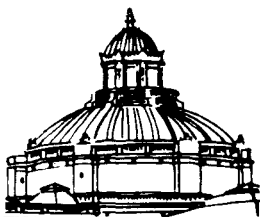


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SOFT VERSUS HARD ENERGY PATHS:
AN ANALYSIS OF THE DEBATE

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ABSTRACT

This paper discusses the major issues of the soft versus hard energy path debate--institutional considerations, distribution of power production sources, size of facilities, and renewability of fuel resources. It outlines major arguments in each of these areas, and discusses the significance of the debate from the viewpoint of meeting future energy needs.

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INTRODUCTION

The debate on alternative energy futures focuses on the extremes of spectrum of energy technologies--the so called "soft" energy path versus the "hard" energy path. The debate is one of large versus small, distributed versus centralized, renewable versus nonrenewable. It is part of a larger debate on the future directions of society, and as such has important implications for legislative action. This paper describes the alternative energy philosophies, analyzes the major arguments, and discusses how possible energy futures fit into these two categories.

Although definitions of soft and hard energy paths are not absolute, soft technologies are generally considered those which are small-scale, distributed, and renewable, whereas hard technologies are large-scale, centralized, and non-renewable. Soft technologies generally seem to include solar collectors, hydroelectric plants, wind machines, biomass-based gas and liquid fuels, and industrial cogeneration. Hard technologies include, in the short term, oil and gas power plants, coal power plants and coal-derived synthetic fuels, and nuclear fission, and in the longer term, fission breeder reactors, nuclear fusion, and perhaps large-scale solar power plants and solar satellite power systems. Therefore the designation "soft" or "hard" is somewhat complex. For example, some technologies, namely conventional hydroelectric and possibly also to some extent, cogeneration, are generally classified as soft even though not small-scale; large-scale renewable technologies such as solar power plants and satellite solar power systems are generally excluded from the soft technology designation; and cogeneration, which is not fuel-specific--in fact, most near-term

systems are envisioned to use conventional fuels--is considered a soft technology.

The soft path is predicated on the apparent inefficiency of using electric power production to meet end-use needs that can be satisfied in other ways. An analysis of energy consumption patterns showed that while 8 percent of U.S. energy uses require electricity, 13 percent of end-use needs are supplied by electricity. Since the generation and transmission of electricity, in the view of soft path advocates, is a relatively inefficient process, it accounts for 29 percent of the fossil fuels used. 1/ The soft path would substitute more tailored energy sources and a greater use of conservation. Proponents of soft technologies claim that they are resource conserving, environmentally benign, under individual control, and less costly because big business does not operate them. Each of these contentions is hotly disputed.

Although the merits of alternative energy technologies have always been a subject of debate, the debate assumed its present structure and intensity in the mid 1970s and most of the major literature on the subject dates from that time. The soft energy philosophy was perhaps first enunciated in its present form by Amory B. Lovins. 2/ Other major exponents of a transition to an alternative energy economy include the Union of Concerned Scientists 3/ and Denis Hayes 4/,

1/ Steifel, Michael. Soft and Hard Energy Paths: The Road Not Taken. Technology Review, v. 82, Oct. 1979: 56-66.

2/ Lovins, Amory B. Energy Strategies: The Road Not Taken? Foreign Affairs, v. 55, Oct. 1976: 65-96. Soft Energy Paths: Toward a Durable Peace. Ballinger, 1977. 253 p. Soft Energy Technologies. In Annual Review of Energy, v. 3. Annual Reviews, 1978. pp. 477-517.

3/ Kendall, Henry W. and Steven J. Nadis (ed.). Energy Strategies: Toward a Solar Future. (A Report of the Union of Concerned Scientists). Ballinger, 1980. 320 p.

4/ Hayes, Denis. Rays of Hope: The Transition to a Post-Petroleum World. Norton, 1977. 240 p.

now Director of the Solar Energy Research Institute. The soft energy philosophy was rapidly embraced by environmentalists, anti-corporation people, and others. The major thrust of the philosophy was that soft energy technologies are an essential element of a new social order to replace the present corrupt, bureaucratic, and inhuman system. The initiation of a soft energy "movement" aroused a strong response from the proponents of conventional technologies and centralized systems. 5/ Central to the concerns of these groups was the perceived emphasis on making a decision to pursue soft energy technologies in the absence of conclusive technical and cost information, and the potential for disruption to society if the soft approach failed.

This paper first provides a discussion of the issues associated with affecting a transition from the present energy economy to a soft energy economy. This discussion brings out some of the major institutional concerns of both sides of the issue. The paper then discusses the major arguments which have been raised regarding degree of centralization, size, and renewability of energy systems. Finally, the paper suggests some of the major questions of legislative concern associated with this issue.

5/ See for example U.S. Congress. Senate. Committee on Interior and Insular Affairs. Alternative Long-Range Energy Strategies. Joint Hearings before the Select Committee on Small Business and the Committee on Interior and Insular Affairs, 94th Congress, 2d session. Washington, U.S. Govt. Print. Off., 1977. Hearings held Dec. 9, 1976.

TRANSITIONAL ISSUES

Proponents of the soft path propose to rely upon the continued use of fossil fuels used in relatively benign energy supply systems during the interim transition period between the present and a full-scale soft energy economy. During this period, intensive conservation efforts would reduce the total energy usage. The transition period is assumed to last about 50 years (until about the year 2025), 6/ after which time essentially all energy needs would be met by soft energy sources, but the basis for such an assumption has not been explained in detail. The transition period would focus particularly on cogeneration, district heating, end use efficiency, alcohol from biomass and fluidized bed combustion. Critics suggest that the time, difficulty and cost required to implement some of these technologies could be considerable and could affect their viability for effective use during the transition period. Furthermore, the temporary nature of the interim transition period could make it difficult to attract the investment capital required. 7/

An important element of the transition is the requirement for institutional barriers to the soft energy path to be successfully reduced or eliminated. These institutional barriers occur at local, State, and national levels. Proponents of the soft path believe that, despite the present predominance of hard technologies, there are at present significant barriers to further development of certain hard technologies--including nuclear siting, regulatory issues, and funding difficulties--that are comparable to, if not more difficult than, the institutional issues associated with the promotion of soft technologies. 8/

6/ Lovins, Energy Strategies, p. 77.

7/ U.S. Congress. House Committee on Interstate and Foreign Commerce. Subcommittee on Energy and Power. Are We Running Out? A Perspective on Resource Scarcity. Washington, U.S. Govt. Print. Off., 1978. pp. 19-20. (95th Congress, 2d session. House. Committee Print 95-57.)

8/ Lovins, Soft Energy Technologies, p. 507.

Desubsidization of present technologies, that is, an equitable access to capital, and the use of long-run marginal cost pricing in the form of "a gradual, equitable move to proper pricing of depletable fuels" 9/ are considered essential requirements for the viability of the soft path and, according to soft energy advocates, the only preliminaries required to implement soft technologies through existing market, political, and social processes. According to opponents of this strategy, this essentially constitutes a requirement that capital, manpower, and expertise be diverted from present processes to alternative forms of energy, to the extent that further development of conventional energy sources would effectively be banned. This, they claim, would be the only way soft energy technologies could become predominant over existing systems. 10/ Furthermore, opponents also suggest that the institutional barriers to the soft energy path are more formidable than the soft energy enthusiasts acknowledge, particularly with regard to investment requirements. 11/

It is, at present, unclear whether the present structure of society might make it difficult to implement a full transition to a soft energy economy. Soft energy critics argue that, in major cities with densely packed large apartment and commercial buildings, it would be difficult to meet energy needs without central power production. Power plants and electric grids might continue to be required for much of industry and commerce, and in particular, for the industry that would have to be developed to manufacture the many devices necessary to make the transition to a soft energy society. 12/ Indeed, soft

9/ Ibid.

10/ Rossin, The Soft Energy Path, p. 58.

11/ Are We Running Out? pp. 19-20.

12/ Rossin, The Soft Energy Path, p. 59.

energy proponents sometimes appear to suggest that there may be some continuing needs for large energy systems, (but believe present facilities are adequate to meet those needs) 13/ although they speak primarily of a requirement for society to be devoted "exclusively" to soft energy paths. It is not clear how much of the national energy need could be met by large systems without diluting the benefits attributed to soft energy systems. Critics claim that the implementation of a soft energy system will depend not only on the availability and reliability of large centralized electric utility supply systems, but also on their being economical in order for people to be able to afford both the solar system and the conventional power backup. These analysts claim that a push to drive energy prices up or introduce a tax-supported subsidy in order to make solar systems more attractive could redound to the disadvantage of solar, and particularly to the disadvantage of the poor and those on fixed incomes. 14/ Furthermore, critics express the concern that the plan to transition to a soft energy society does not provide either sufficient allowance for emergencies, such as oil embargoes, wartime disruptions of suppliers and supply routes, supply shortages, or abnormal weather patterns, all of which have occurred in the past decade, 15/ or sufficient reliability to meet critical emergency needs. 16/

Rossin speculates that, despite conservation, a growing population and the aspirations of people for a better future could still mean growing demands for

13/ Lovins, *Soft Energy Technologies*, p. 489 and pp. 479-480.

14/ Rossin, *The Soft Energy Path*, p. 60.

15/ *Ibid.*, p. 61.

16/ *Are We Running Out?*, p. 19.

energy. If a decision were made not to build new central electric supply capacity, this could ultimately create gaps in various parts of the Nation between the total energy supply capacity and the demands. The possible responses to such a scenario could lead, paradoxically, to an increase in centralization and a consequent decrease in individual self-determination. Shortfalls in energy supply could result in routine or emergency curtailments of electric supplies--brownouts, blackouts, or other actions. Longer term impacts could include local curtailment of industrial growth, thus denying areas jobs, taxes, etc. If insufficient energy supply situations were widespread, there could be widespread drawbacks in commercial and industrial growth, leading to reduced economic growth for the Nation, or even to a depression in the economy. In the event of a serious energy shortfall, the Federal Government could decide to take over the generation of electricity, since, in an emergency situation, there might be insufficient time or money to develop community or neighborhood sources. The total cost of such an emergency approach would probably be high because of the urgent, catch up nature of the action. And most importantly, the result would be energy supplied by a system, the Government, that is even larger and more centralized than present local or regional utilities. Furthermore, given the historical difficulties of decision-making for such an action at the national level, the Government might prove unable to meet the demand. Another alternative might involve the introduction of forced rationing, the setting of priorities for the use of the limited energy supplies available. Such rationing decisions would have to be made centrally, by Government, and thus again would substitute a large centralized system for the decentralized individual decision-making that would otherwise take place. 17/

17/ Rossin, The Soft Energy Path, pp. 61-62.

DISPERSED VERSUS CENTRALIZED

Many of the social benefits attributed to the soft energy path by its proponents are primarily the result of decentralization. Other important considerations relating to decentralization include end-use matching, grid interconnection, and environmental and other impacts. The literature indicates the wide divergence of viewpoints and conflicting arguments regarding economics and other important considerations pertinent to the decentralization issue. 18/

A major argument in favor of soft technologies is the philosophical argument relating to individual self-determination. A dispersed energy supply system, it is argued, allows individuals a greater voice in their own fates, whereas large scale tends to concentrate political and economic power in a few organizations and people. 19/ Both its proponents and opponents seem to agree that the argument is basically one for a new social order.

According to Lovins, "energy . . . offers the best integrating principle for the wider shifts of policy and perception that we are groping toward." 20/ Further evidence that the soft energy path is motivated by a philosophy rather than by safety, economics, or other such factors is suggested by Lovins' assertion that:

If nuclear power were clean, safe, economic, assured of ample fuel, and socially benign per se, it would be unattractive because of the kind of energy economy it would lock us into. 21/

18/ U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Energy and Power. Centralized vs. Decentralized Energy Systems: Diverging or Parallel Roads? Washington, U.S. Govt. Print. Off. 1979. 312 p. (96th Congress, 1st session. House. Committee Print 96-1FC 17.)

19/ Lovins, Soft Energy Technologies, p. 488.

20/ Lovins, Soft Energy Paths.

21/ Ibid.

Opponents assert that there is a lack of detailed understanding of the real consequences of promoting such a new social order. They raise a number of issues relating to the centralization argument. Decentralization, though it would seem at first glance to be an approach to benefitting the individual, has not historically always been the most beneficial alternative. Although the analogy may not be exact, centralized water and sewage treatment systems are raised as examples of centralized systems which resulted in significant improvements in the health and life expectancy of Americans. 22/ Furthermore, they find it is not clear that, given a choice, a majority of citizens would care to make for themselves the decisions that would be required in a decentralized energy supply system.

Another advantage attributed to decentralization is that the energy source can be better matched to an end-use power density requirement. According to Lovins, the present mismatch between supply and load density in the United States has produced a requirement for a transmission and distribution network that in 1972 accounted for about 70 percent of the cost of delivered electricity to nonindustrial users. This is a diseconomy of centralization, both in terms of cost and in terms of energy losses. Furthermore, since transmission failures have been identified as the dominant cause of electric failures, decentralization of energy supply sources would tend to reduce the potential for supply disruptions. 23/ Advocates of centralized systems believe that the economies of scale, discussed further in the following section, outweigh the additional transmission costs.

22/ Rossin, *The Soft Energy Path*, p. 59.

23/ Lovins, *Soft Energy Technologies*, p. 486.

According to Lovins, interconnecting small, dispersed sources through an electrical grid retains the advantages of interconnection of energy sources-- that is, saving capacity by load diversity, and reducing the likelihood of catastrophic failure--while increasing the resilience of the system by reducing the consequences of a failing grid. He further indicates that the reliability requirements for dispersed systems might be less than those for centralized systems in the first place because the impact of failure would be reduced. In a solar heating system combined with long-term thermal storage, for example, a short term system failure would be inconsequential because of the energy stored. If the failure was within an individual system, even if the length of the failure exceeded the storage capacity, relief might be sought from neighboring systems. Such features could allow for an end-use reliability tailored to the need, rather than as at present, where the supply system provides a very high end-use reliability in order to meet the most stringent needs, thus producing another system diseconomy. 24/ Even so, Lovins' overall philosophy largely favors source independence as opposed to interconnection, and according to his critics, experience indicates that without interconnection, large areas of the country could be without electricity for significant periods of time in severe weather. 25/

Dispersing energy supply systems may reduce the magnitude of environmental and social impacts locally, and therefore, increase the total number of sites which can be employed for energy production facilities. Additionally, decentralization, by its nature, tends to allocate operational costs and

24/ Lovins, *Soft Energy Technologies*, p. 506.

25/ Solomon, Burt. *Engineers Reply to Amory Lovins: Hard Numbers vs. Soft Path*, the *Energy Daily*, v. 5. March 14, 1977. pp. 1-2.

benefits to the same people, rather than to different groups, thus possibly decreasing the potential for inequities in the distribution of environmental costs, and increasing the ability of the local residents to be effective in enforcing environmental standards for plant operation. 26/ It is not clear, however, whether, many small plants would ultimately be easier or harder to site than a few larger ones, and what the tradeoffs might be between concentrating energy production impacts in a few areas and dispersing energy production impacts in many areas.

Decentralization is also said to permit easier integration into total energy systems and combined food and energy systems, 27/ but this may not take into full account the potential for cogeneration in large scale conventional systems, the potential for agriculture using waste heat from large power plants, or other large scale combined system possibilities. Finally, according to Lovins, decentralization can reduce other social costs, such as the vulnerability to disruption, sabotage, and war, and can thereby improve national security, 28/ although opponents believe that energy shortfalls could hamper national security and threaten the status of the United States as a world power. 29/

26/ Lovins, *Soft Energy Technologies*, p. 487.

27/ *Ibid.*, p. 484.

28/ *Ibid.*, p. 488.

29/ Solomon, Burt. *Engineers Reply to Amory Lovins*, p. 2.

SMALL VERSUS LARGE

The major arguments regarding size appear to be economic, and consider such factors as economies of scale versus economies of mass production, reliability, maintenance and financing. Other major arguments address research and development requirements and costs.

The results of an economic analysis conducted by Lovins suggest that though soft technologies "may or may not be cheaper than present oil and gas, they are generally cheaper than the things one would otherwise have to do to replace present oil and gas" 30/--(i.e., synthetic fuels). In a ranking of all alternatives considered in his study, the least costly were found to be the end-use efficiency improvements, then the soft and "transitional" technologies, then synthetic fuels, and last, central-electric systems. According to Lovins, this analysis was based on conservatisms that were weighed in favor of hard technologies, particularly by not providing any allowance for low-cost designs or for differences in financing. 31/ Lovins attributes his results at least partly to the fact that many of the economies of scale claimed for large energy systems "may be doubtful, illusory, tautological, or outweighed by less tangible and less quantifiable but perhaps more important disadvantages and diseconomies." 32/

Other research disputes the claims of lower cost for solar technologies. One estimate of the capital investment required to adopt the soft energy path is in the range of two to three times that of equivalent new conventional coal

30/ Lovins, *Soft Energy Technologies*, p. 503.

31/ *Ibid.*

32/ *Ibid.*, pp. 483-484.

and nuclear capacity, even if the soft energy systems could be phased in gradually with no surprises. ^{33/} Furthermore, these researchers assert that they have weighed their results in favor of soft technologies by making certain assumptions about the performance of soft systems (such as the fraction of the total energy requirement that could be met by a soft energy system) that are really more generous than the present state-of-the-art warrants. On the other hand, this research largely discounted the possibility of economic or technical breakthroughs that might reduce soft energy costs significantly, based on estimates that a major portion of the total costs of soft systems is due to labor-related installation charges, and such costs are not likely to be reduced significantly, even if materials and fabrication costs are. ^{34/}

Several of the arguments concerning economies of scale relate to system procurement costs. Although direct construction costs (i.e., materials and labor costs) traditionally exhibit significant economies of scale, Lovins believes that the lower construction cost per unit of output power may be counterbalanced by higher costs in a number of other areas. Furthermore, certain economies of mass production may be operative for multiply-produced small systems which are not in effect for the relatively small numbers of large power plants built. The longer construction times required for large power plants as compared with small ones may lead to some diseconomies of scale because of the greater opportunity for cost escalation and the greater fraction of the plant costs allocated to interest payments (both because of the payment period and the terms generally available for such construction). Other factors which might effect the relative costs of large versus small systems include costs to

^{33/} Rossin, The Soft Energy Path, p. 58.

^{34/} Solomon, Burt. Engineers Reply to Amory Lovins, pp. 1-2.

respond to regulatory changes during the construction period, the relatively high transaction costs of plant siting for large plants, and the hazards of mismatched demand forecasts in long term energy planning for large systems. 35/

One 1977 study estimated a total cost of \$884 billion to supply solar panel systems and home windmills sufficient to supply all U.S. residences with heat and electricity. The additional energy supply capacity is equivalent to increasing the total electric capacity by one-third, whereas the same study claims that for only \$250 billion, the country's electrical generating capacity could be doubled by relying on the more familiar coal and nuclear technologies; and for only a portion of this total investment, an industry of large-scale coal gasification plants could be created that would essentially eliminate the problem of natural gas shortages. 36/ Another concern regarding the mass production requirement for the soft energy approach is the ability to scale up production to meet demands on a national level. A significant increase in production of many soft energy systems would require an increase in various types of industrial activity, from mining, through materials processing, through system fabrication, and could require large capital expenditures to open new mines, construct new factories, or train new personnel.

Several additional points were raised by these researchers, but apparently not explicitly incorporated into the study results. The required investments by individuals, based on optimally cost-effective configurations for solar and other renewable energy systems, would include the costs to install and utilize backup energy capacity from a conventional supply system, thus increasing the effective total cost. Furthermore, it is generally more difficult for

35/ Stiefel, Soft and Hard Energy Paths, p. 58.

36/ Solomon, Burt. Engineers Reply to Amory Lovins, p. 2.

individuals to raise capital than it is for large institutions. This assumption is contrary to Lovins' assumptions in that the cost of money (interest rate) is higher for the soft energy systems and the costs of the facilities themselves would also be higher. If the higher costs of decentralized energy production systems require Government subsidies to make them attractive, that in turn leads to still other costs in the form of taxes to support subsidies and the attendant needs for Federal guidelines, inspection, and enforcement. 37/ If the lifetimes of soft energy systems are shorter than assumed (due to degradation of materials exposed to the sun, etc.), the life-cycle costs could also be increased considerably. 38/

Another argument is that smaller technologies tend to be simpler, and therefore likely to result in lesser requirements for maintenance because of fewer failure modes and easier and faster repairs. When repair needs do arise, they generally require less highly skilled maintenance personnel and standards, and consequently, are less vulnerable to the disruptions created by strikes of select and irreplaceable occupational groups. In addition, the training requirements and cost of spare parts inventories are also less. 39/ However, actual maintenance experience is very sketchy for small decentralized energy systems and there are some indications of problem areas--deterioration over time of glazings of solar collectors upon extended exposure to sunlight; failures of equipment receiving the casual preventive maintenance many homeowners are likely to devote to it; etc. Also, soft energy systems may or may not be technologically simple (see below).

37/ Rossin, *The Soft Energy Path*, p. 58.

38/ Steifel, *Soft and Hard Energy Paths*, p. 61.

39/ Lovins, *Soft Energy Technologies*, p. 484.

Lovins and others claim that there is no evidence for greater technical efficiency in larger units. 40/ In fact, overall experience to date seems to indicate that larger scale in power stations tends to decrease overall system reliability. Major reasons for this are probably fundamental problems due to the complexity of the equipment and operating requirements, and the construction of plants in sizes that exceed the engineering experience for the technologies involved. Unavailability due to low reliability produces a requirement for backup energy generating capacity to assure reliable energy supply, therefore creating diseconomies of scale for operating costs and increasing total energy costs. Studies of typical interconnected grids suggest that building several smaller units could provide the same level and reliability of service with about a third less capacity because the more numerous smaller plants are unlikely to fail at the same time and hence require less reserve margin. 41/ However, whether this would result in a lower net cost would depend on the economies of scale as well as the total capacity.

The major reasons for the contradictory conclusions reached in the various cost studies is that very different assumptions have been made about the future costs and capabilities of different systems. Studies which find soft energy futures to be cost-effective tend to make optimistic assumptions about cost reductions for soft energy systems, tend to assume minimal needs for backup capacity, tend to presume a high degree of owner initiative in installing and maintaining the systems, thus minimizing the high maintenance costs, and tend to make comparisons against future large-scale energy technologies, whose

40/ Ibid., p. 485.

41/ Ibid., p. 485.

costs are also not well known, but are presently estimated to be high. While a comparison of true soft energy costs against future hard energy costs would be a valid one, the uncertainty of all the costs makes it impossible to rely on the results of such an analysis. On the other hand, studies which find hard energy systems to be cost-effective tend to rely largely on the status-quo, presuming neither significant changes in the costs of soft energy systems nor significant adoption of more costly advanced large-scale technologies. They also tend to make their comparisons of soft energy systems largely with electric power systems, thus not fully addressing all the components of the energy supply picture. This approach is equally subject to criticism. Therefore, the economic analyses are probably only of limited value, and in fact, are not considered the primary argument in the soft versus hard energy path debate. 42/

Another factor which may be significant is that soft technologies, built on a smaller scale, could have much shorter technical lead times than complex, large scale systems. The major consequence of this is that the cycle of development, demonstration and deployment might be condensed, many approaches might be tested in parallel at low unit cost and risk, and existing industrial capacity might be readily adapted for production. Thus, "the diversity, simplicity and proven performance of soft technologies make their risk of technical failure lower than that of relying on a few big high technologies, like breeders and high-Btu coal-gas complexes, that are not here and may or may not work." 43/ As an example of this latter point, Lovins points out that 40 percent of all Vermont homes were retrofitted by their owners with

42/ Lovins, *Soft Energy Technologies*, p. 48D-1.

43/ *Ibid.*, p. 506.

wood-burning stoves in a period of just 3 years. Furthermore, the diversity that would result from such a multi-pronged effort would likely lead to an energy production system made up of many different technologies with generally independent rate constraints. That is, the things that might delay one technology, say solar heating systems, would be unlikely to delay another technology which involves very different materials and industries, say alcohol production from biomass. In addition, during periods of rapid technological evolution, with less capital invested in large inflexible plants and infrastructure, it may be possible to adopt the technology improvements more rapidly. 44/

However, if ultimate energy supply is through a variety of diverse technologies, the research costs per unit of power production ultimately realized could be rather high, and the total costs to support research in many different areas may also be high. In addition, although a small-scale system might seem simple, the level of technology development involved in improving the system may be as complex and as sophisticated as research on larger, more complex systems and the requirements for the research and development may be just as important to the viability of the technology. Although there are presently operational soft energy systems, the limited use of such systems is considered an indication of their inacceptability for cost or other reasons, 45/ and significant developments could be required to make them more cost-effective, more adaptable to situations with limited space, more maintenance free, longer-lived, etc. Some examples of critical areas for which significant research and development efforts may be necessary include low-temperature air conditioning systems, control systems, energy storage systems and materials, and

44/ Lovins, *Soft Energy Technologies*, p. 508.

45/ Rossin, *The Soft Energy Path*, p. 58.

solar collector materials. Thus, although soft energy systems are generally regarded as technologically simple--and in many cases are so--they may also incorporate very high technology components or subsystems, which has implications not only for the R&D requirements, but also for maintenance (cited above), fabrication, etc.

RENEWABLE VERSUS NONRENEWABLE

Arguments regarding hard versus soft technologies which are primarily related to resource renewability include environmental, human health and safety, resource conservation, and global political considerations. Some of the issues in these areas were also raised in the context on energy plant size and dispersion. Only those aspects particular to resource renewability are addressed here.

One major advantage cited for renewable energy technologies is that they appear, on preliminary analysis, to be environmentally more benign than hard technologies, and, according to Lovins, their side effects are more amenable to technical fixes. ^{46/} Furthermore, soft energy technologies at present have no known climatic impacts. ^{47/} A soft energy path, therefore, may mitigate against the possible climatic problems of combustion products such as CO₂ by reducing the amount of fossil fuel burning needed. However, this comparison may not account adequately for improvements in conventional technologies, such as scrubbers for coal plant emissions, that may reduce environmental pollution from conventional power plants, nor may it address explicitly the extensive mining and manufacturing activities associated with some renewable resources which could result in significant levels of environmental pollution. Nevertheless, based on present understanding, the environmental threats of renewable technologies appear to be small.

The situation for health and safety impacts, on the other hand, is less clear. Proponents of renewable systems claim that the health and safety effects of such systems are generally small, and many may be amenable to rather

^{46/} Lovins, *Soft Energy Technologies*, p. 506.

^{47/} *Ibid.*, p. 507.

simple technical fixes. 48/ Some studies which have examined the entire life cycle associated with renewable systems (including mining of materials needed, manufacturing, use and maintenance), as well as possible technological improvements to large conventional systems, such as scrubbers for fossil fuel systems, however, have concluded that certain renewable energy systems may have more health and safety impacts overall than do conventional systems, though often of a different nature. 49/

The major issue of resource depletion revolves around the need to save remaining fossil fuels for those energy needs which appear at present to be more difficult to solve by the use of other energy technologies (for example, transportation needs) and for critical non-energy uses, such as petrochemical needs, for which there are few or no available substitutes. On the other hand, the development and implementation of renewable energy systems will require the extensive use of materials other than fossil fuels which may also have a limited resource base and other critical uses. Renewable energy systems require significant uses of metals, such as copper, and other materials, such as silicon, that may be resource-limited on the scale needed for widespread use of those systems.

Finally, on a global scale, the widespread use of renewable energy sources is seen by some as a way to provide a more equitable distribution of energy between the wealthy, resource-rich nations and the poor, resource-deficient nations. 50/ The widespread use and availability of economical renewable energy

48/ Lovins, *Soft Energy Technologies*, p. 506.

49/ Inhaber, Herbert. Risk with Energy from Conventional and Nonconventional Sources. *Science*, v. 203, Feb. 23, 1979: 718-723.

50/ Lovins, *Soft Energy Technologies*, p. 508.

systems could presumably encourage their adoption by Third World countries in place of conventional alternatives that might be a large economic drain. However, the extent to which such a benefit would be realized would depend on the degree to which renewable systems capable of meeting the nation's residential and industrial energy demands could be constructed with indigenous materials and labor, and this is not yet fully established. Furthermore, the substitution of renewable energy resources for conventional energy systems, particularly nuclear, is seen by some as a way to reduce nuclear proliferation, and therefore the threat of nuclear war, 51/ although others believe that effective measures can be taken to minimize the danger of nuclear weapons proliferation without prohibiting the use of nuclear energy for electric power production. 52/

51/ Ibid., p. 509.

52/ International Nuclear Fuel Cycle Evaluation (INFCE). Summary Volume, International Atomic Energy Agency, 1980. 72 p. Perry, Harry & Streiter, Sally H. Multiple Paths for Energy Policy: A Critique of Lovins' Energy Strategy. Energy Communications, v. 4, 1978: 317-378.

CONCLUSION

An interesting feature of the soft versus hard path debate is the essential areas of agreement and disagreement. Both sides really seem to suggest that what they want is some mix of energy technologies, that what they want is for market-place economics to determine that mix, that what they want is for all technologies to have an equitable opportunity to compete in that marketplace. They have very different ideas, however, on what that mix of technologies should be and how it should be achieved. The soft energy proponents are essentially claiming that past and present subsidies of conventional power systems, if continued, would preclude effective marketplace competition from new energy sources, while hard energy proponents largely disclaim that any special benefits are being provided to their technologies and claim that large economic subsidies would be required to make soft energy systems economically attractive. Such subsidies, they claim, would be to the disadvantage of the overall economy if it resulted in the curtailment of the development of conventional energy sources, leading to energy insufficiency. Such a scenario, they feel, would largely cancel the major benefits attributed to the soft technologies, in particular the benefits of self-determination, individual independence, decentralization of social power and a more democratic political milieu.

To the extent that the central argument is one of appropriate societal subsidization, the issue needs to be more fully explored. Important questions are: How were the present technologies subsidized in their initial stages,

including R&D funding, tax advantages, subsidies, and other financial mechanisms? What explicit and effective subsidies are now in effect? What kinds of initial and continuing subsidies might be applied to soft technologies to make them financially competitive and what would this cost? What would be the impacts on conventional technologies? Alternatively, what would be the impacts of withdrawing any existing subsidies for conventional energy systems?

To the extent that the central arguments are not economic, another group of questions needs to be addressed. These include explorations of the putative long-term social hazards of centralized hard technologies and of the putative long-term benefits of soft technologies, the potential for conservation, the adequacy of present systems over the transition period and to meet residual long-term needs, the acceptability to society of the greater individual responsibility required to decide upon and maintain multiple dispersed systems, the materials needs, the R&D requirements, and the adequacy of the industrial infrastructure to support the production of soft energy systems.

In the final analysis, there is a multitude of possible paths between the hard and soft extremes. Which energy path the Nation will adopt will depend to a significant extent on congressional decisions as to the social requirement for a given option, the economic viability of supporting it, and the adequacy of the support mechanisms selected. Therefore, it may become extremely important to be able to weigh the relative costs and benefits of many alternative mixes of energy technologies in order to select one that best meets the Nation's perceived social needs at an acceptable cost.