants for each of four major methods for producing fissionable material: gaseous diffusion, electromagnetic separation, thermal diffusion, and plutonium production. Of course, no site or series of sites existed to carry out this production. To accommodate the Project, approximately 90 square miles of wilderness in eastern Tennessee were acquired as a military reservation. Over 1,000 families were evicted and a new town for about 25,000 residents was constructed. Approximately 100 miles of paved roads were required for the town, with an additional 200 miles needed to reach the production plants. In addition, 37 miles of rail lines were added. The entire area was sealed off from the public. Construction of the Oak Ridge Reservation had begun.

Industrial scale gaseous diffusion, electromagnetic and thermal diffusion plants were built in outlying valleys of the reservation (and in addition included dormitories to house personnel). The gaseous diffusion (K-25) complex was composed of 54 contiguous four-story buildings in a U-shape with 2 million square feet under roof. Population at this facility alone reached 15,000, and because of its distance from the central town of Oak Ridge, housing, a school, a commercial center, theater and three recreation halls were added. The industrial-scale electromagnetic facility (Y-12) constructed at Oak Ridge included nine Alpha tracks racing highly charged particles around a 122 foot long, 77 foot wide and 15 foot high ellipse for the purpose of producing enriched uranium and plutonium. Three Beta racetracks were also built at half the size of their Alpha counterparts; their role was to accept the separated radioactive material from the Alpha tracks and the K-25 facility, and enrich it further. Built by General Electric, Westinghouse, Stone and Webster, Allis-Chalmers, Tennessee Eastman, Phelps-Dodge and Chapman Valve, the complex included 175 buildings and required 22,000 workers to operate. The magnet windings necessary for the creation of the electromagnetic separation process posed a special resource problem for the Manhattan District planners. The scarce supply of copper during the war period precluded its use as a material. In lieu of copper it was decided that silver would be used. The U.S. Treasury agreed to supply 47,000 tons of bullion, and Congress approved the provision of another 39,000 tons. The value of the total shipment (completed in August 1942), was $400 million (Hewlett and Anderson, 1962:153; Kevles, 1987:327). Finally, a thermal diffusion (S-50) plant was located adjacent to the K-25 complex. By comparison, this structure was modest in scale: a 77 foot high by 522 foot long building with 2,142 48-foot process columns, and two auxiliary buildings (each consisting of a boiler plant and a final tank reserve building). Beyond these production and laboratory operations, the Oak Ridge Reservation included the Clinton Laboratories, the X-10 plutonium reactor and a $34 million 238 MW power plant, "the largest steam plant ever constructed in one operation" to date (Robinson, 1950:79-80). The vast Oak Ridge complex was in place eighteen months after Groves and the Military Policy Committee began its planning. Yet as full-scale operation got underway in mid-1944, there was still no demonstration that any of the uranium 235 production would in fact work, much less that a bomb would in fact become a reality.

Shortly after construction on Oak Ridge began, General Groves authorized the planning of a second mammoth nuclear research and production facility at Hanford, Washington. Most of the 600 square mile site was purchased by the federal government. The land was composed of 3,000 tracts held by 2,000 owners and its purchase was "among the most complex ever accomplished by the federal government" (Hewlett and Anderson, 1962:213). The primary focus of research and production activities at Hanford was plutonium development which had significant security issues of both a technical and military nature. First, while much about production remained unknown, it was clear that the manufacture of the new product would yield an unprecedented amount of radioactivity; to date, "all the radium sources in the world could not generate more than a small fraction of the radiation emitted by one nuclear pile" (Hewlett and Anderson, 1962:174). For this reason, the overriding criteria concerning plant location was the remoteness of area in order to minimize effects of technical accidents or sabotage. Hanford met these spatial requirements and, additionally, could supply large amounts of water and hydro-electric power from the Columbia River needed for plant cooling and operations.

Construction of Hanford began in 1943, four months after Fermi's successful experiment in Chicago, and well before a "practical method" of plutonium production was known. The chain reaction had been proven possible, but the Stagg Field pile would have to be in operation for "a thousand years" to retrieve enough plutonium for making of the bomb (Hewlett and Anderson, 1962:174). Groves enlisted the DuPont Company as the industrial engineer for the plutonium project. Its extensive military production experience in chemicals and explosives indicated to both

Groves and Compton that Du Pont's "firm hand at the helm" would provide the much needed co-ordination and administration of the science-military-industry joint project and "assure rapid progress toward the bomb" (Hewlett and Anderson, 1962:188). By January 1943, Groves, Compton and the Du Pont group had begun planning the plutonium producing complex, assembling a considerable wartime manpower effort that included everything from scientific and technical personnel to town planners and welders for the construction of the Hanford Engineer Works. At its peak, 45,000 persons drawn from Alaska to the Mexican border participated in the building of the giant complex which was divided into three main areas: the piles area, the separation area and an area to produce uranium slugs and test pile materials. The piles area, designated as the "100" area and located in the northern part of the complex alongside of the Columbia River, housed three large reactors. Whereas Fermi's first chain reacting pile had emitted less than one watt of energy and the experimental X-10 at Oak Ridge 1,800 kW, each Hanford pile was capable of generating 250 MW during full operation (Hewlett and Anderson, 1962:124, 211, 216). To cool these reactors it was also necessary to construct three municipal-sized water plants next to the piles. Ten miles from the "100" area, in the center of the Hanford Works, a plutonium extraction complex was built where plutonium would be derived from the irradiated uranium slugs by chemical separation. Three separation facilities were built in the so-called "200" area, each containing buildings for the separation and concentration of plutonium, and for radiation disposal and waste storage. Testing and slug fabrication plants made up the "300" area.

Scarcely two years after Groves, Compton and the Du Pont Company had begun preliminary designs for an industrial-scale plutonium facility, the first batch of bomb-grade plutonium had been manufactured. In both Oak Ridge and Hanford, the military-science-industry alliance had conquered the unknowns of producing nuclear fissionable material through organization, science and trial-and-error engineering to successfully conclude what Secretary of War Henry L. Stimson in 1944, called "the largest and most extraordinary scientific experiment in history" (Hewlett and Anderson, 1962:302).

Even as Oak Ridge and Hanford "exceeded the rosiest expectations of their designers," the Manhattan Project was still far from meeting its goal of producing the first atomic bomb. As with all phases of the Project, the actual building of the bomb was planned without any firm knowledge of how to successfully construct one. The transition from "fissionable material" to a "weapon" was to be addressed in the same manner as earlier steps in the process had been: "to turn uranium 235 or plutonium into a bomb required in its own right a prodigious research, design and engineering enterprise" (Hewlett and Anderson, 1962:225). The site for the bomb-making facility was chosen in November 1942. Again isolation, secrecy and access to water were paramount concerns. Northern New Mexico provided all of these and had the additional attraction of containing a large land tract already mostly owned by the federal government. The U.S. Forest Service transferred 54,000 acres to the Department of War and another 9,000 acres were acquired from private owners (Kunetka, 1979:41-42).

For this project, military secrecy and control would be emphasized to an even greater extent. Yet, it was obvious that a scientist rather than a military officer would have to supervise at least the research and development stages of the enterprise. Groves wanted a scientist who was knowledgeable of the field, but who was not very experienced in managing a project of this scale. In this way, he would avoid potential conflicts presented by an independent-minded civilian. He chose J. Robert Oppenheimer. Oppenheimer was a member of the group at Berkeley and was involved early in fast neutron research. He had been instrumental in developing the theoretical basis for techniques of isotope separation. In 1941 he had been asked to join the NAS special commission to evaluate the atomic possibility (Rouze, 1965:42). Many questioned Groves' choice of Oppenheimer, particularly as many of the most notable physicists were already participating on the bomb project and could easily be enlisted as scientific leader. But these were outweighed in Groves mind by a sense that Oppenheimer could be controlled (Lauren 1988:101).

On February 25, 1943 a letter signed by Groves and Conant was officially sent to Oppenheimer formally requesting him to organize a workforce of scientists and technicians for the "development and final manufacture of an instrument of war" (Kunetka, 1979:43). Groves would retain "executive" responsibility and Oppenheimer would supervise science and technology activities (Hewlett and Anderson, 1962:232) Work at the Los Alamos Laboratory was organized into four divisions: theoretical physics, experimental physics, chemistry and metallurgy, and ordnance. Scientists were drawn from the Metallurgy Laboratory in Chicago, MIT, Columbia, Iowa State, Princeton, the University of California, the University of Minnesota, Stanford, Purdue and the National Bureau of Standards.

Nuclear explosion at this point was a purely theoretical idea. Experiments had been impossible due to the unavailability of fissionable bomb grade material and the lack of a facility to build and test bombs. With Oak Ridge and the Hanford-Du Pont Company partnership having solved the first problem, attention now turned to the second. Once more military, science and industry experts would collaborate in finding a solution. In early 1943 Groves set up a reviewing committee composed of Warren K. Lewis (Standard Oil and dean of American Chemical Engineers), Edwin L. Rose, John H. Van Vleck and E. Bright Wilson (both of Harvard), and Richard C. Tolman (California Institute of Technology) to review the state of knowledge on the bomb and propose a schedule for the completion of bomb research and development. Division leaders at the laboratory represented military, scientific and industrial interests as well: Hans Bethe (MIT) and Robert F. Bacher (also from MIT) headed the theoretical and experimental groups; Joseph W. Kennedy (Berkeley Radiation Laboratory) and Cyril S. Smith (Monsanto Chemicals) oversaw the chemistry and metallurgical activities; and Navy Captain William S. Parsons was in charge of ordnance and engineering. On May 10, 1943 Lewis' committee reported that research progress at Los Alamos was "satisfactory" and that emphasis now needed to be given to ordnance engineering and to metallurgy-chemistry issues in the fabrication of bomb materials. The recommendations of Lewis and his colleagues were accepted by Groves who realized that the Laboratory would have to increase in scale substantially if the tasks outlined by the committee were to be successfully pursued.

Expansion of the Laboratory served to highlight a recurring problem of the Manhattan Project, namely, the availability of qualified scientific and technical personnel. This problem was particularly acute for the creation of Los Alamos for two reasons. First, because the weapons laboratory was the culminating stage in the development of the atomic bomb, most of the talent pool was already doing research or under contract at the Metallurgical Laboratory in Chicago, at industrial sites, or at the Oak Ridge and Hanford complexes. Secondly, and of more widespread significance were the dilemmas posed by the conflicts between the military manpower needs of a nation at war and the creation of a large-scale scientific-technical enterprise. The army was facing two possibly self-contradictory military goals with respect to its reserve army of labor: soldiers were needed both to stock the army *and* build the bomb. The physics community overwhelmingly composed of men (approximately 97 percent of the nation's Ph.D.s in physics), perceived itself as highly vulnerable to the military draft (Kevles, 1987:276). As a result, at the prodding of Bush and the OSRD, a Reserve List was established in 1943 that included the names of scientists essential to OSRD projects. Less than a year later as head of the OSRD Bush gained an appointment to the agency responsible for certifying deferments, the Inter-Agency Committee, virtually insuring that no man on the Reserve List would be called to military duty (Kevles, 1987:322-323).

The scientific community had no trouble accepting its special position with regard to military service. Nor was the occasion to directly participate in atomic bomb research a particular problem. Rather, the largest obstacle to the development of the Los Alamos Laboratory which Oppenheimer faced was the recalcitrance with which the scientists viewed an army controlled research program. More than Hanford or Oak Ridge, Los Alamos was to be a wholly military installation for the research and construction of an atomic bomb. Senior physicists such as

Robert F. Bacher and Isidor I. Rabi from the Radiation Laboratory at MIT were refusing to work under a rigid U.S. Army controlled research program. Military command would in their view override decisions that ought to be made on purely scientific grounds. Scientific integrity and autonomy were invoked to challenge the external control of research, war-time or not. The result was a compromise settlement between Conant, Groves and Oppenheimer (Hewlett and Anderson, 1962:231-232):

> During the period of laboratory experiment, organization would be strictly civilian. Personnel, procurement and other arrangements would proceed under a contract between the War Department and the University of California. When the time for the final phase arrived...the scientific and engineering staff would be commissioned officers. This was necessary because of the inherent hazards and the need for special conditions to maintain secrecy...General Groves had over-all executive responsibility under a Military Policy Committee. Oppenheimer was accountable for the scientific work. It was his duty to maintain strict secrecy among the civilian personnel.

Despite the objections of Rabi and Bacher, other scientists were successfully recruited. Oppenheimer's aides in the earliest stages of laboratory development were John H. Manley formerly of the University of Illinois (and Oppenheimer's assistant in fast-neutron research); Robert Serber and Edward Teller both from Berkeley; and Edwin McMillan also of Berkeley (who was also involved in the early experiments which had led to the discovery of plutonium). Investigating teams from other major universities soon followed and by April 1943, before adequate housing or the laboratory itself was fully completed, a staff was in Los Alamos conducting bomb research. While Bacher eventually accepted the position at Los Alamos (until such time as it would become a completely military installation), Rabi decided against joining the staff and acted as a consultant only. Vestiges of research as an individualistic endeavor remained, but it had become clear that with or without Rabi, Bacher and other prominent physicists, organized laboratory research was to be the basis for future scientific and technical development.

With atomic research industrialized, the merely theoretical status of a nuclear explosion was no longer acceptable. The physics of the bomb had pointed to the "intrinsic explosibility" of a plutonium device. But, as Hewlett and Anderson point out, as late as the summer of 1943, "it had not been established that plutonium emitted neutrons on fission" (1962:240). First tests were ordered at Los Alamos in July 1943. Despite the erection of three massive complexes in almost total secrecy, codenames for nearly every aspect of the Project, including the scientists themselves, the plutonium was carried from the Metallurgical Laboratory by Glenn Seaborg in his suitcase (via the Santa Fe train). A Berkeley physicist, Seaborg had been transferred in early 1942 to the University of Chicago operation to assist in the development of a chemical separation process for plutonium. The test results proved the atomic bomb to be a practical device; "theory had been confirmed in the laboratory"--a significant number of neutron emissions were measured (Hewlett and Anderson, 1962:240).

A second hurdle to technical feasibility was cleared in November 1943 when another round of tests showed that uranium fissioned at an optimal rate: neither too slow to result in a fizzle nor too fast to predetonate. But while these tests demonstrated fission feasibility, an outstanding issue remained concerning the method of detonation. Two techniques were under investigation. The first was the gun method which used an old-fashioned weaponry approach--"an artillery field piece to fire one less-than-critical part into another" (Hewlett and Anderson, 1962:235). The second method, termed implosion, employed a more complex strategy developed specifically for this technology and was the unique possession of atomic physics. Indeed, implosion broke new theoretical ground. In this method a subcritical mass would be surrounded by a layer of explosives such that upon detonation the plutonium would be compressed into a "critical conformation" (Hewlett and Anderson, 1962:235). The matter was complicated because of the unsuitability of the gun method for the plutonium device, and the fact that implosion had not yet been achieved. Oppenheimer delegated research in this area to George B. Kistiakowsky, a Hungarian-born emigrant from Harvard with a specialization in explosives. The problem took nearly a year to resolve. Finally, in a test at Los Alamos in April 1944 Kistiakowsky and associates overcame the problem of shock waves created in the implosion process. This triumph paved the way for a test of the plutonium bomb.

Alamagordo, New Mexico was chosen for the test. Oppenheimer and Groves directed the assembly of the bomb at the test site, codenamed "Trinity," and also the construction of facilities for damage measurement, radiochemical analysis and gamma-ray intensity studies, among other things. Various explanations have been given for the codename, but the most likely is that Oppenheimer himself named the the test site in reference to the Hindu concept of Trinity which consists of Brahma, the Creator; Vishnu, the Preserver; and Shiva the Destroyer (Szasz, 1984:41). In the early morning of July 16, 1945, the military-science consortium achieved its objective--the explosion of a twenty kiloton plutonium bomb. The blast was visible in the city of Albuquerque approximately 125 miles from the test site. The "release of nuclear energy," the principal goal of the atomic bomb (Hewlett and Anderson, 1962:377), was so violent that Oppenheimer was moved to quote from the Hindu Bhagavad-Gita: "I am become Death, The shatterer of worlds" (Kevles, 1987:333).

6.5 The Greatest Achievement in Scientific History

In one of the politically most interesting debates of the modern era, the technical, corporate and military elites of the Manhattan Project indulged in a protracted discussion in the spring of 1945 over the proper use of this new weapon. Debate ensued over whether a demonstration of the bomb in an uninhabited area should be announced in an effort to persuade Japan to end its military operations; or whether a military installation should be targeted for an atomic bomb attack, again to persuade Japan to surrender; or, finally, whether a full-scale military attack using the atomic bomb should be planned to release the full destructive potential of this new weapon. Oppenheimer, Fermi, Compton, Lawrence and other scientific principals concluded that there was "no technical demonstration likely to bring an end to the war; we can see no acceptable alternative to direct military use" (Kevles, 1987:336). The War Department agreed, to the great relief of General Groves who had expressed his fear in a March 1945 memorandum that the bomb would not be developed in time to use against Japan. With the bomb now ready, Groves could hardly accept its restricted use (Hewlett and Anderson, 1962:689, footnote 54).

Use of the atomic bomb occurred on August 6, 1945. On that day the prophecy which Oppenheimer had spoken of less than a month earlier came to a fiery rest for over 200,000 Japanese people in the city of Hiroshima. The world learned about the first results of "the greatest achievement in scientific history" through a statement delivered by President Truman (1945:4):

> Sixteen hours ago an American plane dropped one bomb on Hiroshima...It is an atomic bomb. It is a harnessing of the basic power of the universe...And the end is not yet...We have spent two billion dollars on the greatest scientific gamble in history--and won. We are now prepared to obliterate more rapidly and completely every productive enterprise the Japanese have above ground in any city. If they do not accept our terms they may expect ruin from the air the like of which has never been seen on this earth.

On August 9, 1945, "the force from which the sun draws its power" was loosed again, this time upon the people of Nagasaki. Within a month, opposite sides of the earth had witnessed "the unforgettable fire" of atomic energy, but their experiences were worlds apart (Nippon Hoso Kyokai, 1977). The U.S. account was documented by William L. Laurence, the "official" Manhattan Project reporter designated by Groves:

> It was as though the earth had opened and the skies had split. One felt as though he had been privileged to witness the Birth of the World--to be present at the moment of Creation when the Lord said: Let There be Light...A great cloud rose from the ground and followed the trail of the Great Sun...For a fleeting instant it took the form of the Statue of Liberty magnified many times.
>
> They clapped their hands many times as they leaped from the ground--earth-bound man symbolizing a new birth in freedom...The dance of the primitive man lasted but a few seconds during which an evolutionary period of 10,000 years had been telescoped. Primitive man was metamorphosed into modern man--shaking hands, slapping each other on the back, laughing like happy children.

The Birth of the World had indeed brought about a profound change in future relations among societies which the Project cadre could not yet even imagine. Some lauded physicists for inaugurating a "Pax Atomica" (Kevles, 1987:392). But the exuberance with which most of the physicist community first greeted the arrival of modern man was not to be replicated in Japan. There, the exodus of primitive man was bid only in silence (Hiroshi, 1984:60):

No one wept
no one screamed in pain
none of the dying
died noisily
not even the children
cried
no one spoke

CHAPTER 7

POSTWAR CONSOLIDATION OF THE ALLIANCE

With the bombing of Hiroshima and Nagasaki, U.S. society had realized Technological Order. Henceforth, any consideration of the national interest would take place *within* a nuclear context. The Manhattan Project had produced not simply a bomb, it had also brought into being a new social reality governed by technological values. Science, industry, the state and the military had worked together to uphold and promote the value of "the one best means" (Ellul, 1964:21), and had achieved their common goal.

7.1 Pentagon Capitalism

In addition to the creation of the atomic bomb, the nation's scientific and technological resources had been mobilized to deliver a host of military technologies from advances in biological and chemical warfare to development of the proximity fuse, microwave radar and the introduction of electronic warfare. The military, which prior to World War II had been skeptical about the intrusion of science and scientists into the business of war, had become convinced of their indispensability to maintaining U.S. control in the postwar era. Through the military-industry-science partnership the United States had won the war, but only through the maintenance of a strong militarily allied science and industry would continued peace be assured. A counsel to Army Chief of Staff Eisenhower expressed in 1946 the issue succinctly (quoted in Allison, 1985:290):

> The lessons of the last war are clear. The military effort required for victory threw upon the Army an unprecedented range of responsibilities, many of which were effectively discharged only through the invaluable assistance supplied by our cumulative resources in the natural and social sciences and the talents and experience furnished by management and labor. The armed forces could not have won the war alone...This pattern of integration must be translated into a peacetime counterpart which will not merely familiarize the Army with the progress made in science and industry, but draw into our planning for national security all the civilian resources which can contribute to the defense of the country.

The defense establishment moved quickly to ensure that the scientific and technological inroads made during the war would be preserved afterward. While political battles raged over who would govern the atomic complex, the military itself was reorganizing, in large part as a response to the high priorities now being given to research and development. In the National Security Act of 1947, the separate departments of the Army and Navy were coordinated under the National Military Establishment, which also housed a newly created Research and Development Board "to advise the Secretary of Defense as to the status of scientific research relating to the national security and, to assure adequate provision for research and development in scientific problems relating to the national security" (quoted in Allison, 1985:291). The Naval Research Laboratory which had been created in 1916 gave the Navy a substantial headstart in the pursuit of organized R&D, and with the establishment of the Office of Naval Research in 1946, scientific and technological research and development became a permanent responsibility of the U.S. military. In the years immediately following the war, the Office of Naval Research took the lead and funded basic research in a wide variety of subjects and to a range of institutions including non-profit organizations and universities, in addition to its own Navy operated laboratories which conducted research in ships, aeronautics and ordnance (Allison, 1985:298).

By 1949 the Departments of the Navy and Army as well as the Air Force had grown to such an extent that a centralized Department of Defense was required to organize and coordinate the nation's burgeoning defense complex. The importance of military R&D was recognized when responsibility for its administration was assigned directly to the Secretary of Defense. But the continued growth in size and diversity of military R&D activities soon made this arrangement impractical and a separate office of research and development, and engineering applications was created, with the eventual establishment of the position of Director of Defense Research and Engineering under the Deputy Secretary of Defense in 1958 (Allison, 1985:299-300).

Seymour Melman has characterized the emergence in the United States of a military-centered science-industrial complex as the arrival of "Pentagon Capitalism." However, it is important that the reach of this apparatus not be misconceived as narrowly focused on weaponry and other "purely" military needs. Quite the opposite, this apparatus was intended from the outset to guide national economic development. Indeed, its public appeal, according to Melman, was its promise of general prosperity (1974:16):

> From their experience with World War II, Americans drew the inference that the economy could produce guns and butter, that military spending could boost the economy and that war work could be used to create full employment. They observed that these results had not been

> achieved by the efforts of President Franklin Roosevelt's civilian New Deal. To be sure, there were some reservations about the desirability or inevitability of using military spending among Americans as the road to prosperity. Nevertheless, these shared perceptions spurred the development of an ideological consensus about war economy that has permeated the thinking especially of intellectuals and political leaders since the end of World War II. The ideological consensus that evolved from World War II transformed the justification for military spending from a time-limited economic effort to achieve a political goal (winning World War II) to a sustaining means for governmental control of the economy.

There was no doubt that after World War II (unlike World War I), technological values would be institutionalized. In fact, consideration of a national policy had begun as early as the fall of 1942. In that year, the first Congressional hearings were conducted on proposed legislation to mobilize the scientific and technological communities to serve the national interest. At this early point it was already evident that a few corporations and an even smaller number of universities would dominate. As a result of spending at the plants and laboratories of the Manhattan Project, the federal proportion of total science expenditures (public and private combined) in the United States increased from 18 to 83 percent. Yet this dramatic increase in society's investment was concentrated in only a few organizations (Kevles, 1987:342):

> [Sixty-six] percent of wartime contract dollars for research and development went to only sixty-eight corporations, some 40 percent to only ten. OSRD spent about 90 percent of its funds for principal academic contractors at only eight institutions...

The highly concentrated and hierarchical character of the emerging research and development system focused political attention: were these traits to be accepted as the necessary accompaniments of a "national science"? And relatedly, was the high degree of military control over the direction of research to be recognized as the unavoidable consequence of the Nuclear Age?

7.2 Big Science and the National Laboratory System

While these issues would be hotly debated in the national government for a decade, in an important sense a decision had already been reached with the passage of the Atomic Energy Act in 1946. The atomic complex would be governed by the expert few under a military umbrella of national security. The Atomic Energy Act formally established the Atomic Energy Commission as the governing body for the nuclear program. The subject of much national debate and several revisions, the Act finally put in place a "peacetime" administrative structure for the atomic industry. The main source of concern for many both in and out of the Manhattan Project had been the possible continued domination of the military over the business of science. But to scientific leaders such as Bush, Lawrence, Conant, and Compton, as well as many in government, the possible subjugation of nuclear physics to "political hacks or even well-intentioned laymen" was conceived as substantially more threatening to science than the military (Hewlett and Anderson, 1962:409). Even with the Army in control, the cooperative effort of the Manhattan Project had produced significant advantages for science, industry, the military and the state: the average annual federal investment in research grew from $68,000,000 in 1938 to $706,000,000 in 1944; a market for parts and equipment as well as federally subsidized research and development was virtually guaranteed to corporate industry (in addition to special consideration in antitrust matters); and the nation had put an end to the war in the Pacific.

The Atomic Energy Commission was to build upon the successes of the Manhattan Project model. Moreover, establishment of the AEC and its advisory bodies capped the nearly thirty year effort of creating a truly national science. The enabling legislation granted the AEC sole ownership and control over the production and use of fissionable materials; authorized it to sponsor basic and applied research as well as the development of militarily necessary nuclear projects; and vested it with responsiblity for the promotion and commercialization of nuclear-generated electrical power. In short, with the establishment of the AEC the government had designated the research and commercialization of atomic energy a state monopoly.

The Commission itself was composed of five members serving six-year staggered terms and representing leaders of both the public and private sector. Initial members of the Commission were David Lilienthal, former chairman of the Tennessee Valley Authority; Sumner T. Pike, former member of the Securities and Exchange Commission; Lewis Strauss, a lawyer and former Navy admiral; William W. Waymack, editor of the Des Moines *Register and Tribune* and public director of the Federal Reserve Bank of Chicago; and Robert F. Bacher, a noted wartime Los Alamos scientist who had returned to Cornell. The complete "civilianization" of the atomic complex was, however, impossible. With atomic weapons now the basis of national and international security, scientific and technical knowledge as well as military guidance were fundamental for effective atomic development and control. Only the wartime Manhattan participants, Lilienthal later explained, knew and understood the "official mystery and complexity of atomic energy. They were the experts; they knew it all; it was over the head of the public, and public critics were held in disdain" (Lilienthal, 1980:30).

Some of these "experts" were formally integrated into the governance structure through the establishment of the General Advisory Committee. Its purpose was to "advise the Commission on scientific and technical matters relating to materials, production, and research and development" (Sylves, 1987:16). But the GAC was not confined in its advisory role to purely technical matters. Indeed, one characteristic posed by the Nuclear Age was that the political and social had become subsumed within the technical and were no longer viable sources of criticism. The GAC was called upon to consult and advise on military and national security issues as well as private and public nuclear research and development. The first GAC members included the leading scientists of the Manhattan Project, such as, Oppenheimer, Conant, Fermi, Seaborg, Rabi, Cyril S. Smith (a scientist in the metallurgy division at Los Alamos), Hood Worthington (a Du Pont offical at the Hanford Project), Lee A. DuBridge (wartime director of the Radiation Laboratory at MIT and then president of California Institute of Technology), and Hartley Rowe (a wartime consultant at Los Alamos). To insure national defense considerations received their proper due, a Military Liaison Committee was also established to advise and direct on military matters. Unlike the postwar experience of World War I, each sphere did not lapse back into a state of relative autonomy. Instead, the AEC became a mechanism for the full integration of industry, science and technology, the military and the state.

Upon its establishment, the AEC was faced with the immediate task of what to do with the technical resources amassed during the war. Concern within the laboratories over their postwar role had been exacerbated by the protracted Congressional discussion over peacetime management of the complex, and many of the scientists were eager to leave the tumultuous project and return to their university positions. Nearly two years lapsed between the end of the war and confirmation of AEC members. During that period, Groves had remained in control on an interim basis and authorized funds to sustain the laboratories until the AEC could take over.

While a feeling of uncertainty existed among those at the various laboratories and production facilities, there was also recognition among the nation's political, military and scientific leaders of the special position of the atomic complex and of the necessity to sustain it. "[I]f progress in nuclear physics is important to the nation, to the world," DuBridge explained, then these national laboratories "are not whims of crazy scientists but are part of the necessary fabric of the atmosphere in which science flourishes" (DuBridge, 1946:13). By 1950, the value of Big Science was well known; it was providing all the necessary ingredients for the mass production of scientific research in nuclear society: "The AEC needs the National Laboratories," Atomic Energy Commissioner Henry D. Smyth declared, "because it needs secrecy and big groups of scientists who will take orders, and big equipment" (Smyth, 1950:6).

The AEC laboratory network became what one author characterizes as the national "factories of [a] cerebral American System of Manufacturing" (Seidel, 1986), and included the Los Alamos Laboratory, the facilities at Oak Ridge, the Berkeley Radiation Laboratory, and the facilities at the Metallurgical Laboratory at the University of Chicago (which were transformed into the Argonne National Laboratory outside of Chicago in 1946). But many of the Manhattan Project's scientists upon returning to their respective institutions in the northeast returned to sparingly equipped laboratories compared to their well-endowed national counterparts, and found their universities depleted of some of their most prized physicists who remained within the AEC laboratory-university network. As a result of this situation, an Initiatory University Group (IUG) was formed to lobby for the establishment of a national laboratory in the northeast. Brookhaven National Laboratory was formally authorized in 1946 and located at former Army Camp Upton in Long Island, and the participating universities subsequently organized themselves as Associated Universities Inc. (AUI) to assume management of the facility (Needell, 1983:93-122). Responsibility for the production plants at Hanford and Oak Ridge was also transferred to the AEC. In addition to these, by June 1965, major AEC facilities included laboratories, production plants or testing sites at Canoga Park, California; Idaho Falls, Idaho; Jackson Flats and Mercury in Nevada; Rocky Flats, Colorado; Sandia in New Mexico; Pantex and Medina in Texas; Hallam in Nebraska as well as other operations in Paducah, Kentucky; Weldon Spring and Kansas City, Missouri; Ames and Burlington, Iowa; Fernald, Mound, and Portsmouth, Ohio; Bettis and Shippingport Pennsylvania; Princeton, New Jersey; Cambridge, Massachusetts; Windsor, Connecticut; and Pinellas, Florida (Orlans, 1967).

To accomplish its program of nuclear research and development the AEC complex was divided into three broad areas: research and application of atomic weapons; research in reactor development; and basic research in high-energy physics. While some overlap was inevitable, each laboratory specialized in one of these areas. Los Alamos and the Berkeley Radiation Laboratory specialized in weapons, and the Livermore Laboratory was established in July 1952 as a result of the crash program to develop the thermonuclear bomb. The Radiation Laboratory (its name later changed to Lawrence Berkeley Laboratory in honor of Earnest O. Lawrence's work), and Brookhaven became centers for high-energy physics research. Argonne and Oak Ridge were to be primarily concerned with the research and engineering of nuclear reactors.

With the transfer of the Manhattan Project to the AEC, an extensive peacetime weapons R&D apparatus was in place. Having largely conquered the scientific and technical unknowns of the bomb, the next step for the atomic research establishment was to investigate the problem of nuclear power. Given the state of scientific and technical knowledge and the institutional organization of Western research and engineering, overcoming the technical problems of fission for use in explosives was simpler, and therefore easier to resolve, than those of fission for generating electrical power (Byrne and Hoffman, 1987). Postwar R&D first focused on expanding the knowledge and wartime experience of the former in order to refine and improve methods for producing more "efficient" weapons. More importantly, however, nuclear power reinforced an ideology of science as progress; it offered a technical problem of higher order and its solution likewise signified an advance in scientific and technical knowledge. As AEC Chairman Lilienthal explained: "atomic development [is] not simply a search for new energy, but more significantly a beginning of human history in which this faith in knowledge can vitalize man's whole life" (1949:145).

While it is the case that the prospect of nuclear-generated electricity was attractive to military leaders who saw this new form of energy as a source of power for everything from aircraft to submarines, it is clear that the development of commercialized nuclear power was pursued entirely independently of any determination of social need. As late as 1965, Nelson notes that in a study entitled *Energy R and D and National Progress* concluded that fuel shortages or rising energy prices were unlikely in this century. While later events certainly alerted the nation to the consequences of uncertain and expensive energy, such a rationale was not the basis from which nuclear power was advanced. As Byrne and Rich note, "[n]uclear power was not the invention of enterprise; there was no market demand for it and there was no economic supply of it available prior to its institutionalization" (1985:153). Nevertheless, the AEC undertook a national-scale, state-sponsored R&D program for power reactor development (Byrne and Rich, 1985:153):

> This apparatus was then authorized...to deliver the peaceful atom eleven years before the idea could be technologically expressed and seventeen years before the successful demonstration of the first turnkey plant. In effect this society set about to discover and affirm the advantages of nuclear power and to discount its costs without any knowledge of its economic practicality and before the technical means existed to deliver it.

The national government created the conditions necessary for an industry to emerge by fully underwriting the R&D, by supplying the fuel at no charge, and by establishing a liability ceiling on nuclear plant accidents. The one outstanding risk to the operation of nuclear power plants--economic failure--was then absorbed by the power reactor companies who assumed financial responsibility for the initial plants (Mazuzan, 1982:343).

In 1947 the scientific prognosis for commercially viable nuclear-generated electrical power was far from optimistic. The technical obstacles still proved too vast, and extensive experimentation in a number of areas, including high-temperature operations, materials, fuel cycles and fissionable materials, was required (Hewlett and Duncan, 1969:116). Even under the most optimistic forecasts, the GAC in a *Draft Note on Atomic Power* concluded that it did "not see how it would be possible under the most favorable circumstances to have any considerable portion of the present power supply of the world, replaced by nuclear fuel before the expiration of twenty years" (reported in Hewlett and Duncan, 1969:116-117). Despite these reservations, both the GAC and AEC regarded the development of nuclear power as necessary and proceeded on the basis of "the ultimate possibility" (Hewlett and Duncan, 1969:115). In the wake of the successes of the Manhattan Project, the reality of a limitless source of energy seemed only a matter of time, given proper organization of scientific and engineering effort.

Thus, even before the first prototype nuclear power plant was in operation, Alvin Weinberg, then director of the Oak Ridge Laboratory, was celebrating "the unborn technology" of atomic energy as the "solution to one of mankind's profoundest shortages" (Weinberg, 1956:299). As noted in Chapter 3, a fundamental assumption of industrialized Western societies has been that economic growth is dependent upon plentiful supplies of energy for power. With the arrival of the machine-economy and the rise of the power complex to deliver fossilized energy, increased energy consumption was regarded as an essential fact of growth and social prosperity. A corollary to this is that without equivalent increases in energy supply to meet the needs of an expanding economy, society must risk the prospect of stagnation and ultimate decline (Basalla, 1980:39,40):

> We foresee a doomed civilization with tractors paralyzed in the fields, abandoned automobiles rusting on weed-choked freeways, factories as quiet as tombs, and our haggard descendants facing a life of everlasting drudgery...A retreat from rising energy consumption under those circumstances means far more than minor discomfort of living in a warmer house in the summer and a cooler one in the winter, or driving a smaller car less frequently and more slowly. As less energy is available per capita the nation is thought to lose its standing among the world's civilizations.

Nuclear power was seen as the scientific and technological promise for releasing humanity from poverty, scarcity, and as Lilienthal advocated, ignorance.

After a half-century of commitment to technological progress, many in U.S. society were untroubled by the leap of faith required for support of nuclear power development. Indeed, while researchers generally agree that the twentieth century has been dominated by this commitment to technology, some point to such a commitment as the essence of "Americanness." Daniel Boorstin refers to the United States as the "Republic of Technology" in recognition of this deep rooted faith in the synonymy of science, technology and social progress. Nuclear energy fit perfectly the aspirations of American ideology. On the one hand, it promised realization of an "abundant energy machine" (Byrne and Rich, 1985), while at the same time tackling the truly challenging problems of high energy physics. In this way nuclear power simultaneously fulfilled the dreams of technological plenty and scientific reason. Seen in this context, the pursuit of nuclear power could only be judged as positive (Kevles, 1987:392):

> Atomic explosions were discussed as ways to dig tunnels and canals...Placed by the shores of underdeveloped countries, they could generate electricity for development while desalinating sea water for irrigation; the breeder reactor promised to produce not only power but new fissionable plutonium even while it consumed uranium fuel.

To carry out its quest, the AEC relied largely on the cooperative relations between industry and the state that had developed during the war. Without continued technical assistance from corporations such as Du Pont, Westinghouse, Union Carbide and others, it was feared that atomic R&D would languish. Du Pont, however, had made its decision to terminate its role as operator of the Hanford Reservation even before the AEC had come into being. Du Pont officials considered the future of nuclear energy research too uncertain for it to be of any value to the company. Moreover, because of its involvement in war production during World War I, the company already had the image of the "merchant of death." It did not wish to further this perception after World War II (Hounshell and Smith, 1988:343-344). As a result, Groves negotiated with the General Electric Company to take over Hanford, as well as to design and construct a government-owned research laboratory at Schenectady for basic research, which the AEC later approved. Du Pont would re-enter the atomic establishment in 1950 when it was contracted to design, construct and operate heavy-water reactors at Savannah River for the crash program to develop the thermonuclear bomb. Union Carbide was contracted to manage Oak Ridge, after a brief attempt by the Monsanto Chemical Company and the University of Chicago to run the complex, and Westinghouse remained a major actor in atomic research in the thermal submarine reactor program.

Coincidentally with this corporate participation, university involvement under the AEC was also significantly enhanced. The University of California's Radiation Laboratory continued as the lead laboratory in basic research, and it remained as the sponsor of the Los Alamos Laboratory as well as undertaking a similar role for the Livermore Laboratory upon its establishment; the University of Chicago assumed management of Argonne; and a consortium of nine northeastern universities including Columbia, Cornell, Harvard, Johns Hopkins, MIT, Princeton, Yale, Pennsylvania and Rochester formally incorporated to operate Brookhaven National Laboratory (see Needell, 1983; and Seidel, 1986).

7.3 The Technocratic State in the Nuclear Age

Conflicts arose almost immediately after the dimensions of the atomic establishment were made known to the public after Hiroshima and Nagasaki. Political process had been circumscribed during the war, but postwar rationalization between the security needs of the nuclear program and democratic principles of public participation and accountability needed to be fashioned. Traditional political institutions seemed neither organized nor competent to meet the governing needs of the nuclear enterprise. The entire Manhattan Project had been built without public consent, and most of it without public knowledge. Even within the scientific community (upon whose knowledge the success of the bomb project ultimately rested), only an elite had full disclosure of the entire program; national security had dictated it. As a result of having been explicitly excluded from the development of the entire Manhattan Project, the unfamiliarity of civil government to the task of nuclear politics could hardly be surprising. The question remained however, as to how civilian political considerations would be reconciled with the hierarchical, elite-controlled public project that had been built.

As the nation became aware of the atomic program and its implications, substantial public debate ensued over the future administration of the enterprise. Numerous organizations such as the National Education Association, the American Association of Women, the United Council of Church Women, the Catholic Association for the United Nations, the National Farmers' Union, the United Steelworkers, the CIO, the National Council of Jewish Women, the National League of Women Voters, and the Disabled American Voters all sought an active voice in the formulation of a politically responsive nuclear program (Hewlett and Anderson, 1962:447). Similarly, Congress recognized as early as October 1945, that in regard to atomic matters "an extraordinary legislative device was essential" (Green and Rosenthal, 1963:3). Toward this end a Special Committee was created in the Senate with the purpose of garnering at least an elementary level of scientific and technical knowledge in order to review available information and draft appropriate legislation. But when Edward U. Condon, the Special Committee's scientific advisor, requested details on raw materials, supplies, bomb stockpiles, production rates and military intelligence, he was refused access. Groves asserted that not only was revealing such information far too risky, it was also, in his view, unprecedented; the full details of the U.S. atomic program "had never [been] revealed...to any human being" (Hewlett and Anderson, 1962:450). After some debate the Special Committee finally acquiesced to the need for secrecy. Against the backdrop of a proliferating Cold War, it was decided that political accountability was secondary compared to the potentially greater threat to national security of a nuclear educated and informed public.

Political insularity was formally institutionalized with the passage of the Atomic Energy Act which established an innovative legislative device specifically to deal with nuclear research and development. The Joint

Committee on Atomic Energy (JCAE) was created and given "full jurisdiction" over all matters relating to the AEC and to the atomic program. Only the select Congressional members of the JCAE, on behalf of Congress, were privy to the details of AEC policy; and even they had access to only partial information. It was explicitly decided that members of the Congressional military committees would not be allowed knowledge of the program. In lieu of public accountability and participation, a government of expert bodies integrated with limited Congressional oversight had become institutionalized (Green and Rosenthal, 1963:199).

> [T]he JCAE did not conceive its mission to be one of informing Congress or stimulating Congressional and public discussion of atomic energy. On the contrary, the Committee's attitude seemed to be that the atomic-energy program could be debated in Congress only by those with immediate responsiblity who were already privy to atomic secrets...The Committee took its commitment to preserve security so seriously that almost no information of substance was communicated to the rest of Congress.

The battle between military versus civilian control and the security and 'national interest' implications of the pervasive Cold War became *the* paramount issues in the organization of postwar atomic R&D. Even those scientific and technical experts who were outside the Manhattan cadre and calling an end to military domination were careful not to engage in confusing the "real" issue. As John

A. Simpson, Jr., a leader in the newly organized Federation of Atomic Scientists cautioned his colleagues, "we must be sure that other groups which really have no scientific interests at heart and no more background do not join us openly" (quoted in Hewlett and Anderson, 1962:447).

Opposition to the "one best means" was forestalled in a number of ways, the most effective of which involved purging those of questionable loyalty from the project. In 1946 Frank Graham, then President of the University of North Carolina and the Oak Ridge Institute of Nuclear Studies was denied security clearance because of his "liberal civil-rights and labor record" (Seidel, 1986:140); in 1948 Edward U. Condon, former Special Committee advisor and then director of the National Bureau of Standards, was charged with communist ties and labelled as "one of the weakest links of our atomic security" (Hewlett and Duncan, 1962:325); in 1949, after a "known communist" was awarded a fellowship, Congress ordered that all recipients of AEC graduate fellowships were required to attain security clearances regardless of whether their work occurred in a "sensitive area" or not; participation in academic conferences and meetings restricted foreign scientists and engineers; and the national laboratories developed an informal policy of selectively excluding uncleared or "unreliable" visitors from participating in their facilities. Many in the scientific community decried these acts as violations of a free and open science, but even as early as 1947 the director of security and intelligence of the AEC had received over 6,000 requests for clearances and another 7,000 awaited final review (Hewlett and Duncan, 1969:333). To expedite the process, formal criteria were developed to determine who would be acceptable and who would not. A final list included "character traits" "such as careless-ness or personality difficulties," personal associations and evaluations of friends, spouses and other relations (and their personal associations) and "loyalty."

Regardless of the peacetime political structure, whether civilian or military controlled, technocratic val-ues of efficiency, rational organization and system con-trol would govern all aspects of nuclear development. For example, until 1949 Los Alamos operated under military supervision with the suspension of all civil rights, but it was doubtful that this could continue in a non-wartime situation. Traditional forms of democratic governance were also out of the question, at least in the immediate future. The solution was to incorporate the Zia Company expressly for the maintenance and operation of Los Alamos under contract with the AEC. To those involved this new form of government was not to be viewed negatively. On the contrary, Los Alamos illustrated the efficient manner in which such a community could be organized and managed (McKee, 1950:15):

> Los Alamos is a novel city, a new community without roots. It has no old people, no undertaker, and no cemetery. The citizens pay no municipal taxes and own no real property. There is no unemployment in Los Alamos because if anyone should quit his job for any reason, he would leave the town of Los Alamos, and the house he was living in would probably be needed for whoever took his place, he would be required to move out of town. Therefore there are no idle people.

In the years that followed, the entire atomic R&D program insulated from public scrutiny and criticism became a dominant model of national science. Its position in energy R&D alone was such that by the "outset of the 1970s, 86 percent of all federal energy R&D policy funds that had been spent since World War II had gone to [the Atomic Energy Commission]" (Lambright, 1976:33). Few if any continued to question the lucrative integrated model. Universities not only appealed to the AEC for greater access to the expensive machinery in operating laboratories, but they also entered the competition for their own AEC funded high-energy research equipment. There were 29 participating universities at Argonne and 14 other universities organized to create the Oak Ridge Institute of Nuclear Studies. Together with the nine northeastern universities of AUI these institutions all vied for use of AEC R&D facilities. But soon participation in established AEC laboratories was not enough, and the continued state monopoly in nuclear research came under fire. As of 1952, 84 percent of AEC research and development funds were directed to its own contractor-operated facilities and access to the expensive and highly specialized laboratory equipment by other scientists not specifically employed by the AEC had become severely limited. One effort at breaking the monopoly was initiated by the Midwestern Universities Research Association (MURA was composed of the University of Minnesota, the University of Illinois, Indiana University, and the University of Wisconsin). MURA attempted to enter into the AEC establishment by gaining support for the construction of its own experimental facility, but met with little success. The national laboratories had achieved a position of considerable authority and prestige and they regarded MURA as a challenge to their reputation and to their budgets. While the MURA approach failed, Stanford University *was* able to acquire a $100 million accelerator and, another facility, the National Accelerator Laboratory, was established in

Weston, Illinois. New groups such as the Western Accelerator Group (comprised of the California Institute of Technology, the University of Southern California, and the University of California at Los Angeles) were subsequently formed, all "aspiring for the next high-energy plum from the AEC pie" (Seidel, 1986:171).

A similar diffusion process occurred in the industrial sector. By 1952 major AEC contracts with corporations beyond the original few included such companies as Monsanto Research Corporation; Westinghouse; Bendix; Phillips Petroleum; Dow Chemical; Goodyear Atomic Corporation; National Lead; Mason & Hanger; Sandia Corporation; North American Aviation; Edgerton, Germshausen & Grier; Holmes and Narver; Reynolds Electrical Engineering; and so on. The major focus of reorganization within the AEC came as a result of appeals for greater involvement in the nuclear program, particularly among corporate industry. While it was generally acknowledged that the "perpetuation of a few, trusted and responsive contractors enabled the government to get its work done and yet maintain that tight control needed in top secret organizations" (Orlans, 1967:21), industry had begun to challenge the highly restrictive character of the nuclear R&D market. As a result, the Atomic Industrial Forum was created in 1953 to advise and report industry perspectives to the AEC on government policy. Revision of the Atomic Energy Act in 1954 provided for private ownership of nuclear reactors and the licensing of nuclear materials, enabling at least some some corporations to adopt their own initiatives for nuclear power (Green and Rosenthal, 1963:13). The intent of these provisions was to strengthen the role of corporate industry in the nuclear program and by 1963 AEC contracts and subcontracts for materials, supplies and equipment totalled approximately $3.4 billion. The wide involvement of industry, universities and the government led David Lilienthal to label the spreading complex the "Atomic Consortium." But even as it was spreading across the national economy, the highly concentrated and hierarchical character of the complex remained essentially unchanged. Through most of the 1960s over half of AEC expenditures were distributed to only five industrial giants (Union Carbide, General Electric, Bendix, Sandia and Du Pont) and two academic contractors (University of California and University of Chicago) (Orlans, 1967:13).

7.4 The Atomic Energy Commission: Home of Big Science

While initially organized on a mission basis, the diffusion experience of the 1950s led the AEC to involvements well outside its charter. The laboratory system of the AEC had become what one writer referred to as the "home" of Big Science (Seidel, 1986:164), where multidisciplinary teams could be assembled to address almost any scientific and technical problem. Seidel characterized the capability of the laboratories by the end of the decade as follows: "whether the object of study was photosynthesis, reactor materials, or nuclear propulsion, they were equipped to bring to bear a range of expertise on the question" (1986:165). The AEC system produced a highly flexible and easily mobilized scientific industry whose role was to support the emerging national political economy. In its 1959 report to the JCAE entitled *The Future Role of the Atomic Energy Laboratories,* the AEC identified its new role as "strengthening free enterprise on the one hand and the universities as centers of education and learning on the other." Its resources were "held in trust for the nation as a whole" and were ready to be deployed when "national needs...called for out-of-the-ordinary arrangements, efforts, and ability." The atomic energy field was only one area of national interest that had been and could be served by the AEC, and the Commission pledged in its report, "to make room for new projects and undertakings" (quoted in Seidel, 1986:165). The AEC's effort to define an expanded role for itself was based on the argument "that it was not what the laboratories did, but how they did it" (Seidel, 1986:166). In this effort the organization was highly successful. By the end of the 1960s the AEC had all but shed its mission basis as a rationale for funding, and its budgets had grown. Its clients included the Department of Commerce, the National Academy of Sciences, the National Institutes of Health, and a host of corporations; and it was engaged in research in such diverse topics as desalienation, civil defense and carcinogenesis. Seidel reports that by 1973 "work for others" comprised 11 percent of laboratory funding (1986:167). In its mature form the AEC represented a new model of industrial organization and production method. Through state sponsorship predicated on national security needs and, more generally, the national interest, a "scientific estate" (Price, 1965) had been assembled to collaborate with industry in the production of highly expensive scientific goods (including a system of fully equipped national laboratories) and sophisticated technologies (such as power reactors, nuclear submarines, ballistic missiles and a host of laser related inventions).

In this respect the AEC constituted a model of scientific-industry-state cooperation that was at the center of the transformation of the U.S. political economy from its traditional manufacturing base to its present technology base. The model was duplicated in a number of other science-based industrial fields perhaps the most important of which is aeronautics. A federally-sponsored science organization for research in aeronautics dates back to 1915 with the establishment of the National Advisory Committee for Aeronautics (NACA). Until 1958, when it was transformed into the National Aeronautics and Space Administration (NASA), NACA had conducted research on aerodynamics and missiles and had enjoyed "long, close working relationships with the military services in solving their research problems, while at the same time translating the research into civil applications" (Anderson, 1976:17). NACA coordinated research in aeronautics for the military, particularly during and after World War II, but it had remained organizationally independent; the Army and Navy controlled and operated their own research facilities in this area. But with the transformation of NACA into NASA a new organizational model was "charted." Along with NACA's research staff and facilities, NASA assumed control of appropriate projects from the Army, Navy and Air Force. Along the lines of the AEC model, the new NASA would conduct and operate research and development facilities on aeronautics and space research, integrate appropriate military projects, and engage in joint ventures with industrial contractors (Anderson, 1976:24-28). Many of the same corporations doing business with the AEC were among the largest NASA contractors, including General Electric, Westinghouse, Bendix, Zia and others. As for its university linkages, by 1970 NASA had contributed over $32 million for university laboratories and equipment, and $50 million in university research grants.

The atomic energy and aeronautics consortia have together been major sources of postwar science-based industrialization. Micro-electronics, communications systems, computer technologies, laser devices, composite materials, computer-aided design and manufacture, robotics, radiology and many other industrial fields are directly indebted for their existence to the efforts of these consortia. Certainly the state's role in the development of these fields was both substantial and intentional. The national government heavily skewed its R&D activities in support of these consortia, providing by almost any standard a sizable capitalization of their efforts. As Table 7.1 shows, the AEC and Department of Defense dominated research activities of the U.S. government through 1961, when they were joined by NASA in determining the use of scientific and technological resources.

Table 7.1: Federal R&D Expenditures By Agency, 1940-1971.

(in million dollars)

	DOD	AEC	NSF	MED	NACA*	OSRD	NIH
1940	26.4	-		-	-	-	-
1941	143.7	-	-	-	2.6	5.3	-
1942	211.1	-	-	-	5.0	11.0	-
1943	395.1	-	-	77.0	9.8	52.2	-
1944	448.1	-	-	730.0	18.4	86.8	-
1945	513.0	-	-	859.0	24.1	114.5	-
1946	418.0	-	-	366.0	23.7	36.8	-
1947	550.8	37.7	-	186.0	35.2	5.6	-
1948	592.2	107.5	-	-	37.5	.9	-
1949	695.4	196.1	-	-	48.7	-	-
1950	652.3	221.4	-	-	54.5	-	-
1951	823.4	242.6	.1	-	61.6	-	-
1952	1,317.0	249.6	.5	-	67.4	-	-
1953	2,454.8	378.1	2.1	-	78.6	-	53.2
1954	2,487.2	393.1	3.6	-	89.5	-	52.3
1955	2,630.2	385.4	8.5	-	73.8	-	-
1956	2,639.0	474.0	15.4	-	71.1	-	-
1957	3,371.4	656.5	30.6	-	76.1	-	125.7
1958	3,664.2	804.2	33.7	-	89.2*	-	154.5
1959	4,183.3	877.1	54.1	-	145.5	-	223.9
1960	5,653.8	985.9	64.2	-	401.0	-	256.0
1961	6,618.1	1,111.1	82.7	-	741.6	-	294.8
1962	6,812.0	1,284.3	112.6	-	1,251.3	-	403.0
1963	6,848.8	1,335.6	153.1	-	2,539.5	-	511.6
1964	7,517.0	1,505.0	202.9	-	4171.02	-	638.0
1965	6,727.6	1,520.0	206.3	-	5,092.9	-	555.0
1966	6,746.1	1,461.9	240.9	-	5,933.0	-	597.0
1967	7,680.1	1,466.9	277.4	-	5,425.7	-	710.2
1968	8,163.6	1,894.3	314.9	-	4,723.7	-	875.2
1969	7,868.4	1,654.0	342.3	-	4,251.7	-	852.3
1970	7,587.4	1,616.0	324.1	-	3,753.1	-	876.6
1971	7,706.0	1,604.9	373.9	-	3,381.9	-	905.8

Source: National Science Foundation, 1958, 1971 and 1972.

DOD: Department of Defense
AEC: Atomic Energy Commission
NSF: National Science Foundation
MED: Manhattan Engineering District
NIH: National Institutes of Health
OSRD: Office of Scientific Research and Development
*NACA: National Advisory Committee on Aeronautics
Formed into National Aeronautic and Space Administration in 1958.

Throughout the period of 1945-1971, U.S. R&D was largely military sponsored with university and chemical/ engineering industry partners working in conjunction with the national laboratory system to guide national technological development. Among the top six agencies listed in Table 7.1, never less than 90 percent of public R&D funds went to DOD, AEC and NASA in support of the big science-big industry technology model. The concentration of federal funds into a few large corporations was characteristic of the R&D complex as a whole. In 1967 the 100 largest contractors received 65 percent of all military contracts and the top ten received 30 percent. The leader, Lockheed Aircraft, devoted 88 percent of its sales to military contracts from 1960 to 1967. Others such as fifth-ranked General Electric established subsidiary divisions specifically for defense contract work. Nearly 20 percent of all GE sales involved DOD, AEC or NASA during the same period (Melman, 1970:77-78). Universities likewise found it lucrative to turn their research attention to Big Science topics from the development of weapons systems to social control techniques (Melman, 1970:100), and defense production became a highly profitable academic enterprise.

Many of the universities developed separate laboratories and research centers for federally funded research. A Congressional study revealed that in 1964 ten universities received 38 percent of all federal funds to institutions of higher learning and the top 50 received 75 percent. Those universities which were not participants in the elite group found innovative ways to compete for Pentagon, AEC and NASA dollars. One such initiative was Project Themis. Instituted in 1967 with a budget of $20 million, and raised to $30 million in 1969, Project Themis was designed as an effort to incorporate smaller universities into the defense R&D circuit by awarding research contracts in detection and surveillance, navigation and control, energy and power, information sciences, environmental sciences, and social and behavioral sciences (Melman, 1970:100). Universities, in the words of former Michigan State President John Hannah, "must be regarded as bastions of our defense, as essential to the preservation of our country and our way of life as supersonic bombers, nuclear powered submarines and intercontinental ballistic missiles" (quoted in Lens, 1970:127).

In saying this, there is not the implication that national science was exclusively military/atomic/aeronautic based. U.S. postwar policy was not monolithic.

Indeed, after Word War II, it was recognized by many that a science model should be pursued. A movement which traced roots to the National Research Council's search for a national but independent science sought continuous national funding for scientific research that was neither large-scale nor industrially and militarily based. Led by Vannevar Bush, this movement established a National Science Foundation (NSF) which would explore "the endless frontier" of knowledge (Bush, originally published 1945). The ideology underlying the NSF movement had an undeniable influence on popular opinion about science. Indeed, in many ways this ideology of science as free, open and objective inquiry has shaped the public view of the scientist and his/her contributions to society far more profoundly than the AEC. But it is equally clear that the AEC has had far more substantial impact on the nature of science than NSF. In this vein, NASA was perhaps the most successful in realizing the best of both models: it appropriated the ideology that informed the establishment of NSF for its exploration of the endless frontier of space; but was realistic enough to adopt the AEC-Big Science method and organization in pursuing its endless frontier.

While NSF represented an alternative approach, it has never rivalled its Big Science competitor in R&D funding (See Table 7.1), nor has it had the impact on the technological order of its counterpart. At the same time it has carried out its role as the alternative to Big Science, not by challenging the political and economic relations of modern science, but rather by reinforcing the idea of the individual scientist as the new entrepreneur. Foremost, in creating the NSF, it was considered necessary to ensure the independence and freedom of science, the scientist, *and* the institution in which basic research was carried out. In practice, this meant that instead of establishing its own facilities, NSF supported basic science through distribution of grants to individuals and academic institutions directly. NSF sought to give the scientist, as a Bush advisor declared, "the intellectual and physical freedom to work on whatever he damn well pleases" (quoted in Kevles, 1987:346).

Justification for public supported science on the one hand, and acceptance of government coordination by the scientific establishment on the other, was much easier in 1950 than it had been in 1916. In his well-received report to President Roosevelt on postwar scientific research, Bush outlined his program on what in fact was to become the official charge of the National Science Foundation (Bush, 1980:31):

> [NSF] should be a focal point within the Government for a concerted program of assisting scientific research conducted outside of Government. [It] should furnish the funds needed to support basic research in the colleges and universities, should coordinate where possible research programs on matters of utmost importance to the national welfare, should formulate a national policy for the Government toward science, should sponsor the interchange of scientific information among scientists and laboratories both in this country and abroad, and should ensure that the incentives to research in industry and the universities are maintained.

Relieved of the "constant pressure to produce in a tangible way," NSF would underwrite the needs of basic science "to explore the unknown" (Bush, 1980:32). In contrast to the research and development activities already existing in government and industry, NSF was to support only basic research. In this manner, science would be free to function independent of "standards of operation or production" (Bush, 1980:32). Such a conception of science fulfilled an ideological need in postwar U.S. society to dissociate itself from overt military and industrial control. Yet Bush's vision was never intended to build a science entirely independent of military and industrial considerations. Certainly Bush did not subscribe to a view of science as a source of criticism for the emergent power of the military-industrial alliance. Indeed, Bush proposed that NSF should fund research on new weapons (1980:32), *and* should support basic research in order to strengthen industrial research (1980:21). The independence he sought was on the narrow question of *who* decides what projects were funded: through NSF, scientists rather than politicians, or military officers, or industrial officials, would decide. As director of OSRD, he hardly sought a fundamental shift in research direction; it was not the substantive aspects of the science that concerned him, but the virtual absence of scientists (and, some believe, him specifically) in governmental decision-making as to which projects would be supported.

7.5 The Military-Industrial-Science Complex

Both the AEC and NSF models envisioned a society increasingly supportive of and defined by scientific and technological values. The kind of science and technology to be promoted was to be consistent with national goals but, as this analysis has tried to show, the principal national institutions at this juncture were the military, the state, the power complex and a small number of very large corporations. National purpose and need were defined in the context of the operations of these institutions. It was this institutional reality that concerned Dwight D. Eisenhower and prompted him in his farewell address in January 1961 to attach a new name to the integration that had occurred since World War II. He also warned of the simultaneous rise to power and authority in national and international affairs of this institutional alliance (quoted in Kevles, 1987:393):

> In the Councils of government, we must guard against the acquisition of unwarranted influence...by the military-industrial complex...We must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite.

In retrospect, the *military-industrial-science* complex might have been a more fitting characterization of the basis of power in the emergent institutional order.

Eisenhower's warning was intended to heighten social awareness about the infiltration of the military into industrial and scientific affairs, and about the growing concentration in political power of a military, industrial and scientific expert few. But the warning went largely unheeded. In fact, Eisenhower's own policies had been central to the build-up of the complex. In response to the Soviet Union's explosion of an atom bomb, and the successful launching of the first Soviet satellite, Sputnik, Eisenhower undertook to regain a leadership position for the United States by creating the post of Special Assistant to the President on Science and Technology; organizing a full-time presidential Science Advisory Committee; and signing into law the National Defense Education Act which was designed to improve public science education with an initial allotment of $250 million for upgrading school facilities and laboratories (Kevles, 1987:385). Eisenhower drew directly from the established scientific leadership cadre of the Los Alamos generation to fill these new positions; his first Special Assistant on Science and Technology was MIT president James R. Killian, followed by Los Alamos implosion researcher George B. Kistiakowsky. Federal R&D funds more than doubled during Eisenhower's second term (1957-1961), and federal expenditures on basic research were increased three-fold (Kevles, 1987:386).

There was little doubt in the minds of the national administration *and* the public that the future of the United States depended upon its scientific and technological standing in the international order. As Kevles notes, it was a period in which scientists, and in particular physicists, were lauded as the architects of a progressive era (Kevles, 1987:391-392):

> [P]hysicists, among other scientists, were identified not only as the makers of bombs and rockets but as the progenitors of jet planes, computers, and direct dial telephoning, of transistor radios, stereophonic phonographs, and color television; when research and development

> in what President Clark Kerr of the University of California called this "age of the knowledge industry" were believed to generate endless economic expansion; when electronic and computer firms were assumed to follow close upon the heels of local Ph.D. programs; when Governor Edmund G. Brown of California reported that, on the basis of an experiment in his state, space and defense scientists could solve problems of smog, sewage or waste disposal, and transportation.

One of the premier nuclear physicists of the age expressed the enthusiasm for science and technology that pervaded postwar society, and that promised to change everything for the better (Weinberg, 1956:302):

> I do not think it unreasonable to propose that much of mankind's social and political tradition will become obsolete with the full flowering of the Scientific Era simply because all of the traditional doctrines were conceived in an economic and technological era which bears little relation to the age of abundance and moderation which I envisage. In particular, the doctrines of communism and of nationalism would become irrelevant. In a world of plenty, it is hard to conceive of the survival of a doctrinaire communism which is based on the notion that what is available is limited and that therefore the problem of distribution is central. Similarly, with life acquiring a gentler, more abundant aspect, with the probability of war fading, a meaningful nationalism is difficult to imagine. The bitterness which has been assumed to be part of all political struggle--whether intra- or international, will be mitigated because the basic conditions of life have become easier.

Fears of the military-industrial-science complex seemed to be confined to a small number in the society, principally a few "academics, humanists and counter-culturalists" (Kevles, 1987:401).

ENERGY, TECHNICS AND POSTINDUSTRIAL SOCIETY:

THE POLITICAL ECONOMY OF INEQUALITY

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CHAPTER 8

THE POSTINDUSTRIAL URBAN ORDER

With postwar scientific and technological exuberance as the social norm, it appeared anti-progressive to raise questions about the trajectory of future Western society. When Alvin Gouldner in *The Coming Crisis of Western Sociology* (1956), and C. Wright Mills in *The Sociological Imagination* (1959) tried to do precisely this, their ideas were attacked by many for being against modernity. But the problem Mills described had different and deeper roots than his critics allowed. Mills characterized postwar Western society as in a state of alienation: both the biographical and historical senses of self were seen as pervaded by feelings of distance, rootlessness and isolation (1959:3-11). For much of the twentieth century, sociologists had attributed this condition to the disruption of traditional society by the advance of industrial-urban order. By this explanation, the alienation of individuals and groups was an unavoidable, in some sense necessary, concomitant of social progress. Whatever the validity of this argument for the explanation of the effects of the early period of industrialization and urbanization, Mills believed it was inappropriate to the present condition. The modern condition of alienation was not an outgrowth of epochal change, but a manifestation of the jeopardized state of human identity in contemporary society (1959:4-5). In the context of this analysis, the issue was not resistance to change but the prospect of human autonomy superceded by technical considerations. Certainly fears that the aims of society might be subverted by a politically unaccountable military-industrial complex and scientific-technical elite represent something other than anti-progressive anxieties toward social change.

Two recent events, and the social responses that they evoked, usefully illustrate the issue. The urban fires and rebellion of the 1960s directly challenged this society's restructuring to meet the needs of the new postindustrial economy, in the process exposing the deep class, gender and race divisions in the urban order. During a second crisis period experienced in the 1970s, the energy and environmental foundations of the new order were shown to be self-contradictory to sustainable development. In both periods of crisis, society was forced to confront the consequences and implications of the expanding technicization of human life. These crises are examined below in this and the following chapter in order to clarify the conflict between the social and the technical, and the dilemmas this conflict raise for human autonomy.

8.1 Technological Positivism and Social Change

Few in the social science community shared Mill's concerns. Quite the opposite, the 1950s and 1960s represent an era of technological euphoria. Steady economic growth combined with the ascendance of the U.S. to superpower status and the triumph of being the first nation to put a man on the moon seemed to confirm the longstanding American faith in technology-led social progress. Technological positivism is nowhere more evident than in the social research literature where it was routine for writers to observe that, "technological development progressed not on an *arithmetic* scale...but that the process was *geometric* or even logarithmic in growth" (Pursell and Kranzberg, 1967:3 italics in original). It was commonly assumed that social support of science and technology would produce the level of material affluence necessary to resolve the most vexing problems of Western civilization: "poverty would be abolished; technology's benefits would spread worldwide to do away with misery and insecurity and hence with class and international warfare" (Kranzberg, 1973:63). The promise of the future seemed boundless to many (Gordon, 1965:77):

> We may be in an era of productivity unmatched in history. This productivity would result in 'free' food, clothing, and shelter for all men, the guarantee of the necessities of life...To provide these things could be as natural as community water or sewage disposal.

The U.S. in particular seemed ready to assume the role envisioned by Rene Descartes: "instead of the speculative philosophy now taught in the schools," we can, by "knowing the nature and behavior of fire, water, air, stars, the heavens, and all the other bodies which surround us...make ourselves masters and possessors of nature" (1956:40). In this master role, not only was the human frame disburdened, but the human imagination freed as well (Mishan, 1971:4):

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

The U.S. could achieve emancipation of the individual through technologically delivered abundance *and* the whole of society from destiny. Neither nature nor social privilege would govern human potential. In the modern technological era, it would be possible to choose the future guided only by the objective principles of science and the logic of technical application. In this respect, the U.S. was poised to implement Francis Bacon's ideal of a *New Atlantis* in which dominion issues not from force or the scarcities of nature, but from understanding.

To realize this possibility however, the boundary between the technical and the social would have to be altered, and most important, the meaning of "social" would have to undergo radical change. Alvin Weinberg sketched out the issue and its postindustrial solution in a 1966 paper entitled, "Can Technology Replace Social Engineering?" Observing that social problems are far more complex and difficult to define and solve than technological ones, he proposed that we recast social problems as far as possible in technical terms. In this way, we could simultaneously take best advantage of our scientific and technological resources while avoiding "the frustrating business" of inducing effective social change (Weinberg, reprinted 1972:28). As Weinberg proposed the problem, the technological approach was destined to be superior (1972:28,27):

> The technologist is appalled by the difficulties faced by the social engineer; to engineer even a small change by inducing individuals to behave differently is always hard even when the change is rather neutral or even beneficial. For example, some rice eaters in India are reported to prefer starvation to eating wheat which we send to them...By contrast, the availability of a crisp and beautiful technological *solution* often helps to focus on the problem to which the new technology is the solution.

Weinberg was well aware that such a technological focus failed to address the causes of social problems and, moreover, could be a source of new problems because "technological solutions to social problems tend to be incomplete and metastable, to replace one social problem with another" (1972:33). On the other hand, if we insisted upon solving social problems by social means, Weinberg feared that we would tie our future to a utopian hope for a perfect social order, and would neglect the rational options presently available. While technological fixes do not directly address sources of social problems like inequality, they can nevertheless overcome such conditions: "[t]o the discrepancy between haves and have-nots, technology offers the nuclear energy revolution, with its possibility for haves and have-nots alike" (Weinberg, 1972:34). Following the technological path, the condition of social inequality could be made obsolete despite the failure to address causes. In this way postindustrial society could escape the historic threats to order and set itself on a course of technologically secured harmony (Weinberg, 1972:34):

> [T]echnology has provided and will continue to provide to the social engineer broader options, to make intractable social problems less intractable; perhaps, most of all, technology will buy time--that precious commodity that converts violent social revolution into acceptable social evolution.

Of course, there was no guarantee that elites which had used technology in the past to secure their position would not again employ postindustrial machinery to enhance their own control and power. But for postindustrial visionaries both the problem and solution were clear. Buckminster Fuller nicely summarized the postindustrial consensus on the source of the problem in a 1964 essay published five years later (1969:284-285):

> All political machine professionals of all political states will always oppose loss of sovereignty for their own state. Solution of the impasse, if it comes at all, must clearly come from other than political initiative.

Fortunately, advances in science and technology permitted a solution to the impasse (Fuller, 1969:285):

> Now for the first time in history, employing its literary voices, world society can give design science its popularly mandated priority over political initiative with realistic hope as the impelling motivation.

If we grasped the unique opportunity presented by postindustrial science and technology and replaced the political with the technical, society stood only to gain (Fuller, 1969:141):

> Take away all the politicians and all political ideologies and leave all the inventions in operation and more will eat and prosper than now while racing on to take care of 100% of humanity.

All that was required to realize the postindustrial possibility was to "learn to accept mechanized altruism" and recognize machines as "colleagues rather than slaves" (Gordon, 1965:77). While the zeal of postindustrialists like Fuller strained the credulity of the message to even some of its believers, few in or out of the postindustrial camp doubted the greater efficacy of technology to politics in addressing the problems of modern society.

8.2 Postindustrial Theory and the Urban Order

Daniel Bell sought in his 1967 "Notes on the Post-Industrial Society" to synthesize the period's understanding of the relation between science, technology and society. The presupposition of social forecasting generally, and of Bell's work specifically, was that a technology-led transition in society was underway. Revolution, a term usually reserved for the description of political change was appropriated to characterize developments in the fields of communications, transportation and production. But these revolutions were different from their political counterparts: instead of the haphazard nature of change provoked by social movements and palace revolts, the present transition, according to Bell, stemmed from theory-based "controlled experiments" made possible by the advance of modern science. In fact, Bell regarded the improvements in science to be so extensive as to permit investigation, for the first time, of societal-level transformation. Through computer-based simulation procedures, Bell envisioned large-scale experiments in the social sciences which would "allow us to plot 'alternative futures,' thus greatly increasing the extent to which we can choose and control matters that affect our lives" (1967a:30).

The new communications, transportation and production technologies had already produced an overhaul of national economies. Their industrial bases were being rapidly replaced by a new basis of production: "the ganglion of the post-industrial society is knowledge" (Bell, 1967a:28). The earlier system's dependence on "heavy, excessive, and soul-destroying labor" had given way to a new *intellectual* order (Bell, 1967a:27). The economic component of the postindustrial transition was nearly complete (Bell, 1967b:28):

> In one respect, 1956 may be taken as the symbolic turning point. For in that year - for the first time in American history, if not in the history of industrial civilization - the number of white-collar workers (professional, managerial, office and sales personnel) outnumbered the blue-collar workers (craftsmen, semi-skilled operatives, and laborers) in the occupational ranks of the American class structure. Since 1956 the ratio has been increasing: today white-collar workers outnumber the blue-collar workers by more than five to four.

The next phase of the postindustrial transition would involve a reordering of political and community institutions. As to the former, Bell pointed to the spread of the "technocratic mode" as the central influence on the political organization of society. The rise in the number of people in technical occupations, the increasing importance of technology networks on the quality of life, and the growth in years of formal education had created a new political constituency *and* a new ordering of social priorities. As a constituency, scientists and technologists would push "for more amenities, for a more urbane quality of life in our cities, for a more differentiated and better educational system, and an improvement in the character of our culture" (Bell, 1967a:35). Simultaneously, the achievements of science and technology would bolster a normative disposition to value highly what these institutions valued (Bell, 1967a:32):

> In the technocratic mode, the ends have become simply efficiency and output. The technocratic mode has become established because it is the mode of efficiency - of production, of program, of "getting things done."

But perhaps the most enduring impact of the technological transition according to Bell would be the redefinition of the communal basis of society. Scientific and technological advances had increased the "number, interaction and density of population" making this society both "permeable" and "less insulated" (Bell, 1967b:108-109). This result produced both benefits and dangers. On the one hand, "the loss of 'insulating space' itself may permit the setting off of chain reactions which may be disruptive of civil politics and reasoned debate" (Bell, 1967b:110). At the same time however, postindustrial society could choose to respond to permeability by placing its faith in "disinterested" approaches to the resolution of social conflict. Bell was hopeful that the aims of participatory democracy would be realized in terms that were consistent with scientific method and technical rationality. For this reason he forecast the emergence of the university as "the primary institution of the new society" (Bell, 1967a:30). As a model of social organization, the university integrated the best of postindustrial possibilities: an emphasis on theory, observation, and testing; status based on education and talent; and an ideology of quality and merit which could spell the end of political ideology which had for so long divided the West and pitted class against class. The imitation of university organization as a substitute for traditional political ones such as the state and the city would not necessarily dissolve inequalities of class, race and gender, but the "weights" of the social system would be shifted toward a more humane accounting of social needs, costs and benefits (1967a:35; and 1967b:114-118).

Bell gave only passing attention to the impact of postindustrial progress on the organization of social space. His brief remarks on the phenomenon of disappearing "insulating space," however, and his celebration of the university as an organizational model of economy and community indicate his awareness of perhaps the most profound social effect of postindustrialization, namely, the demise of the city as a significant social institution. Theoretical anticipations had been most fully developed in the areas of regional and locational economics. Utilizing geometric logic and the mathematics of points, lines and volumes, a branch of economics had emerged to at once characterize the spatial relations of society and the processes by which human "containers" were shaped, filled and emptied. A guiding principle of this analytic effort was that social space in its original natural state is undifferentiated, boundaryless, featureless. Mapped onto what William Alonso termed the featureless plain (1964:15) were the "cheek by jowl" interactions of economic agents seeking to materialize space in socially useful ways (Hoover, 1975: 8). The conception of social interaction on such a plain pointed to a related principle of the discipline, one which Francois Perroux elucidated in 1950-- "the fact that economic units or activities *cannot be localized"* (1950:24). Instead, there are only "illusions of localization," the temporary spatial aggregations of people and economic activity. As technology and economics evolve, so does the size, density and location of these aggregates. Although common sense definitions of city, region and nation presume an autarchy of space, Perroux argues this is merely a "vice of the original thought" and that in actuality social space is continuous and ever-changing (1950:33). Social space is best understood as a field of forces in which centers and poles emerge in response to technological and economic developments. Cities and other human settlements represent such phenomena within the field of forces. As Perroux puts it, they are "complex aggregates of monetary and financial organisms--the 'places'" (1950:30). Their evolution is dictated by the process of monetarization of space: "the monetary flows attracted towards and issuing from one of these financial 'places,'...the variations of their direction, their composition and their volume, actualize a monetary space" (Perroux, 1950:30). Because of the features which make one monetary spatialization more attractive than another are always subject to change, these aggregates are never more than "a place of passage" in the field of forces; they "take an *essentially variable* meaning, which can never be made precise by their outline or by their container" (Perroux, 1950:34).

By the 1960s, spatial ideas like those of Perroux had been married with the micro-economics of utility maximization to render an economic theory of social space. Represented in the work of Alonso (1964), Isard (1975), Mills (1972), and Hoover (1971), this theory argued that the forces of technology and economics, if unimpeded by government, would produce socially optimal configurations of space. Citing the same technological ganglia of postindustrialism--those of communications, transportation and production, these theorists portrayed the century-long decentralization process (the emptying of the urban "containers") as the natural result of residential preferences for open space, more land, and more greenery; and of the high-tech knowledge revolution in the industrial structure. Social space under this treatment had little if anything to do with community. Cities and every other form of human settlement became just another place auctioned in a market bazaar for their amenity value.

When joined, Bell's idea of postindustrialism and the neoclassical economist's idea of delocalization of space projected an image of community alienated from place. While some were disturbed by the idea, the mainstream of social science accepted the prospect as a necessary concomitant of social progress. Indeed, the characteristics of the modern "place" would now be seen as mobility, efficiency, adaptation. David Lewis contrasted the new and the old in the following terms (Lewis, 1969:302-303):

> Traditionally, for the last five thousand years, since the Sumerian civilization, when Mesopotamian man first began to live in urban settlements, cities have been concentrations of great insularity, intricate, teeming and compact, in powerful juxtaposition to the countryside surrounding them. They were closed-form cities--autonomous, mononuclear and culturally insular. To some extent the great cities of the United States eastern seaboard--Boston, New York, Philadelphia, Baltimore and Washington--still function in this traditional way...But cities in our

> age of unprecedented dynamism are no longer autonomous and self-sufficient. This implicitly inward-looking, insular form of the single-center city is in conflict with the dynamism of modern mobility and communication systems. The United States as a whole has become a complex network of communications and services; and every major city, and thus every citizen, is a component of this intricate network--connected by telephones and television, power grids and consumer production, airways and highways...The closed urban form, the finite and mononuclear city of tradition gives way to a new species of urban form in which the basic factor is mobility; an open form, multi-nuclear, multi-directional city--a city which is infinitely additive and infinitely variable in its capacity for growth and change.

The vision of the new place and the new community emphasized the interaction of human with technological; human-to-human interaction was all but ignored. For example, Lewis forecast by the year 2000 the appearance of the "super city," "a gigantic urban form...based on an attenuated network of communication systems, with high-density nodes at the interstices" (1969:311). In this social space human experience would be technologically circumscribed (Lewis, 1969:311):

> Already in our current technology we have mastered the major problem of providing a continuous and unbroken microclimate, constantly agreeable summer and winter, across the entire city. From our thermostatically controlled, air-conditioned, centrally heated and equably humidified colonial farmhouses in the city, we may bowl along limited access highways in our private air-conditioned maximum visibility bubbles at 60 m.p.h., accompanied by a full orchestra, and arrive in the parking decks of our multideck air-conditioned, pedestrian/traffic

> segregated urban centers, for work, education, shopping or culture, without even venturing into the open air!

As this vision diminished the value and importance of the social, it elevated the status of science and technology. True, scientific and technological advance emptied and filled urban containers in a manner that created high levels of social distress, but we would eventually recognize the logic of the universalizing technological culture (Lewis, 1969:315):

> One of the most hopeful factors in the world today is the implicit internationalism of scientific knowledge. The impact of these dynamic or exponential progressions on the cultures of the world--bringing them rapidly, if at the present time unequally, into a single cultural family--is ensured by the speed of development in our communications and mobility systems.

Social barriers created and defended by closed social forms like neighborhoods, cities and nations would fall under the influence of science and technology. Even the barrier of racism would be overcome (Gordon, 1965:73):

> "Well, Mr. Brown, that just about completes your re-orientation. Pretty soon you'll be able to enter our society. Are there any questions you want to ask?"
>
> "Please take no offense, but there's one thing that puzzles me. It's the color of your skin. In my day, we had no end of trouble from that; yellow brown, and white. But you're blue, lavender, pink; I couldn't keep track of all of the hues."

"Yes, we're colorful all right. When we first got control over heredity, our scientists experimented with specialization. You know, big hands for manual laborers, special brains for scientists, and so on. This gave us a lot of trouble with everybody lobbying for the trait they thought best for mankind. So the whole thing was abandoned except for cosmetic effects. And that had the most benefit of all. It eliminated the races. Anybody can be any color he wants."

8.3 Social Contradiction and the Urban Crisis

The summer of 1967 brought an abrupt halt to postindustrial exuberance. Neighborhoods in over 150 cities caught fire as racial tensions combined with pervasive poverty to trigger what were officially designated as "urban riots" (National Advisory Commission on Civil Disorders, 1968). For others, the events of that summer represented the seeds of revolt. The interrelated conditions of inequality, racism and as we only later admitted, sexism, that were at the root of the 1967 urban fires were not cosmetic and could not be resolved, delayed or avoided by a technological fix. Rather, these problems as the National Advisory Commission on Civil Disorders (hereafter cited as the Kerner Commission) would report to President Johnson, were endemic to the political economy and national culture.

The Commission identified three main causes of the urban chaos (1968:91):

> [T]he most fundamental is the racial attitude and behavior of white Americans toward black Americans...White racism is essentially responsible for the explosive mixture that has been accumulating in our cities since World War II...The second is the massive and growing concentration of impoverished Negroes in our major cities...and the continuing movement of the white middle class to the suburbs. The consequence is a greatly increased burden on the already depleted resources of cities, creating a growing crisis of deteriorating facilities and services and unmet needs...Third, in the teeming racial ghettos, segregation and poverty have intersected to destroy opportunity and hope and to enforce failure. The ghettos too often mean men and women without jobs, families without men, and schools, where children are processed instead of educated, until they return to the street--to crime, to narcotics, to dependency on welfare, and to bitterness and resentment against society in general and white society in particular.

The Commission report recorded the concentration of urban poverty among black and female headed families. It noted that black median family income was only 58 percent of the white median; that 73 percent of black families had incomes below $7,000; that 31 percent of nonwhite families lived in poverty compared to 8.8 percent of those with white heads; and most alarming, that 81 percent of female-headed nonwhite families with children under the age of six lived in poverty (Kerner Commission, 1968:123-128). But while these statistics in themselves were disturbing, the Commission observed that the trend since world War II had been a worsening of the gap between black and white (1968:123):

> Negro family income is not keeping pace with white family income growth. In constant 1965 dollars, median nonwhite income in 1947 was $2,174 lower than median white income. By 1966, the gap had grown to $3,036.

As the Commission documented conditions of poverty, and race and gender inequality, it also reported the failure of national policy to address such conditions. Based on a detailed survey of federal anti-poverty programs in Detroit, Michigan, Newark, New Jersey and New Haven, Connecticut, the Commission concluded that "the number of persons assisted by [manpower, education, housing, welfare and community action] programs in almost all cases constituted only a fraction of those in need" (Kerner Commission, 1968:79). As illustrations of policy failure, the Commission noted that less than 20 percent of Detroit's unemployed received manpower training; that education programs for Detroit's poor children assisted only 31 percent of the eligible population; that in the three cities the number of low-income houses demolished for highway construction and urban renewal with federal funds was more than 26,500; and that only 19 percent of Detroit's eligible poor received welfare assistance (the number was 40 percent in New Haven and 54 percent in Newark).

Other analyses of the period substantiated the survey results of the Commission. A 1969 report of the U.S. Department of Health, Education and Welfare stated that "in 1965, only 20 percent of poor persons received public assistance payments, and of those, 82 percent remained poor after payment" (1969:49). Another study estimated that at the end of 1965 there were 600,000 public housing units, but 8 1/2 million poor families needing such housing (Pascal, 1967:6). As a result of urban renewal efforts 126,000 low-income housing units had been demolished by 1961. The 28,000 new units that were constructed were "in no way sufficient to house the 113,000 families and 36,000 individuals who were displaced" (Judd, 1984:275). And in a comparative study of 14 high-GNP nations, the U.S. was found to have the lowest social welfare expenditures in relation to its level of economic inequality and was "the lowest in its effort to redistribute income through government programs" (Cutright, 1968:563; see also pp. 558-562).

8.4 The Policy Response

Two interpretations were advanced to explain the dual reality of American urban society. One school regarded inequality as the unavoidable result of industrial economic development. Pointing to the improvements in absolute income levels, proponents such as Simon Kuznets (1963), Glazer and Moynihan (1964), Gerhard Alinsky (1966), James Q. Wilson (1968) and Oscar Ornati (1968), sought to characterize poverty as a condition of *relative deprivation* accompanying economic development. For this school, racism and sexism represented socio-psychological pathologies which grew out of conditions of persistent inequality and status group efforts to maintain or improve their relative standing on the socio-economic latter. From this perspective, the urban fires of the late 1960s underscored the need for policies which would redistribute income and establish a minimum base of social welfare.

In contrast, a second school considered the interrelated conditions of poverty, inequality, racism and sexism as the outgrowth of the class basis of the American political economy. C. Wright Mills (1956), Gabriel Kolko (1962), Piven and Cloward (1971), Michael Harrington (1962), and William K. Tabb (1970), among others, argued that unequal economic and political power derived not from the laws of industrial development, but the laws of capitalist social relations. In this view, poverty was functional to the political economy because it provided the necessary condition for an elite to secure and maintain great wealth. Racism and sexism were regarded as highly effective cultural instruments for enforcing inequality. Social science and urban policy alike were preoccupied throughout the 1960s and through much of the 1970s with the debate of these two interpretations. While other points of view, and even third schools of thought emerged during the period, none were more powerful in setting the research and policy agenda than these two.

In his State of the Union Address in 1964, President Johnson declared "unconditional war on poverty" (printed 1965:113-114):

> Unfortunately, many Americans live on the outskirts of hope--some because of their poverty, and some because of their color, and all too many because of both. Our task is to replace their despair with opportunity...Our aim is not only to relieve the symptom of poverty, but to cure it and, above all, to prevent it.

Johnson's message was indicative of the national attention being given, belatedly, to issues of urban poverty, racism, and to a lesser extent, sexism. A crisis in American society had been grudgingly recognized and a sense of urgency for action was evident. High priority was given to reforming the conditions of the urban underclass and rehabilitating the decaying physical infrastructure of large cities.

While there were debates over the *sources of inequality*, a consensus had emerged regarding the *outcome*. In the research literature and policy, race had become recognized as virtually synonymous with poverty and underprivilege, and gender with the separation of work and home. Racism and the later acknowledgement of sexism were identified as socially problematic because they resulted in a condition of localized dependency among minorities and women. While a general pattern of economic and technological spatial deconcentration was advancing, another trend toward community concentration and segregation was also occurring. This was most evident in the dichotomies that had come to express the urban spatial order: black versus white, educated versus uneducated, female-headed versus traditional family households, employed versus unemployed, skilled versus unskilled, productive versus nonproductive were all characteristics used to delineate the factors of crisis in contemporary society.

Throughout the period, a basic policy assumption was that first and foremost improvement of the economic conditions of the ghetto population was needed. Mobilization of national resources toward the alleviation of poverty, and the elimination of at least the most blatant and overt forms of discrimination, were designed to relieve the manifest conditions of segregation and inequality. What began as the "war on poverty" eventually gave way to urban "revitalization" of the inner core but, regardless of their focus, solutions continued to affirm a faith in technology-led progress; indeed, a central focus of national policy during this period was to provide assistance in order to enable minorities and women to meet the technical, economic and mobility requirements of postindustrialization (Moynihan, 1970:31-32):

> Urban policy must have as its first goal the transformation of the urban lower class into a stable community based on dependable and adequate income flows, social equality and social mobility. Efforts to improve the conditions of life in the present caste-created slums must never take precedence over efforts to enable the slum population to disperse through the metropolitan areas.

While racism and to some extent sexism were understood as instruments of segregation, by assigning as "Negro work" and "women's work" those jobs that were at the bottom rung of the economic latter, the role of integrating capital and technology in race, gender and community relations went largely unchallenged. Most of social science instead focused on questions of "who governs" (Dahl, 1961), the nature of community power (Hunter, 1953), differences in pluralism from above or below (Parenti, 1974), social capacities for the "mobilization of bias" and "non decision making" (Bachrach and Barantz, 1970), the "alternative futures of of the American ghetto" (Downs, 1968), and many others which were debated without result. Two exceptions were William K. Tabb's *Political Economy of the Black Ghetto* (1970) and Robert Blauner's *Racial Oppression in America,* both of whom argued that the systematic marginalization of minorities and women represented a form of "internal colonialism." For Tabb and Blauner, the socio-spatial contradiction in U.S. society was not unlike the domination of societies during colonial rule (Tabb, 1970:24):

> The spatial separation of colony and colonial power is secondary to the existence of control of the ghetto from the outside through political and economic domination by white society. An historical comparison of the forms colonialism has taken, and a description of the place of blacks in the American economy make clear that internal colonialism is an apt description of the place blacks have held and continue to hold in our society.

According to Tabb, urban ghetto economies exhibited conditions of underdevelopment similar to those of the colonized Third World: "low per-capita income; high birth rate; a small weak middle class; low rates of increase in labor productivity, capital formation, domestic savings; and a small monetized market" were characteristics shared by both external *and* internal underdeveloped societies (Tabb, 1970:22). Moreover, with the technical reordering of economic, political and community institutions, lack of minority and female conformity, assimilation or participation in the productivity of U.S. society constituted further proof of the Western conception of "technologically backward cultures" (Landes, 1969) as sources of poverty and inferiority. Political, religious and philosophic ways of knowing that articulated realities divergent from the Western scientific and technological ideal were regarded as failures; "They can not furnish leadership in the modern world," Baranski noted, "they are potent factors of disorder" (1960:44). It was this imperialistic nature of Western science and technology that Blauner addressed (1972:114):

> The depreciation of the cultural integrity of non-Western people appears to be a result of specific values and emphases within the Western ethos, not just a matter of ignorance, arrogance, and ill will. The leading concepts of Western culture...include control and dominance, property and appropriation, competition and

> individualism...Particularly important has been the conflict between the Western technological orientation of engineering mentality and the more organic harmonious notions of the relation between man and nature that were held by societies dominated by colonialism. The aggressive implementation of such an exploitative attitude toward the external world often disrupted non-Western ways of life and contributed to the white man's depreciation of people of color.

Analyses like those of Tabb and Blauner, however, were largely ignored; or worse, they were characterized by many in the mainstream as "abstract" and "Marxist phobia." Social science began the period divided over the explanation of the dual reality of urban society and remained in that state as urban programs were abruptly eliminated or shrunk. Social momentum slowed almost as quickly as it had gained speed. National goals of empowerment soon were regarded as threats to established political authority; attention to eradicate inequality brought forth worries about the impact on economic growth; and the increase in federal resources for anti-poverty programs prompted cries of political imbalance and charges of central government interference in state and local concerns. The short-lived era of national action ended when a regime of policy reaction was installed in the early 1970s with the withdrawal of "maximum feasible participation" (which specified that community action programs should be developed, conducted and administered by those members of the community they were designed to serve) in the Model Cities program; the shift from categorical to block grants; the adoption of a fiscal ideology of revenue-sharing; and an increased emphasis on federal management, measurement and cost-effectiveness. The reversal of trend was so fast as to prompt one analyst to characterize 1970s urban policy as "the assassination of the Great Society" (Lekachman, 1981:60).

8.5 Postindustrialism and the Logic of Urban Growth

While the Tabb-Blauner thesis of the colonialism of technology was ignored, and while the mainstream remained divided over the issue of transition versus crisis, another strand of social science argument was emerging which sought to revive the postindustrialist vision. Led by Edward Banfield, this approach accepted as unavoidable a permanent underclass and argued that the whole of U.S. society was undergoing a social and economic transition on a scale equivalent to earlier industrialization. But in this version of postindustrialism, the idea of social transition would be recast in a logic of social imperative: societies could either adapt to technological and economic forces now shaping them, or experience decline in the evolving world competitive order. In this argument the underclass was a necessary cost, cities were dispensable institutions, urban and social policy were doomed to failure, and ideals of community and equality were irrelevant and obsolete.

The first step in Banfield's rehabilitation of the postindustrialist doctrine was to refute the view that present society was in a state of crisis. Blaming the media (1970:198-199), the civil rights movement (1970:199-201), liberalism (1970:171), and interest group politics (1970:203) for promoting the view that we were suffering from an urban crisis, Banfield instead argued that we were witnessing simply the social outcomes of the logic of metropolitan growth. This logic could be dissected into the three imperatives of changing demography, changing technology and changing economics (Banfield, 1970:23):

> Much of what has happened--as well as of what is happening--in the typical city or metropolitan area can be understood in terms of three imperatives. The first is demographic: if the population of a city increases, the city must expand in one direction or another--up, down, or from the center outward. The second is technological: if it is feasible to transport large numbers of people outward (by train, bus and automobile) but not upward or downward (by elevator), the city must expand outward. The third is economic: if the distribution of wealth and income is such that some can afford new housing and the time and money to commute considerable distances

> to work while others cannot, the expanding periphery of the city must be occupied by the first group (the "well-off") while the older, inner parts of the city, where most of the jobs are, must be occupied by the second group (the "not well-off").

The earlier generation of postindustrialists had erred in building expectations about a social future whose problems would be cured by technology. For Banfield it was quite the opposite. Social problems would continue and trends in demography, technology and economics would serve to *constrain* our public options (Banfield, 1970:24):

> The word "imperatives" is used to emphasize the inexorable, constraining character of the three factors that together comprise the logic of metropolitan growth. Indeed...given a rate of population growth, a transportation technology, and a distribution of income, certain consequences must inevitably follow; that the city and its hinterland must develop according to a predictable pattern and that even an all-wise and all-powerful government could not change this pattern except by first changing the logic that gives rise to it. The argument is not that nothing can be done to improve matters. Rather, it is that only those things can be done which lie within the boundaries--rather narrow ones, to be sure--fixed by the logic of the growth process.

Indeed, any effort to change significantly the direction of urban development was doomed. Banfield sought to demolish liberalist intervention strategy by arguing that public actions to materially affect urban life and order could actually result in the rapid demise of cities.

Thus, he suggested that if Manhattan had adopted zoning ordinances to prevent objectionable land uses (1970:42),

> [T]he old Knickerbocker mansions would still be standing--but there would be no city...If towns are to grow into cities and cities into metropolises, old residential districts necessarily must decline and disappear.

Similarly, if housing codes had been enacted to prevent the appearance of sub-standard dwellings, this "would have prevented the city from growing fast and from growing into a metropolis." The logic was unassailable (1970:42):

> In order to grow fast, the city had to become a center of warehouses, shops, and factories, which meant that it had to have a plentiful supply of cheap labor which meant that it had to have a plentiful supply of housing that such labor could afford.

And if cities had tried to guarantee adequate housing through the adoption of a social welfare system, the result would have been the loss of competitive advantage (1970:42):

> Had all places provided adequate housing, the city would have been under a cost handicap, and its development would have been impeded accordingly. The fundamental fact was that it would have cost more to provide adequate housing in the city than elsewhere.

The only remaining challenge to postindustrialism--that presented by class analysis--was dispatched by, in part, agreeing with certain conclusions from such analysis, and by providing an alternative theory of poverty. Banfield accepted the argument that class rather than race, place of origin, or gender had the greatest explanatory power in matters of inequality (1970:73). Moreover, he agreed that a "lower class" was a permanent institution of modern societies. His reasoning however, was substantially different from writers like Tabb and Blauner. As he observed, "the logic of growth" cannot fully account for inequality or poverty (1970:45-46):

> [T]he logic of growth does not explain the existence of slums. A slum is not simply a district of low-quality housing; rather, it is one in which the style of life is squalid and vicious. The logic of growth *does* require that, in general, the lowest-income people live in the oldest, highest-density, most run-down housing, which will be nearest to the factories, warehouses, stores, and offices of the inner, or downtown, part of the central city; however, nothing in the logic of growth says that such districts must be squalid and vicious.

To explain the squalor and viciousness of slums, Banfield turned to a fourth imperative of class culture in which community orientations are distinguished by two factors: the "ability to imagine a future" and an ability "to discipline one's self to sacrifice present for future satisfaction" (1970:47). He argued that future-oriented communities are able to adapt to the changing urban environment and even to prosper in the midst of change. By contrast, present-oriented communities lag behind permanently because of the absence of an appreciation for the future. Differences in class culture were at the root of wealth inequality, according to Banfield (1970:125-126):

> Extreme present-orientedness, not lack of income or wealth, is the principal cause of poverty in the sense of "the culture of poverty." Most of those caught up in this culture are unable or unwilling to plan for the future, to sacrifice immediate gratifications in favor of future ones, or to accept the disciplines that are required in order to get and to spend.

Utilizing the theory of a "culture of poverty," Banfield rejected arguments that a "racial" factor is at work in urban poverty. Performing his own "Gedanken" experiments, Banfield asked what would happen if overnight, Negroes turned white. He concluded, "most of them would go on living under much the same handicaps" (1970:73). The reason for this conclusion was that "New-Whites" would still disproportionately share an extreme present-orientation and thus would not escape "inwardly caused" lower-class poverty (1970:126). Efforts to assimilate Negroes into "New-Whites" affect poverty only "superficially" (1970:126), since the source of the problem was neither race nor income, but class culture. Thus, amidst an upward "middle-class-ification" social movement there continued to exist a sizable lower class (albeit smaller than a century ago). Often cited urban "objective" conditions such as inadequate housing, unemployment and poor schooling in fact had less influence over the urban rebellions, than did the cultural lack of social conscience: "The morality of lower-class culture is pre-conventional, which means that the individual's actions are influenced not by conscience but only by a sense of what he can get away with" (1970:163). The riots of the 1960s simply expressed this predilection of the "culture of poverty" toward violence and crime.

For Banfield, the issue was not merely that we had gotten the causes of poverty wrong. In some ways even more dangerous was the attendant predilection to look for external, "structural" causes and remedies of urban violence. The urban riots were ample illustration of the problem in Banfield's mind. Under his diagnosis the urban riots could be traced to "frustrated teen-agers who happen to be black"; "an outbreak of animal--usually young, male animal spirits"; "a foray for pillage by young toughs who find 'taking' things the easiest way of getting them...the toughs are Negro, but they could as well be white"; and, generally, a pathological tendency within the culture of poverty to steal, rob and loot "for fun and profit" (1970:187,189,198). Yet U.S. social institutions seemed determined to assign blame outside the culture and seek remedies that were likewise outside the culture's structure. Thus, for Banfield what began as rampages of lower-class youths "acting out" was accelerated to widespread rioting by "sensational television coverage" which "recruited rampagers and pillagers"; the absence of fear of punishment as a result of court victories of the civil rights movement; the professionalization of police departments; and a belief nourished by the news media and academics that black poverty was rooted in racial injustice and white racism (1970:198-200).

The underlying causes of urban rioting were demographic and economic and not readily affected by public actions. These included "a large supply of boys and young men of the lower-classes" concentrated in the inner cities: "lower-class youth in every generation and in every ethnic and racial group are extremely violent as compared to middle- and upper-class adults" (1970:202). Second, the increasing "middle-class-ification" of the population and of public institutions had diminished the social authority of the more stable elements of the lower class (1970:203):

> [E]xclusion from institutions of those who are not able or willing to participate on the terms set by the now predominant middle class has the effect of reducing the influence within the lower classes of those persons who, although not able to perform according to the standard set by

> the middle class, could nevertheless lead and set an example for--and thus place some restraint upon--less able members of their class.

Third, the demographic and economic transformation of the metropolitan U.S. had resulted in a spatial conjunction of upper- and lower-classes which was feeding false expectations among the latter (1970:204):

> A considerable number of upper-working-class, middle-class, and upper-class people who have made large income and status gains in recent years and are impatient to make even larger gains live in the inner city in close proximity to the lower classes. Upwardly mobile members of earlier slum populations very quickly left not only the slum but the inner city as well, and usually the neighborhoods they vacated were occupied by some different newly arrived ethnic group. In the case of the Negro, the outward movement has been rather slow, partly because of job and housing discrimination and partly because of a preference Negroes have for living near other Negroes; moreover, in the case of the Negro, the places of those who *have* moved away have usually been taken by newly arriving Negroes. Upwardly mobile Negroes who for one reason or another live in or near the slum tend, of course, to be very sensitive to the dangers and unpleasantnesses of slum life and to blame them not on conditions common to the white and the Negro (for example, lower-class culture, low income, and so on) but on racial injustice past and present, real and imaginary. If, like the upwardly mobile members of earlier groups, these Negroes lived in suburbs far from the inner-city slums, they would not be available physically (and perhaps psychologically) for participation in riots. As it is they do not participate in them actively in large numbers. They do provide enough politically motivated rioters, however, to make possible the interaction effect that,it was argued earlier, tends to escalate a rampage-foray into a major riot. Even those who do not participate in the rioting tend to help legiti-

> mate it in the eyes of potential rioters by putting forward or concurring in the claim that it has a political purpose.

Such "background causes" made it highly likely that society would experience frequent "rampage-forays and some major riots" for at least twenty years. Policies directed at racial injustice, inequality, unemployment and so on would have no appreciable effect, according to Banfield, on the extent of rioting. Instead the only effective long-run remedy was that "eventually, much of the inner city population would move to the suburbs"(1970:205).

Banfield's analysis led him to three conclusions. First, that a permanent urban underclass was unavoidable; second, that urban policy was ineffective in addressing this circumstance; and third, that the decline of cities was inevitable, natural and highly desirable. A postindustrial order organized around suburban lifestyles and values was impelled by the larger forces of technology, economics and demography. What stood in the way of realization of this future was political and sociological doctrines that misrepresented social relations and falsely characterized the capacities and effectiveness of public institutions and public policy. Banfield was particularly concerned about two doctrines prevalent in the U.S. The first was the doctrine of white racism which unduly focused attention on inequality and stressed the need for structural policies to redistribute political and economic power to the poor. For Banfield such thinking only prolonged the transition to postindustrialism. He specifically blamed the Kerner Commission report and the successful sale of 1.3 million copies of its analysis which "almost certainly made it easier for many Negroes to commit crimes" (1970:172-173). In Banfield's view, so long as lower-class blacks believed that white racism was a cause of their condition, faith would be placed in "massive government welfare, housing and other programs" which would only breed a dependence upon the state and reduce self-initiative and community-wide efforts to improve their situations. According to Banfield, white racism was a "self-fulfilling prophecy" which promoted a "reign of terror" and raises social expectations, especially among poor blacks, and denies the reality of "the logic of growth" (1970:260).

The second doctrine, Banfield described as the "DO SOMETHING, DO GOOD" syndrome which was specifically encouraging national efforts to revitalize the economies of large cities. Banfield traced this doctrine to a combination of middle-class utopianism and confusion about the nature of the urban situation. Middle-class ideology of hard work rewarded by material wealth had led many to believe that all of society's problems, and certainly its urban problems, could be addressed if the commitment to "DO SOMETHING, DO GOOD," was made and implemented in an effective well-organized efficient manner. This led to a utopian belief among many that anything was possible, even the resurrection of large cities. Relatedly, Banfield accused the middle-class of overlaying their amenity views about comfort, convenience and business advantage onto a troubled urban landscape, and believing that if society could simply "beautify" its cities in the image of the suburbs that all would be well. But, Banfield challenged, amenity by definition favored the suburbs, and in any event, the forces of demography, economics and technology mooted the whole effort. Only by abandoning the syndrome to "DO SOMETHING, DO GOOD" could the "good health of society" be permanently improved. The assumption "that an improvement in material welfare is bound to make a major contribution to the solution of almost any problem" could not be demonstrated, and even if it were true, such improvement is unlikely to be the result of government policy. Such a notion could foster, for example, a belief in the effectiveness of welfare policy.

But, Banfield argued, this badly defined the problem as social rather than individual: it was the difference between a diagnosis of urban poverty as a "lack of income and material resources (something external to the individual)" rather than the correct formulation as the "inablity or unwillingness to take account of the future or to control impulses (something internal)" (1970:256). Banfield countered that "in general the effect of government programs is to exacerbate the problems of the cities...government cannot solve the problems of the cities and is likely to make them worse by trying" (1970:257). He urged the society to resist the pessimism of "massive" government policy and embrace the optimism of market and technical rationality. The "good society" would be one which placed its faith in "facts, rational analysis, and deliberation about the nature of the public interest...in the formation of both opinion and policy" (1970:263). This would come about when businessmen and technologists, rather than politicians, took charge of decision-making.

8.6 Postindustrialism and the Logic of Urban Decline

Banfield's analysis was pathbreaking in its revision of the urban problem, the interrelation of race, inequality and poverty, and the role of public policy and public institutions. He recast postindustrial theory in terms which removed an obstacle of urban crisis to postindustrial progress. While initially attacked by academic and political liberals, major portions of Banfield's argument have been accepted by the mainstream of urban analysis. As I have observed with colleagues elsewhere: "Banfield's ideas were the subject of protracted debate throughout the 1970s. In the 1980s, however, ideas very much like Banfield's have emerged as the dominant framework for urban policy" (Byrne et al., 1985:124).

Microeconomics proved to be a fast ally of the Banfield approach. The earlier achievements of regional and locational economics had paved the way for a new subdiscipline--urban economics--which wrestled with the problems of slum development and the general decline of central city economies. In a now classic paper on urban economic development, Nobel laureate Kenneth J. Arrow provided economic support for Banfield's contention that urban policy could only do more harm than good in erasing the problem of inequality. Using a micro-economic model to describe the historical development of cities, Arrow explained the positive process of urban growth (1970:14-15):

> [I]n large measure the natural and beneficent result of economic forces...The economically

> induced shift to the cities has repeated itself wherever industrialization has occurred...From the economic viewpoint this movement must be judged overall a great success.

Similarly, suburbanization could also be traced to benevolent economic forces (Arrow, 1970:16):

> The suburbs offer attributes desired by many if not most individuals: space, greenery, and in some cases better education and other public services. These are costly, so that suburban living is something of a luxury good. As incomes rise, more individuals can afford the luxury, and the flight to the suburbs is on...Again, this movement in good measure conforms with the theoretical model of overall improvement due to the price system. Those who do move presumably are better off; otherwise they would not go. Those who do not move are no worse off; indeed the movement of so many out of the city reduces the competition for urban space and keeps rents and property below what they otherwise would be.

This model offered a common explanation for the in and out migration of cities, for the rise and decline of city economies, and for the burgeoning growth of suburban economies. All of these phenomena were the results of "natural and beneficent" economic tendencies toward social efficiency. In this way of thinking, government policy is conceived as an exogenous force. Its impact and success are intimately dependent upon the degree of correspondence between the logic of the policy and the logic of economic forces. Any policy effort, including ones directed at urban poverty and racial inequality, must be analyzed against the reference of economic forces. Arrow was straightforward in this regard in his assessment of urban policies to redress the conditions of poverty and inequality. He recognized these policies as attempting a redistribution from rich to poor, and asked how we might evaluate proposals to carry out this goal. In one direction, he suggested (Arrow, 1970:21-22):

> [R]edistribution might occur with federal aid, which may be used, for example, for ghetto jobs, housing, or other special services. But we must ask how the economic system as a whole will react to such measures.

His reply was that if such redistribution had a specific urban focus, it would almost certainly trigger the opposite result from what was intended (Arrow, 1970:22):

> In actual fact, improving the status of the poor and the blacks in particular cities and especially in particular areas is likely to induce further in-migration and preservation of the ghetto as natural economic responses.

Indeed, from Arrow's analysis, government policy could be seen as a primary contributor to the emergence of urban slums and racial ghettos. In his mind, if we were genuinely interested in resolving the problem of racial urban ghettos, specifically urban polices should be dismantled in favor of national redistribution policies. Echoing Banfield's standard of the good health of society, Arrow argued that such a redistribution effort would have to be weighed against "the variety of resource allocation problems for which the market fails to find a solution" (1970:22). While not directly addressing the broader question of *permanent* urban decline, Arrow's paper nonetheless hinted at the emerging argument for urban triage: "to recapitulate, the present state of cities, including their fiscal crises and their tensions, is in good measure the outcome of natural and beneficial forces in the market" (1970:22).

In a paper published ten years later, William Baumol, (a past president of the American Economic Association) grasped the larger issue and called for recognition of a "new urban equilibrium" in which the relation between city and society was dramatically altered. Relying on a slightly more sophisticated version of Arrow's thesis that cities derived from natural and beneficent economic forces, Baumol sought to write an urban history of growth *and* decline. In this history, cities came into being because of their locational and scale advantages, and certain technological constraints on economic activity, especially in transportation. Recent technological innovations however, reduced considerably the economic advantages of urban social organization, specifically the development of the telephone, the automobile, the interstate highway system, and continuous production processes. These technologies freed economic development of its earlier geographic tendencies (for example, proximity to ports and mines), its spatial dependencies (such as the proximity to large consuming populations), and its technological dependencies (including the reliance on particular forms of transportation). According to Baumol, innovation and reduced site needs of business were leading to "a reduction in the equilibrium volume of economic activity within the city" (Baumol, 1981:6). Overall, this meant that cities retained "residual economic advantages" which include serving as office headquarters for large corporations; providing variety retailing such as "unusual electronic components, rare tropical woods, unusual food products"; and supplying a host of specialized amenities ranging from ethnic restaurants to certain cultural institutions which would be too costly to replicate in the suburbs (for example, theater districts, large museums and opera houses) (Baumol, 1981:11-12). As businesses no longer "found it essential to locate cheek by jowl," the urban system was experiencing "a 'natural sequence of events in the adjustment...to a new equilibrium involving a reduced level of economic activity and a reduced population" (Baumol, 1981:4, 8). The exodus of industries, the rise in unemployment, deterioration of housing stock, higher crime rates, and increasing violence and destruction of property were all components of the natural sequence. While painful and socially disruptive, these steps were nonetheless necessary if the transition was to be completed (Baumol, 1981:10):

> As the housing stock of the poor continues to deteriorate and even to disappear, as jobs fail to materialize and tend to become scarcer, net migration of even the poor can be expected. Those who came into the city will be induced to leave and they will be accompanied by still others who once had a place in the city's economy. This must be so, if the new equilibrium involves a smaller number of unskilled and semi-skilled jobs than the old and therefore calls for a smaller number of impecunious inhabitants. Their equilibrium number will not drop to zero--probably it will be far from that. But it will be significantly smaller than it was before.

If society could accept the steps in the process, Baumol was optimistic: "the long-run prognosis...is relatively encouraging. After a painful transition process cities will emerge significantly smaller, but economically viable and even prosperous" (1981:10). But like Banfield and Arrow, Baumol feared that society might not let the logic of economic forces govern the transition. While recognizing that "the welfare of generations of city dwellers" was at stake, Baumol warned against "attempts to rehabilitate and improve...to any substantial extent."

National programs aimed at the rescue of cities and their communities were doomed to failure, but even more importantly, they would extend the social pain associated with this latest technologically induced adjustment (Baumol, 1981:12-13):

> [S]uch programs are to be questioned not only because they are wasteful and their benefits destined to be short lived but, more important, because they actually serve to stretch out the unhappy period of transition and impede the readjustment toward the new and more desirable equilibrium. A rebuilt South Bronx can only lure the jobless into remaining longer where they have no economic prospects. One can be fairly confident that the reconstructed homes will be transformed into slums soon enough, and that the torch will be back at the task of destroying them soon enough.

National urban policy was "a cruel gift" to the culture of poverty (Baumol, 1981:12).

At the close of the paper Baumol addresses the implications for social theory and analysis. The postindustrial vision was predicated not only on the relation between technology and society, but between knowledge and social action. Baumol explained these parallel changes succinctly (1981:13):

> The basic point is that at least some historical forces cannot be resisted for long. Attempts to undo their effects are not only bound to be fruitless but may well make things worse. This does not mean that we are powerless to influence the course of events. Understanding of the underlying forces offers us knowledge of the constraints which circumscribe our policy

> options. It is within the limits imposed by these constraints that we are free to act in a way that contributes to social welfare.

The postindustrial thesis of circumscribed social action and its relation to an imperative of social progress was soon extended beyond economics into social inquiry generally. Several of the social science disciplines including sociology, urban planning and urban geography have lent their support to the postindustrial vision of segregation and inequality, and the view that there was little gained in assigning responsibility for these conditions. In this framework, communities are seen as seeking a territorial base from which they can determine "associational selection" of members. Suttles argues that this territorial base represents a "universal cultural form required by the mechanics of life itself" (1975:40-41). Race, gender and income are not denied as essential elements in the creation of postindustrial communities. Indeed, the internal coherence of communities stems from the freedom to implement effective barriers for the exclusion of the "dangerous classes" from membership, and to build and maintain social distinctions between "us" and "them" (1975:47). For Suttles, the existence of local community depends upon the capacity of "defended neighborhoods" to utilize geography and social sanctions which "segregates people to avoid danger, insult and the impairment of status claims" (1975:42, 57). Neighborhood defense is both natural and necessary from this perspective if urban order is to be maintained. One outcome of this community defense strategy is the creation of "dumping grounds" of individuals with marginal social and economic ties. The forced integration of these individuals into the city culture is doomed to failure. Instead, Suttles counsels that the relation between community identity and community boundary be recognized. National social policy should work *within* the already established system of communities. He also encourages policy-makers to recognize the "limited role" of local community: residential groups are small parts of the larger administrative unit of society and should not stand in the way of changes in the societal system of stratification. As Suttles notes, local community "rights cannot be insured," but only protected to the limited extent of creating a small world within which people who are generally distrusted can find trust on more provincial grounds" (1975:59).

This theme of urban provinciality within a larger technological societal cosmopolitanism is echoed in the work of urban geographer Brian J.L. Berry. His characterization of postindustrial urban society as a mosaic culture suggests that from its many segregated and fragmented parts, a larger social whole of harmony is nevertheless assembled. With technological advances in transportation and communications, Berry argues that the needs for traditional community forms has greatly diminished. In their place is being substituted the phenomenon of "daily urban systems" composed of commuter groups, car poolers and other "work trip" informal associations. The workplace as well becomes a fertile basis of sociality. Such casual community ties are then anchored in residential enclaves of shared socio-economic interest. This pattern of community association and spatialization is, in Berry's view, "natural" and outside the proper purview of urban planning and urban policy. In a direct challenge to sociologist Louis Wirth's thesis that technological development (in the form of industrialization) threatened the basis of community, and required planning to prevent social fragmentation, Berry argues that community has always been a flexible and adaptive institution. Indeed, a successful community in Berry's theory is one that accommodates technological and economic change. The aim of planning and policy, therefore, should be to complement evolutionary trends in urbanization in recognition of the inherent elasticity of community.

The postindustrial view of urban planning was characterized in an editorial to the November 1986 issue of *Planning,* in which the principle of urban triage was presented as "sound regional planning." The author begins the essay with the question, "do all urban places have a right to life?," answers that "ghost towns are a part of the American landscape" and chastizes the planning profession for helping to "institutionalize the worst form of self-aggrandizement." Moor urges his colleagues to break with their past "urban anthropomorphism" and to redirect their attention to the task of creating "regional institutions needed to aid the recoverable and to comfort the inoperable." He concludes that we must learn to "pull the plug" on "played-out" cities in a manner which "cushions the impact of failure." Only in this way can we hope to foster long-term social development (Moor, 1986:46).

Strong and often eloquent criticism could be found to the postindustrial view. Early and consistent opponents such as John Kenneth Galbraith (1985), Richard Titmuss (1968 and 1971), and Robert Lekachman (1981), attacked the tendency of social science to glorify technology and economics. A specifically urban literature, often nourished by a neo-Marxian revival of class analysis, also came to the fore to challenge urban postindustrialism. The work of David Harvey (1982 and 1989), Manuel Castells (1977), Michael Dear and Allen J. Scott (1981), as well as William K. Tabb and Larry Sawers (1978), are representative of this type of criticism. Norton Long (1972) maintained his critical stance toward contemporary urban thinking, utilizing the ideas of democratic theory to challenge technologism and economism. A new generation of analysts continued and expanded this style of critique, as illustrated by the work of John Friedmann (1973), John Logan and Harvey Molotch (1987), Gordon Clark (1983), Susan S. Fainstein, et al. (1983), and John Forester (1989). While significant, this critical work remains largely reactive to the more dominant stream of social science and thought, invariably forced to answer: "Why is efficiency necessarily antithetical to democracy?," and "Why is class necessarily antithetical to social progress?"

8.7 The New Urban Order

Postindustrial thinking found expression in the national policy arena with the publication of a report entitled *Urban America in the Eighties* (President's Commission on a National Agenda for the Eighties, 1980b). Issued at the close of the Carter administration by the

President's Commission on a National Agenda for the Eighties (whose members included Daniel Bell and other postindustrialism proponents and hereafter cited as President's Commission), the report was outlined in *National Agenda for the Eighties* (President's Commission's, 1980a). The studies were warmly embraced by the Reagan administration and constituted a blueprint for national urban policy over the eight years of that administration. The reports are resolutely postindustrial in their diagnosis of the urban situation. Rather than a national crisis, declining cities are understood as necessary adjuncts of social transition (President's Commission, 1980a:64):

> In large measure, [urban changes]--including the transformation of local economies, the lower-density settlement patterns, and the growth in location beyond metropolitan areas--are often beneficial to the nation as a whole, even though they may have undesirable short-term effects on specific communities.

Insisting that "there are no national urban problems," the report adamantly opposes placing "the swirl of local and regional concerns ahead of an overall concern for the nation" (President's Commission, 1980b:99,100). Such a policy perspective would be "inappropriate and ill-advised," and would only serve to repeat the mistakes made in past federal policy efforts: "in the past two decades, federal policies have sought to preserve the functions inherited and the scale achieved by cities, rather than assist them in adjusting to an emerging post-industrial era" (President's Commission, 1980b:100,90). Rather than seeking to prevent decline of some cities and regions, the report calls for a new national orientation of "policy-guided disinvestment" and urban "slenderizing" in order to prepare U.S. society for the global competitive order of postindustrialism (President's Commission, 1980b:105).

Echoing Banfield, the report identifies the same shaping forces of social order--technology, economics and demography. These forces are dynamic and far too powerful for governments to affect, much less transform. Rather, the report agrees with postindustrial strands of analysis in economics, sociology, planning and geography which recognize urban change as the manifestation of an inherently ordered dynamic system operating across time and space. Evidence of the workings of this system can be found in the globalization of markets and technology, the emergence of the world-city structure, and an international division of labor which allocates physical and mechanical work to regions with plentiful low-wage workers and organizes technology-based services in areas with highly developed infrastructures and highly trained populations in advanced technologies. In the presence of such powerful forces, it is essential that societies learn what cannot be done, so the report proposes that government policy restrict its efforts to assisting communities "in adjusting to redistributional trends rather than to attempt to reverse them" (President's Commission, 1980b:4). In advocating such a policy attitude, the Commission recognizes and accepts as unavoidable the existence of a permanent underclass. For them, the report urges social responsibility for humane care: "the government [should] adopt social policies...insuring that...those who cannot work are able to lead a life of dignity while their welfare is provided through alternative means" (President's Commission, 1980a:65).

In the evolving postindustrial order, cities as discrete spatial entities have lost much of their previous technological and economic value. Rather than undertaking what one author has characterized as a "counter-productive effort to keep losers afloat" (Long, 1983:21), the Commission recommends benign neglect: "the general implication is that, in the long run, the fates and fortunes of specific places will be allowed to fluctuate" (President's Commission, 1980a:65). As Banfield had argued for the "good health of society" as the paramount goal, so too do the *Urban America* authors elevate social progress over the merely local and the survival of particular communities: "national economic vitality should take precedence over the competition for advantage among communities and regions" (President's Commission, 1980b:4). The endorsement of a process of social triage is not seen as radical or inhumane. Far from it, one of the architects of the report has characterized the approach as fully consistent with the American immigrant tradition through which economic conditions of diverse ethnic and racial communities are substantially improved (Donald Hicks quoted in Fallows, 1985:68):

> I was being told...by people whose last names would have been very much at home in Florence or Milan...how I dared to tear people away from the roots they had established. I wasn't cheeky enough to say anything then...[but] so many of their families had decided to migrate and they'd found a better life. They were angry at the advice that America help others do the same.

The report's approach and proposals were buttressed by analyses issued by two prominent national institutions of research: the National Research Council in the 1983 report of its Committee on National Urban Policy, *Rethinking Urban Policy: Urban Development in an Advanced Economy* (Hanson, 1983), and the recent Brookings Institution study, *The New Urban Reality* (Peterson, 1985). The premises of an imperative logic of growth and limited capacities of national policy to affect change underpin both studies. Both suggest that the development of U.S. cities has occurred within a technologically circumscribed process. During the period of industrialization, large-scale technologies led to the creation of large, concentrated, manufacturing-based cities that had several comparative cost advantages over other forms of social organization including a large and abundant labor pool, centralized long-distance transportation facilities, and sizable and accessible consumer markets. In the postindustrial era, however, significant advances in production, transportation and communication technologies "have virtually wiped out the comparative advantages of metropolitan cities" (Kasarda in Peterson, 1985:35). Out of these advanced technological capacities new competitive "strengths" have emerged to lead urban development: "[t]hese emerging strengths are in the administrative office, communication, financial, professional, and business service sectors and in cultural, leisure, and tourist industries" (Kasarda, 1985:35). Between 1974 and 1984 Kasarda notes that nearly 1.8 million *new* entry-level jobs were created in the service sector, "more than twice the total number of production jobs that exist in America's automobile manufacturing and iron and steel industries combined" (Kasarda, 1985:66). Policies which have been aimed at reindustrializing cities and their economies are only "nostalgic" remnants of an outdated era, and they serve to "saddle" the nation with a costly, inefficient and uncompetitive economic base. Instead, more future-oriented policies are required which anticipate and compliment new-growth industries such as "fast food and drink establishments" (1985:66), and forestall public assistance programs which are "inadvertently attracting or bonding large groups of disadvantaged persons" (1985:67). In the spirit of Banfield and *Urban America in the Eighties,* the Brookings study likewise argues that "the urban problem" is more apparent than real, and that city decay and decline can actually be regarded as a measure of postindustrial success (Peterson, 1985:10):

> The decline of the older city can thus be seen as little other than an unfortunate by-product of technological advance and economic success in a land-rich society. Americans have the wealth and resources to live in less congested, cleaner, warmer, greener and seemingly happier places.

Both the Brookings and National Research Council studies lament the painful, yet unavoidable consequences of postindustrialization on people and places that are less capable of adapting to change. But as the *New Urban Reality* warns, it "is hardly sufficient grounds for active action to retard an otherwise desirable transformation" (1985:10). In the postindustrial framework, the overriding challenge is to accept the reduction of the social and political status of urban communities. Large cities represent outmoded parochial "special interests" which manifest sluggish reactionary attitudes toward change and ultimately serve to impede the postindustrial transition (Peterson, 1985:63):

> The industrial city has become an institutional anachronism. If the great manufacturing centers of Europe and the American Snow Belt developed as by-products of the industrial revolution, their decline is no less ancillary to contemporary technological change...Two or three decades ago urbanists sought to save the industrial city by redeveloping central business districts, or creating model cities that would transform poverty-stricken neighborhoods, or "energizing" citizens to participate in planning their community's future. Few would venture to propose such schemes today. Quite apart from political changes that have occurred in Washington, economic and social changes have moved so far that reversing their direction no longer seems feasible or even desirable. Industrial cities must simply accept a less exalted place in American society.

In lieu of the industrial city, the studies point out that a "new urban system is emerging" which unlike its predecessor, *can* accommodate the rapidly changing forces of development. The most salient characteristic of the new system is its transformation of the urban landscape into loci of integrated and specialized centers of production and distribution. There are no cities in the language of the National Research Council, but rather constellations of national, regional and sub-regional "command and control centers," "diversified service centers," "specialized service centers," "consumer oriented centers," and "production centers" all of which are neither spatially nor locationally constrained. Each constellation constitutes a combination of technological, economic and demographic integrations or what Castells has called a "space of flows" (1985) through which materials and services are processed, packaged and distributed. Having shed its "physical realities" the new urban system is instead "process-oriented" and propelled by the underlying logic of efficiency and adaptation. As far as possible policy efforts ought to abandon traditional place-based strategies in favor of people-oriented ones; direct social investment to defense and internationally oriented industries and disinvest in those with localized bases; emphasize physical infrastructures and "technology centers" which can promote greater efficiencies in the production and transaction of goods and services in lieu of social welfare programs; subsidize private capital projects through "enterprise zones" and development "incubators" which more appropriately express market signals; and promote labor mobility and "mid-life retooling" to more closely correspond with the movement and needs of technology and capital (Hanson, 1983: 2, 3, 7, and 126-127).

Social conditions which twenty years ago were declared the causes of an urban crisis are now taken by the mainstream of the academic and policy communities to represent the necessary costs of transition.

CHAPTER 9

THE POSTINDUSTRIAL ENERGY ORDER

The urban crises of the late 1960s had brought into sharp relief the contradictory nature of postindustrial development. Economic growth required an underclass; technological progress presumed a featureless plain. However, the urban expression of these contradictions often had the appearance of being a local matter. Communities were being attacked by common enemies, but the battles could occur in apparent isolation of one another or, frequently, involved a process of triage which pitted one community against another in the quest for survival. It was with the arrival of the energy crises of the 1970s that a national and even global dimension of the contradiction could be seen. The rise of the technology network, corporate organization, big science/big technology, and the national security state have given postindustrialism a distinctly centralist caste and have produced an integrated technological reality with capacities for surplus, quantification and rationality well beyond those of traditional Paleotechnicism. The energy sector has anchored the centralist transformation in a manner similar to its role in the movement from Eotechnicism to Paleotechnicism. For this reason, challenges to the social validity and viability of the system of energy production and use constitute threats to postindustrial reality.

Preceded by a series of social confrontations over the environmental consequences of energy system operations, interruptions in the flow of oil in 1973 and again in late 1978 cast serious doubt on the sustainability of the prevailing energy order. Skepticism quickly spread beyond the energy system to the functioning of the larger technological framework. At least momentarily, bigger no longer seemed better.

9.1 Energy Abundance and Social Progress

Once again, most in the social science community were not concerned with the centralized power complex and its impact on the environment. Indeed social science anticipated with enthusiasm the forthcoming technological society based on high energy consumption. The significance of the provision and use of energy as an essential element in societal development was taken up by many in social inquiry. Theories of energy/electricity-based social progress were written to explain and appreciate the new order. Illustrative of this literature is the energy-culture thesis articulated by anthropologist Leslie A. White. In a 1943 paper, White argued that cultural advancement was fundamentally a product of the technological capacities of societies to utilize energy to transform the materials of nature into "human need-serving goods and services" (1943:346). According to White's scheme, history could be divided into three distinct phases: a period of "savagery" in which human survival depended upon reaping what was available in nature through hunting and gathering; a period of "barbarism" in which agriculture and animal husbandry were developed; and a period of engines and fuels which White argues marked the beginning point of *"civilization."* Cultures advanced as the technological methods to provide food, shelter and defense were improved. For this reason, social progress was intrinsically tied to the forms and means of energy conversion available among societies. Only when human beings are released from the toil of continuously having to provide for their own subsistence can their more creative impulses emerge (1943:339):

> The human struggle for existence expresses itself in a never-ending attempt to make of culture a more effective instrument with which to provide security of life and survival of the species. And one of the ways of making culture a more powerful instrument is to harness and to put to work within it more energy per capita per

> year. Thus, wind, and water, and fire are harnessed; animals are domesticated, plants cultivated; steam engines built. The other way of improving culture as an instrument of adjustment and control is to invent new and better tools and to improve old ones. Thus energy for culture-living and culture-building is augmented in quantity, is expended more efficiently, and culture advances.

White's contention was not that qualitative distinctions among cultures did not exist. Variations among individuals, societies and their environments mediated the energy-progress relation and could either enhance or thwart its expansion. But the *motive* forces of social change were essentially non-social (Tylor quoted in White, 1943:353-354):

> We...have a certain type of social system...because we have factories, railroads, automobiles; we do not possess these things *as a consequence* of a certain kind of social system. Technological systems, engender social systems rather than the reverse.

Having located the objective conditions of cultural evolution in increased energy production and use, White sought to express his thesis using the simple formula: Energy x Technology = Progress. Cultural advance could result either from increases in the amount of energy put to work or from improved efficiencies in the technological means by which energy is converted to work. While White resisted explicitly defining the characteristics of the emerging energy transformation (other than it would be atomic based) he was willing to forecast that Western society was "entering upon the second stage of the second great cultural revolution of human history" (1943:350). The dimensions of the new order were still uncertain, but one thing was clear: social progress was not inevitable. Unless social institutions adapted to the new technological configurations of this revolution, cultural evolution would cease and possibly even recede. But White was optimistic that the "Power Age" would not be denied, and that the old social system was indeed "in the process of destruction" (1943:350).

Empirical evidence for this thesis came from many sources, but perhaps the most important confirmation was provided by economics. In a 1960 Resources for the Future study directed by Sam Schurr and Bruce Netschert, the role of energy generally, and electricity in particular, to economic growth was quantified. Between 1880 and 1910 energy consumption per unit of GNP increased 133 percent, indicating the centrality of energy use to productivity. After a decade-long plateau, the relationship was shown to reverse course as energy consumption per unit of output fell 35 percent between 1920 and 1955 (Schurr and Netschert, 1960:64). However, the post-1920 trend was deceptive, masking a vigorous positive relationship between electricity and GNP. During the 1920-1955 period electricity consumption per unit of GNP expressed in kilowatt-hours increased by a factor of 3.5 (Schurr and Netschert, 1960:175. The substantial contribution of electricity to productivity could be easily missed if measured in primary energy units (which includes conversion losses). While the heat content of the fuel used in electric generation remained constant, thermal efficiency of power plants had increased substantially thereby producing an increasing number of kWhs per BTU of fuel input. Schurr and Netschert's analysis of the period showed that the improved thermal efficiency of generation had resulted not only in an increased market share for electricity, but a fundamental transformation in industrial operations (1960:189):

> It seems probable, therefore, that the greatest impact of electricity on the efficiency of industrial operations was achieved not as a result of the replacement of Btu's which were less efficient thermally by more efficient ones, but in terms of electricity's impact on the total economics of industrial operations. The release from the restrictions of internal mechanical energy transmission systems opened up wholly new possibilities for applying modern techniques of industrial and business management. It is, therefore, not farfetched to speculate that the marked acceleration in the increase in labor and capital productivity after World War I is attributable in some degree to the new methods of organizing production made possible through the growing electrification of industrial operations.

Energy and technics had combined to produce staggering numerical growths. In a 35 year period energy consumption had doubled from 19.8 quadrillion BTU to 39.7 quadrillion BTU. Electricity consumption growth was even faster, doubling each decade during the postwar period (Electric Power Research Institute, 1979:82). This energy diet had been complemented by a tripled GNP (Schurr and Netschert, 1960:175). White's equation of energy and culture had been demonstrated, at least in economic units.

The association of energy quantity with social advance became a central tenet of postindustrial ideology. To supply the expanding appetite for energy, especially electrical energy, postindustrialists turned to nuclear power. There could not have been a more compatible relation between technology and ideology than that between nuclear energy and postindustrialism. Advocates of nuclear power were in complete agreement with the energy-civilization equation. Thus, as the first chairman of the U.S. Atomic Energy Commission observed (Lilienthal, 1980:10):

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

Similarly, nuclear power advocates recognized the need to locate the development of this technology within a globalist framework (Lilienthal, 1980:10):

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

Nuclear proponents agreed with the postindustrial premise that advanced societies such as the United States were at a historical crossroads. In the nuclear vision, existing social institutions were destined to be replaced as advances in science brought forward new technologies of abundance. Alvin Weinberg succinctly stated the position of nuclear advocacy on this point (1956:302):

> [S]ocial and political tradition becomes obsolete with the full flowering of our Scientific Era simply because all of the traditional doctrines were conceived in an economic and technological era which bears little relation to the age of [nuclear powered] abundance.

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

But as the accumulation of scientific knowledge continues to foster technological change through new discoveries, social institutions too often fail to keep pace. According to some, nuclear power had been saddled with the problem of social inertia almost from the outset. Thus, Lilienthal warned in 1949 that unless institutional changes were made, "the atomic adventure may be stifled in the throes of politics, of routine, of sluggishness and apathy" (1949:146). For the scientifically informed, this was unacceptable; failure to respond to the new challenge was tantamount to social retrogression (Lilienthal, 1949:145, 147-148):

> Atomic energy is a force as fundamental to life as the force of the sun, the force of gravity, the forces of magnetism. It is an unfolding of new knowledge that goes to the very heart of all physical things. Perhaps the greatest single opportunity for new fundamental knowledge about the nature of the physical world lies in the development of atomic energy. Within the atomic nucleus are those deep forces, so terribly destructive if used for warfare, so beneficent if used to search out the cause and cure of disease, so almost magical in their ability to

> pierce the veil of life's secrets...For the citizens of the world's leading democracy to be in the dark as to the nature of the fundamental structure and forces of the atom--and of the great good as well as evil this knowledge can bring--would be for them to live in a world in which they are, in elementary knowledge, quite blind and unseeing. It would be almost as if they did not know that fire is hot, that water is wet; as if they did not know there are seasons and gravity and magnetism and electricity.

How should society meet the challenge of nuclear power? Consistent with the postindustrial tendency to seek technical responses to social and political questions, nuclear power promotion was generally focused on strategies to infuse greater technical discipline, order and organization into the social structure. For the technically minded, the greatest threats to progress in the nuclear project was political interference. Attention was concentrated on the development of nuclear power outside existing political channels. Here again nuclear power advocates found themselves in close agreement with postindustrialist ideology. Conventional democracy was ill-suited to govern the development of nuclear power and would therefore have to change to reflect new scientific and technological realities (Lilienthal, 1949:151):

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

The solution to the problem was technocracy. For Daniel Bell, this meant a new social order in which "[t]he shaping of conscious policy, be it in foreign policy, defense, or economics, calls to the fore the men with the skills necessary to outline the constraints ahead, to work out in detail the management and policy procedures, and to assess the consequences of choices" (Bell, 1967b:107). While Bell's solution implied a social contract in which the advantages of technology were traded for the loss of some degree of public participation, the terms and conditions of the contract were only vaguely anticipated. Nuclear power advocates were far more clear and specific about the dimensions of the trade. Alvin Weinberg presented the basic dilemma of reliance on a technology like nuclear power when he noted that while the probability of life-threatening nuclear plant accidents was low, expanded use of the technology would lead to an increased frequency of accidents and enlarged risks and hazards. In this respect, the "strains" and "hard decisions" forecast by Lilienthal were inevitable and inescapable. Weinberg recognized the conclusion to be drawn from right technical thining of what needed 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 exhaustable source of energy...But the price that we demand of society...is both a vigilance and a longevity of

> our social institutions...In a way, all of this was anticipated during the old debates over nuclear weapons...In exchange for atomic peace, we have had to manage and control nuclear weapons...[W]e have established a military priesthood which guards against inadvertent use of nuclear weapons, which maintains...a precarious balance between readiness to go to war and vigilance against human errors that would precipitate war...[P]eaceful nuclear energy probably will make demands of the same sort on our society, and possibly of even longer duration.

Weinberg's insight was to recognize that the purpose in garrisoning the nuclear project was to secure this technology from precipitous social abandonment. The fear within the scientific community was that ill-informed public officials, mass hysteria and contemporary Luddite orientations might 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 could be created to meet the social and political challenge of the atomic adventure.

Nuclear power would not play a measurable supply role until after 1970, and in this sense its importance lay in what its advocacy revealed about postindustrial ideology rather than its immediate impact on the energy system. In particular, nuclear promotion underscored a growing belief in science and industry that widespread social change would be needed to prepare the United States for postindustrial transition; and further, that such change would encounter popular resistance which would have to be put down. An incipient determinism evident in nuclear advocacy was not unique to this technology but implicit in postindustrial theory generally. Nuclear energy was simply a forerunner of the pending shift in society-technology relations envisioned in postindustrialism.

Perhaps most significant, the promotion of nuclear power pointed to the reconceptualization of social institutions underway. Weinberg and Lilienthal conceived the future as a test of societal commitment to science, objectivity, truth, reason. It was the presumed irrational prospect of societal resistance to the use of advanced science and technology that prompted these and other postindustrialists to search for new social forms that would protect the public from its own baser tendencies. Postindustrialists were animated by the possibility of technological disloyalty. In their view, social optimism would be found not in the emotional rejection of technological advance, but in its reasoned embrace--what Quirk and Carey have termed in recognition of the electronic foundation of postindustrialism, an ideology of the "Electric Sublime" (1970).

9.2 The Environmental Warning

Postindustrial enthusiasts had ignored (for many, intentionally) the Paleotechnic foundations of the electronic revolution. Technocratic efforts to avoid this reality were rudely exposed in January 1969 when a well off the shores of Santa Barbara, California drilling to a depth of nearly 3,500 feet suffered a "blowout, an uncontrolled eruption" of oil (Easton, 1972:8). The well was one of 56 slotted in a 3,000 ton platform suspended in 188 feet of water. The rig was certainly a technological marvel, performing the extraordinary feat of balancing pressures in excess of 1,000 pounds per square inch. However, when pressures exceeded 1,100 pounds, the well began spewing mud and oil; rock and sand fissured in the geologic formation and oil issued into the ocean waters in miniature geysers. The eruption lasted 12 days, creating an oil slick of one to three million gallons of oil (according to the President's Panel on Oil Spills--see Easton, 1972:252) and covering an area of 800 square miles (roughly two-thirds the size of Rhode Island). Fifty-five miles of coastline were washed with a "black tide" of approximately 1.3 million gallons of oil. The greatest danger occurred along a seven mile stretch of Santa Barbara waterfront where 390,000 gallons of crude came ashore. The toll on wild life was substantial: 6,000 to 15,000 birds died as a result of the blowout, as well as 74 elephant seals, five whales and three dolphins (Easton, 1972:257-261). The well was eventually capped with a 3,400 foot column of cement but significant seepage from rock and sand fissures caused by the blowout continued for several years.

While concern about the environmental consequences of development had been building throughout the 1960s (stimulated in part by Rachel Carson's *Silent Spring),* the Santa Barbara blowout gave the media and the public an all too visible indication of the potential magnitude of disaster immanent in an advanced technological system. The event exposed the conflict between the requisites of postindustrial development and of nature. Preserving technological momentum could require, as the Santa Barbara disaster had shown, acceptance of environmental degradation; a necessary trade-off if progress was to be sustained. Society could of course go without oil retrieved from beneath the sea, or oblige investment in expensive anti-spill technology; but such choices would mean, potentially, surrendering greater economic growth and, possibly, calling into question the quantification ideology. Perhaps more important, failure to take environmental risks would multiply problems in other sectors of the postindustrial system which depended upon smooth operation of the power complex. Restrictions on new oil exploration could upset the balance of the technological system in sectors ranging from transportation and industrial production to electricity generation. All of this became evident with corporate reactions to political suggestions of the need for greater regulation. As the public soon learned, the postindustrial system is highly unadaptive; the burden is on society and the natural environment to adapt.

After a week of unchecked seepage, a supervisor for the city of Santa Barbara appeared before the U.S. Congress asking that a moratorium on offshore drilling in the Santa Barbara Channel be declared. "Gentlemen, we need help and protection" the supervisor asserted, and restated the standing objection of the community to such projects. In response, the president of the Union Oil Company whose well had suffered the blowout characterized the logic of such an action as "like shutting down the California education system because there's a riot at San

Francisco State." While the company president conceded that there was a problem, he urged Congress and the public to keep things in perspective. After all, he noted, no human life had been lost; an interruption of oil pumping could hardly be justified because of "the loss of a few birds" (quoted in the *New York Times*, February 6, 1969). Officials in the oil fraternity came to the defense of Union Company. When a U.S. Interior Secretary proposed tightening controls on the offshore leasing program, a Gulf Oil official warned against "unwarranted protection of the environment" (quoted in the *New York Times*, August 3, 1969).

Congress debated the issue for over three years but did not legislate additional regulation. Even proposals to conduct public hearings before offshore oil drilling resumed met staunch resistance. A representative of the American Petroleum Institute (API) testified against public hearings on the ground that they "would divert attention from important concerns involving national defense and anticipated fuel needs and provide a forum largely devoted to an emotional attack on the oil and gas industry" (quoted in Engler, 1977:151). Instead, he argued that Congress should place its confidence in an industrial "history of efficiency and cooperat[ion] with the government in the conservation of natural resources and protection of the natural environment" (quoted in Engler, 1977:151). A federal court of appeals refused Santa Barbara's request to mandate hearings by the U.S. Department of Interior and none was held. In his Congressional testimony the API official summed up why the natural environment could not and should not be a restraint on the technological environment (quoted in Engler, 1977:149-150):

> The nation's real goal should not be preservation...but proper development and use. The U.S. resources are not so vast that we can much afford [the] luxury of dedicating areas to non use. [Government restrictions on oil exploration] permanently impair the innovative economic process whereby many individuals making individual decisions assure the most productive development of resources.

The indispensability of energy (and at least at this time, oil in particular) to economic development and the complexity of the postindustrial system of economics and technics together ruled out social actions to address environmental risk through the suspension of certain industrial activities. Society and nature would have to bear the costs.

From the Santa Barbara episode a dialectic of postindustrial crisis could be discerned. A technology failure or accident would reveal weakness in the postindustrial system. Two diagnoses could be made of this situation. On the one hand, a failure or accident could be seen as a threat to system operations, and corrective action to reestablish control by system managers could be asserted. In the case of the Santa Barbara blowout this was the position of Big Oil and the U.S. Department of Interior. In opposition to this view, a diagnosis could be made that the technological system itself is the problem and social action is needed to deconstruct at least certain features of this system and replace them with a new politic of public accountability, responsibility and participation. This was the view presented by the city of Santa Barbara and several environmental groups. The far greater political and economic power of the first group in such situations means "system maintenance." But there is an additional reason for the preponderance of this outcome. In nearly all cases, the cooperation and expertise of large, interrelated technological systems is needed if change of any magnitude is to take place. For example, when Congress passed the National Environmental Policy Act (NEPA) requiring environmental impact statements including assessments for proposed new drills, the very possibility of conducting such analyses depended upon the willing assistance of the existing technological framework, in this case a framework designed to further exploration. Regulations written by the Department of Interior to implement NEPA in the oil drilling area depend upon (Engler, 1977:152):

> [F]ull disclosure of all the facts about leasing plans, motives, timetables, and alternatives; adequate time for participation by noninvesting citizens, experts, and environmentalists not on the corporate payroll; and meaningful coordination of planning at all stages of the exploration and leasing process with local, state, and regional agencies.

Yet, much of this information can be withheld on the grounds of "corporate privacy" which must be protected for competitive reasons, thereby producing what Engler has described as "a Kafkaesque situation" in which communities are supposed to provide public comment on secret corporate plans and/or challenge company claims about risk when company geological and geophysical data are privileged information (1977:152). A similar fate visited community efforts to utilize the federal Coastal Zone Management Act to challenge offshore drilling plans. The Act proved of limited value to those communities where offshore leases already existed. In these cases, state and local governments found themselves "automatically lock[ed]...into a program which must accommodate the growth caused by oil and gas processing plants onshore." The rationale of national security which had initially justified the leasing policies of the 1960s created a situation in which community efforts to reexamine coastal zone uses constituted, from the standpoint of the technological system, a reneging on "basic commitments for development already made" (Engler, 1977:152).

In the end, the public had little choice but to seek actions within the logic of postindustrial development. As the API representative had suggested, societal goals of environmental conservation and protection would be best served by reaching agreements with the companies organized to exploit the national environment. It is the only feasible action in an advanced technological order, and explains why an apparent paradox--namely, reliance on the technological order to police itself and define appropriate corrective action--is the all too common norm in postindustrial society (Engler, 1977:153-154):

> [N]ature flourishes under its benign stewardship: oil derricks stimulate fish to spawn, just as road building projects have opened up forage areas and migratory routes for moose. Should, perchance, there be a spill, the American Petroleum Institute has studies on spills, and beach cleanup and it offers literature for the rescue of waterfowl who have been incapacitated.

The Santa Barbara blowout provided a glimpse of the process by which crisis in a postindustrial society can become the rationale for increased dependence upon the very institutions which are at the center of the problem. Events in the world market in late 1973 and early 1974 initiated on a national and worldwide basis a process of crisis which would eventually result in public actions that presumed an imperative logic of postindustrial development.

9.3 The OPEC Embargo and Project Independence

Just as the environmental implications of postindustrialization were being regarded as effectively managed through various policy enactments including the National Environmental Policy Act and the Clean Air Act among others, a more immediate challenge to the technological system was emerging. U.S. oil consumption continued to increase steadily even though domestic production had reached its peak in 1970 leading Nixon to abolish U.S. import quotas. World petroleum demand was also expanding rapidly. With the outbreak of war in the Middle East and the already tight market condition of the international petroleum system, the instability of the power complex was quickly exposed. As the Organization of Petroleum Exporting Countries (OPEC) exerted a stronger presence in the world competition over highly profitable oil, the illusion of order and abundance in the energy system was penetrated. In October 1973 OPEC organized to cut its oil production by 25 percent and simultaneously raised its prices nearly 300 percent from an average of $1.77 a barrel to $7.00 a barrel (and a sevenfold increase over 1970 prices), marking the first official oil embargo (Stobaugh, 1983:32). The technological and economic base of U.S. postindustrialization was severely threatened as a condition of energy abundance was transformed almost overnight into one of high prices and energy shortfall. By the time of the embargo, U.S. consumption had reached a rate of over 16.8 million barrels of oil a day with over one-third of its petroleum budget being supplied by foreign sources.

The effects of the embargo were both immediate and long-term. The Foreign Petroleum Supply Committee (a body composed of international oil company executives), which had been established in 1951 to advise the U.S. government on problems of foreign oil supply, was resurrected to aid in "coping with problems and coordinating worldwide shipments so as to minimize any adverse impact upon the United States...upon orderly production and marketing relationships" (Engler, 1977:180). But as the shocks to the U.S. economy implied, the embargo threatened more than the brotherhood of oil; according to nearly all the relevant indicators U.S. postindustrial development was in serious trouble. In 1974 and 1975 the United States suffered one of its deepest recessions as GNP fell 6 percent between 1973 and 1975 while unemployment rose from 4.7 to 9 percent (Dohner, 1982:61). Calculating the amount needed to maintain the energy economy after the OPEC-induced price hike, Robert Dohner estimated that an additional $16.4 billion was required to pay U.S. imported oil bills, equivalent to 1.2 percent of GNP (1982:60).

The economic impact of interrupted supply and precipitous oil price increases spread throughout the industrialized world. The seven OECD nations together experienced the worst recession since the 1930s and, for the first time in postwar history the aggregate volume of exports for these countries fell primarily due to a decline in trade among themselves (Dohner, 1982:61). The OECD general price level was inflated directly by two percentage points as a result of the OPEC price increase. When the indirect effects of oil price increases on wages and other prices are taken into account, the inflationary impact was severalfold. The worst effect of the oil embargo was felt in 1975 when the real GNP of the OECD countries fell 0.7 percent, while prices escalated in that year alone by 10.9 percent (International Monetary Fund, 1981:111). The Third World found its export markets dry-ing up and its import bills skyrocketing. Between 1973 and 1975 oil-importing developing countries (OIDC) saw their trade deficit nearly quadruple from 10.5 to 40.4 billion in U.S. dollars. The OIDC import bill in this two year period increased 164 percent greatly straining these countries' balances of payments (International Monetary Fund, 1981:125). While these countries make only modest demands on the world oil market the negative effects of changes in this market were by no means modest: "the heavy weight of the oil price shocks...has proved devastating. The rise in real oil prices has...creat[ed] what the World Bank has described as 'unsustainable trade deficits'" (Yergin, 1982b:6).

President Nixon officially judged the effects of energy shortfall and high prices resulting from the OPEC actions as a "national crisis" (quoted in Engler, 1977:2). But the offical understanding of the sources of the crisis and their solution was not what ordinary speech might suggest by the term. Crisis, as Nixon saw it, concerned first and foremost the threat to U.S. access of stable and inexpensive supplies of oil caused by the embargo. Nixon saw national wealth as intimately linked to a regime of cheap and abundant energy, and therefore found OPEC's actions a challenge to continued U.S. preeminence. However, Nixon's speeches also provided a subtext to the idea of crisis. The oil embargo represented, in addition, a political test for the country: would society have the will to do what was necessary to stimulate domestic production that could overcome the shortfall? Both text and subtext focused on energy as a supply problem. In the former case, the international system was failing U.S. needs and needed to be repaired. As Nixon conceived it, the United States deserved a share of foreign oil supply, was not getting it due to the embargo and so national and international policy efforts were needed to restore the American share. Nixon portrayed this dimension of the crisis in a November 26, 1973 speech (quoted in Engler, 1977:1):

> We use 30 percent of all the energy...that isn't bad; that is good. That means that we are the richest, strongest people in the world and that we have the highest standard of living in the world. That is why we need so much energy and may it always be that way.

To address this dimension of crisis, Nixon advocated the coordination of industrial consuming country energy policies. Such coordination would have two goals: (1) to create an energy security system for the industrialized world which would include multilateral development of not only energy policy but foreign policy, as well; (2) the development of an emergency sharing system so that the United

States and other consumers could be assured of a "fair" division of the available pool of foreign oil. These goals were formally recognized with the creation of the International Energy Agency in 1974.

On a second front, Nixon targeted environmentalism and regulation as the culprits in holding back domestic production. He appealed for passage of the Alaskan pipeline bill, the deregulation of natural gas prices, adoption of policies to expand mining and exploration on public lands, general relaxation of environmental restraints and antitrust laws, increased use of domesic coal and accelerated commercialization of nuclear energy. For a time, oil prices might have to be regulated--they had been since 1971 when Nixon sought to bring down inflation by the implementation of general wage and price controls--but the objective of such regulation was to phase in higher prices for domestically supplied oil thereby permitting smoother adjustments throughout the economy. Invoking memories of the atomic bomb project and the man-in-space program, Nixon presented a proposal, including the above initiatives, to the U.S. Congress entitled Project Independence (quoted in Yergin, 1982a:105-106):

> Let us set our national goal, in the spirit of Apollo, with the determination of the Manhattan

> Project, that by the end of this decade we well have developed the potential to meet our own energy needs without dependence on any foreign energy sources.

Relying on the Project Independence, both the Nixon and Ford administrations sought to develop three fuel-policy regimes. For oil and natural gas, the goal was to permit market prices to rise while encouraging an expansion of domestic exploration and a program of new investment in refining and fuel transport facilities. The appeal for market set prices was sweetened with a proposal for a windfall profits tax, but neither administration was successful in persuading Congress to adopt this approach. Instead, the price controls adopted one month after the embargo (through the Emergency Petroleum Allocation Act) defined national policy in this area. A second prong of the oil/natural gas fuel policy regime was to encourage greater exploration. Nixon had sought to triple the yearly amount of acreage leased in the outer continental shelf in the belief that offshore areas bore the greatest potential for the discovery of new oil and gas. Amendments to the Outer Continental Shelf Act called for a substantial increase in offshore leases but the Santa Barbara disaster continued to plague policy efforts. Nonetheless, over 800,000 square miles of the outer continental shelf under federal jurisdiction had been leased with restrictions by 1977 (Engler, 1977:153). To step up terrestrial exploration, Nixon utilized the Project Independence initiative to lease 10 million acres of public land which was "more than the total acreage leased in the previous twenty year history of the program" (Engler, 1977:155). At the close of the Ford administration, the Federal Lands Policy and Management Act was passed which eventually "opened up vast portions of federal lands" to oil and gas development and at least for developers, "established a more stable, predictable environment" (Kash and Rycroft, 1984:202-203). The third prong of the oil and gas policy regime sought to expand refinery capacity, add the Alaskan oil pipeline and establish a petroleum reserve with a capacity of one billion barrels of oil (Kash and Rycroft, 1984:205). The pipeline and strategic reserve components were successfully put in place (although the billion barrel goal is yet to be achieved), but Ford's "high production" strategy of adding 30 new oil refineries was rejected by Congress (Yergin, 1982a:106).

A coal policy regime emphasizing the opening of new mines and construction of coal-fired power plants was also advanced by the Nixon and Ford administrations. The Energy Supply and Coordination Act was passed in 1974 requiring utility and industrial boilers to be converted to coal. Ford set targets in January 1975 for the addition of 250 new coal mines, 150 new coal-fired power plants and 20 synthetic fuel plants. While several parts of this fuel policy initiative failed in Congress, Presidential actions in this area helped to steer debate around supply questions and demands to reduce environmental restrictions.

The most ambitious supply goals were reserved for nuclear power. Project Independence called for 50 percent of U.S. electricity to be nuclear-based by the end of the twenty-first century (at the time, nuclear plants represented just over five percent of installed electricity capacity) (Bupp, 1983:134). To accomplish this goal, 102,000 MW of nuclear power was called for by 1980. This would amount to a 4.5-fold increase in nuclear capacity in seven years, an equivalent of 25 percent of total electrical generation which stood at just under 440,000 MW in 1973 (see Federal Energy Administration's *Project Independence*, 1974; and *Energy Statistics Sourcebook*, 1988:379). Streamlining of licensing and regulation would be needed as well as greater involvement of construction vendors and architects in the regulatory process. While neither administration was able to meet its goals, the belief in a nuclear-fix underscored the continuing role of this technology in shaping the ideology of postindustrial progress. This ideology was shared by the utility industry which placed its highest orders of 38, 41 and 28 reactors with capacities, respectively, of 41,373, 46,975, and 33,265 MW over the years 1972-1974. Orders for these three years represented half of the entire nuclear capacity ordered in the United States from 1953 until the end of the 1980s (Energy Information Administration, 1989:81-86).

9.4 Transition or Crisis

Herman Kahn, a predecessor of Daniel Bell and proponent of social forecasting, captured the gist of this thinking when he suggested that the OPEC embargo was not a crisis but a *watershed* event (1976:59). Noting that there was no physical shortage of oil, only a cartel's effort to withhold supply from the market, Kahn welcomed the embargo for actually *lowering* the likelihood of future energy shortages. Thanks to OPEC, "the rate at which new energy came on the market" would increase, and "the rate at which energy was used" would decrease (Kahn, 1976:59). Civilization was on an irreversible transition from exhaustible to inexhaustible energy, propelled by advances in technology ranging from fusion to a whole variety of hydrogen-based fuel systems. Cost, and environmental and technical assessments of these new systems, according to Kahn, pointed to commercialization within twenty years. Indeed, in Kahn's view, "too many options for new supplies already exist and they will increase over time...the basic message is this: Except for temporary fluctuations...the world need not worry about energy shortages or costs in the future" (Kahn, 1976:83).

Improvements in energy technology favored large-scale centralized production, and in this regard, were most likely to take the form of electric power. Nuclear and hydrogen were two examples of this tendency (Kahn, 1976:78). According to Kahn, this pattern of energy development was but one part of the larger postindustrial transition in which the scale of industrial systems would likewise expand. He forecast that "in the emerging postindustrial society the scale of industry expands to the point where the TVA becomes a middle-sized project and the scope expands to include most of a continent if not the world" (Kahn, 1976:200). The escalation in the scale of technology was tagged by Kahn as a period of "superindustrial" growth. During this phase of development social problems would emanate not from failures, but from successes (Kahn, 1976:201):

> [A]nomie resulting from successful promotion of social mobility; blue-collar "blues" resulting from the successful transition out of the class structure and struggles of early industrial society; pollution resulting from successful rapid growth; perverse outbreaks of the martial spirit as a result of a generally peaceful world and the imposition of peaceful values; and intense concern with recreation and leisure issues because so many have nothing more important to be intensely concerned about.

The greatest challenge in this phase would be "the graceful acceptance of affluence" (Kahn, 1976:196). The energy "watershed" nicely illustrated this challenge. We could diagnose the energy problem as the ideology of abundance and pursue a "fashionably antimaterialistic" "neo-Malthusian" strategy emphasizing reduced energy consumption and reduced commodity consumption generally. And we could react to the energy situation by stressing environmental preservation above economic growth. Kahn recognized both responses as all too probable ones in an affluent society. But such orientations represented "disastrous counterreactions" to progress and, as with any effort to stall postindustrial development, they were "catastrophe-prone" (Kahn, 1976:155). Thus, antimaterialism would almost certainly result in great harm to the less affluent. In a highly interrelated world economy, there was a moral imperative for superindustrialism: "the clearest...argument for further growth in the developed world (and against artificial and forced limitation), is that it aids the poor both within and outside the developed countries" (Kahn, 1976:19). Failure of the United States to consume its share of energy would only trigger national and perhaps international depression. Similarly an over-attachment to the environment would court social catastrophe. As with the DDT case in which millions contracted malaria when use of this chemical was halted, so with environmental objections to coal mining, ocean drilling for oil and gas, and nuclear power, millions would be denied the energy basis for affluence while the middle and upper classes enjoyed nature (1976:145-150).

Of the two responses, environmentalism was the most worrisome to Kahn. He repeatedly stressed in his work that technology could solve pollution problems. But affluent societies seemed to have been unwilling to rely on technology and instead, gave in to a puristic politics of the "clean environment." This political attitude threatened progress and had to be overcome. In a critique of the Ford Foundation study, *A Time To Choose,* which had called for lower energy use in part on environmental grounds, Kahn scoffed (1975:144):

> [W]e must learn from our mistakes and not permit excesses in our pursuit of a clean environment. Let me use the Alaska pipeline as an example. If we are to cope with our energy problems, some

> damage must be done to the environment; the question is, how much and where: I have asked many people where they would put an 800 mile pipeline if one must be built somewhere. Siberia usually comes in first, followed by Alaska. I can only agree. Since there are about 600,000 square miles in Alaska, I would argue that plenty of unmoved landscape will be left over, even after a pipeline is built. We really have so much low quality real estate in Alaska that we can afford to regard it as expendable, if the goal is urgent and important enough.

In Kahn's view, modern society had made a "Faustian bargain," relying on science, technology and industry to improve the human condition. Like Faust, humanity was now "compelled to use and then perforce...to proceed to the next experience, the next project--or be forever damned." All societies are "involved in a process that probably cannot voluntarily and safely be stopped, or prematurely slowed down significantly, even if there are good arguments for doing so" (Kahn, 1976:164). To cope with the "growing pains" of postindustrial success, social commitments to science, technology and industry would have to be redoubled. In the case of energy this means the accelerated development of large-scale centralized systems of energy production, compromises on the environment that will permit growth, and a willingness to take technological risks--including the acceptance of "local disasters" (such as Santa Barbara) as inevitable (Kahn, 1976:164).

While social science energy forecasts and national energy policy shared the postindustrialist vision of progress, dissenting views also emerged after the embargo. Broadly, two schools of criticism developed to challenge postindustrial orthodoxy: one emphasized the corporatist foundations of the postindustrial energy economy; and the other presented a wide-ranging attack on the centralist and militarist organization of the global postindustrial order. Both schools regarded the postindustrial energy economy as a threat to democratic governance, with an inherent tendency to reinforce soical inequality nationally and internationally, and predicated on unsustainable principles of ecological degradation.

Representative of the first school was Robert Engler's analysis of "the brotherhood of oil" (1977). Engler began his criticism of postindustrial orthodoxy with the observation that it was based on an assumption that "the immediate events...had no history" (1977:2). Policy actions and social science analysis seemed oblivious to the possibility that the condition of vulnerability was traceable to corporate ownership planning and policies. Also ignored was the acquiescence and support of public government in the "private government of oil" (1977:4). But as Engler argued, national security in the case of oil constituted a policy of insuring corporate security. Throughout the century, he observed, the U.S. government had followed a policy goal of "helping to keep supply down and prices up at levels wherein maximum gain accrues to the energy corporations." This policy framework intended to preserve "the continuous freedom of corporate forces to control and allocate capital, resources, technology, and labor, as well as political power in harmony with their private definitions of growth and need (1977:209-210). Far from violating these principles, OPEC's actions served to reinforce corporate power and wealth. The regime of multinational oil now threatened human survival (1977:209):

> Organizing basic natural resources on premises of greed, whether individual, corporate, or national, remains destructive for the environment and for human solidarity. Accelerated "liberation" of the energies of nature, long equated with the liberation of human energies and spirit, becomes mindless looting of irreparable proportions when divorced from concern for the full social price for the living and the unborn. Comprehensive bookkeeping of a sort men have been reluctant to devise is required to assess the worth of immediate comforts and penetrate the disguise behind which energy-intensive techniques have increased, rather than decreased, the dependence of individuals and communities upon forces beyond their control. Spreading the benefits of industrialism a little more widely may mute criticisms. But it does not resolve the issues of power and of respect for the environment.

A new system of governance was needed based on a "fundamental reappraisal of the rules of the game that have shaped energy and growth policy" (1977:209). While weighing options including the breakup of the oil companies, increased regulation and changes in tax policy, Engler found none of them satisfactory. In his analysis a private government was "nesting cozily within the public bureaucracy" and the only effective action would be to take over the nest (1977:211). Calling for the establishment of a national energy committee "with the specific mandate to develop alternative approaches for public control and for the transition requirements for phasing out private control" (1977:214), Engler argued that nationalization of the oil companies was the sole defense against the logic of technocratic centralization which governed the brotherhood. Anything less "would concede the end of political imagination and the irrelevance of democracy for industrial life" (1977:223). The replacement of politics with a public system would bring forth a mode of energy governance that could be participatory and publicly accountable. But more than this, a public system would begin the process of addressing interrelated issues of ecology and equity (1977:238):

> [A] corporate and political leadership whose finest vision is to pledge the search for more and "the use of all we can get" must be chal-

> lenged for its vacuity. The theme of "more," sustained by the presumed magic of technology and myth of limitless resources, too long has been used to evade the tougher questions about just distribution at home and abroad. Supersonic speed for the well-heeled and for warfare, contrasted with limping subways for urban majorities and starvation for third world peoples, mirror the prevailing class-income patterns and priorities...[I]f machines require much of mankind to serve a minority master technocratic race, and if more equitable and ecologically sane alternatives cannot be developed, then such "progress" must not be allowed. At its heart, then, technological planning involves the moral quest to renew the essential humanity of humans.

The United States had no right to consume a disproportionate share of world energy resources when "200 million Americans use more energy for air conditioning alone than China's population of 700 million use for all purposes" (Engler, 1977:238). The postindustrialists were correct in conceiving the energy system in global terms but, for Engler, their presumption of the appropriateness of American dominance in that system reduced the argument to just another rationale for imperialism. It was time to break out of the politics of greed and base U.S. energy policy and plans on a more humane and environmentally sustainable vision of the "global society." As Engler concluded (1977:250):

> To restore from exile the ideal of the public interest and governance based upon the consent of the governed remains the underlying challenge of the recent energy crisis and of the political economy which produced it.

A second school of criticism focused on the institutional architecture of high-energy consuming postindustrial societies. In his pathbreaking book *Soft Energy Paths: Toward a Durable Peace,* Lovins argued that the energy system was a social structure in which needs and patterns of energy use derive from the political, economic and technological character of the system, rather than the other way around (1977:147, 153). His analysis suggests that societies such as the United States had come to depend upon a highly centralized capital-intensive energy system marked by social characteristics of rigidity, concentrated political and economic power and militarism. Using an analogy of a crossroads (1977:59), Lovins distinguished two institutional architectures, one based on large-scale systems with low adaptiveness--a "hard energy path," because of its unforgiving social nature; and a decentralized energy system with high adaptiveness--a "soft energy path," due to its greater social diversity and comparative environmental benignity (1977:38-39). The United States had steadfastly pursued the hard path throughout the twentieth century guided by a logic that places "means above ends, and goods above people" (1977:162). Energy and capital had combined to commodify social life continuously eroding even the human dignity of work (1977:164):

> [W]e strove mightily to mechanize, automate, and fragment work. But while that effort at first relieved mindless drudgery, it came increasingly to deprive people of meaningful roles, even of jobs themselves. As the craftsperson working creatively with tools was displaced by the machine demanding a stultified operator, people, especially those whom age or sex or ability ill-suited for economic roles, were deprived of a share in a visible and widely shared public purpose. We systematically substituted money and energy for people, calling this "improving productivity"--by which we meant labor productivity--and then reinforced this mistake by concluding that we should use still more labor-replacing high technologies to fuel the economic growth needed to employ the people disemployed by that very process. We defined work as obtaining a commodity (a job) from a vendor (an employer)--so that work itself became a commodity produced, no less, by a process of production, like a brick or a car. We substituted earning for an older ethic of serving and caring as the only legitimate motivation for work. Thus alienation in place of fulfillment, inner poverty alongside outward affluence, a pathologically restless and rootless mobility became the symptoms of a morbid social condition that corroded humane values.

Hard path institutional architecture maintains and enhances technological values by insisting that all change be evaluated against system fit. To illustrate, Lovins pointed to efforts in the United States to establish "central regulation of domestic solar technologies, lest mass defections from utility grids damage utility cash flows" (1977:154). It was just this dynamic opposition to change that gave the hard energy path its coercive and authoritarian character. As Lovins observed, the hard energy path was governed by its "coefficients," that is the narrow tolerances of the technology and the political structure associated with it. In this regime type, "local objections must be stifled by national imperatives" (Lovins, 1977:147, 154). Social conformity is the hallmark of the hard energy path as technologists themselves experience increasing peer pressure to accept the "apparent consensus" of technological imperatives "even at the expense of personal ethics": "it is common, for example, in nuclear safety programs to find excellent technologists whose public and private views perforce must differ, so corroding both personal and technical quality" (Lovins, 1977:157). The social inflexibility of the hard path meant that only certain solutions were feasible. Invariable hard path logic required change to come in the form of complex gigantic capital-intensive technological systems. In this framework electrification was the ideal solution because it fit within the existing ensemble of technology and promised to increase technical flexibility. Correspondingly nuclear power was the ideal technology, satisfying all the technical characteristics of the hard path. That the electric solution amounted to a kind of "friendly fascism" (a term coined by Bertram Gross) in which "the consumer can have anything he or she wants so long as it is electrified" hardly deterred hard path architects (Lovins, 1977:58, 152). Similarly, that nuclear power contemporarily was the "main driving force behind the proliferation of nuclear weapons" was no reason from the standpoint of hard path logic to abandon its development (Lovins, 1977:176).

Such institutional preferences were not driven by considerations of inherent social efficiency or cost-effectiveness, and had little to do with advancing the ideals of social justice, democratic participation or public accountability. Indeed as Lovins pointed out, the hard path by certain measures was highly inefficient (1977:28-29):

> [A]t least half the energy growth never reaches the consumer because it is lost in elaborate conversions in an increasingly inefficient fuel chain dominated by electricity generation (which wastes about two-thirds of the fuel) and coal conversion (which wastes about one-third). Thus in Britain since 1900, primary energy--the input to the fuel chain--has doubled while energy at the point of end use--the car, furnace, or machine whose function it fuels--has increased by only a half, or by a third per capita...

The hard path was also incredibly expensive. As Lovins observed, implementing the 1975 proposals of the Ford administration for an energy program to sustain high-energy consumption from 1976 through 1985 would cost over one trillion dollars, and require three-fourths of the cumulative net private domestic investment of the United States over that decade (1977:30). Rather than autonomous indices of performance, efficiency and cost-effectiveness are determined *within* a particular institutional framework. *If* one accepted the correctness of hard path logic, then increased electrification and reliance on nuclear power were efficient and cost-effective since only these options offered the least disruption to system operations. But acceptance of hard path logic also involved what Lovins described as the "spiral of impossibility" (1977:31):

> [L]arge capital programs poor cash flow higher electricity prices reduced demand growth worse cash flow increased bond flotation increased debt-to-equity ratio, worse coverage, and less attractive bonds poor bond sales worse cash flow higher electricity prices reduced (even negative) demand growth and political pressure on utility regulators overcapacity, credit pressure, and higher cost of money worse cash flow, etc.

Lovins concluded that maintenance of the hard path system would only reinforce the already strong tendencies in U.S. society toward elite technocracy and a "centrifugal politics" which denied the individual and community any moral standing in the judgment of social performance (1977:148). Eventually hard path politics would erode the legitimacy of democratic government itself. Lovins forecast a "paramilitarization of civilian life" principally with the expanded use of nuclear power. As he remarked, "hard technologies are often Siamese twins of weapons" (e.g., nuclear power plants are a technological extension of uranium enrichment facilities and in this sense capable of supplying electricity and bomb-grade fissionable material). But the postindustrial commitment to technological progress mystified this relation (1977:158). While Lovins believed that certain research in the laser and nuclear field "should be abandoned forthwith because of the sensitive knowledge it proliferates," there was no chance of such a social decision so long as society remained on the hard path (1977:158). Worldwide, the hard path promoted a condition of "dependence, a cargo-cult mentality, and the enrichment of urban elites" (1977:155). U.S. society and the world political economy were at a critical point. The choice was between a world order which internalized the spiral of impossibility, was silent on the Siamese twin phenomenon of nuclear technology development, and required unquestioning faith in an elite technocracy; or a reconstructed social order guided by an entirely opposite set of system principles epitomized by the soft energy path. In concrete terms, it was nuclear power versus energy conservation, but such a choice in structural terms was between mutually exclusive and institutionally incompatible social orders (Lovins, 1977:49):

> [E]fficient cars versus offshore oil, roof insulation versus Arctic gas, cogeneration versus nuclear power. These two directions of development are mutually exclusive: the pattern of commitments of resources and time required for the hard energy path and the pervasive infrastructure that it accretes gradually make the soft path less attainable. That is, our two sets of choices compete not only in what they accomplish, but also in what they allow us to contemplate later. The are logistically competitive, institutionally incompatible, and culturally antithetical.

9.5 The Second Crisis and the "Moral Equivalent of War"

The challenge to postindustrial orthodoxy had barely been framed when the world experienced a second "energy shock." A brief period of economic recovery in 1976 and 1977 was quickly grasped by postindustrialists as confirmation that the events of 1973-1974 were mere aberrations. Faith in a beneficent future was restored as many policy-makers shared in Kahn's optimism about the future of postindustrialization. Among these were then Michigan Congressman David Stockman who dismissed the notion of energy crisis as "reminiscent of Chicken Little's defective logic" (quoted in Stobaugh and Yergin, 1983:282). By official interpretations of the crisis, the policy framework adopted by the Nixon and Ford administrations had largely achieved its goals. Overall, availability of energy supplies was increasing, growth in primary energy use resumed, and once again the energy-growth relation had been restored. By 1978 oil consumption was nearly 16 percent above its 1974 levels, and despite projections about resource exhaustion, domestic production had remained relatively steady throughout this period. With order restored in the world oil market, mainly by the addition of non-OPEC crude supplies from Mexico, the United Kingdom, and the Soviet Union (Stobaugh and Yergin, 1983b:62), the United States took quick advantage and increased oil imports by 2.3 million barrels a day above original crisis levels. Foreign oil in 1978 constituted nearly half of all oil consumption in the United States (Stobaugh, 1983:19).

But in late 1978, the event which Stockman had forecast as not "not likely to re-emerge," did (Stobaugh and Yergin, 1983b:282). The 1973-1974 nightmare recurred when during a revolution to overthrow the Shah of Iran, oil production in that country was halted. An emergency condition prevailed as the world market was deprived of five million barrels of Iranian crude a day (Stobaugh, 1983:32). Once again there was national and international turmoil over insufficient and even more expensive oil supplies. The effects of the OPEC price escalation and petroleum shortage were in many ways much more severe than in 1973-1974. World oil price tripled within a matter of weeks, as the average price of oil skyrocketed from an average of $12 a barrel to $40 in 1981 (Stobaugh and Yergin, 1983a:4). But this time, because both overall and imported U.S. consumption was significantly higher, economic impacts were greater. The results of increased U.S. dependence on a high-energy supply system were quickly made apparent. Simply to maintain 1979 levels of U.S. imported petroleum consumption would cost an additional $44 billion or 1.8 percent of GNP, by 1980 (Dohner, 1982:62). A repeat of the disruptions that occurred after the first embargo spread throughout the U.S. economy. Unemployment rates which had been slowly declining in the post-1973 embargo recovery years reversed trend jumping from 5.8 to 7.5 percent in 1980 (International Monetary Fund, 1981:65); the most severely affected were the oil-dependent automobile and steel industries, the former suffering employment losses of 21 percent from 1979 to 1980 (Dohner, 1982:74). During the period between 1975-1977 and 1980 inflation soared from an average rate of 7 percent to 13.5 percent, and in 1980, the U.S. economy again experienced an absolute decline in GNP (International Monetary Fund, 1981:65, 111).

The economic impact of the 1978-1979 petroleum disruption once more affected all the economies of the industrialized world. A massive shift in economic resources was immediately required, as a roughly threefold increase in the share of GNP devoted to pay energy costs was needed to maintain the Western and Japanese economies. Fiscal budgets among industrial nations were severely affected as surpluses were transformed into deficits with combined losses totalling $80 billion in the period between 1978 and 1980 (International Monetary Fund, 1981:4). A condition of rising unemployment *and* rising inflation, tagged "stagflation," plagued the industrial countries. Overall price increases in OECD nations rose 3.7 percentage points in 1978 through 1980, unemployment increased 1.5 percent, and the rate of growth in disposable income dropped two percent in real terms (International Monetary Fund, 1981:28; Organization for Economic Co-operation and Development, 1983:75). Stobaugh estimated that when the overall effects of the two oil embargoes were calculated, the industrialized nations suffered $1.2 trillion in lost economic growth by 1981 (1983:50).

Third world impacts were even more profound. Oil importing developing countries (OIDCs) never really recovered from the first oil price shocks, and impacts of the second crisis only served to intensify their economic dependence. Trade deficits of OIDCs tripled during the 1977-1981 period from $23.3 to $75.2 billion, and their import payments were 220 percent higher (International Monetary Fund, 1981:125). The most severe impacts from the increases in oil prices fell on these marginal participants in the world energy market (Duersten and von Lazar, 1982:266):

> The total net imports of all the OIDCs in 1980 were 4.5 million barrels per day. In terms of world oil consumption, these countries are modest players in the world market. But it is the impact of expensive energy on their domestic economies that represents the real concern in the 1980s. The cost of imported energy will mean that the OIDCs will have less to spend on domestic programs; they will have to sacrifice attempts to help the poor and disadvantaged in their own societies.

With the arrival of a second energy crisis, the warnings by Engler and Lovins, particularly of the tendencies toward unsustainability and inequality resident in the existing system, took on new weight. The economic skew in postindustrial society was once again revealed as the new escalation in world energy prices fattened the value of oil reserves held by the multinational corporations by approximately two trillion dollars. Since 1973, the brotherhood of oil had "earned" a four trillion dollar increase in the value of assets. While the transfer of such immense wealth to American oil companies would be acceptable if paid by foreign consumers, there was an increasing unwillingness to have such an economic burden borne by U.S. consumers. Popular demands for the break up of the oil empire, or at least a tax on their fast growing wealth became widespread. This conflict between increasing multinational wealth and declining social income brought forward renewed criticism of the postindustrial ideal of progress based on cheap and abundant energy. Doubts surfaced among many sectors in the society about the sustainability of postindustrialism and discussion began in earnest about a post-petroleum, or at least a high-cost energy future. Interest in alternative sources of energy, especially solar and conservation options rose dramatically. Public concern about environmental damage associated with the prevailing energy-industrial system likewise accelerated.

Yet in retrospect, while these doubts and concerns held the *potential* for challenge to postindustrial ideology, they were never politically realized. The policy formulated to express the new realities of high-cost energy, dwindling fossil fuel supplies, an alarming increase in social inequality, and worsening environmental conditions relied upon an old logic of production incentives, technical fixes and market forces. The bulk of fiscal and political resources mobilized immediately after the second crisis were to accomplish three things. First and foremost, the national government sought to increase domestic energy supplies especially oil, coal and nuclear power. Displaying the well entrenched supply mentality of American energy policy, the Carter administration oversaw the most rapid increase in oil and gas drilling in the nation's history (Kash and Rycroft, 1984:198). The largest budget proposal for an energy project made by Carter was the Synthetic Fuels Corporation, aimed at extracting oil from shale deposits. The initial proposal was for an $88 billion project, but it was scaled back by Congress to less than a quarter of that figure. Still, no other Carter initiative compared with it. Federal R&D in coal approached one billion dollars per year by 1980. A Strategic Petroleum Reserve was created and by 1979 had inventoried 70 million barrels of oil at a cost of over two billion dollars. Finally, the Carter administration sought licensing reform for nuclear power plants in an effort to speed the utilization of this technology. Paralleling the policy stances of Nixon and Ford, Carter believed that "conventional nuclear power had to be retained as a viable option in a nation short of energy" (Kash and Rycroft, 1984:221-222).

The risks of continued reliance on nuclear power as a future energy option were displayed in March 1979 at the Three Mile Island nuclear complex in Pennsylvania. In the "worst nuclear power accident in U.S. history" (Walsh, 1988:33), one of two nuclear generating units underwent a partial meltdown when, due to a series of crew actions and technical equipment failures, cooling water was blocked from the reactor core for approximately 16 hours (Walsh, 1988:33). Radioactive gases were emitted into the atmosphere, and thousands of gallons of radioactive water spilled into the containment building. A condition of confusion and miscommunication prevailed during the next week as the owner utility withheld information from the Nuclear Regulatory Commission. The Commission in turn, actively sought to minimize the extent of the damage. After two days, then Pennsylvania Governor Richard Thornburgh ordered 23 schools closed and advised the evacuation of preschool children and pregnant women. Fearing the worst, 200,000 people eventually evacuated the area. TMI is generally regarded as a watershed event in the history of U.S. nuclear power. The economic losses in the region due to the accident have been estimated at over $26 million, and clean up costs anywhere from one to three billion dollars (Nelkin, 1981:133). Nonetheless, despite TMI and its aftereffects, nuclear power has remained a major part of U.S. energy policy. Efforts to streamline the nuclear regulatory apparatus were promoted by every U.S. president from Richard Nixon to Ronald Reagan.

A second thrust of national policy was to deregulate oil and gas prices in order to allow market forces to determine allocation of these resources. President Carter announced in April 5, 1979 a plan to deregulate oil prices beginning December 30, 1981 (Kash and Rycroft, 1984:197). The administration rationalized this step as the logical prerequisite for societal recognition of the true higher costs of energy. It was for Carter, a pronouncement of the end of an era of cheap energy, and the beginning of a new one based on greater conservation and the greater utilization of alternative fuels. Seemingly at odds with postindustrial ideology, Carter projected an energy and social future which would be less materialist and slower growing. However, many supporters of the deregulation initiative distanced themselves from this interpretation, arguing instead that free market determination of energy prices would bring forward new energy supplies in great quantities and would permit the national economy to structure production in more efficient ways. An example of this reasoning was provided by Congressman Stockman who later became Director of the Office of Management and Budget for the Reagan administration (Stockman, 1982:11):

> This task of reordering of the worldwide capital stock [is] so far-reaching--bearing implications for the insulation thickness of attics, the design of transmissions, the mix of industrial boiler fuels, and competitive position of natural rubber and cotton versus synthetics, residential development and commuter patterns, oil-patch discovery and recovery technologies, transportation versus extraction tradeoffs on the world's energy frontiers, among other things--that no computer model, think-tank seminar, international energy secretariat, Department of Energy or congressional subcommittee could hope to figure out.

The third policy prong addressed growing social perceptions of ballooning corporate wealth from high energy prices, and increasing demands for programs to protect the environment. On the environmental front, legislation to encourage renewable energy and to promote energy conservation was enacted, including the Energy Policy and Conservation Act in 1975 which set standards for automobile and fuel efficiency; the Energy Policy Conservation Act of 1978 which revised building standards to promote greater conservation and use of passive and active solar techniques; passage of the Energy Tax Act in 1978 which gave incentives to business and residential solar applications; and the enactment of the Public Utility Regulatory Policy Act of 1978 which encouraged competition in the electric generation market, particularly by providing a legal framework for small-head hydro and cogeneration energy projects to be considered on equal footing with conventional central station facilities. There was also a significant increase in federal R&D expenditures on conservation and renewables and the Carter administration set a target of a 20 percent renewable energy base by the year 2000 with the use of energy conservation as a primary focus of intermediate policy activities (Frankel, 1986; Savitz, 1986; Hoffman, 1983; MacKenzie, 1983). Environmental considerations were also given attention, particularly with the adoption of stricter amendments to the Clean Air Act in 1977 which tightened emission standards in the industrial, utility and transportation sectors. Despite the legislative activity, conservation and renewables remained "pygmies" in comparison to the policy treatment aimed at the conventional fuel giants (Kash and Rycroft, 1984:248).

The primary response to energy-induced social inequality was the creation of a windfall profits tax. Between 1971 and 1976, growth in earnings of 16 of the 23 largest U.S. oil companies exceeded 100 percent, and seven exceeded 200 percent (National Petroleum News Factbook, 1977:22-23). With the average income per capita in society was falling during the same period, a tax on company profits quickly gathered political support. During both periods of economic recession which followed jumps in world energy prices, the oil majors dominated the *Fortune 500*. Four of the top six and one-third of the top 50 U.S. industrial companies were petroleum-based (Stobaugh, 1983:55). After heated debate, Congress settled on a formula of a minimum 30 percent tax rate on oil wells brought into production after 1978 and a ceiling tax rate of 70 percent. The total amount to be collected in taxes was $227 billion and the tax was to be phased out by 1993 (Kash and Rycroft, 1984:198). The target amount for the 10-year tax was but another indication of the extravagant wealth being collected by the brotherhood of oil. But the agreed-upon allocation of these tax revenues exposed the meager political interest in addressing inequality. Only 25 percent of the revenues were targeted for low-income assistance, while 60 percent would go to income tax reductions for middle and upper income households, and 15 percent would support federal energy and transportation programs (with a sizable portion of that 15 percent returning to the oil majors themselves) (Stobaugh and Yergin, 1983b:286). National legislation was passed to provide fuel assistance and weatherization to low-income households but these programs were never large, and certainly were never budgeted enough to redress the energy induced poverty of the 1970s. A 1985 analysis revealed the highly unequal distributional impacts of high energy costs (Byrne and Rich, 1985:89):

> [T]he household energy crisis has been most severe for families in the lower income brackets and for elderly families. For these households, large shares of relatively small increases in income are being absorbed by continuously more expensive energy...In 1981 the average upper income household allocated 22 percent of net income to food and energy purchases. The average family in the lowest income quintile, however, spent 70 percent of its net income to pay for its energy and food needs...While the household energy crisis has exacerbated the problems of all households, its impact has been especially great on those whose resources are the most limited.

9.6 Reagan and the Transcendental Order of Free Markets

It took the election of Ronald Reagan to establish a clear national policy agenda. Reagan had signalled the direction his administration would take in his acceptance speech for the Republican National Convention (quoted in Kash and Rycroft, 1984:259):

> [The United States] must get to work producing more energy...Large amounts of oil and natural gas lie beneath our land and off our shores...Coal offers great potential. So does nuclear energy produced under rigorous safety standards...It must not be thwarted by a...minority opposed to economic growth which often finds friendly ears in regulatory agencies for its obstructionist campaigns.

The policy agenda devised in the first two years of the administration was fully consistent with the Convention speech. The energy culprits were government regulation, government spending, government interference. An overactive effort to protect the environment was singled out as one of the principal obstacles to solving the energy problem. The administration objected strenuously to the idea of an inherent value in the environment and called for a policy orientation which relied on the market to decide the relative worth of environmental improvement or degradation. By executive order, the administration demanded that environmental regulations pass a cost-benefit test, and empowered the Office of Management and Budget to veto any regulations which might have "significant adverse effects on competition, employment, investment, productivity, innovation or the ability of American enterprises to compete with foreign-based corporations in domestic or export markets" (Kash and Rycroft, 1984:267). Reagan also announced a program to unlock federal lands from leasing regulations which had, in the opinion of the administration, denied reasonable access to energy producers and developers (Kash and Rycroft, 1984:262):

> The National government's most direct impact on America's energy future arises from its position as the steward of 762 million acres of publicly owned land...The federal role in national energy production is to bring these resources into the energy marketplace.

In the view of the Reagan energy analysts, the other major obstacle to solving the energy problem had been government control of oil and gas prices. Reagan's first action in office was to sign an Executive Order which instantly deregulated oil and gas prices. In place of the pessimistic policies of malaise and "no growth" mentality of the previous administration, this regime would take the optimistic view. Three months into the first year of the new administration, its first Secretary of Energy James Edwards announced that the solution to the energy problem was to "produce, produce, produce" (quoted in Kash and Rycroft, 1984:260). The Secretary also projected the regime's hostility toward conservation when he noted that "the human body uses least energy when it's asleep or dead" (quoted in Kash and Rycroft, 1984:262). In a two year period, the administration proposed to virtually eliminate conservation and renewables R&D from the energy budget. Cuts of 91 percent in conservation and 87 percent in renewables were proposed in the FY 1982 and FY 1983 budget messages. In addition, energy-related environmental R&D, which was funded through the Environmental Protection Agency, was targeted for a decrease of 65 percent during the same period (Kash and Rycroft, 1984:271).

It is important to note that these policy directions were put in place *before* world oil prices fell. For Reagan, the issue was explicitly ideological: a contest between beliefs in a capitalist dream of abundance and a liberalist/socialist vision that he and the Republican party frequently (and successfully) characterized as "gloom-and-doom" (Crist, 1982:5). Describing the policies of the Carter administration as a "slide down to national serfdom," David Stockman argued that the energy problem "was tailor made almost exclusively for markets." The solution was to "liberate the inventive capacity of free men and free markets" (Stockman, 1982:11, 16).

Through deregulation, selective budget cuts, elimination of the windfall profits tax and the imposition of an OMB embargo on government action, the first term of the Reagan administration sought to impose what it characterized as a free market system of energy production and delivery. "Government stupidity" in promoting a national energy plan, according to Stockman, served only to distort appropriate market signals: "excessive" consumption was encouraged through artificially low prices; and supply development was discouraged by interventionist tax and environmental policies (Stockman, 1982:15). The administration was selective in its criticism of government intervention, however. Little if any mention was made of the pre-embargo oil economy which resembled a "private government" as Engler had put it, rather than a private market. Likewise, administration officials were unbothered by the fact that *domestic* oil prices even with federal controls, had risen over five-fold during the decade of the 1970s (Energy Information Agency, 1989b:95); and by the fact that the world reference price used by these officials as evidence that domestic oil was selling too cheap, had actually been set by cartel actions. Domestic prices were too low and consumption too high; there could be no other view in this administration. Reagan furthered his free-market orientation during the second term of his tenure. A major source of costly government intrusion, according to the administration was taxation policies which penalized oil producers for undertaking profitable ventures. Throughout his regime, Reagan lobbied Congress to repeal the Windfall Profits Tax. With passage of the Omnibus Trade and Competition Act in 1988, this policy goal was achieved. In practice however, the administration had already nullified the tax by executive mandate. It had collected "virtually no tax revenues since 1986" (Department of Energy, 1988:xii).

Policy during the Reagan terms specialized in public non-action and retreat. Imitating a decade of national urban policy, the administration sought to disestablish the public interest in energy issues by adopting the goal of "do nothing or at least less" (Byrne, 1988). A comprehensive strategy of policy disinvestment was followed including efforts to eliminate the Department of Energy itself. Even emergency preparedness plans were scrapped in the belief that *anything* that would distort market signals must go (Kash and Rycroft, 1984:266). There was no definable limit to the de-planning of the public interest. External vigilance was needed against government meddling. And in any event, "the market" in the minds of the Reagan officials was not of this world (Byrne and Rich, 1983:129):

> The concept of deregulation is so inclusive as to be boundless; it incorporates any action or inaction which can be interpreted as being consistent with decision making under a hypothetical condition of perfect markets. Like perfect markets, deregulation is always an aspiration, never a reality. In seeking a hypothetical world, we can never be certain what actions are required or whether any actions are truly effective. As advocates claim, such wisdom and foresight is reserved only for the market.

In his role as a principal ideologist for the regime, Stockman argued that "the market" operated in a universe that was beyond human intention and creation (1982:12, 15):

> The point is that the world petroleum market works, even if we do not like its outcome in general or any particular moment in time. Dogmatic insistence that it is rigid or rigged, artificial and avoidable will not make it so. It will only encourage Congress to heap controls, entitlements, thermostat rules, woodstove tax credits, and assorted other wasteful or coercive baggage on our domestic energy markets. To be sure, the long-run price and supply trends are worse than they would have to be in a totally enlightened world...From the beginning, the oil exhaustion hypothesis rated with the flat earth doctrine...[T]here are prodigious tar sand accumulations, coals and shales, and some allowance should be made for the expansionary effects of technology, price, and time on the trillion barrels of oil-in-place underlying conventional reserve estimates...If there is any good bet, it is that technology will change well before the resources are extinguished...

Directly put, enlightenment was not a characteristic of human thought and action, but of market logic and laws, and technological progress. Postindustrialism constitutes a transcendental order. There is no human choice in energy matters, for example, since literally, there is no other possibility of a long-term energy outcome other than one dictated by markets and technology. Human beings act, interact, prefer and value things *within* a preordered environment. The substantive character of social life evolved from the interplay of humans and this environment. Government policy, or any other collective act, could not produce a particular substantive outcome that is for long inconsistent with the underlying laws of social order.

This is our world "even if we do not like its outcome in general or at any particular moment in time" (Stockman, 1982:12).

9.7 From Postindustrial Criticism To Conformity

In considering social analyses of energy, the decade of the 1980s is remarkable for what was *not* written. All but absent from the period are critical analyses of the institutional organization of energy production and distribution. Despite the enormous and frequently disruptive effects of energy-related changes on societies, social research produced very little that questioned the authority and legitimacy of the prevailing energy order. Indeed, the few points of criticism that had been developed in the 1970s all but disappeared from the arena of debate in the 1980s.

The quickest to fade were criticisms of the private government of energy. While the American public remained suspicious of the scale and greed of the oil giants, there was little enthusiasm for the assertion of public control. Nationalization, even by its advocates, was considered a less-than-satisfactory strategy. Citing the British Petroleum experience, Engler concluded that government ownership and operation "shows no evidence of any higher adherence to public objectives" (1977:216). The alternative strategy of breaking up the oil companies likewise rallied little support. Fifty years of antitrust court actions, particularly those aimed at the oil companies, had achieved only a string of "inconclusive consent decrees" (1977:215). Increased public regulation in a national political environment that was trumpeting the need for exactly the opposite was highly doubtful, and some worried, could actually enhance private control (Engler, 1977:221):

> Centralizing public responsibility for energy appears to be the most likely administrative change to result from the energy crisis. Given the longtime fragmentation in some sixty federal agencies whose focus has rarely been national energy policy and whose activities are generally uncoordinated, save by private government, such reform is understandably tempting. Yet, Interior has long been a captive of industry. And in matters of economic regulation, the old Atomic Energy Commission was, in Senator George D. Aiken's (Republican, Vermont) phrase, "an agency of acquiescence." Without transformations of the underlying structure and power of the energy industry or the present mandate of public government, such "logical" administrative reorganization conveniently parallels the emerging integration of the various energy sectors into the private government of oil. Reform simplifies the cooptation of the public bureaucracy into the expanded energy establishment. It eases the transition to a corporate state.

What the corporatist critique of the 1970s had failed to anticipate, and what Reagan and the Republican leadership had counted on, was the resilience of postindustrial ideology, especially its emphasis on the interrelated ideals of material and energy abundance and its "can do" positivism toward markets and technology. In the midst of one of the deepest economic recessions in the nation's history, these themes were embraced by many in the working, middle and upper classes alike. National energy and environmental strategies would have to reflect the capitalist nostalgia of Reaganism if they were to have popular appeal. The private government of energy was hardly an acceptable focus of criticism in this political atmosphere.

Even more striking was the fate of the soft energy path critique. With political emphasis on system preservation and renewal, the ideals of a decentralized social order predicated on small-scale, environmentally benign and socially responsive technology would appear to directly contradict prevailing thinking. Yet, Lovins the architect, in a dramatic revision of the thesis concluded that the only things needed to implement the soft path option were: 1) an understanding of "the potential contribution which end-use efficiency and appropriate renewable sources can make in enhancing national security--especially in minimizing the consequences of terrorist acts" 2) the implementation of a free-market approach which is "long overdue and can produce immense benefits in efficient energy investment" and 3) a national commitment to remove market imperfections, especially the subsidies and favored treatment given to hard path technologies, in order to end "a frustrating and persistent lack of *opportunity* to respond to price signals" (Lovins and Lovins, 1982:295, 297). The Lovinses went so far as to chastise those who would fail "to distinguish their technical conclusions from their ulterior political preferences," and announced that (Lovins and Lovins, 1982:219-220):

> [I]n point of fact...neither common sense nor careful study of the actual institutional impact of smaller energy technologies supports the contention that they require people to live, or to manage their affairs, in a less centralized fashion.

The degree of social centralization was instead determined by the level of reliance on markets for social decision-making (Lovins and Lovins, 1982:233):

> [T]he success of the free-market economic philosophy on which American enterprise has been built depends very directly on the collective speed and efficiency of many individually small decisions and actions by sovereign consumers. It is precisely because those decisions are the fastest and most accurate means of giving practical effect to private preferences that Americans have opted for a market system--one of decentralized choice and action--rather than for a centrally planned economy on the Soviet model. And in energy policy, recent events amply vindicate that choice.

Not only was the soft path compatible with market ideology, it could be combined with hard path options to build a "resilient" rather than a "brittle" energy economy. "[S]imply by permitting market forces to achieve the optimal economic balance between investments in efficiency and a new supply," the Lovinses argued that a "least-cost" energy system would be organized which contributed to "national strength, security, and prosperity" while "reducing price volatility and price increases,...countering inflation and unemployment,...reducing environmental and social impacts,...moderating tensions and inequities, and...alleviating the global risks of climate change and nuclear proliferation" (1982:262). The institutional incompatibility of soft and hard path architectures had all but dissolved. Rather than a distinctive political choice, the soft path had been reduced to an industrial strategy for stimulating economic growth at lower cost (Lovins and Lovins, 1982:219):

> This book asks only how our *energy* system, through incremental choices of different *technologies,* might be made secure within the framework of our present institutions. This analysis is limited to examining how to construct an energy system with maximal economic and national security benefits to meet the needs of a heavy-industrial, urbanized society--a society, moreover, that is assumed to wish to continue rapid economic and population growth. Exploring what might be the most desirable form of social organization is far beyond the scope of this work.

With the debate focused on the level of subsidies for nuclear power versus solar energy and the need to take advantage of cost-effective, end-use efficiencies, social analysis offers little opposition to postindustrial ideology. As Byrne and Hoffman have suggested (1987:28):

> A large part of social analysis is poorly prepared to challenge the future of nuclear power. Techniques and methodologies such as probabilistic risk, cost-benefit analysis and technology assessment, which are intended to address the relative impact or worth of socio-technical actions, in fact represent applications of the very mode of technical thinking which they are to evaluate. Each method takes as given a particular technical, economic, and political regime as their analytical background. Either the existing institutions or some specifiable surrogate must be assumed for any calculation of impact or worth to be possible. As a result, these approaches ignore altogether the problem for evaluation...mutually exclusive and antagonistic institutional 'architectures'.

U.S. energy policy and analysis have become mutually absorbed in recreating a cycle of crisis rationalization. Energy and related environmental problems are alternately regarded in this cycle as self-correcting, in need of modest public intervention, and finally, requiring the defense of existing systems against threats of significant change. A national posture of "denial-containment-crisis control" is assumed with each new challenge, as public action is dedicated too "charging the costs of change to...alternatives, while avoiding any systematic evaluation of the costs of remaining the same" (Byrne and Rich, 1983:176-177). In this respect, U.S. energy policy and analysis is replicating the response to the urban crisis: "do nothing, or at least do less," is as much the motto of energy politics and research as of its urban counterparts (Byrne). While the urban and energy facets of postindustrialism share an ideological resignation to the unstoppable power of technological and market forces, each displays its own set of imperatives for development.

9.8 The New Energy Order

If the urban crises of the 1960s reveal imperatives of *internal colonialism* (the creation of a permanent underclass) and *placeless development* (the stripping away of a sense of place from community existence) operating in the postindustrial order, what can be understood from the recent energy and environmental crises? Before answering this question, it should be observed that postindustrial imperatives of development--whether energy- or urban-based--tend eventually to function at an international scale. Thus, placeless development is a phenomenon affecting not only intra-national socio-spatial boundaries, but also international ones; the flight of capital from Detroit to Houston in the 1970s is coincident with its relocation from the United States to the Phillipines. Energy markets and technology similarly metastasize their principles of order to the international scale. However, there is a notable difference between the two. Whereas urban order is by its nature, at least originally, territorially organized, and through postindustrialism undergoes progressive delocalization (so that social space increasingly resembles a featureless plain), the energy order long ago shed territorial definitions. As has already been described, this occurred with the invention of the horizontally and vertically integrated multinational corporation in the case of oil and with the invention of the holding company, state monopolies and grid systems in the case of electricity. In this respect, energy markets and technology constitute a motive force for delocalization and are in this sense spatially unbounded modes of social organization. Consequently, imperatives of development issuing from this sector tend to take ubiquitous form. Three imperatives are observable from the energy crisis-and-response period of the 1970s and 1980s: technicism, unequal development and environmental commodification (Byrne 1990).

9.8.1 Technicism

Because it has been an institutional node influenced by and influencing science-based industrialization, military-industrial cooperation and the organization of Big Science, the most generic ordering principle emanating from the energy sector is technicism. The energy complex has throughout the twentieth century promulgated the ideals of technocracy including efficiency, standardization, centralization and system. Moreover, it has led the way in the development of a network mode of organization in which individual production and management units are linked. This can be found in the internal organizational structures of corporate oil and the large utilities. But more importantly, it is found in the inter-organizational consortia such as Aramco in which Exxon, Texaco, Standard Oil of California and Mobil, with the assistance of American foreign policy "manage" Saudia Arabian oil fields (and only in the 1970s permitted significant Saudi participation) in the several North American and European interconnection systems which ally separate utilities into coordinated production and bulk power pricing systems; in the shared-ownership compacts to manage pipelines and other infrastructure which may cross national and even continental boundaries; in the American and European atomic laboratory systems which combine government and industrial departments and personnel to research, demonstrate and develop nuclear technology; and in the multilateral policy organization such as the International Atomic Energy Agency (in this regard, OPEC represents a Third World effort to "leapfrog" national interests into a countervailing network organization). While these networks abide by the profit principle and often seek to enhance profit levels of individual participants, even corporate profits must conform with the general requisites of overall system operation.

It was the managed environments of several of these individual and collaborative organizations that were challenged by the oil shocks of the 1970s. And it was the defense of these organizational environments that national and international policy principally sought. One imperative of development, therefore, to emerge from the experience of the 1970s was the restriction of "solutions" to those which are compatible with the prevailing technocratic system. We are learning just how narrow these solutions are: expanded reliance on the private government of multinational oil; expanded use of electricity in the energy mix; and resurrection of nuclear technology initiatives.

9.8.1.1 Private Government of Energy

As to the first, Paul Tempest of the Bank of England has put the matter succinctly (1983:258):

> In recent years, the scale of energy exploration and development has increased massively, involving a multiplicity of governments, companies and individuals. But at the heart of the free world system still lie the major corporate organisations which are multinational in character. They, above all others, have the resource and drive to apply the latest appropriate technology wherever it is needed. They operate simultaneously in arctic icefield and equatorial swamp, in the depths of the North Sea and the sands of Arabia, switching their well-trained and experienced workforce and the latest equipment easily between them. In this flexibility lies their immense resilience and vitality.
>
> Each government and economy will, of course, find its own way of protecting its own national interest with its own institutions, licensing, royalties, taxation and other forms of control...But if governments persist in interfering to the extent of blocking the free international flow of skill and technology or seriously distorting the optimum development of global energy resources, they will only do so at the peril of our long-term global welfare and prosperity.

The necessity for worldwide support of the private government of energy is, then, one manifestation of the energy technicism imperative.

9.8.1.2 Electrification

A second manifestation is the requirement to expand the electric energy system. It too, is built on a "take-it or lose-it" logic. As Kahn noted in 1976, in postindustrial society "there is little debate...that most of the energy produced on a large-scale will be in the form of electric power...based upon...production at central plants" (1976:78). Throughout the century, there has been a steady substitution of electricity for other energy forms both in the organization of industrial production and the power complex itself. Centralized power, in cooperation with the military and the state insured that an increasing share of U.S. energy consumption would be electricity-based. In this regard, the energy-civilization ideology undergirding postindustrial development has been refined as an electricity-GNP relationship (Navarro, 1985:76-77):

> [The] link between [U.S.] GNP and electricity demand has continued...as the link between nonelectric energy demand and GNP growth has been decoupled. Indeed while total nonelectric energy demand grew at about 0.8 times GNP during the 1960-73 period, that figure has actually declined slightly in the postembargo era...Between 1960 and 1973, average annual electricity demand grew 1.7 times faster than GNP...since 1973, conservation has brought that ratio down somewhat, but electricity demand has still grown 1.2 times as fast as GNP...This electrification of the economy is evident in the fact that in 1960 one-fourth of all energy used in America went to generating electricity; today that figure is one-third. At the same time, electricity's share of the total U.S. energy consumption has risen from 23 percent in 1972 to 34 percent today.

Technical innovations and increases in productivity in U.S. industry have been located in those sectors which are electricity-intensive. In a widely quoted econometric study of the role of energy in U.S. industrial productivity growth, Dale Jorgenson concluded that (1984:28-29):

> [T]echnical change is electricity using for twenty-three of the thirty-five industries in the study. The first and most important conclusion is that electrification plays a very important role in productivity growth...technical change results in an increase in the share of electricity input in the value of output, holding the relative prices of all inputs constant.

Investments needed to sustain the electricity basis of postindustrial growth, however, are substantial. According to energy analyst Peter Navarro, new plant capacities of 438 gigawatts (or 70 percent of existing capacity) with costs totalling one trillion dollars by the year 2000 are needed "just to keep the lights on and the industry growing" (1985:55; and 1983:87). Electricity conservation can help us to postpone these costs. But in a postindustrial order, reliance on conservation is problematic. If it is to be cost-effective, conservation must address utility load requirements, which means that as a strategy it must offer opportunities to profitably manage or shape load patterns. Unprofitable load management and shaping counts as a cost of conservation. Thus, for example, reduced utility revenues associated with customer conservation practices jeopardize the ability of Centralized Power to meet the replacement investment needs of maintaining existing service levels. In postindustrial society, the utility must displace the consumer as the decision maker if *cost-effective* conservation is to result. Only then can there be any assurance that the technical dimensions of energy choice are fully accounted for.

The displacement of electricity conservation with what the Electric Power Research Institute calls utility demand-side management represents more than role reversal. By turning conservation investment decisions over to Centralized Power, the prospect of institutional change and restructuring is blunted. The industrialization of conservation leads to the development of but another market segment in the business operations of Centralized Power. Once captured, conservation becomes an investment option, "expensive" like every other utility investment, and requiring "rate relief" to pay for it. Further, the costs of electricity generation are the yardstick for measuring effectiveness and eventually a point is reached where new plant capacity costs the same or less. The only answer in the end is for flows of capital to the Centralized Power system to grow if the "dimming" of postindustrial society is to be averted (Navarro, 1985:xxiv):

> Unfortunately, after more than a decade of rapidly rising energy and capital costs, the electricity cornerstone is now threatened. Amidst the falling stock prices and bond ratings of a once blue-chip industry, the dimming of America--in the sense of massive electricity shortages and stoppages--has been predicted...Driving America toward this dim future is a greatly flawed system of electricity regulation, which, for a multitude of largely misunderstood reasons, is unable to keep pace with abrupt and rapid changes in energy and capital costs and equally jolting changes in energy demand and use patterns. The result of this regulatory failure is "rate suppression," a pernicious phenomenon marked by electricity rates that continually rise but never fast enough to cover the true and steadily escalating costs of generating electricity. As a result of this phenomenon, and despite the fact that electricity rates have more than tripled since the early 1970s, many utilities have seen their real earnings cut almost in half.

Thus, it is argued that utilities must be released from the constraint of public policy in order to acquire the capital necessary to sustain postindustrial progress.

9.8.1.3 The Spread of Nuclear Power

There is no better illustration of the technicist imperative of postindustrial development than the case of nuclear power. As already discussed extensively in Chapters 6 and 7, the introduction and utilization of nuclear technology has been determined by technocratic logic and ideology. But it is relevant at this juncture to point out two additional characteristics of this technology movement which further substantiate its imperative status in postindustrial development. The first concerns the invincibility of nuclear power to virtually all conceivable (certainly, experienced) financial and social costs. The second is the assured legacy of the technology even without further plants being built.

As to the invincibility, pre-Chernobyl experience includes the deaths of two workers in 1945-56 at the Los Alamos plutonium processing plant; a partial core meltdown in 1952 in Canada's Chalk River plant; the 1957 fire at Britain's Windscale plant; the explosion at an experimental nuclear reactor facility in Idaho which killed three operators; the 1966 partial core meltdown at the Fermi reactor near Detroit; a breeder reactor accident in 1973 in the USSR which took an unknown number of human lives; the electrical fire in 1975 at the Browns Ferry Alabama plant which crippled the emergency core cooling system; the accident that could not happen and did at Three Mile Island in 1979; the closure in 1986 of the French Super Phenix fast-breeder reactor after an unexplained leakage of 25 tons of highly volatile coolant (Byrne and Hoffman, 1989:658). Likewise, before Chernobyl, the nuclear power project was associated with the largest default in the history of the municipal bond market. Declaring its inability to meet financial obligation for $2.1 billion, the Washington Public Power Supply System (WPPSS) cancelled two of the five plants in the project. Remaining debt of $6.7 billion in principal and $23.8 billion in interest on three other WPPSS nuclear power plants is owed. None of these plants is expected to operate in the forseeable future; the destiny of the project is for partially complete facilities to "be left to sit in the rain" (Gleckman, 1984:35). While no other default on a U.S. nuclear facility was experienced before 1986, an U.S. Energy Information Administration study reports that the industry has routinely witnessed cost overruns comparable to those in the WPPSS project; as of 1982, 72 percent of American nuclear plants had cost 1.5 to 4 times their original investment (Energy Information Agency, 1983:7). Even the French nuclear industry, reputed to be the most efficient in the world, had shown the financial strains that accompany promotion of this technology. By 1986 Electricite de France (EDF), the French nuclear authority, had 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). Despite forty years of world experience with nuclear power as a hazard to public safety and an unreliable, exceptionally high-cost economic investment, enthusiasm for its use remained strong. Harold Agnew, former director of the Los Alamos National Laboratory and an official of Reagan's Department of Energy, summarized the reasons for this technology's social and economic invincibility (1983:1):

> Was Dwight D. Eisenhower wrong when he foresaw and proclaimed an energy abundance that would benefit all mankind by setting in motion his Atoms for Peace Program in 1954? The answer is no. Despite the difficulties and problems that have beset the industry in recent years, the vision of Eisenhower was and still is correct for these simple reasons: abundant, inexpensive energy supplies are the foundation upon which major advances of the past one hundred years--and the accompanying rising standard of living--have been based; where fossil fuels carried us into--and perhaps through--the industrial age, nuclear energy, both fission and fusion, represent the fuels on which future progress will be based; and nuclear is the only non-fossil energy source that will be available to us in sufficient amounts to support our current civilization and to fuel progress for the forseeable future. While technological advances have often been resisted, it is comforting to note that throughout history people have never turned their backs on progress for any significant periods of time.

On April 26, 1986 the worst accident yet at a nuclear facility occurred at the Chernobyl No. 4 reactor in the Soviet Union. Emitting the largest level of radioactive material ever released in a single accident (27 megacuries), the environmental and human costs of nuclear power were made dramatically evident. Thirty-one people to date have died either as a result of the accident itself, or in the efforts to contain the damage and another 237 were diagnosed as having "serious" radiation sickness (Marples, 1988:37). Total human toll, however, remains unknown. Present projections estimate a range of between 5,000 to 75,000 future cancer deaths are expected as a result of the Chernobyl disaster (Byrne and Hoffman, 1989:658). Chernobyl's effects were not confined to Soviet borders, as radiation contamination spread throughout much of the European continent. Approximately 400 million people across 15 nations were put at risk of unhealthy levels of radiation exposure. Yet the accident did little to diminish worldwide development of the technology. Undeterred by the social and economic costs of the Chernobyl disaster, Soviet General Secretary Mikhail Gorbachev, scarcely three weeks after the accident reflected the invincibility principle of nuclear power when he announced: "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" (1986:516). Echoing this stance, Chancellor Helmut Kohl of West Germany assessed the role of nuclear power in that country's development future: "Abandoning nuclear power could spell the end of the Federal Republic as an industrialized nation." And Great Britain's Energy Secretary similarly argued that nuclear development is unavoidable (quoted in Flavin, 1987:62):

> [I]f we care about the standard of living of generations yet to come, we must learn 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.

The post-Chernobyl commitment to nuclear power has not been merely rhetorical: a recent U.S. Department of Energy study projected the global addition of 84 operating nuclear plants between 1987 and 1990 (Department of Energy, 1987:183); and construction orders worldwide for 118 new plants remained for start-up by 1990 (Ramberg, 1986:318). International development of nuclear power continues at a brisk pace.

But the impact of this technology is not only defined by the number of operating plants and construction orders. Even if no further plants were added, the legacy of nuclear power is assured. The half-life of nuclear waste and its convertability to bomb-grade material force the effects of this generation's utilization of nuclear power upon many generations to come. One thousand year security arrangements are a concomitant of even a brief period of use, and the threat of nuclear proliferation is permanent. Moreover, because of the huge size of nuclear plants, a new order of centralization has been introduced into the Power Complex which will remain for at least 20 to 50 years. A glimpse of this legacy can be gained from U.S. experience. Despite the absence of new plant orders in 11 years and the reversal of every nuclear investment decision between 1974 and 1978 (a total of 41 projects), the percent of U.S. electrical generating capacity supplied by nuclear power grows. Nuclear generation in 1989 represented 19.5 percent of the U.S. total, more than five-fold the amount generated in 1973, the last year in which a plant order was placed and subsequently completed (Energy Information Administration, 1989a:3). Projections to the year 2000 of U.S. total electrical and nuclear generating capacity indicate that the nuclear share will grow by another nine percent (World Nuclear Industry Handbook, 1988:13). Finally, the image of abundance and the promise of energy independence, so deeply associated with nuclear power in the postindustrial context, will continue to shape ideas of energy choice both in the United States and throughout the world. It is this aspect of the nuclear legacy which leads Third World countries such as India, to tie their developmental aspirations to the utilization of this technology (Byrne and Hoffman, 1987:21-22):

> At independence in 1948, Nehru diagnosed India's problem in these terms: "she fell behind in the march of technique and Europe, which had long been backward in many matters, took the lead in technical progress." To catch up with Europe, Nehru initiated an atomic energy program in which nuclear technology was considered "the technology of the future which promised tremendous possibilities for the economic transformation of the Indian society. India could not afford to lag behind in this field. She has already suffered for having missed the industrial revolution. Now, when the second 'Industrial Revolution' was on the anvil, she did not want to be left behind."

9.8.2 Unequal Development

A second imperative of postindustrial energy development is the reproduction of a structure of inequality. The energy political economy is predicated on patterns of unequal development both geographically and socially, and fosters inequality in rich as well as poor countries (although differentially). Inequality is a pervasive attribute of the postindustrial energy system.

Although the richest in the world, the U.S. economy could not escape the effects of the oil shocks of the 1970s. As already noted, the economy suffered absolute declines in GNP in the wake of both oil shocks, while the oil majors experienced unparalleled profit growth. These two phenomena are not unrelated, but are a logical expression of the dualistic structure of the energy economy. For "energy producers" to reap the magnitude of gains made possible by world price increases, "energy consumers" had to pay. This is true of the United States and every other country. The valorization of energy resources takes place through a market structure in which producers control far more of the financial base than do consumer groups. This means that during periods of high prices, value flows disproportionately to producers, creating the duality of corporate wealth and national recession. In periods of falling world prices, value continues to flow to producers, but some relief is also experienced by consumers. Only consumers and satellite enterprises of relatively small-scale producers are at significant risk in this political economy with the greatest burden, of course, borne by the poorest in society. Occupying the least insulated housing, depending upon out-dated heating and appliance equipment, unable to afford to conserve energy, the poor are locked in a state of energy poverty. As with the urban transition, so with the energy transition--the poor are simply redundant, marginal populations without paying roles. Their incomes are eroded the quickest by high energy costs, and they are the last to experience real income relief when price increases slow.

At the international level, the imperative of unequal development can be even more pernicious. The poorest countries are faced with a Hobson's choice. On the one hand, they can rely upon traditional fuels, attempt to sell their agricultural produce on world markets which offer little or no return, and remain impoverished. As the World Commission on Environment and Development observed, the probable outcome of this choice for many nations is the exhaustion of domestic energy sources such as fuelwood while setting in motion forces of ecological destruction which eventually attack the subsistence economy and threaten national abilities to feed populations (1987). On the other hand, poor countries can seek to develop commercial energy complexes. As the oil shocks of the 1970s showed, the consequence of this choice is a debt spiral. In addition, the need to acquire technology consistent with the commercial energy choice typically means inviting transnational capital to arrange the transfer of technology and organize and manage the technological complex. As Nigeria learned, even an oil rich Third World country may not break the chains of economic dependency that come with this development option. Despite an increase of 7,400 percent in the income produced in the Lagos oil complex between 1960 and 1980, Nigerian per capita real income fell prompting Peter Olayiwola to characterize the development experience as "growth without change" (1987:1). The vagaries of world energy prices can only exacerbate the poverty of the poor. As an analysis of the post-shortage period of 1980-1985 demonstrates, lower energy prices led to no discernable improvement in the lowest income countries (Wang, et al., 1988). In fact, the poor of the world experienced declining GDP growth rates during this period, while per capita energy consumption continued to increase. By contrast, the richest countries experienced higher GDP growth rates and lower per capita energy consumption. This study concludes (Wang, et al., 1988:4.114):

> [T]he energy-development relation is leading to uneven growth opportunities among the rich and poor countries of the world. As conventional supplies diminish and the price of remaining stocks increase, the impact of energy on world development patterns and opportunities is likely to grow. In the wake of the 1970s energy shortages, our analysis suggests that a disturbing polarity may be emerging between rich countries who are reducing their economic requirements for increasingly costly energy and poor countries who are unable to develop economically without additional growth in energy use...it is past due for supporting change in an energy distribution system which continually denies those societies most in need of energy services the capacity to meet those needs.

Recent projections by the World Resources Institute indicate that energy consumption in developing countries would double between 1980 and 2020, an amount equal to 40 percent in existing *world* energy use, under the consumption of moderate economic growth (Goldemberg, et al., 1987). It is difficult to conceive how the poor could afford this increase within a postindustrial regime of energy supply without further deepening the dependent state of their development. Such a circumstance is not a haphazard result of postindustrial progress. It is part of the design.

9.8.3 Environmental Commodification

Finally, there is the disposition of Nature. As Mumford had established over five decades earlier, the technics and economics of industrialism presumed a foul environment. A machine-produced order transforms Nature into a waste repository. Under an assumption that the repository was virtually volumeless, the only brake on pollution, Mumford had observed was the profit-making potential for its reduction. Since this analysis, some understanding of the finiteness of the carrying capacity of land, air and water has emerged and scientific calculations of precise volumetric capacities of each "medium" are underway. Specialized analytic techniques including risk assessments, environmental impact analysis, and risk-cost-benefit analysis have been devised to steer national and international environmental policy. None of these developments, however, directly questions the cash nexus between economic growth and the environment; quantification proceeds with only a quantitative qualification--a sustainable environment is pursued only if it is associated with sustainable profit.

The postindustrial stage of development has brought with it a new dimension. Advanced technology and chemistry, in conjunction with an energy appetite nourished by the postindustrial ideology of abundance, have empowered the machine world with the capacity to directly alter the cycles and processes of nature. Where the stage of carboniferous capitalism tested the statics of nature, namely, the absorption capacities of land, water and air, postindustrialism challenges the dynamics of nature, in particular, the seasons, the tides, the breathing of the planet, and even the reproductive cycle of the atmosphere. While the emblems of postindustrialism, like carboniferous capital remain waste and pollution, there has been a fundamental breach in the nature-society relation. Postindustrial life transpires not simply outside the constraints of nature, but relegates nature to commodity status, to be purchased and sold in the world political economy along with other products and services. Postindustrialism *presumes* that sustainability is a technological and economic matter. Although this presumption is typically manifested in economic terms and thus continues to be most concretely presented in discussions of trade-offs between environmental protection and material progress, its deeper implication is the demise of any idea of the inviolability of nature. There is *nothing* in postindustrial logic beyond technological manipulation; not the climate, not the atmosphere, not specie diversity. Nature is stripped altogether of a social status.

In this context, the manufacture of acid rain and holes in the upper ozone, the extinction of plant and animal species (and the engineering of new ones), the reduction of the planet's capacity to breathe (due to deforestation, among other things), and the creation and satisfaction of consumptive appetites which in their aggregate portend a change in global climate, become rational and efficient. The debate over global warming and the possible need to restrict world carbon dioxide emissions is illustrative of the postindustrial mind. In a recent article in the *New York Times* (November 19, 1989), Harvard economist Thomas Schelling points out that, "both the will and technological ability to adapt to radically different weather [has changed rapidly]. In 1860 two percent of Americans lived outside temperate or sub-tropical zones. By 1980 the percentage had increased to 22 percent." Schelling is further reported to have argued that (1989:):

> [T]he appealing idea of bequeathing the biosphere intact seems arbitrary. The quality of life in 100 years...will depend as much or more on the endowment of technology and capital as on the percentage of carbon dioxide in the air. And if money to contain carbon emissions comes out of other investment, future civilizations could be the losers.

Citing a study by the U.S. Environmental Protection Agency which estimates the cost of protecting American coastal cities from a three-foot sea rise at $73 to $111 billion, the article notes that this is "a lot of money but not so much compared with the likely cost of prevention." The reporter concludes from interviews with Schelling and other economists and technologists for the article that an analytical consensus is emerging: "it may be cheapest to deal with the effects of global warming rather than the causes."

CHAPTER 10

PREDICAMENT AND PROSPECTS

The analytic strategy for this dissertation was developed, as described in Chapter 2, from the institutional approach of Lewis Mumford. The reader at this point is surely well-aware of the intellectual debt owed this thinker. The study has now reached the point of prognosis and it seems only fair that Mumford's judgments on the tendencies of and options for postindustrial society be consulted as part of the concluding analysis.

Mumford's diagnosis of Paleotechnicism focused on the tendency toward destruction of community and environment as a necessary consequence of this path of economic and technological progress. In implementing the quantitative logic of "bigger as another way of saying better," Paleotechnic technology and industry combined to overpower urban culture and to substitute a commercial pseudomorph based on mass-production and mass-consumption. It was this assault on what another writer has termed "the space of places" (Castells, 1985) that Mumford regarded as among the most dangerous attributes of Paleotechnicism. He reluctantly came to the realization that the transformations of the alliance's partners did not merely amplify the threat, but actually implied the dissolution altogether of community. Thus by the 1960s, Mumford warned (1961:540):

> Whereas the first extension of the factory system produced a multitude of new cities and greatly augmented the population of existing centers, the present diffusion of the area of settlement has largely halted this growth and has enormously increased the production of relatively undifferentiated urban tissue, without any relation either to an internally coherent nucleus or an external boundary of any sort.

The spread of the metropolitan economy underscored for Mumford the crucial role played by the social organization of space in determining the meaning and possibilities of community. The increasing "technicization" of space constituted a devolution of community in Mumford's framework. For this reason, he characterized the emergent conurbation as a contest between "automatic forces" and "human purposes," between a "machine-oriented economy" and the "goods and goals of life" (Mumford, 1961:540 and 541).

What had brought Western society to this point? For Mumford the key was the increasing tendency of the alliance to manifest itself in the form of highly centralized energy, capital and technology networks. From the mid-nineteenth to the early part of this century, these networks supported an urban landscape dominated by the concentrated, centralized, mono-nuclear city; while for the last fifty years a reversing pattern of deconcentration and then decentralization has controlled social space. This cycle reflects the transforming organization of capital, energy and technology in the modern order. During the epoch of spatial centralization, energy, capital and technology achieved large-scale operation and the first experiments in equivalent-sized distribution systems were begun. The deconcentration phase records the triumph of integrated networks of energy, capital and technology over other social forms in determining the spatial relations of society. The principal agent in both spatial epochs was the power complex (Mumford, 1961:540):

> [T]he original forces that created the conurbation were supplemented by the electric power grid, the electric railway, and still later by the motor car and the motor road: so that a movement that was at first confined largely to the area accessible to the railroad now is taking place everywhere.

As Chapter 3 describes, the U.S. petroleum and electricity industries in partnership with the state, designed markets during the first half of this century which exceeded the urban boundary. Their common aim was to avoid local economic "constraints" and local political authority (see also Morris, 1982). The advantages of vertical and horizontal integration demonstrated by the growth of the power complex were soon mirrored in other industrial sectors, especially chemicals, machinery, transportation, metals and rubber. The spread of corporate and system methods was and is the most important instance of technology transfer in the development of the American system of industrial production.

The spatial resolution of the new postindustrial social order set the stage for the late-twentieth century conflict between the human and the technical (Mumford, 1961:541-542):

> The metropolis is in fact a processing center, in which a vast variety of goods, material and spiritual, is mechanically sorted and reduced to a limited number of standardized articles, uniformly packaged, and distributed through controlled channels to their destination, bearing the metropolitan label.
>
> 'Processing' [is] the chief form of metropolitan control; and the need for its constant application has brought into existence a whole range of inventions, mechanical and electronic, from cash registers to electronic computers, which handle every operation from book-keeping to university examinations. Interests and aptitudes that do not lend themselves to processing are automatically rejected. So complicated, so elaborate, so costly are the processing mechanisms that they cannot be employed except on a mass scale...That which is local, small, personal, autonomous, must be suppressed. Increasingly, he who controls the processing mechanism controls the lives and destinies of those who must consume its products, and who on metropolitan

> terms cannot seek any others. For processing and packaging do not end on the production line: they finally make over the human personality.

Although Mumford's analysis in the first half of the century had projected the possibility of a fruitful combination of humanism, organicism and mechanism, the events of the post-World War II period changed his mind. Twenty-five years of postindustrial progress after the war led Mumford to conclude that modern society was at greater risk than ever of losing control of its destiny. The full-scale technicization of the power complex had resulted in the overwhelming of humanistic and organic structures and possibilities by technocratic mechanism. Rather than a renewed appreciation of humanity's link with nature, Mumford saw in the twentieth-century movement to electricity a fusion of power never before possible in societies. From social control and political domination to the conversions of energy into economic products, these elements had co-existed independently but were now brought together into a coordinated organization of "megamachine" power.

> [W]ith the construction of the megamachine, all the modes of power became available for work--both constructive and destructive--on a colossal scale otherwise unattainable. The megamachine, accordingly, is *not* a mere administrative organization: it is a machine in the orthodox techni-

> cal sense, as a "combination of resistant" bodies so organized as to perform standardized motions and repetitive work...With nuclear energy, electric communication, and the computer, all the components of a modernized megamachine at last became available.

The interconnections of the electrical grid supported the formation of extended technical systems of communication, transportation, information and capital exchange. With the introduction of nuclear power the integration was nearly complete. Integrated networks of technology pervaded not only the economic sphere but were affecting human intimacy and individuality. Nearly all forms of human interaction, thinking and work were influenced by and in some ways had become dependent on this network and reality; the social sphere itself was being technicized. Science and technology had created a new kind of authoritarianism in which social options had become routinely evaluated within a framework of scientific and technological feasibility (Byrne and Hoffman, 1988). Langdon Winner has similarly concluded that "the rule of technological circumstances in the modern era does in fact supplant other ways of building, maintaining, choosing, acting and enforcing, which are more commonly considered political" (1977:257).

Mumford focused on the failure of science and technology to refashion the power complex along a more humanistic Neotechnic model and also warned of the new threats posed by their elevated status in the social sphere. The destructive tendencies of Paleotechnicism, in his view had hardly been resolved. Instead, they merely assumed a new form. Mumford acknowledged the gains in productivity attributable to improved methods for generating and distributing energy, the material abundance made available by innovative technologies, and the elimination of at least the most offensive pollutant-emitting Coketowns. But, Mumford argued, evaluation of science and technology was not so straightforward. In addressing the old problems and limitations of Paleotechnicism, megatechnics imposed its own measures of control. Modern society was now constituted on "the megatechnic bribe" (1970:338):

> Now megatechnics offers, in return for its unquestioning acceptance, the gift of an effortless life: a plethora of prefabricated goods, achieved with a minimum of physical activity, without painful conflicts or harsh sacrifices: life on the installment plan, as it were,...with an unlimited credit card...If the favored human specimen is ready to give up a free-moving, self-reliant, autonomous existence, he may, by being permanently attached to his Leviathan host, receive many of the goods he was once forced to exert himself to secure, along with a large bonus of dazzling superfluities, to be consumed without selection or restriction.

But as with all bribes, there was a price for this material advantage which Mumford characterized as the "democratic-authoritarian social contract" (1964:6). Society might accept the megamachine's gift of material affluence, "[b]ut on one condition" (1964:6):

> [T]hat one must not merely ask for nothing the system does not provide, but likewise agree to take everything offered, duly processed and fabricated, harmonized and equalized, in the precise quantities that the system, rather than the person, requires.

The democratic-authoritarian bargain projected by Mumford as underlying contemporary society is now the controlling context in which major social decisions are made. Allegiance to technocratic rule, unequal development and environmental commodification are pledged in national policies and justified by a promise of material comfort and convenience. The effortless life is all in the postindustrial Leviathan, as Mumford forewarned.

Yet, in postindustrial society this reality operates mundanely. Characteristic of this era is the very rationality and practicality of understanding that poverty cannot be eliminated even in the midst of postindustrial abundance; but that instead social policies can be designed which insure "that those who cannot work are able to lead a life of dignity while their welfare is provided through alternative means" (President's Commission, 1980a:65). It is the reasonableness of the premise that while racism should not be tolerated, social intolerance of racism may itself be objectionable--that affirmative action may be discriminatory; better to be guided by the ideal of a color-blind society where we have "eliminated the races...[a]nybody can be any color he wants" (Gordon, 1965:73). It is recognizing that, realistically, cost-effectiveness requires a certain extent of environmental degradation; "if we are to cope with our energy problems, some damage must be done to the environment; the question is how much and where" (Kahn, 1975:144); and "the quality of life in 100 years...will depend as much or more on the endowment of technology and capital as on the percentage of carbon dioxide in the air...if moving to contain carbon emissions comes out of other investment, future civilizations could be losers" (Thomas Shelling quoted in *New York Times,* November 19, 1989). And it is knowing that, objectively speaking, technological progress is society's best hope for the future (editorial in the *New York Times, April 20, 1989):*

> Nuclear energy..is a way to minimize the feared warming of the earth's climate. That threat seems more real than ever, and Western societies are wondering how to reduce use of fossil fuels whose waste gases help heat the atmosphere.

The sensible voices of postindustrialism are guided by the logic of technique which Jaques Ellul precisely captured: "Efficiency is a fact and justice a slogan" (Ellul, 1964:282). It is this frame of reference that explains the confidence of the modern mind in science and its distrust and fear of the subjectivity of the human being. It is also this frame of reference which explains such social facts as that black men in Harlem are less likely to reach age 65 than men in impoverished Bangladesh (McCord and Freeman, 1990:174); and how in the same society, nuclear plants with Chernobyl-type pressure suppression containment systems are permitted to continue operation by submitting plans for controlled venting of radiation gases as "a central part of their accident fighting strategy" (the Chernobyl explosion in this language, is an uncontrolled release of radiation--Mariotte, 1990:7).

While at times overwhelming to the social spirit, we must never lose sight of the fact that the imperative character of postindustrial development is a *social construction*. And in this regard, we should remind ourselves that it is the postindustrialists, with their message of forces of technology and economics too powerful to be changed, who are the real pessimists. Indeed, we have options; we can engage in social actions which *can* affect the forces of postindustrialism and open opportunities for constructive social change. These include the following (and the list is not intended to be comprehensive): steps to reduce the mobility of capital (see, e.g., Bluestone and Harrison, 1982); policies that empower urban communities to socialize space; local, national and international strategies to restructure the power complex around principles of resource conservation and renewability; and worldwide cooperation to halt the exploitation of the environment (including ceilings placed on carbon dioxide emissions of industrialized countries).

These steps, in themselves, cannot be expected to halt postindustrialism. They are instead symptomatic of the need to overhaul the normative basis of society and culture. Postindustrialism is built on the values of centralism, gigantism, technicism, abundance, quantity and commodity. Societies need to value differently: ideals of community, place, quality, nature, justice and equality, participation and democratic governance should inform our actions and institutional organization.

The realistic, rational, practical social order of postindustrialism is a fundamental threat to the human prospect. Social action to challenge the forces of postindustrialism is urgently needed.

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