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This assessment reviews the potential of a family of solar energy equipment called "onsite" energy systems because they are designed to be located on or near the buildings or groups of buildings which they provide with heat or electricity. The technologies examined produce useful energy directly from sunlight; equipment making indirect use of solar energy, such as wind machines or devices using biological materials as a fuel, is not examined.

The technical feasibility of most direct, onsite solar energy systems has been experimentally established. While onsite solar energy systems are competitive with conventional energy sources in a limited number of applications today, widespread use will require demonstrating that projected cost reductions can be achieved. By the mid-1980's, the range of costs which can be reasonably forecast for energy from onsite energy devices will overlap the range of costs forecast for energy from conventional sources for a variety of residential, commercial, and industrial applications. An uncertainty inherent in such comparisons is the price society will be willing to pay for the social and environmental benefits of onsite solar energy.

If energy can be produced from onsite solar energy systems at competitive prices, the increasing centralization which has characterized the equipment and institutions associated with energy industries for the past 30 years could be dramatically altered; basic patterns of energy consumption and production could be changed; energy-producing equipment could be owned by many types of organizations and even individual homeowners. Given the increasing fraction of **U.S. industrial assets which are being invested in energy industries, tendencies toward centralization of many aspects of society could also be affected.**

The onsite solar energy industry is in most cases a straightforward extension of existing heating, cooling, and air-conditioning industries. It could clearly develop without Federal participation. Unless a concerted effort is made to identify the special problems of onsite technology, remove regulatory barriers, provide financial incentives, and support an aggressive research, development and demonstration program, however, it is unlikely that onsite equipment will be able to contribute significantly to U.S. energy supplies by the year 2000. With such support, it is possible that onsite solar devices could be made competitive in markets representing over 40 percent of U.S. energy demand by the mid-1980s, although the output of solar equipment installed by this date is unlikely to be able to meet more than a small fraction of this potential market. Existing Federal programs controlling fuel prices and subsidizing nonsolar energy sources have created a situation where, without compensating subsidies, solar energy is **uniquely disadvantaged. Federal support of solar energy has concentrated disproportionate attention to central electric generating systems instead of exploiting the special opportunities provided by onsite equipment**

RESULTS OF THE ECONOMIC ANALYSIS

1 **Solar systems designed to provide domestic hot water (3,5 percent of U.S. energy demand) are competitive with electric hot water systems in most parts of the United States today if comparisons are based on the average monthly payments made for energy during the life of the system. Solar space-heating**

for new residential and commercial buildings (1 7.8 percent of U.S. energy demand) is somewhat less advanced but is, or should soon be, marginally competitive with heat pump and electric resistance space heating in many areas of the country.

2. On the same basis, solar space-heating and hot water systems may be competitive with oil or gas delivered to typical residential or commercial customers by the mid-1980's. The solar energy equipment should be competitive with heating systems using synthetic oil and gas.

3. Solar energy from systems which provide 100 percent of the heating and hot water required by large buildings or groups of houses may not cost significantly more than energy from systems designed to meet 50 to 70 percent of these demands.

4. Cost reductions and improvements in the performance of solar cells (photovoltaics), small engines powered from solar sources, and solar collectors possible by the mid-1 980's may result in onsite solar energy systems capable of producing electricity for residential and commercial buildings for $0.04 to $0.10/kWh — a price which would probably be competitive with electricity delivered to these customers from conventional utilities.

5. Full exploration of the potential for energy conservation and the use of simple "passive" solar space-conditioning techniques should clearly precede any attempt to use more complex solar energy equipment.

6. It will be possible to construct onsite energy systems capable of supplying all electrical and thermal energy needs of a building from direct solar energy systems, but it will usually be less expensive to rely on some other form of energy as a backup if this alternative is available. In some of the cases examined, the 100-percent solar systems did not cost significantly more than smaller solar installations on a life-cycle cost basis; in other cases, however, 100-percent solar systems were twice as expensive.

7 Providing backup electricity to onsite solar energy systems may, in some cases, cost electric utilities more per unit of energy delivered than the average utility cost. Solar energy systems are not unique in this respect, however, since many conventional buildings impose demands on electric utilities which adversely affect utility costs. When the real incremental cost of producing electricity for each type of building is computed, the total cost of operating solar energy systems backed up with conventional electric utilities is, in many cases, comparable to the cost of operating conventional all-electric buildings. Most solar heating systems are equipped with energy storage devices which, at a modest additional expense, can be used to reduce or possibly eliminate most adverse effects on electric utilities attributable to solar demand patterns.

8 Existing rate structures and available metering equipment may not be adequate to produce an acceptable pattern of charging and discharging onsite storage equipment. As a result, onsite storage equipment may not be able to eliminate al I adverse affects of solar equipment on electric utilities. It is extremely expensive to leave costly generating equipment idle; large electric-generating systems may therefore not be the most attractive way to provide backup power to onsite solar energy systems, particularly if the onsite devices generate electricity as well as thermal energy and low-cost electric storage is not available. The best technique for providing backup power requires a careful understanding of the relative costs of onsite and centralized storage equipment, energy distribution costs, and the costs of maintaining standby generating capacity. These costs vary greatly around the country.

9. By the mid-1980's, solar systems designed to provide agricultural or industrial process heat at temperatures below 5500 F (2 to 7 percent of present U.S. energy demand) will not be competitive with direct combustion of coal in large industries but may be an attractive alternative in situations where the direct use of coal is expensive or restricted because of environmental regulations, lack of access to coal supplies, or other factors.

10. The fact that onsite solar energy systems are calculated to be competitive on the basis of monthly costs does not mean that these devices will rapidly penetrate the market. The fraction of U.S. energy supplies which onsite systems wit I supply will depend on the extent to which customers make purchases on the basis of operating costs (instead of comparing only the initial purchase price), the rate at which an infrastructure for manufacturing, installing, and supporting such systems develops, the removal of regulatory barriers, and the incentives which are available.

11. The small size of onsite solar equipment does not preclude utility ownership, although there may be regulatory problems associated with such an arrangement. Utilities can provide market aggregation and financing for systems where building owners are unable to raise capital. Utilities will uniquely compare the cost of energy from new solar equipment with the cost of energy from new conventional plants — energy which typically is more expensive than the average cost of energy delivered to utility customers.

ONSITE SOLAR TECHNOLOGY

1. Onsite technology is not characterized by a single dominant design concept but rather by an enormous variety of competing approaches. Systems must be tailored to specific climates and applications. The equipment works best when the building or industrial process which it serves is designed to make the most efficient use of the solar resource.

2. There are no clear economies of scale in solar collectors, solar cells, or in many types of engines compatible with solar energy, although there are economies of scale in many kinds of energy storage equipment. Small, distributed energy systems can readily "cogenerate" heat and electricity and have several advantages not easily expressed in conventional economic terms: relative ease of using low-temperature heat, short construction times which permit rapid adjustment to changing energy demand; relatively small investments in each installation; and efficient land use (since collectors can be located on rooftops).

3 Development of simple collectors– both stationary systems and devices which move, tracking the Sun — is of central importance. While a wide range of applications can probably be found for collectors which cost $7 to $12 per square foot, development of collectors costing $4 to $7 per square foot would greatly increase the number of potential near-term uses for solar energy equipment. The optical and mechanical problems confronted in developing such devices will more probably be overcome with patience and clever designs than with fundamental research breakthroughs.

4 The potential of low-cost thermal storage has not been adequately explored. This should make possible solar heating systems requiring no backup energy. Development of a chemical reaction capable of storing solar energy efficiently and economically in chemical form would greatly expand the potential uses of solar energy. Neither approach has been given adequate priority.

5. The cost of solar cells can be reduced by mass producing current silicon cell designs, developing thin films of amorphous silicon material, cadmium sulfide, or other materials with acceptable efficiencies, or by designing low-cost optical systems to focus light on high-efficiency cells. Solar engines can be designed to operate at 1300 to 2000 F using machines that are essentially refrigerators running backward, at intermediate temperatures (using standard steam engines and advanced designs), and at high temperatures (1,400 °F) using Stirling engines and other machines with potentially high efficiencies. A funding strategy must be developed which amounts to a system for placing bets on a broad spectrum of schemes.

6. There is a large overlap between technology developed for onsite solar energy systems and technology developed to improve the efficiency of using conventional energy sources — particularly in energy storage and engine design.

7. No major technical problems should be encountered in connecting solar thermal or solar electric systems to electric utility grids. Utilities should be able to purchase excess electricity generated in onsite units for 25 to 100 percent of the price they charge for electricity.

MAJOR IMPACTS

1. Onsite solar energy services can be easily integrated into the existing construction and heating, ventilating, and air-conditioning industries. The equipment can be manufactured, installed, maintained, financed, and insured by the organizations and individuals now performing the same services for conventional heating and cooling and industrial equipment.

2. If small solar energy systems prove economically attractive, the concept of the "natural monopoly" of existing utilities would need to be reviewed.

3. The widespread use of onsite equipment would increase the number of jobs required to generate energy. Jobs would be created because imported oil would be replaced with energy from domestically produced solar equipment and because solar energy is more labor intensive than energy from conventional sources. The new jobs would be primarily in construction trades, metals, and chemicals. They would tend to be located where such jobs now exist and should provide a relatively stable source of employment, The long-term implications of a shift to labor-intensive energy sources, however, are not well understood.

4. Solar energy systems produce far less aggregate air and water pollution during their manufacture and operating lifetimes than energy systems based on fossil fuels. Solar equipment may be a particularly attractive energy source in areas where increases in emissions are prohibited. The major environmental problem of solar equipment is the use of land. However, this impact on land use can be minimized by carefully integrating solar collectors into building designs, but densely populated urban and suburban communities may have regions where shade from trees or buildings make the use of onsite solar energy unattractive.

5. Widespread use of solar energy worldwide could greatly reduce tensions associated with world competition over diminishing sources of fossil fuels without encouraging the use of technologies which increase the risk of nuclear weapons proliferation. Growth of a solar industry would reduce imports and encourage investments in the U.S. economy,

WHAT CAN THE FEDERAL GOVERNMENT DO?

1 The most straightforward, but politically the most dIfficult, approach to stimulating markets for onsite solar energy would be to remove prIce controls and implicit subsidies granted to conventional energy sources, and allow energy prices to rise to the cost of energy from new productIon facilities

2 The marketing of solar equipment could be seriously disrupted if incompetent or unethical dealers give the technology a reputation for poor performance Performance standards and uniform testing procedures must be developed rapidly to prevent abuses It is necessary, however, that these standards be continually updated to keep pace with a rapidly moving technology and to insure that the regulations do not inadvertently discriminate against new concepts

3 Investment tax credits, low-interest loans, exempt ions from property tax, and accelerated depreciation allowances on solar equipment can significantly reduce the cost of solar energy perceived by prospective buyers No one program will work equally well to provide incentives for all systems to a l l types of owners, Similar kinds of incentives applied to manufacturers could be used to reduce the price of solar equipment.

4 Regulations governing the rates at which energy is sold to and purchased from onsite energy systems need to be developed rapidly, Regulations preventing nonutility ownership of onsite generating equipment, and interfering with utility ownership of onsite energy equipment need to be reviewed and updated.

5 A variety of Federal subsidy programs already exist which can be modified to encourage the use of solar energy systems The use of solar equipment on Federal installations can stimulate sales and reduce costs,

6 A significant amount of basic research and advanced development work remains to be done. Promising areas of research were noted in the previous discussion of onsite technology

7, The U.S. program in onsite solar energy could be improved through closer cooperation with foreign programs. Many types of onsite solar energy are likely to be economically attractive abroad before they enter commercial markets in the United States. It is unlikely that other nations will move rapidly to integrate solar energy options into their energy planning unless the United States makes a major commitment to use of solar energy.

8. Perhaps the most important step which can be taken with respect to onsite solar energy is to insure that the advantages of the onsite approaches are seriously considered in constructing overall U.S, energy planning,