DOE/ER/10072-1

MASTER

SOCIAL ACCEPTABILITY OF SATELLITE POWER SYSTEMS (SPS)

THE NEAR-TERM OUTLOOK

May 1980

Prepared by:
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DISCLAIMER

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AS05-79ER10072

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Printed in the United States of America
Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed copy: A04
Microfiche copy: A01

NOTICE

PREFACE

What follows is the first draft of an ambitious (some would say, audacious) effort to trace the currents of contemporary social change that are likely to shape the overall development of U.S. energy policy during the next twenty years. When I began this project, I had not expected to have to address issues as broad and complex as these. It soon became clear, however, that only within this broader context is it possible to anticipate, however tentatively, the forces that will affect the social acceptability of Satellite Power Systems. For their helpful comments on an earlier version of this paper, I am grateful to the following official and unofficial "peer reviewers": Arrie Bachrach (of the Environmental Resources Group), Charles Bloomquist and Sherry McNeal (of the PRC Energy Analysis Company), Sally Cook (of Exxon Company, U.S.A.), John Freeman and Chad Gordon (of Rice University), John Klineberg (of the Lewis Research Center, NASA), David Sills (of the Social Science Research Council), Paul Stern (of the Program on Energy and Behavior, Yale University), and René Zentner (of Shell Oil Company).

ABSTRACT

It is important, at this early stage in the concept development and evaluation of Satellite Power Systems, to explore as fully and objectively as possible aspects of contemporary social change that may be expected to complicate the process of achieving the necessary support of the American public for this new technological venture. Energy policy is a social and political issue, even more than it is an economic or technological one. Current public attitudes make it appear unlikely that a consensus will evolve during the 1980s favoring costly efforts to develop vast new supplies of conventional energy. Opinion polls reveal a pervasive worry over inflation, a broadening of aspirations to encompass "quality-of-life" concerns, a growing distrust of central governments, large corporations, big science and technology, and a continuing commitment to environmental protection -- all of which suggests a social environment that is likely to resist the development of a major new high-technology energy system such as the SPS.

Opposition to satellite power will focus on the high front-end development costs, on environmental and technical uncertainties, and on a generalized distrust of large bureaucracies and esoteric technologies. The SPS concept is also likely to be viewed with skepticism by those with vested interests in the long-run uses of coal, shale, fission, fusion, or on-site solar technologies, and even by space scientists concerned about the diversion of funds from smaller-scale space projects.

All such opposition would be overcome if there develops a broad-based conviction that vast new energy supplies will be desperately needed in the near-term future. Here, however, the growing commitment to energy

conservation and the spreading deployment of dispersed renewable-energy systems strongly suggest that the unmet U.S. demand for centrally generated electricity is unlikely to grow sufficiently over the next twenty years to convince a reluctant public of the need for so large an investment of scarce resources in the SPS program. Satellite Power Systems will have a problem in the area of public acceptability.

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I. INTRODUCTION

The U.S. Department of Energy is exploring several options for generating electrical power to meet future energy needs. One of these options is the Satellite Power System (SPS), a method of collecting solar energy in space for use in producing electrical energy on earth. A three-year preliminary evaluation of the SPS concept, undertaken jointly by the Department of Energy and the National Aeronautics and Space Administration, is about to be completed. The objective of the Concept Development and Evaluation Program was stated by the Secretary of Energy in 1977: "To develop, by the end of 1980, an initial understanding of the technical feasibility, economic practicality, and the social and environmental acceptability of the SPS concept" (cited in U.S. Department of Energy, 1979).

The present study constitutes a small part of that broader evaluation effort. It is a tentative assessment of the way this potential new energy system is likely to be perceived by the public at large, in the context of predictable social trends through the 1980s. It does not explore directly the development of public opposition to nuclear power, for that history and its implications for perceptions of SPS are the subject of a separate study being prepared by Professor Chad Gordon of Rice University. This paper seeks to complement the earlier analyses of Bachrach (1978) and Naisbitt (1978) by drawing on the most recent literature and on the events that have unfolded during 1979. It attempts to develop a realistic and objective appraisal of the broad social and political forces that appear to be shaping energy policy in the United States.

The national energy picture remains fluid and confused, but emergent trends are becoming clearer, and the eventual public response to the SPS concept can be discerned with somewhat more confidence today than was true even one year ago, when the Bachrach and Naisbitt papers were written. That response does not now appear to favor the development of the SPS system. It is important to recognize, however, that new events can change a pattern dramatically, and that any predictive judgment of this sort can be little more, at best, than carefully considered and informed guesswork. The crystal ball, as one pundit observed, is not a precision instrument.

A. The SPS Concept

While all of its technical specifications are open to modification in the light of continuing research on emerging technologies, a reference system has been defined as one plausible approach to the problem of delivering energy to earth from space. The concept envisions constructing a collection of large arrays of solar panels at geosynchronous orbit in outer space. There, the solar energy is converted to microwaves, beamed to ground receiving stations (rectennae), and then reconverted into conventional electricity. Each SPS satellite is expected to supply up to five gigawatts (five million kilowatts) of energy into the electrical grids of the nation.

In its latest "System Definition Study," Boeing estimates that it will cost 117.4 billions of 1979 dollars to develop and complete the first five-gigawatt SPS power plant. In comparison, Crossley (1978) notes that the total bill to put a man on the moon was $25.6 billion (about $40 billion in 1979 dollars), and Seltz-Petrash (1979) points out that U.S. private utilities invested a total of $30 billion in coal and nuclear plants during 1978, in order to increase electrical capacity by 22.8 gigawatts. The SPS system can therefore be economically competitive only if the space transport system on which it depends is completely reusable and if the project is carried out on a large enough scale to benefit greatly from economies of mass production. The reference-system full-scale SPS program thus envisions a minimum of sixty satellites, launched at the rate of two per year over a thirty-year period, and ultimately supplying 300 gigawatts of electricity at a total cost of somewhere between 600 billion and 1 trillion 1979 dollars.

Once in place, the satellites are expected to be relatively maintenance-free in a space environment devoid of rain, wind, earthquakes, or gravity. Solar radiation is four to eleven times greater in space than at the best earth locations. Sunlight in geosynchronous orbit is unobstructed and available 24 hours a day during most of the year. The SPS concept is thus one of the few solar options that offers continuous power generation on a scale substantial enough to meet a significant portion of future energy demands (Glaser, 1978). Given these distinct advantages, NASA and DOE would surely have been remiss if they had not undertaken at least a limited program to explore the feasibility of the SPS concept and to determine as soon as possible whether to recommend proceeding with more elaborate tests and space demonstrations.

B. Questions of Feasibility

The technological challenges of the SPS system will press American engineering capabilities to the limit. Construction bases in space, launch and mission control bases on earth, and fleets of space vehicles will be needed to build and maintain the satellites. The program will call for the development of a heavy lift launch vehicle five times larger than today's rockets, a powerful space tug (the cargo orbit transfer vehicle), and two new shuttle-type spacecraft (the personnel launch vehicle and personnel orbit transfer vehicle) capable of ferrying engineers and technicians into low earth orbit and from there into geosynchronous orbit, where the satellites will be assembled. It will take years to design and test all these complex launching, space transportation, and construction techniques, and to select the best of the technical options that are available at every step. As yet, no reason has come to light for concluding that the system could not be built or operated successfully, at least in principle (AIAA, 1978; Glaser, 1978; Grey, 1979).

In practice, conflicts over land-use for rectenna siting and over the allocation of geosynchronous positions in outer space may prove extremely difficult to resolve. The prospect of solar satellites serving as military weapons or targets may further stimulate the orbital arms race and require new forms of international agreement, control, and ownership that may be difficult to reconcile with the need to attract private funds seeking profitable investments. There are also serious health and environmental questions.

Research is now underway to simulate and measure the probable effects upon radio-frequency communication systems of heating the ionosphere with constant microwave beams or with space vehicle exhaust emissions (a full-scale SPS program might entail as many as 500 rocket launches every year for 30 years). Little is known as yet about the effects that exposure to relatively strong microwave energy will have on SPS workers at rectenna sites or on airborne species flying through the beam. Controversy continues with regard to the long-term effects of continuous low-level microwave radiation, such as would surround the receiving stations, on the people, animals and ecology in the vicinity of the rectenna sites. Here again, it will take years of testing to establish the environmental acceptability of this complex and large-scale program.

The experience with nuclear power generation raises the further question of whether, whatever the actual results of research, a sufficient consensus on the ability to mitigate the environmental risks can be achieved within the scientific community and then accepted as legitimate by the public as a whole. Studies of risk perception indicate that the technologies that arouse the greatest public resistance are those whose risks are perceived as being borne involuntarily, with delayed and unknown effects, and as largely uncontrollable, unfamiliar, and potentially catastrophic (Lowrance, 1976; Slovic, Fischhoff and Lichtenstein, 1979). The perceived risks of nuclear power are unrelated to actual frequencies of death or injury; they arise instead from perceptions of a high potential for disaster and from the menacing picture of "invisible" long-run dangers that even the "experts" cannot agree upon. Clearly, many (though by no means all) of these same uncertainties are associated with microwave radiation. As public awareness of them increases, they will complicate on-going efforts to establish the environmental acceptability of the SPS system (see Bachrach, 1978). There are also broader and more subtle aspects of contemporary social change that will play an even greater role in shaping the eventual social acceptability of SPS. These are the focus of the present study.

C. The Importance of Public Perceptions

Even with its environmental and technological feasibility established to the satisfaction of all reasonable observers, with rectenna sites chosen and international treaties in place, there is no assurance that the SPS system will actually be deployed. As Robert Ayres (1979, p. xi) has shown,

> there are many examples of "possible" technologies that, for a variety of reasons, are unlikely to be developed in the near future even though scientists and engineers are set to proceed with all deliberate speed. But economists, businessmen, politicians, and citizens may see things differently.

Whether or not the 1980s will witness a sufficient convergence of perceptions to support the large investment of funds and technological talent that this project demands will be the result of a wide variety of economic, political, and social forces whose individual developments and complex interactions are impossible to predict with assurance. Unanticipated changes in social attitudes and public perceptions continually confound the prognostications of experts.

At this early stage in the assessment of the SPS concept as a potential energy option, it is nonetheless important to explore as fully and objectively as possible those aspects of contemporary social change that may be expected to complicate the process of achieving the support of the American public for this new technological venture. There are compelling reasons to believe that the SPS concept -- in the type of technology, the scale of deployment, and the size and uncertainty of the social costs that it entails -- is running counter to some of the major currents of social change that appear likely to inform the closing decades of this century. Those reasons need to be examined in detail. This report is a preliminary effort in that direction.

II. THE ENERGY PROBLEM: VINTAGE, 1980

The Arab oil embargo of October 17, 1973 marked the end of the era of cheap and dependable oil and gas, and the difficult beginnings of the transition toward a much more diversified and balanced system of energy supply. There is growing public recognition (see section IIIB) of the genuine fragility of the American energy system, dependent as it is on depletable, non-replenishable fuels for close to 95 percent of its total supply, on increasingly insecure and expensive oil and gas for 75 percent of its energy, and on imports for almost one-half of the oil it consumes. A continuing balance-of-trade deficit, threats of sudden supply disruptions, pressure on prices from an excessive U.S. demand, the insecurity of the international economy attributable to the declining value of the dollar -- these are only some of the most obvious costs incurred by an American oil import bill that grew from $4 billion in 1971 to $50 billion in 1979 and that is expected to reach $90 billion in 1980. The domestic production of oil peaked in 1971, that of natural gas in 1973; in spite of enhanced recovery techniques and the vigorous exploitation of marginal reserves, the outlook for both is for declining supplies.

A. The Dismal Alternatives

The energy problem is difficult to resolve and will be painful to endure precisely because alternative fuel supplies entail painful tradeoffs among competing commitments and incompatible goals. All of them involve potentially greater environmental damage and human risk, higher production costs, and less versatility than the oil and gas they are intended to replace. None can be developed without arousing the anxiety and opposition of the diverse groups of people who are affected by them.

Energy strategy is therefore primarily a social issue, even more than it is an economic or a technological one. It entails a continuing struggle over questions of social structure -- of who makes the key decisions, of who benefits and who sacrifices when it comes to social and economic costs, to "boomtowns" and strip-mining, to the risks of a nuclear accident or environmental contamination. In their incisive assessment of the nuclear power controversy, Bupp and Derian (1978, p. 195) point to the problems that confront virtually all alternative fuel supply options:

> One of the most persistent difficulties in evaluating the social acceptability of nuclear power is that its benefits and costs accrue to different groups. . . In a decentralized political system, this characteristic increases the practical difficulty of arriving at a society-wide consensus. Furthermore, the lack of a straightforward and generally accepted standard for comparing benefits and costs exacerbates the problem. There is no good way to equate jobs with morbidity or mortality, and many technologies offer economic growth for a measure of sickness and death.

Virtually every effort that has been made in recent years to increase the domestic supply of energy has proven to be disruptive to the political and social fabric of the nation. Whether it involves constructing an Alaska pipeline, drilling on the continental shelf, opening vast areas of Wyoming, Montana and North Dakota for strip-mining, accelerating the development of processes for converting coal or shale into synthetic fuels, or building more nuclear power plants, the trade-off between energy production and environmental protection entails a conflict among social groups. It invariably pits region against region, central authority against local autonomy, industrial forces against household communities (Klausner, 1979; Gerlach, 1980).

B. The Relevance of Social Attitudes

Under these circumstances, continued high energy growth in the United States is unlikely to occur unless there develops during the 1980s a strong social consensus favoring a dramatic acceleration in both nuclear power and coal development. It would necessitate, as Harman and Carlson (1977) have shown, a significant retreat on environmental protection, the widespread restoration of public faith in business, government, and science, and sweeping alterations in the whole legal system so that a determined minority could no longer obstruct the "wheels of progress":

> Continued high economic and energy growth is neither automatically desirable or feasible. No invisible hand will move us toward high growth. A deliberate social decision is necessary to enact all the new laws we will need to achieve high growth. This fact alone makes low growth both more appealing and more likely (Harman & Carlson, 1977, p. 102).

Energy and economic decisions will be strongly influenced by the social attitudes and values, fears and aspirations, beliefs and hopes of the American people as a whole. An exploration of the changes in public perceptions that have occurred in the economy, energy, and environment areas during the decade of the 1970s would lead most observers to conclude that we are unlikely to see a consensus emerge in the 1980s of the sort that would support costly efforts to develop vast new supplies of conventional energy.

III. THE EVOLUTION OF PUBLIC OPINION

From the days just after World War II until the early 1970s, continual economic growth and a continuous expansion in energy use to support that growth were largely unquestioned aspects of American life. If the economy faltered, it was thought to be a temporary set-back on a path of unending expansion. If energy (or any other resource) threatened to run short, the solution was to be confidently sought in new discoveries or new technologies. Over the course of the last decade, however, the vision of unlimited abundance began to look like a mirage, and the American consensus that placed the importance of economic growth above virtually all other values has gradually crumbled.

A. A New Sense of Limits

A number of important themes emerge from recent surveys, none more striking than the dramatic shift away from the traditional faith in an unlimited future. From the 1950s through the 1960s, Americans consistently believed that the present was a better time for the country than the recent past and that the future would inevitably be better still. In 1964, for example, the public gave the past of the United States ("about five years ago") an average rating of 6.1 on a ten-point scale; they rated the present at 6.5, and the future ("about five years from now") at 7.7. By 1978, that normal pattern had completely reversed itself, in a general decline that saw the past of the United States at 5.8, the present at 5.4, and the future at 5.3 (Yankelovich & Lefkowitz, 1979). In February and March of 1979, the comparable figures were 5.7, 4.7, and 4.6 (Cambridge Reports, 1979). As a recent Labor Department study put it, "What is new . . . and alarming is the finding that, unlike all previous measures, the public feels things are not going to get any better in the future" (cited by Magney, 1979).

Americans remain optimistic about their personal lives, but by much more narrow margins than ever before: In 1976, 57 percent expected some improvement in their own economic well-being over the next five years; that was true of only 31 percent in 1979, while 32 percent foresaw no change, and 25 percent expected a turn for the worse (H. Smith, 1979). "The new age of limits" was the way Newsweek (19 November 1979) characterized the 1970s:

> The decade's most remarkable moment in U.S. politics came when Paul A. Volcker, the new Federal Reserve Chairman, warned last month that the standard of living would have to decline -- and no firestorm of protest erupted, not from Congress, the Administration, or the public (1979, p. 89).

There was no protest because by that time, the public was becoming reconciled to lowered expectations. In early 1979, 62 percent of Americans had already agreed that "Our current standard of living may be the highest we can hope for." Perhaps even more indicative of the profound psychological shift that has occurred among Americans is the overwhelming 72 percent of the public who concur with the view, "We are fast coming to a turning point in our history where 'the land of plenty' is becoming 'the land of want'" (Yankelovich & Lefkowitz, 1980).

B. The Working-Through Process

Yankelovich and Lefkowitz (1980) suggest that the public is still in the early stages of coming to grips with these new realities, torn between traditional expectations of continuing economic expansion and more recent quality-of-life aspirations, unsure what concessions will have to be made in the pursuit of one side or the other, and now engaged in a "working through" process, an effort to adapt to a radically changed set of "rules of the game." It is not surprising to find that process accompanied by emotionalism, incredulity, overreaction, scapegoating, and wishful thinking.

The evolving perceptions of the energy problem suggest that Americans are indeed working through to a realization that the energy shortage may, in fact, be real -- though the process is severely compromised by a pervasive mistrust of American institutions. Gallup polls periodically ask the open-ended question, "What is the most important problem facing this country today?" Between 1973 and 1977, energy was never mentioned by more than one-fourth of the public, except at the very height of the Arab oil embargo between December 1973 and February 1974 (Rosa, 1978). Energy concerns were overshadowed by the growing economic problems of stagflation, and in the relatively mild aftermath of that first energy crisis, the public was receiving mixed messages about the reality and seriousness of the problem. The vast majority remained convinced that the situation was contrived by institutions and individuals for their own benefit.

Even in 1978, when most Americans had concluded that energy shortages were real and many were blaming their own wastefulness, sizeable minorities were still deeply suspicious (Farhar et al., 1979). They continued to be skeptical about the information that industry spokesmen and government representatives were providing. As Schneider (1979) has shown in his analysis of the polls through 1978,

> Americans seem quite realistic about their own wasteful habits and about the limited availability of energy resources. But . . . they do not feel that these "facts" adequately explain the energy crisis. The energy crisis is perceived, like so many other ills these days, as an abuse of power.

They believe the oil companies, OPEC, and the federal government to be powerful, monopolistic, and irresponsible, and they suspect that the shortages are being manipulated by the energy companies in order to enrich themselves at the public's expense, with the full compliance of the government.

Recent events, however, have made the vulnerability and precariousness of the country's energy situation unmistakable to almost all Americans. As Stobaugh and Yergin (1980) have shown, twenty years of anticipated change were dramatically telescoped into fewer than that many months:

> From $12-13 per barrel in late 1978, oil prices had risen to the $30-35 range, a level that many 1978 predictions had not anticipated until the year 2000. And political threats to the world's oil supply that had been discussed as potentially serious 5 to 10 years in the future had become visibly critical in 1979 alone. It was a fateful 18 months (1980, p. 563).

By August of 1979, even before the taking of American hostages in Iran, the Soviet invasion of Afghanistan, and the anarchic Caracas meetings of OPEC, 73 percent of the public were prepared to agree with the view, "The energy crisis is real, and is a clear and present danger to the country" (Harris Survey, 1979).

C. Distrust of Institutions

Reflected in the length of time that it took Americans to reach that conclusion is the public's pervasive and deep-seated mistrust in the dominant institutions of society. The decline of confidence in government has been swift, charp, and all-encompassing:

> In 1964, a 69 percent majority of the American public had faith in the competence of government officials ("They know what they are doing."); by 1978, the number of Americans holding this view dropped to 40 percent (Yankelovich & Lefkowitz, 1979). Between 1964 and 1976, the proportion of Americans agreeing that "people in government waste a lot of the money we pay in taxes" went from 47 to 74 percent; that "government is pretty much run by a few big interests looking out for

themselves" from 29 to 66 percent (Magney, 1979).

The decline of confidence in government has been more than matched by the public's changing perception of the country's corporate establishment.

> Between February 1966 and January 1980, those expressing "a great deal of confidence" in the people in charge of running "major companies" dropped by 36 points, from 55 to 19 percent. During the same period, confidence in the "executive branch of the federal government" dropped from 41 to 18 percent, and in "Congress" from 42 to 11 percent (Harris, 1980).
>
> In 1976, 55 percent of Americans believed that the government "should put a limit on the profit companies can make" (up from 28 percent in 1962). While 68 percent agreed that the federal government "is getting too powerful for the good of the country," 55 percent said government should "require pollution control equipment in new cars," and 63 percent favored governmental action to "require local businesses to meet job safety standards" (Magney, 1979).

D. <u>Declining Faith in Science and Technology</u>

Given this plummeting confidence in leaders and experts, it was perhaps inevitable that the public's unrestrained optimism and faith in science and technology -- a faith that was so characteristic of the thirty years from the Manhattan Project in 1940 to the moon landing in 1969 -- would also be followed by disillusionment and distrust. The 1970s marked the watershed between a time when matters of science and technology could be confidently left to the experts and the new era when society at large would demand a far greater decision-making role.

The decade brought accelerating revelations of the long-term and often invisible hazards of new technologies -- in the unintended consequences of DDTs and PCBs, of asbestos and phosphate detergents, of the potential cumulative effects of burning fossil fuels on levels of carbon dioxide in the atmosphere, of fluorocarbons from spray cans on stratospheric ozone, of radioactive waste management on future generations. What is emerging is an increasingly skeptical appraisal of the costs and benefits of a technological society, of the possibilities and the limits of scientific inquiry itself (Holton & Morison, 1979; Marshall, 1979).

The proportion of Americans who believe that science will find a cure for cancer in their lifetime declined from 71 percent in 1976 to 55 percent last year (Harris, 1979b). A bare majority of 52 percent continue to believe that "Technology will find a way of solving the problem of shortages and natural resources." Significantly, the slippage in this traditional faith in technology is greatest among the youngest and best educated segments of the population. Only 29 percent of people between the ages of 18 and 34 who had attended college agreed that resource problems can be solved by technology, compared with 69 percent of the older, less educated, lower-income segments of the population. "Whatever the reason," Yankelovich and Lefkowitz (1980) conclude, "the important point is that skepticism about technology is likely to spread in the future. Almost invariably, the young and well educated anticipate attitudes that spread to the larger society."

E. The Broadening of Aspirations

Scientific research and technological development are seen as mixed blessings in modern American society (Harris, 1978): 92 percent agree that such research and development "are necessary to keep the country prosperous"; for 69 percent, they "are the only way we can clean up air and water pollution"; for a similar percentage, they constitute "the main factors in increasing productivity." On the other hand, 65 percent of Americans are prepared to blame the development of science and technology for making "people want to acquire more possessions rather than enjoying non-material experiences," 56 percent for making "everything bigger and more impersonal," 52 percent for tending "to overproduce products, and this is wasteful."

The data suggest a perceptible shift in what Americans seem to want out of life. Material possessions, economic security, and social mobility remain important, but new motives and concerns have made these older aspirations less powerful and more relative than they used to be. In a May 1979 survey, for example, the public was asked to choose among competing societal goals:

> By 53 percent to 40 percent, a majority rejects putting more emphasis on "satisfying our needs for goods and services," and instead gives a higher priority to "learning how to get our pleasures out of non-material things."
>
> By 55 percent, they would choose an emphasis on "learning to appreciate human values more than "material values" rather than on "finding ways to create more jobs for producing more goods."
>
> Perhaps most significantly, an impressive 72 percent would opt for "breaking up big things and

getting back to more humanized living" instead of "developing bigger and more efficient ways of doing things" (Harris, 1979a).

"The future that Americans envision," Harris (1979a) concludes, "is going to depend far more on the country's ability to find economic growth in the people-intensive service areas than in the physical goods areas." More generally, he writes:

> A thread running through Harris Survey results over the past few years is that America appears to be well into a post-industrial era, where the main drive in society is no longer the production of better gadgets or physical objects. Instead, the message emanating from the public again and again is that nonmaterial experiences are valued far more than the acquisition of products (Harris, 1978).

The survey data suggest that, while most Americans would welcome the return of a high consumption, growth-oriented economy, they are no longer sufficiently committed to it to be willing to sacrifice the broader aspirations that they have developed or to deny their growing distrust of big government, business, and science. "We believe that Americans will <u>not</u> choose to turn the clock back to the great period of dynamic growth in the two decades following World War II," Yankelovich and Lefkowitz (1980) conclude. "Whatever the future may be, it will not recapture the past."

F. <u>The Strength of Environmental Concerns</u>

Americans also seem unwilling to accept any significant retreat from the commitment to environmental protection. In August 1978, only 20 percent of the public agreed that "We must relax environmental standards in order to achieve economic growth," and 18 percent thought we could have both environmental protection and economic growth simultaneously; but some 58 percent concurred with the view, "We must accept a lower rate of economic growth in order to protect our environment" (Mitchell, 1979). Similarly, Harris (1979d) reports that, while 59 percent favor new industrial growth in their communities, and 49 percent would favor it if it only made the air "a little dirtier"; if industrial growth turns out to "make the air a lot dirtier," 80 percent of the American people say they would oppose it.

Concern for the environment, contrary to the expectations of many in business and industry circles, does not seem to be a passing fad promoted largely by a zealous upper-middle-class elite (Carter, 1979a). In his review of all available polls, Mitchell (1979) shows that public support for environmental protection remains strong and broadly based:

> Thirteen percent think of themselves as active participants in the environmental movement, an additional 47 percent are sympathetic to the movement, 30 percent are neutral, and only 4 percent are unsympathetic.
>
> Shortly after Californians passed Proposition 13, only 10 percent of the public agreed with the view that "Pollution control requirements and standards have gone too far; it already costs more than it is worth." A middle option was favored by 31 percent: "We have made enough progress on cleaning up the environment that we should now concentrate on holding down costs rather than requiring stricter controls." By 53 percent, a clear majority favored a third alternative: "Protecting the environment is so important that requirements and standards cannot be made too high and continuing improvements must be made regardless of cost."

The evidence suggests that environmental groups continue to represent a substantial and broad-based constituency of the American people. When specific trade-off questions are asked and respondents are forced to consider the costs of achieving environmental goals, pluralities nevertheless continue to opt for environmental protection over lower prices, lower taxes, higher economic growth, or more jobs. Only on the energy/environment trade-off is there strong ambivalence, with sizable minorities favoring each side of the issue (Mitchell, 1979; Farhar et al., 1979). When gas-lines appear or other shortage-related events occur, the public leans toward the side of ensuring adequate energy supplies.

Thus Harris (1979c) reports a sharp increase since 1976 (from 46 to 61 percent) in public support for "going slow" in the environmental area "if it could be shown that the country could cope with its energy problems more effectively if the movement to clean up air and water pollution were slowed down." As long as the energy problem is perceived as a serious danger to the country, a majority of the public will opt for enhanced domestic production, even if pollution control efforts are delayed by doing so. "This finding," Harris (1979c) insists, "should not be taken as a sign that Americans want to abandon cleaning up air and water pollution. It only means that people are now willing to wait a little longer for the job to get done." The goals of the environmental movement have become a permanent part of the political value system and an irrevocable factor in the acceptability of any new energy supply option.

IV. THE SOCIAL CLIMATE FOR SPS ACCEPTABILITY

The public opinion data indicate that a shift in perceptions and values has occurred among the American people as a result of the events of the 1970s. The old consensus that favored putting economic imperatives above virtually all other considerations gradually crumbled during that decade, and there are few signs to suggest that it might soon be restored. Clear majorities of the American public now believe that the economic prospects for themselves and their country are dismal, and they have reluctantly but decisively lowered their expectations. Worried above all about inflation and unemployment, they hope for economic stability, and they are determined to preserve the material gains that they achieved in the early 1970s (hence the dramatic increase in working wives and the trend toward smaller families) -- but they do not seem prepared to make major sacrifices in order to reconstruct a high-growth economy.

A. Public Opinion and the SPS Concept

Deeply mistrustful of the central government, Americans have developed what Yankelovich and Lefkowitz (1980) call a "take back" psychology, believing that too much power has been delegated to government and wanting to return at least some of it back to the people. Equally mistrusting of major corporations, they are seeking greater control over their own lives and more direct participation in the decisions that affect them. When a predominating concern about inflation and a pervasive distrust of the central government and of major corporations combine with a substantial commitment to environmental protection and a declining faith in science and technology, the resulting social environment is unlikely to favor the development of a major new high-technology energy system such as the SPS.

During a period that seems destined to be marked by slower economic growth, continuing budget deficits, and persistent inflation, there is certain to be strong resistance to the large front-end development costs that the SPS program would require, that would have to be put up long before the first satellite became operational and would be added on to what is already viewed as an enormous federal energy budget. The DOE/NASA bureaucracy would grow still larger, further strengthening federal control over energy policy, and joining the government and the aerospace industry in the development and deployment of what will be perceived as a highly exotic and potentially dangerous energy technology. Indications of the kind of perceptions to which much of the public is likely to be receptive may be found in recent anti-SPS articles by Crossley (1978), Hochschild (1978), DeLoss (1979), and Marinelli (1979) -- see also Section VID.

A further suggestion of the "social acceptability" problems that portend came on November 16, 1979, when the House of Representatives passed by a vote of 201 to 146 a bill to authorize an additional $25 million to accelerate exploratory R & D on the SPS concept. Environmental proponents joined forces with fiscal conservatives to comprise a much stronger opposition than the year before, when a similar measure was approved by 267 to 96. Prospects for Senate passage, if the bill is even brought out of committee, are extremely doubtful, "given the environmental unknowns and trillion-dollar scale" (Carter, 1979c).

B. The Inevitable Competition for Scarce Resources

Clearly, every potential energy supply will be championed by vested interests and fought by diehard opponents. There are no risk-free or inexpensive alternatives to oil and gas, and no single long-range energy source can meet all or even a large proportion of future energy needs. In

1978, 44 percent of U.S. electrical power capacity was generated by coal, 17 percent by oil, 14 percent by gas, 13 percent by uranium, and 13 percent by hydroelectric dams (Bodansky, 1980). Since only the last can be considered to be a renewable energy source, it is apparent that some 87 percent of current U.S. electrical capacity is generated from depletable fuels, for which substitutes will eventually have to be developed. There are currently on the horizon only three major long-term alternatives that appear capable of producing ubiquitous base-load electricity on a large scale from renewable sources: breeder reactors, nuclear fusion, and the satellite power system.

Both of the nuclear alternatives have been under intensive exploration for a great many years; they have been the recipients of large federal allocations; they have powerful supporters in the Congress, the federal bureaucracy, the industrial sector, and among the public. Satellite power, in contrast, is a new and unfamiliar concept. The Sunsat Energy Council that has formed in its support is comprised largely of aerospace and construction industries, relative newcomers to the energy field. They are likely to be resisted by the already-established energy companies that have vested interests in the long-run uses of coal, oil shale, and nuclear energy, and are now beginning to make important investments in on-site solar technologies as well. Under these circumstances, the burden of proof will fall on the SPS advocates. Merely equal promise with the nuclear alternatives, or evidence of problems that appear to be no more severe than theirs, are not likely to be sufficiently compelling to bring about the necessary commitment of funds and scientific talent. "'Benign neglect' or 'tolerance' of the (SPS) concept without positive support and interest," Kraft (1979) has written, "is tantamount to its abandonment."

Strong popular support that is specifically committed to the SPS system will therefore need to develop during the 1980s. Its most likely source would appear to be the large public constituency that is enthusiastic about the prospects of space exploration and impatient to participate (if only vicariously) in the extension of human civilization beyond the confines of the earth's surface. Since opening in 1976, the National Air and Space Museum has been the biggest tourist attraction in Washington, outdrawing the combined appeal of the Lincoln Memorial, the Washington Monument, the U.S. Capitol, and the White House. Bainbridge (1978) found that 60 percent of a sample of Seattle voters thought that the prospect of generating electricity in space for use on earth was a good reason to continue the space program. However, communications and earth-resource satellites, scientific knowledge, and technological spin-offs were far more popular justifications for the NASA programs.

As the much-delayed and increasingly expensive space shuttle prepares for its debut, the American space program has entered a period of great uncertainty. "In the era of limits," R. J. Smith (1979) observed, "space is perceived as well within the outer reaches of the earth's atmosphere; fiscal pressures fall particularly heavily on such high-visibility, basic research." Part of the reason for the space community's interest in SPS stems from the concept's status as "one, <u>if not the only</u>, potential space project that appears possible within our capability that can provide a needed resource of incomparable importance" (Kraft, 1979). Some space scientists, however, are concerned that the SPS program might absorb all the effort, capital, and technology available for space development and exploration, putting important smaller-scale projects in jeopardy and perhaps even damaging the credibility of space enthusiasts in the Congress on whom the fate of these smaller proposals depends (R. Smith, 1979).

C. The Importance of Electrical Demand

Opposition to the SPS system thus seems likely to focus on the high front-end development costs, on questions of technical feasibility and environmental risks, and on the generalized distrust of large federal and corporate bureaucracies controlling highly centralized and esoteric technologies. All such opposition could be overcome, if there were to develop during the 1980s a broad-based conviction that vast new energy supplies will be desperately needed in the near future. If the decade of the 1980s should witness continued exponential growth in the U.S. demand for centralized electricity generation, while opposition to the accelerated development of coal and nuclear power plants remains firm and the prospects for the nuclear breeder and fusion pale considerably, then the chances of "selling" the SPS system to the American people as an important solution to impending energy shortages will be significantly enhanced.

Public acceptability of the SPS system will therefore depend to an important degree on the belief that the additional electricity the program would provide in the late 1990s and beyond will be sufficiently needed to justify the front-end costs and environmental risks associated with a project of this magnitude. Thus, Jesco von Puttkamer, Program Manager of Long-Range Planning Studies at NASA, argues for the SPS in terms of a desperate energy gap:

> The problem of satisfying the estimated energy demand of the industrialized world will reach near-critical proportions over the next 25 years. The electrical power capacity of the US alone is expected to triple (from 500 to 1500 gigawatts) before 2000, requiring investments on the order of a trillion dollars. No obvious single source can satisfy this growth in demand . . . . By the

> year 2000, solar energy satellites could supply tens of thousands of megawatts of electricity to our energy-starved cities, meeting perhaps up to 20% of the power requirements of the U.S. at that time (von Puttkamer, 1979, pp. 196, 199).

U.S. electrical demand is not likely to grow during the 1980s and '90s at the "historical" rates of the 1950s and '60s. There are persuasive economic, technological, political, and social reasons for anticipating instead a dramatic decline in the growth of American demand for conventional supplies of energy during the closing decades of the twentieth century. If that expectation proves accurate, it will be difficult to secure the degree of public support that would be required for the rapid development of Satellite Power Systems during the remaining years of this century.

V. THE ENHANCEMENT OF ENERGY EFFICIENCY

Nowhere is the fluidity of the American energy picture more clearly seen than in the changing conceptions of the relation between energy use and economic well-being. The quasi-universal assumption that the nation's vitality could be measured by the growth in its per capita energy consumption has been severely tempered by the emerging recognition that the greater the amount of expensive and imported energy the U.S. consumes, the weaker its economy becomes. The "wastefulness" in current American consumption patterns is now viewed as an opportunity to increase the efficiency with which scarce energy is used, and visions of future demand that are based on a projection of past trends are simply no longer believable.

A. Changing Relations between GNP Growth and Energy Use

Since 1973, estimates of U.S. energy needs have changed dramatically. At least six major studies, conducted under widely disparate auspices, have recently converged in concluding that there is surprising flexibility in the historical linkage between economic growth and energy consumption. The studies come from the Ford Foundation (A Time to Choose, 1974), Resources for the Future (Schurr et al., 1979), the Harvard Business School (Stobaugh & Yergin, 1979), the President's Council on Environmental Quality (Warren, Speth, & Yarn, 1979), the Union of Concerned Scientists (Nadis, 1979), and most recently, the long-awaited report of the National Academy of Sciences (Energy in Transition: 1985-2010, 1979).

The argument over whether the U.S. economy can get along with much slower energy growth than was assumed is now over. It has already demonstrated that it can. The only remaining questions have to do with how much more rapidly and dramatically the historical correlation between GNP and energy use can change. From 1973 to 1978, U.S. energy consumption grew by 5 percent, while GNP, corrected for inflation, expanded by 12 percent. During the preceding five years, however, the pattern was reversed: between 1967 and 1972, energy use went up by 22 percent, while GNP rose by only 17 percent (Parisi, 1980a; Sawhill, 1979).

The differences in per capita energy use among various industrialized countries with comparable living standards are further indications that quite substantial energy savings in the U.S. are not only practicable but may also be less painful than is usually assumed. Per capita energy use in Sweden, for example, is approximately 60 percent of the U.S. figure; yet during the winter, people are just as comfortable in Stockholm as they are in Minneapolis (Ward, 1979, p. 47). Through the mid-1970s, American industries were consuming twice as much energy per dollar of output as were comparable Japanese firms (Darmstadter, Dunkerly, & Alterman, 1977). West Germany was using 73 percent as much energy for each dollar of gross national product as was the United States, and France only 54 percent (Yergin, 1979, p. 143). Between 1975 and 1977, however, U.S. industry, in response to anticipated increases in energy prices, expanded its output by 15 percent per year while consuming only 5 percent more energy per year in the process. As former Secretary of Energy James Schlesinger concluded, "There is no longer a need to assume that economic vitality is inevitably tied to lock-step increases in energy use" (cited by Halloran, 1979).

Energy use increased at such rapid rates from 1945 through the early '70s not because it was needed, but because it was cheap. High per capita consumption patterns were rational responses to existing energy prices (Rostow, 1978, p. 81). Between 1951 and 1971, the real price of electricity actually fell by 43 percent and that of petroleum by 17 percent (O'Toole, 1976, p. 40). In attempting to cope with the sudden explosion in energy prices, Americans have discovered that surprising savings are possible by relatively simple changes in patterns of energy use and capital investment (Parisi, 1979b; Taylor, 1979). Over the longer term of the next two or three decades, far more substantial conservation opportunities will become available.

Virtually all the capital assets of the United States (its houses, office buildings, factories, machinery, automobiles, and appliances) were designed for an era of cheap and abundant energy. The nation has made enormous social and political accomodations to high energy use, in the location of homes in relation to jobs, in the interstate highway system and the deterioration of railroads and mass transit systems, in the shape of cities and patterns of regional specialization. It will take time to turn over obsolete assets and to reorganize social patterns. There are distinct limits to what can be accomplished in the near term, but the direction in which American society is now moving is clear.

B. The Growing Commitment to Conservation

More than purely economic considerations are involved in shaping these societal directions. It is clear, for example, that oil and gas have so many advantages over any readily available substitutes that the longer the U.S. can rely upon them the better off it will be (Schneider, 1978a). Improvements in energy efficiency can "stretch out" the nation's reserves and extend the time available for a smooth and orderly transition to the renewable energy sources of the future (whatever they prove to be), thereby minimizing both the environmental damage and the political conflicts associated with rapid energy development.

Recent events in Iran and Afghanistan have dramatized more strongly than ever the vulnerability of the American economy to supply disruptions and international blackmail. It is increasingly recognized that the U.S. cannot produce itself out of dependence on "hostile" oil, at least not for many years, and that only a vigorous national commitment to conservation can bring about a rapid and significant reduction in American oil imports.

Union and minority opposition to an all-out program of energy efficiency, while never unanimous (see Jordon, 1978), was based on the belief that energy conservation would necessarily result in slower growth and greater economic deprivation, especially for lower income groups.

Experience has shown it instead to be a workable, job-creating alternative to new energy projects (Grossman & Daneker, 1979; Komanoff, 1979). Whole new industries are beginning to develop around rising demands for such conserving technologies as cogeneration equipment, heat recuperators, materials recycling, computerized energy management systems, insulation and weatherizing. "All these conservation schemes," Barbara Ward (1979, p. 129) has written, "could stimulate the demand for labor while actually reducing resource consumption -- an almost classic definition of uninflationary growth."

Not surprisingly, therefore, public attitudes are becoming increasingly supportive of strong conservation efforts:

> The Opinion Research Corporation (1979) found that over half of the public in all population subgroups believed that significant energy conservation will require the passage of tough new laws, and it concluded that "Americans seem ready to 'bite the bullet.'"
>
> The latest Harris Survey (1980) found that 87 percent of the public now believes that the federal government "should take much tougher measures to conserve energy here at home." Though 75 percent would prefer voluntary approaches to reducing energy consumption, by 57 percent a clear majority is convinced that voluntary actions alone are insufficient and that "we need compulsory conservation measures."

The conservation achievements of a Portland, Oregon or a Davis, California reflect a surprising willingness on the part of Americans to accept a high degree of public control over such private decisions as the height of fences or the style of landscaping, when these compulsory regulations are viewed as fair and in the public interest.

Such exemplary cases further demonstrate that the broader popular appeal of conservation is not just economic. There is the exhilaration of a community working together to meet a collective challenge, and of individuals regaining a sense of personal control over their daily lives and their monthly energy bills. Rufus Miles (1976, p. 101) suggested that Americans may even be getting ready to abandon their "love affair" with the automobile, and again for reasons other than the price of gasoline alone:

> Large numbers of people are finding driving less and less enjoyable under conditions that require them to contend and compete with traffic at both ends of the day and at other times as well. Their bodies are deteriorating for lack of exercise and their tempers and nerves are deteriorating from too much exercise. They are becoming psychologically ready to reduce their dependence on the automobile, but it will not be easy.

During the 1970s and increasingly as the decade progressed, more bicycles than automobiles were sold in the United States. Since 1978, the demand for gasoline (representing almost 40 percent of total U.S. oil consumption) has been dropping steadily, down by 5 percent in 1979 and by 10 percent in the first two months of 1980 (Emshwiller & Roche, 1980).

In conservation strategies, energy, environmental, economic, and foreign policy goals all coincide and are attainable simultaneously. For these reasons, laws have been or will soon be enacted to decontrol completely the price of domestic oil and gas supplies; to establish thermal performance standards for new buildings and higher energy-efficiency targets for appliances, automobiles, and machinery; to provide tax credits and other assistance for the rapid deployment of cogeneration equipment in industry, and of solar collectors, weatherizing and retrofitting in buildings; and through a national program of "energy doctors," information campaigns, and financial incentives, to encourage conservation actions on the part of millions of dispersed and largely ill-informed energy consumers (see Hirst & Hannon, 1979). Yergin (1979, p. 136) is convinced that with policies such as these, the United States might well consume 30 percent less energy than it does today, while enjoying the same or an even higher standard of living -- a proposition that is still viewed by some as wildly over-optimistic (e.g., Chapman, 1979b) and by others as far too modest (e.g., Steinhart *et al.*, 1979).

C. The Implausibility of "Historical" Projections

Meanwhile, the economy as a whole appears to be gradually adjusting to escalating energy prices by accelerating its on-going tendencies toward services and information systems and away from the dominance of such energy-intensive heavy industries as steel and aluminum, automobiles and petro-chemicals (Hamrin, 1980). As Daniel Bell (1973, p. 26) suggested in his depiction of the United States as a "post-industrial" society, "One can say, without being overly facile, that U.S. Steel is the paradigmatic corporation of the first third of the twentieth century, General Motors of the second third of the century and IBM of the final third." More and more of the world's business is being conducted through computer print-outs and microprocessors, satellite communication systems and information retrieval. New modes of wealth-generation and new bases for technological growth are being developed in electronics and biotechnology, industries that require much less energy input than traditional twentieth-century enterprises (McHale

& McHale, 1979; Toffler, 1980, chapter 12).

The economy of the year 2000 will not be the 1980 economy expanded by some constant. On-going developments in technology, resource use, and demographics, as well as in social values and human aspirations, indicate that the growth requirements of the next decades can be satisfied by less per-capita energy use and that economic productivity will expand in more diverse ways than in the quarter century that followed World War II (see also Harman & Carlson, 1977; McHale, 1979).

> Governments have lowered their projections for future energy use, but they still tend to base these projections on past trends. More highly insulated buildings, more efficient energy appliances, and the trend toward smaller, more efficient automobiles, coupled with a stabilizing population and a steadily less energy-intensive productive sector, simply contradict the notion that energy use must grow year after year (Ward, 1979, p. 59).

Throughout the 1970s, utilities consistently overestimated the nation's peak demand for electricity. The year 1978, for example, was expected to record a 6.2 percent increase in electrical demand, but the actual growth was only 2.7 percent. Nevertheless, because of a need to allow for possible error and because the costs of underestimating demand exceed the costs of having excess capacity, the industry as a whole still projects an average annual increase in electricity sales of 5.4 percent through 1987 (Carlson, Freedman, & Scott, 1979). For all the reasons examined above, it is unlikely that growth rates of that magnitude will materialize.

Some further growth in electrical demand may be stimulated by efforts to reduce American reliance on imported oil, bringing about an accelerated development of electric cars, buses, and trains; of electric heat pumps and resistive heating; of alternatives to the oil and gas that now generate some 30 percent of U.S. electrical capacity (see Bodansky, 1980). Any rapid growth in demand, however, is likely to be tempered by intensified conservation efforts and by the public resistance and escalating costs associated with the rapid development of new coal- or nuclear-fired power plants; and it is likely to stimulate the development of alternative ways of generating electricity that can be brought on line in the relatively near term (such as wind, biomass, and terrestrial photovoltaics).

During the year 1979, the peak U.S. demand for electricity was expected, as usual, to rise by 4 to 7 percent. It is reported to have grown instead by a total of 0.6 percent (Scarlett, 1980). So far during 1980, electrical consumption has actually dropped by 1.4 percent, and some analysts now believe that, with coal and conservation, utilities will be able to meet the nation's electrical demand in the year 2000 without having to order a single additional nuclear power plant (Parisi, 1980b).

The unmet U.S. demand for centrally-generated electricity is unlikely to grow sufficiently, at least over the next twenty years, to convince a reluctant public of the necessity for so large an investment of capital, material, and technical resources as would be demanded by the development and deployment of a full-scale SPS system. This conclusion is further reinforced by a consideration of the likely contribution that will gradually be made to the nation's over-all energy mix by the many small-scale, on-site renewable-energy technologies that are now in various stages of development.

VI. THE COMING OF SOLAR ENERGY

U.S. energy demand will probably continue to grow, though at decreasing rates, throughout the rest of this century, and replacements for the oil and gas that still comprise 75 percent of total U.S. energy supplies will have to be developed in the relatively near term. In addition to continued nuclear and coal development, to enhanced recovery techniques and synthetic fuels, there has been growing interest in the potential contribution of the smaller-scale technologies that are designed to harness the renewable energies of the sun.

A. <u>The "Solar Transition"</u>

They come in a wide variety of forms. Passive solar design features that make sophisticated use of natural solar flows add little to initial construction costs and have been shown to save substantial amounts of fuel over the lifetime of a building. Solar space and water heating systems are already economically competitive with electrical heating, though initial equipment costs are still high, and as long as storage problems are unresolved, conventional back-up systems remain necessary. Biofuels are rapidly coming into increased use through such well-known processes as the burning of wood and wood wastes, the anaerobic conversion of urban garbage, animal wastes, algae or ocean kelp into methane, and the distillation of alcohol from "energy crops" such as sugar cane, manioc, cassava, or corn. New sources of electricity are being developed from wind generators based on space-age technologies, from additional generating facilities installed at hydroelectric dams, from the temperature differences in ocean water, from geothermal and tidal power, from solar thermal power tower systems, from the growing uses of cogeneration units, and -- most promising of all -- from the direct electrical conversion of sunlight with photovoltaic solar cells (see Carlson, Freedman & Scott, 1979; Commoner, 1979; Hayes, 1977; Maidique, 1979; Moran, Morgan & Wiersma, 1980, chapter 19; Nadis, 1979; Ward, 1979).

Because of the diffuse and intermittent nature of solar radiation, energy storage remains a critical problem for many of these technologies. A wide variety of alternative storage systems are currently under development, and it may well be only a matter of time before ground-based solar technologies are able to meet base-load, small-scale energy requirements (see Kalhammer, 1979). Meanwhile, conventional fuels are providing back-up energy, and some indirect solar sources, such as the biofuels and ocean- or geothermal, are far less intermittent than the sun or the wind. By integrating oil and gas, coal or nuclear power with solar energy systems, the depletable fuels can be saved for peak periods or cloudy days and their useful life extended.

Already, both the Department of Energy and the major energy companies are investing heavily in the mass production of photovoltaic cells, in the expectation that they may become cost-competitive for on-site electricity generation as early as the mid-1980s (The Economist, 1980). Wind power is attracting increasing interest on the part of the nation's utility officials (Smith, 1980). A study directed by Paul McCracken concluded that American industry by 1985 could meet approximately one-half of its own electricity needs by cogeneration alone, compared to about one-seventh today (Hamrin, 1980, p. 83). On the basis of several recent studies (see Carter, 1979b; Speth, 1980), the Carter Administration has concluded that the goal of meeting, by the year 2000, as much as 20 to 25 percent of U.S. energy needs by earth-based solar technologies (compared to 6 percent today) can be achieved at acceptable costs. Writing of the energy bill now working its way through the Congress, Jaroslovsky (1980) notes that, "for the first time, the federal government is proposing to spend more money on developing solar power and other renewable energy sources than on nuclear fission."

Earth-based renewable energy systems will play an increasingly important role in the American energy picture. The development of mass production techniques and supportive government programs will gradually bring down the real costs of these technologies, while the price of conventional fuels will continue to escalate. As was the case with conservation, moreover, economic considerations are by no means the only criteria relevant to energy choices.

B. Social Concomitants of Decentralized Systems

There are qualitative differences between solar rooftop collectors and nuclear power-plants that belie the "naive assumption that competing sources are neutral and interchangeable" (Hayes, 1977, p. 25). The differences have less to do with size per se than with the social consequences of energy choices -- with presumed vulnerabilities to malfunctions and deliberate disruptions, with the choice between the stability that derives from a diversity of small, dispersed technological units and the economic efficiency that a smaller number of larger units can provide, with the concentrations of political and economic power that tend to accompany the large-scale centralized generation of electrical energy, with the provision of jobs and the allocation of one's time and personal energies, with the scope of one's dependencies and the sense of self-reliance (see especially, Lovins, 1977; Hayes, 1977; Stokes, 1978; Spreng & Weinberg, 1980). The issues here have less to do directly with economic costs or conversion efficiencies than with valued social configurations and conceptions of individual freedom.

In comparison with large-scale coal or nuclear plants, for example, the deployment of on-site renewable energy systems generally creates a large number of jobs for a relatively small monetary investment. The Council on Economic Priorities explored in depth the employment implications of a conservation and solar-energy alternative to the construction of a new nuclear plant on Long Island, N.Y. It found that a comparable investment in existing conservation and solar technologies (weatherizing all residences and installing solar hot-water heaters in 3.35 percent of the region's existing homes and in 15 percent of new construction) would not only meet the same energy needs more cheaply, but would also create 2.2 times as many jobs as would the proposed new nuclear unit (Scarlett, 1979). On a national level, it is estimated that a massive shift from oil and coal use to on-site solar energy would result in a net gain of almost 3 million new jobs by 1990 (Associated Press, 1979). The capacity of energy-saving equipment and on-site solar technologies to generate jobs in local communities represents an additional attraction of these technologies, one that may be particularly significant if, as many observers suggest (e.g., Best, 1978; Harman, 1978), unemployment remains a persistent problem in advanced industrial societies.

C. "Appropriate" Technologies for Third-World Development

In the developing countries of the third world, unemployment threatens to reach disastrous proportions. The demographic explosion of the post-war years is bringing enormous numbers of young people into the labor force. One-half of the population of Latin America is under the age of fifteen. In 1975, there were an estimated 300 million workers without adequate employment in third-world countries. An additional 700 million will be seeking employment by the turn of the century. More than 30 million jobs will have to be created every year for the next 20 years just to keep pace with this inevitable explosion (Norman, 1978). As Newland (1979, p. 6) has written, "The figures are numbing. They are also notoriously imprecise. But even a generous allowance for error cannot blunt the challenge of finding work for more than one billion job-seekers by the year 2000." It is becoming clear that a wholesale transfer of capital-intensive, energy-consuming, labor-saving Western technologies would be inappropriate to the development needs of third-world nations.

We have noted that the manufacture and installation of dispersed, renewable-energy systems generate more useful employment than do centralized power facilities that run on nuclear or fossil fuels. The decentralized technologies are also particularly suited for bringing energy rapidly to the more than two billion people who have no electrical outlets nor anything to plug into them, but who need ways to heat, cook, light, and pump (Lovins, 1977, p. 51). They can be assembled in remote villages using indigenous materials and local labor (Hayes, 1977, p. 26). Because they do not require a technical elite to install and maintain them, they can also help to build the pride in achievement and the self-reliance that are often sapped by an overreliance on imported technologies and technicians (Rensberger, 1979). As A. K. N. Reddy of the Indian Institute of Science has insisted, "The growth of confidence that you can tackle your own problems is the crux of development" (cited by Holden, 1980). The World Bank, in recognition of this imperative, is reported to have begun a major shift in emphasis, from the conventional large development loans geared to growth in GNP to increasingly small-scale and local projects that have a better chance of reaching directly the poorest of the poor (Nossiter, 1980).

Meanwhile, the traditional third-world energy sources (firewood, draft animals, cow dung) are being rapidly overtaxed by escalating demand, and it would appear that the only short-run hope for meeting the basic human needs of exploding populations lies in the rapid deployment of decentralized renewable sources. It is estimated that more than a billion people subsist on primitive agriculture in small rural villages (numbering 50 to 100 families), located in remote areas far from national power grids. Usmani (1979) has suggested that the energy needs of these villagers might best be met by the development of "rural energy centers" located on the outskirts of each village, that could generate electricity from wind, hydro, or photovoltaics (producing, say, 50 kilowatts of peak capacity), along with biogas from animal wastes to be used for cooking. If American technology and foreign aid were to focus on these kinds of needs, it could be the basis for an unusually effective technological assistance program. "How much better," Steinhart et al. (1979, p. 71) have argued, "to offer developed solar, wind, and geothermal technologies that may be adapted more easily to labor-rich third-world countries than to offer capital-intensive nuclear plants or oil-dependent machinery." The expected demand for satellite power on the part of the energy-poor developing nations may fail to materialize.

The case for small-scale renewables is often overstated, however, in a quasi-religious fervor for the "soft" path to peace and prosperity. The intensity of sunlight is as poorly distributed as oil reserves and is often subject to extreme seasonal variations. Winds are equally variable, massive deforestation is almost universal throughout the third world, and acute shortages of fertile land often make the growing of "energy crops" impossible, while plant by-products already serve a variety of other indispensable uses. Small-scale renewables generally cannot supply sufficient concentrated power to meet the most critical development needs for nitrogenous fertilizers and good quality pig iron (Smil, 1979).

It is obvious that third-world countries need all available ways of increasing their energy supply -- in an array from which no resource and no scale should be excluded. "Small-scale technologies may be appropriate to local needs," John and Magda McHale (1979) have concluded, "but [they] can hardly meet the larger requirements of growing national populations and increasing world trade." Satellite power systems might well meet a part of the long-term energy needs of third-world countries embarked on the path of industrialization. In the near term, however, it seems clear that the conventional overemphasis in development strategies on the most highly sophisticated centralized energy technologies will need to be balanced by investment decisions that reflect the particular appropriateness of small-scale, dispersed, and relatively simple energy technologies that have been found to stimulate local initiative, improve productivity, and lead to durable, self-sustaining development.

D. The Appeal of Dispersed Renewables

For similar reasons, decentralized solar energy systems are becoming the focus of growing public interest in the United States as well. The pervasive distrust of central governments, of major corporations, and of esoteric technologies that the public opinion polls reveal has enhanced the attractiveness of these dispersed, small-scale technologies and convinced the vast majority of Americans that they are the key to the country's energy future (see Harris, 1979e). The remarkable growth of interest in on-site solar-energy systems appears to derive primarily from their decentralizing and self-reliant qualities, from the prospect they offer of independence not only from limited and polluting fossil fuels, but also from industry and government controls over energy supplies.

The 1970s witnessed a broad-based growth of efforts on the part of consumers to become producers as well, to do more to help themselves in a wide variety of disparate areas. "Sweat equity," for example, has been renovating urban housing. The U.S. Department of Agriculture estimates that as many as 43 percent of all American households may now be growing some of their own food (Stokes, 1978). Both rich and poor are caught up in the do-it-yourself boom of assembling their own furniture, building their own patios, and repairing their own cars. It is estimated that almost 75 percent of all Americans now regard themselves as "do-it-yourselfers" (U.S. News, 1979). In a new willingness to take greater personal responsibility for one's health, jogging has been transformed from a fetish of the few into a habit of the many; and some 500,000 different self-help groups in the United States now attest to the growing disenchantment with an overdependence on professionals (Toffler, 1980, p. 285). The appeal of on-site renewable-energy technologies reflects the evident desire on the part of many Americans to be more directly involved in meeting their own energy needs at the individual and local level, using technologies that they themselves can understand and manage.

These were clearly the dominant themes at every regional public hearing that was held by the Department of Energy in 1978 to review its solar energy policies: a pervasive suspicion of large centralized government and industry projects, and the insistence that government has a responsibility to help individuals meet more of their own energy needs through an emphasis on the small-scale local technologies that are also thought to build community and to enable small businesses to compete for energy dollars (U.S. Department of Energy, 1978). Amory Lovins, author of the highly influential Soft-Energy Paths (1977), has been aptly described as "the intellectual's Ralph Nader, the true champion of all consumers who wish to do more than consume" (Green, 1979, p. 12).

The SPS system is surely not in direct competition with rooftop solar collectors or biogas installations. Both centralized and dispersed energy systems are needed in any complex and heterogeneous society. They can be utilized in mutually supportive ways through a regional approach to energy problems that reflects the varying needs, resources, and traditions of the American people (Thorne, 1980; see also Weinberg, 1978). The late Fritz Schumacher, father of the "Small-is-Beautiful" movement, was also seeking a balance that many of his followers appear to have lost: "What I wish to emphasize is the duality of the human requirement when it comes to the question of size: there is no single answer. For his different purposes man needs many different structures, both small ones and large ones, some exclusive and some comprehensive" (Schumacher, 1973, p. 61). Even Amory Lovins insists that he is not advocating a decentralized non-electric future: "I seek a degree of centralization and electrification appropriate to our spectrum of end-use needs. It is as silly to run a smelter with little wind machines as to heat houses with a fast breeder -- both are a mismatch of scale . . ." (in Nash, 1979, p. 372).

While virtually all responsible observers recognize the compatibility between the centralized, high-technology solar satellites and the dispersed, low-technology renewable systems, it is nevertheless the perceived inappropriateness of the size and quality of the SPS system that most agitates the proponents of terrestrial solar energy. As he was celebrating the installation of a solar hot-water heater on the White House roof (20 June 1979), President Carter declared, "No one can ever embargo the sun or interrupt its delivery to us!" Some critics see in the SPS an effort to do just that: to make solar energy "as expensive -- and bring it under the same monopoly control -- as our current energy forms" (Denman & Bossong, 1979). Representative Richard Ottinger (D - N.Y.) has accused the "space-industrial complex" of trying, with the SPS, "to pervert our solar priorities" (cited in Hughes, 1978). "Solar may not be allowed to happen." writes Kirkpatrick Sale (1978): "The chances of wisdom winning out over foolishness -- and the interests of the many winning out over the interests of the few -- have never, in our society, been particularly bright" (Schneider, 1978b, p. 58). Wasserman (1979, p. 240) expressed a similar concern in his "report on the energy war":

> While most solar advocates see renewable technologies as naturally decentralized, there's no guarantee they'll stay that way. When utility, oil and nuclear advocates speak of solar power, they talk in terms of giant collectors and outer space. There's no law, natural or otherwise, that says solar energy must be democratically owned or community controlled.

Many solar advocates fear that the high front-end costs of the SPS system will preempt a multitude of less expensive alternatives, siphoning off hundreds of millions of dollars in R & D funds that are needed for the development of improved small-scale solar technologies and energy-storage systems (DeLoss, 1979). As Chapman (1979a) views it,

> Most of the money spent directly to advance solar development has been spent on extravagant and impractical projects that serve no purpose but to provide work for high-priced aerospace engineers and scientists. Solar projects are probably the fastest-growing boondoggle in the federal budget.

And Parisi (1979a) quotes Barry Commoner's assessment of the SPS concept: "It is entirely possible to be in favor of solar and be stupid at the same time."

VII. CONCLUSION

The eventual near-term public response to the SPS concept does not now appear to be favorable. At a time when renewable energy systems are seen to promise more democratic and local control over energy supplies, satellite power would centralize solar electricity and perpetuate the monopoly control of the utility companies. In a period of declining faith in central governments, large corporations, big science and esoteric technologies, the SPS program would further the growth of federal and corporate control over energy policy, in the development and deployment of some of the biggest and most impressive technologies of all. During the early years of difficult transition to a much more diversified and balanced energy system, based on both depletable and renewable sources, in both large and small-scale systems, the SPS would concentrate what many perceive to be a disproportionate share of available capital in the pursuit of a single dramatic "solution." Most importantly, the predictable growth of conservation efforts and the spreading deployment of dispersed renewables suggest that the unmet U.S. demand for centrally generated electricity is unlikely to grow sufficiently over the next twenty years to convince a reluctant public of the necessity for an investment of capital, material, and technological resources on the scale demanded by the Satellite Power System.

Heppenheimer (1977, p. 56) described the SPS concept as "a twenty-first-century solution to a twentieth-century problem." Parisi (1979a) suggested that any system using photovoltaics to generate centralized power represents the burdening of a twenty-first century technology with nineteenth-century trappings. However one might choose to characterize the mismatch of technology and social context that this paper has explored, it does seem clear that the SPS concept represents an approach to energy development that is running counter to many of the dominant trends of American society. Satellite Power Systems will have a problem in the area of public acceptability.

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