Chapter III

FEDERAL POLICY FOR PROMOTING AND REGULATING ONSITE SOLAR ENERGY

Chapter III- FEDERAL POLICY FOR PROMOTING AND REGULATING ONSITE SOLAR ENERGY

Page

A Surveyof Policy Options 61
Policies That Would Increase the Cost of Conventional Energy Sources. 61
Policies That Would Reduce the Net Cost of Producing and/or Purchasing Solar Equipment 61
Research and Development Support. 63
Legal and Regulatory Considerations. 63
Policies That Would Establish Foreign Assistance Programs Involving Solar Technology 64
Programs in Education and Public information. 65
Policy Options From Three Perspectives 65
Perspective. 65
Perpsective B.... 67
Perspective C, ... 73
issues 74
Issue I. Federal Tax Laws. 74
Issue 2. Financing Onsite Solar. 80
issue 3. Solar Installations on Federal Buildings 90
Issue 4. Use of Existing Grant Programs . . . 96
Issue 5. Proprietary Interests vs. Public Dissemination of Information 98
Issue 6. Competition. 99
Issue 7. Consumer Protection 100
Issue 8. Demonstration Programs 101
Issue 9.CoordinationofFederal R&D. 103
Issue l0. Priority Given to Decentralized Soar. 104
Issue ll. Priorities in Solar RD&D 105
Issue 12. DOE Solar Funding 109
Issue 13. SERi 110
Issue 14. Staffing Limitations 111

LIST OF TABLES

TableNo. Page

I. The Effective Cost of Solar Energy in Omaha, Nebr., for 20 Percent Investment Tax Credit [¢/kWh] 72
2. The Effective Cost of Solar Energy in Residential Buildings in Omaha, Nebr., [¢/kWh]WithaHigh Level of Incentives 75
3. Property Tax Rates unselected U.S. Cities 78
4. Authorizing Appropriations for the Energy Research and Development Administration, U.S. House of Representatives, 95th Congress, Conference Report No.95-671 109
5. Authorizing Appropriations for the Energy Research and Development Administration, U.S. House of Representatives, 95th Congress, Conference Report No.95-671 110

LIST OF FIGURES

Figure No. Page

I. Effective Capital Costs as a Function of Investment Tax Credit. 76
2. Effective Capital Costs as a Function of Depreciation Schedules. 77
3. Effective Capital Costs With and Without Property Taxes 79
4. The Effect of Loan-To-Value Ratios on Overall Capital Costs. 82
5. The Effect of interest Rates on Coverall Capital Costs 83
6. Lender Perceptions of Likely impact of Incentive Options on Loan Decisions 85
7. The Effective Cost of Capital to the Government as a Functionof the Discount Rate Used in Decisionmaking 92
8. The Effect of Federal Discount Rate on the Perceived Cost of Federal investments in Three Types of Solar Installations. 93

Chapter III
Federal Policy for Promoting and Regulating Onsite Solar Energy

One of the attractive features of onsite solar energy is that it can be developed and marketed with very little special assistance from Federal or State governments. A small solar industry already exists and the analysis of this paper suggests that a market for unsubsidized equipment may expand rapidly. Solar energy systems are easily compatible with existing institutions: They can be produced by any of a large number of existing industries; financed in conventional ways; built and operated with existing labor skills. Moreover, they will not have a major negative environmental impact. As a result, their introduction will not need to be controlled by an elaborate set of new regulations, legislation, or regulatory agencies—modest adjustments of existing regulations governing conventional heating and cooling equipment should suffice i n most cases. The solar industry may not be able to have a major impact on U.S. energy supplies, however, without coherent and sustained support from Federal and State governments.

Since onsite solar technology will apparently develop without Federal incentives, it might be tempting to conclude that the best policy for the Government to adopt would be no policy at all Existing Federal energy policy, however, will affect onsite solar energy equipment whether or not an attempt is made to develop a specific policy for it. The energy market in which solar technology must compete is highly artificial because of the layers of Federal regulations, controls, and subsidies which have accumulated over the years; energy legislation adopted during the next few years is likely to increase the complexity of these regulations rather than eliminate them. In many ways, current policies acting as disincentives for on site solar equipment include:

- **Policies which maintain the price of residential fuels at artificially low levels;**
- **Policies which permit tax advantages to mining and drilling operations and larger utility-owned generating facilities but which do not provide equivalent subsidies to onsite equipment.**
- **Policies which subsidize research on centralized generating facilities without giving serious support to onsite equipment.**

The fact that these policies have the effect of reducing the cost of fossil and nuclear energy relative to solar energy may be largely inadvertent. They have, however, produced a situation where a decision to make no change in policy translates into a decision to continue disincentives to onsite solar energy.

Without Federal assistance, the fledgling solar industry is likely to grow slowly. Typically, several decades are required before major innovation moves out of a laboratory and becomes a commercially marketable product. In the case of solar products, there are a number of reasons for delay, Consumer concerns about the reliability of the technology, about the resale value of buildings with the equipment attached, and about the possible rapid obsolescence of novel equipment must be allayed. Investors and financial institutions must be convinced that a market of sufficient size exists to justify the investments required for mass production. Installers, architects, code officials, and equipment designers must feel that they have reliable and accurate information about the costs and performance of the equipment and about techniques for evaluating competing designs before they can seriously consider the options offered by a novel technology, Insurance companies must be convinced that risks are acceptable.

As a burgeoning technology, solar energy faces a uniquely difficult marketing problem because it requires a large initial investment; that is, the bulk of the money spent for solar energy goes for purchasing the equipment rather than paying monthly fuel bills. Thus, the attractiveness of solar equipment is generally only apparent if "life cycle costing" techniques are used, but such techniques are currently seldom employed by consumers.

No matter how modest the objectives, developing coherent and useful legislation for onsite solar technology presents a challenging problem. Unlike the Federal programs to develop nuclear fission or fusion reactors where a relatively small number of organizations manufacture or purchase the facilities, development of an adequate policy for stimulating onsite solar equipment will require the Government to assess the needs and preferences of large numbers of groups and individuals, each with its own interests. Units will be built, owned, and operated by individuals and organizations with skills and expectations that cover a wide range. And, because solar technology must be tailored for specific climates, buildings, and energy requirements, incentives must apply to a large variety of different system concepts.

One of the greatest challenges in designing an effective Federal program in this area will be to insure that the programs deal fairly with the diverse group of individuals and organizations that may be affected by the policy. It will be necessary, for example, to find a way to deal equitably with innovations originating from organizations which differ greatly in size. Similarly, it will be necessary to insure that policies designed to affect consumers provide incentives which are accessible to persons with low incomes. (It does little good to provide a low-interest loan or a tax credit to an organization or individual unable to provide the downpay - ment for a solar device.)

There will, of course, be disagreement about the types of legislation needed in regard to onsite solar energy generation since different observers will have different perceptions about the future costs, availability, and acceptability of different energy sources; moreover, different observers will attach different values to the environmental and social benefits which solar energy can offer. While there may be disagreement about the desirability of action, however, there is little doubt that Federal legislation can accelerate the rate at which solar equipment enters the market, if this is judged to be a desirable objective.

By way of caution, however, it must be remembered that the Government has almost no history of intervening in the development of commercial products. While it has a well-established role in supporting basic research and in regulating the impact of new technologies which have become established, it has rarely set about to nurse a specific technology out of the research laboratory and into the marketplace. The one noteworthy example of Federal success in this area is the agricultural extension program which has, on a continuous basis, transformed university-born concepts into routine farming practices, Another possible example is the Federal program to develop a commercial nuclear power program, although many in the industry seem to feel that Federal participation in the program has been at best a mixed blessing.

Most of the products which have reached the commercial market because of Federal development funding have been serendipitous "spinoffs" from projects sponsored by the -Department of Defense or by the National Aeronautics and Space Administration. In these cases, the commercialization process was not a goal of the Federal support program, but rather resulted because the Federal contract enabled the company to develop equipment and expertise needed to meet a commercial application. Some outstanding examples are the transistor industry developed by Texas Instruments and other companies as a result of space and defense requirements and the Boeing 707 jet aircraft which grew out of that company's design of the military KC-1 35.

It is important to recognize that there are dangers associated with overzealous Federal participation in the development of commercial products. A poorly designed program can interfere with the normal development of business relationships, promote inferior products, encourage the wrong enterprises to enter the field, and otherwise distort the development of normal markets. It is certainly possible to find examples where Federal efforts to alter existing market structures have failed. The "operation breakthrough" program, an attempt to reshape the home building industry in the image of the aerospace companies, would almost certainly have been designed very differently if the Government had had an adequate grasp of the real problems faced by builders.

Successfully administering a program for the commercialization of solar technology, with its complex matrix of problems and opportunities, will severely tax Federal bureaucracies accustomed to dealing with small numbers of well-structured projects. An effective program will require imagination, flexibility, and a willingness to try new ideas and live with some mistakes.

A SURVEY OF POLICY OPTIONS

Before turning to a more detailed discussion of the different kinds of incentives available, it may be useful to review the kinds of policy options which have been proposed for promoting and regulating solar energy, and the likely effects of each:

POLICIES THAT WOULD INCREASE THE COST OF CONVENTIONAL ENERGY SOURCES

One of the simplest and most powerful ways to provide incentives to solar equipment would be to increase the cost of conventional fuels. This could be done by (a) removing implicit subsidies, (b) freeing prices from controls, or (c) taxing the energy sources directly. This technique would require virtually *no net* Federal expenses and would require the least Federal involvement in decisions made by the free market. Increasing the cost of conventional energy sources could be justified solely on the basis of the need to conserve those resources which are being rapidly depleted under the current price structure. It could also be justified as an attempt to have prices include such external costs as environmental damage, social disruption, the indirect drain on foreign-exchange resulting from oil imports, and national security risks.

A policy of increasing the cost of conventional energy would clearly not be without problems. Such a policy would create inflationary pressures and the burden would be borne most heavily by people with low incomes unless some compensating mechanism of repayments can be found. Continuing our present course of increasing oil imports, with the attendant balance of payments deficits problems which such policies create, can also be inflationary. It is unclear how long Federal policy will be able to maintain U.S. fuel prices at their current levels while world prices increase rapidly. There is reason to believe that it would be preferable to encourage a gradual increase rather than to find prices growing explosively during a short interval.

POLICIES THAT WOULD REDUCE THE NET COST OF PRODUCING AND/OR PURCHASING SOLAR EQUIPMENT

Policies designed to accomplish this objective fall into four basic categories:

1. Providing financial incentives to poten-

tial owners to encourage them to purchase solar equipment, thereby creating an expanded market and justifying mass production. Techniques for accomplishing this include:

- –Giving income tax credits and allowing accelerated depreciation techniques (see Issue 1). *
- – Removing barriers to obtaining financing for solar equipment (see Issue 2).
- –Encouraging States and municipalities to exempt solar equipment from property taxes and sales taxes (perhaps by providing Federal payments to States in compensation for lost revenues, see Issue 1).
- — Permitting tax exemptions for income derived from loans for solar equipment.
- — Enhancing consumer confidence in equipment by developing a system of unified performance standards by certifying (and perhaps subsidizing) testing laboratories (see Issue 7), and by ensuring proper training for building inspectors.

These incentives could have a significant effect on the perceived cost of solar equipment. One potential problem, however, is that although tax incentives would minimize Government interference in the free market, they could so reduce the risks of purchasing novel equipment that an opportunity would be opened for fraud through the marketing of unreliable systems. This prospect could be diminished by requiring that all who wish to qualify for incentives must purchase only equipment that meets minimum Federal standards. A balance must be found between the desire for a free market and a need for Government oversight.

2. Using Federal purchases of solar devices to stimulate the market by advertising and demonstrating their utility (see Issue 3).
3. Providing direct incentives to manufacturers of solar equipment in one or more of the following ways:
   - — Loan guarantees and loan subsidies.
   - –Tax relief similar to that discussed for equipment purchases (i.e., investment tax credits, or accelerated depreciation allowances).
   - –Cost-sharing through direct grants (see Issue 4).
   - — Encouragement of exports (particularly to developing countries).

Incentives to manufacturers could be extremely useful today, since solar equipment is developing rapidly. Manufacturers are understandably reluctant to invest in production equipment that they feel may soon become obsolete. This reluctance could be reduced considerably if they were permitted to "write-of f" manufacturing equipment over a relatively short period through accelerated depreciation allowances. Another problem for firms attempting to market a new concept, availability of financing, can be particularly troublesome for small companies lacking established relationships with lending institutions.

Designing an effective policy for assisting manufacturers of solar equipment will require overcoming a difficult problem. It is desirable to ensure that the results of federally sponsored development programs are widely disseminated and utilized. If the company performing the research is unable to maintain any proprietary interest in the product developed, however, it may be reluctant to invest in production (see Issue 5).

It will be necessary to ensure that no organization gains monopoly control over crucial areas of the solar industry and to ensure that small businesses are fairly treated (see Issue 6).

4. Providing assistance in developing equipment standards and a testing capability in private testing la boratories..

*These numbers refer to the next section of the report, which is organized around several crucial issues and provides a more complete discussion of these topics

This assistance would be valuable because it could help to alleviate concerns about performance and reliability which have been a major barrier to sales.

RESEARCH AND DEVELOPMENT SUPPORT

Federal support for basic research and development of small solar energy equipment can clearly accelerate the rate at which new types of solar devices reach the market. The investment required to develop most of the onsite equipment considered in this assessment may be consistently smaller than that needed to develop operational systems using synthetic fuels, fusion, or advanced fission reactors. As a result, it should be possible to explore a wider range of small, onsite technologies than if the same amount of funds were invested in developing technology for larger, more centralized equipment. This means that investments can be made in promising, but high-risk projects without committing large amounts of Federal capital.

On the other hand, if the Federal Government does not provide the relatively modest funding required for development of onsite solar equipment, the effect will amount to a disincentive; that is, the current disproportionate Federal research emphasis on nonsolar technologies would place solar equipment at a disadvantage in relation to subsidized energy supplies

LEGAL AND REGULATORY CONSIDERATIONS

Policies Governing the Relationship Between Utilities and Onsite Generating Equipment

The vast majority of all energy consumed in the United States is generated and sold by electric and gas utilities utilizing large, centralized equipment. As a result, State laws and regulations governing the operation of small energy generating equipment are frequently archaic, and sometimes confusing, In some cases, they can present serious barriers to the use of onsite equipment:

- In some States the owner of an apartment building or shopping center would apparently be unable to sell solar-derived energy to clients or customers without filing as a public utility. The procedural complexity of operating as a utility would almost certainly prevent the installation of onsite equipment.
- Laws establishing the right of utilities to own and operate energy generating equipment located in buildings not owned by utilities are frequently unclear.
- There is no well-established procedure for ensuring that utilities will provide backup power for onsite equipment at rates which would be fair to all parties, and there are no procedures governing the rates at which utilities should purchase energy from onsite generating systems during periods when such facilities are generating more energy than is needed onsite. The analysis of the legal aspects of onsite energy equipment which appears in chapter VI of this report indicates that these utility-related problems are the principal legal and regulatory issues likely to require immediate attention.

Policy alternatives for dealing with these issues fall into two categories:

1. Policies designed to clarify the rights of owners of onsite energy equipment Alternatives include:
   - Exemption of onsite equipment from regulation by public utility law (some definition will be required to distInguish "onsite" equipment from conventional utility equipment),
   - Establishment of the right of owners of onsite energy equipment to purchase power from existing utilities at fair rates.

— Establishment of the right of owners of onsite energy equipment to sell energy to electric utilities at fair rates

2. Policies designed to encourage utility ownership of onsite equipment, to perm it flexibility in joint ownership projects, and to clarify the difficulties which might arise if a utility owned or operated equipment located in buildings not owned by the utility.

The techniques available for implementing these utility policies depend critically on whether a statement of Federal jurisdiction in this area, such as the one contained in the proposed National Energy Act of 1977, becomes law. If Congress finds that "the generation, transmission, and sale of electric energy and the transportation and sale of natural gas affect interstate commerce, and that adequate and reliable supplies of electric energy and natural gas are necessary for the general welfare and national security,"[1] the options discussed above can be directly implemented by Federal legislation requiring State utility commissions to impose the regulations and procedures recommended. Otherwise, the Federal Government's power would be limited to persuasion, encouragement, and perhaps the provision of analytical support and guidelines for the recommended policies.

Sunrights

Another area which requires some attention is the issue of "sunlights. " Although there are presently no Federal laws designed to protect the right of an owner of solar equipment to have adequate access to sunlight, the analysis prepared for this study has indicated that probably none will be needed. The Federal Government could, however, facilitate efforts along these lines being made by State and local regulatory bodies. Options include the following:

— States could be encouraged to require new subdivisions, commercial malls, and industrial parks to formulate covenants which will protect the sunrights of al I property owners,

–The Federal Government could subsidize training programs for local planners and zoning officials which would help them to use local regulations more effectively to protect sun rights.

— The Federal Government could encourage States to confirm the rights of individual property owners to negotiate easements guaranteeing light and air, as has already been done in Colorado, and help prepare standard forms and recording procedures,

—A requirement to assess solar energy impacts could be added to the list of factors which must be considered in evaluating federally sponsored or regulated building projects, State governments could be encouraged to follow suit.

POLICIES THAT WOULD ESTABLISH FOREIGN ASSISTANCE PROGRAMS INVOLVING SOLAR TECHNOLOGY

These foreign assistance programs would have the objective of relieving stress on world fuel markets by helping to provide the means to use locally available energy. Such programs could also stimulate an overseas market for onsite solar equipment developed and possibly manufactured in the United States. Options for Federal policy include:

– Ensuring that onsite solar energy technologies be included in programs for foreign economic assistance whenever appropriate,

—Subsidizing the training of foreign nations in the skills needed to design, manufacture, and install solar equipment.

—Augmenting the funds available to international lending institutions for loans related to solar energy equipment.

[1] Proposed National Energy Act of 1977, Sectlon 501 (a)

–Providing a continuing international flow of information about products, technical developments, analytical work, and other progress made in solar equipment.

—Tailoring the U.S. research program to maximize its usefulness internationally whenever this is possible. (For example, if a choice between a complex and a simple approach is difficult. The decision may be tilted in the direction of developing a simple system, if international needs are considered.)

PROGRAMS IN EDUCATION AND PUBLIC IN FORMATION

One of the barriers to the introduction of onsite equipment is the shortage of architects, builders, system designers, installers, and operators familiar with the practical problems and advantages of the equipment. This could be remedied in a variety of ways:

–A program offering federally funded fellowships and scholarships in engineering and architectural programs.

— Federal assistance for midcareer training in the problems of designing energy-efficient buildings and industrial systems for architects, engineering consultants, and other relevant groups. This could be done under the auspices of existing trade associations.

—A program subsidizing labor union training programs designed to develop additional skills needed to install and operate on site energy equipment.

Another problem is the fact that most potential customers for onsite equipment will not consider it as a serious alternative when making purchasing decisions simply because they are unfamiliar with the approach. This could be remedied to some extent with programs designed to bring life cycle costing to the attention of prospective buyers (possibly through the auspices of lending institutions). It might also be useful to conduct brief training programs for professionals in a position to affect the decisions made by their organizations about building designs and the purchase of energy-related equipment,

POLICY OPTIONS FROM THREE PERSPECTIVES

Selection of a specific set of policies from the catalog of options just discussed is not an easy process since such decisions must be made without the comfort of confident forecasts about the long-term costs of solar or any other energy technology. Moreover, political judgments must be made about the ultimate value of the potential benefits of solar equipment which cannot be evaluated in conventional economic terms. The following section discusses three different perspectives on these issues, and presents groups of specific policies which might be chosen to meet each objective.

PERSPECTIVE A

It is sometimes argued that the Nation's energy requirements can be met, at least for the next several decades, by gas, coal, and nuclear sources — and without dramatic cost increases, a dangerously high proportion of imports, or unacceptable environmental risks. Adherents of this position believe that these sources will last until their use is superseded by a new technology — fusion being the most commonly mentioned. It is assumed that this *new* technology will provide energy at prices very close (in constant dollars) to those charged for electricity today. In this view, solar energy would play only a minimal role; indeed, its only function would be to serve as a kind of insurance against the failure of fusion to develop into a usable technology.

From this perspective, it is logical that Federal policies concerning solar energy

should be limited to: (a) those designed to eliminate obstacles to development and use of the technology, and (b) those providing for basic research. Such research would be of a comparatively low priority and could not be expected to have an impact on the commercial energy market for many years. The resources committed to the effort would be relatively modest.

In more specific terms, the following policies would appear to be consistent with Perspective A.

POLICY OPTIONS FOR PERSPECTIVE A

Incentives for Owners of Buildings

1. Amend the National Housing Act to make it clear that Federal Housing Administration (F HA) insurance can be given to solar energy projects under Title I (for retrofit of solar devices and for mobile homes) and under 203b (for new construction).
2. Amend the Federal Home Loan Mortgage Corporation Act (FHLMCA) so that the Federal National Mortgage Association will be empowered to provide a secondary market for mortgages and loans covering onsite solar energy equipment.
3. Amend the National Housing Act to permit Federal Housing Administration Title I funds to be used as second mortgages associated with Farmers Home Administration (FmHA) loan guarantees.
4. Provide funds to ensure that techniques for measuring the performance of collector and storage systems are developed by the National Bureau of Standards or its designers and that these techniques are rapidly communicated to private testing laboratories.
5. Require that all collectors and onsite storage systems sold be accompanied by literature clearly showing the equipment's standardized performance characteristics as measured by reputable laboratories.

Programs to Provide Information About Solar Equipment and Education Programs for Designers and Installers

1. Require that any energy audits conducted of Federal buildings, and any standards established for Federal purchase and rental, include an analysis of the potential contribution of solar energy equipment for heating, cooling, and cogeneration.
2. Require similar energy audits of all housing and building projects which receive any Federal assistance or which are under the jurisdiction of Federal agencies (this would include public housing, housing repossessed under defaults in FHA, Veterans Administration (VA), and FmHA loan guarantee and insurance program s,)
3. Provide midcareer training for public officials in a position to make judgments about building designs and energy-related equipment for Federal buildings. Such training would familiarize them with solar technologies, design alternatives, and techniques for evaluating their economic merit.
4. Subsidize midcareer training programs for architects, engineers, and interested builders.
5. Establish a university fellowhsip and scholarship program which would provide training in areas of science and engineering relevant to solar energy development programs.
6. Develop standards for emerging solar equipment and certify testing laboratories.

Research and Development

From this perspective, the most profitable strategy would be to fund a number of basic research projects, looking for ways to dramatically reduce costs or improve the performance of solar equipment. An orderly procedure would be developed to test the many advanced concepts which have been

proposed before making any decision about large-scale demonstrations.

Analysis of Policy Options Above

1. **Effectiveness.** – These policy options have limited objectives. They would remove obvious impediments to wider use of solar technology, but they would not greatly accelerate the rate at which solar equipment enters the market. Commercial markets could well overtake federally sponsored efforts.
2. **Cost.**– Since most of the elements of this policy are regulatory in nature, the proposals would cost very little. The only direct expense involved would be for energy analyses of buildings (investments which should be cost-effective) and training programs.

PERSPECTIVE B

A second view holds that the future price and availability of all nonsolar fuel sources is very uncertain and that solar-based technology holds real promise of playing a major role in supplying energy in the near future. Those who accept this view also believe that the real price of fossil fuels could increase by as much as as a factor of 2 or 3 and electricity prices increase by as much as 50 percent over the next two to three decades and that the price levels for energy produced by such planned nonsolar technologies as fusion may be high enough to make solar technology competitive.

Thus, they feel that solar technology should be treated on an equal basis with all other promising new energy sources. This perspective would require additional Federal action as outlined below.

POLICY OPTIONS FOR PERSPECTIVE B

All of the Policies Discussed Under Perspective A (except as modified below)

Incentives to Stimulate Market

1. All owners would be given an investment tax credit of 20 percent on qualifying solar equipment (including heating, cooling, process heat, heat pumps and other applications requiring mechanical drives, and electric generation). After a 5-year experiment with these incentives, depreciation schedules would revert to standard and tax credits would be reduced to 10 percent. Homeowners and owners of residential apartment buildings, however, would retain the right to use credits and depreciation schedules permitted for industry. Refunds would be made if the credits exceeded tax liability.
2. An easy-to-use computer program would be subsidized to evaluate the effectiveness of a variety of solar hot water, space-heating, cooling, and electric generating systems which may be used on typical building types. The program would be adjusted for each climatic region and would need to be updated annually to maintain current information about costs and performance. Such a program could be developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASH RAE) or some other professional society with Department of Energy (DOE) support. It should be flexible enough to reflect local climatic conditions and building costs, and to assess the potential of the equipment when used on a number of typical building types. It should provide practical information about anticipated initial and life-cycle costs, which should be based on a predetermined consumer discount rate (perhaps 10 percent for homeowner-owned units and higher for commercial systems). Life-cycle costing would be based on an assumed rate of increase in conventional energy costs to be established by DOE. The program should be accessible on a time-sharing basis via computer terminal and telephone from as many regions as possi-

ble. It should be made simple to understand, easy to operate, and inexpensive to run.

3. The National Housing Act, the Serviceman's Readjustment Act, and the acts establishing the Federal National Mortgage Association (FNMA), the Federal Home Loan Bank Board, and the Farmers Home Administration could be amended to require that all applications for guarantee, or mortgage insurance, and all mortgages eligible for repurchase by FNMA or the FHLMA be accompanied by a document showing that the building has been reviewed for energy efficiency under an approved procedure which includes assessment of the potential of solar equipment. The Federal analysis program described above could be used for this purpose. This would permit both the prospective borrower and lender to review the current and future costs of supplying energy for the building and to give both parties an opportunity to analyze the value of solar equipment in reducing these costs. It would, in effect, be equivalent to legislation requiring that the efficiency of consumer products be clearly shown whenever the items are sold.

4. All Federal buildings, including defense installations in the United States and abroad, and all buildings operated under Federal auspices (e.g., public housing, repossessed housing) would be reviewed to establish the cost effectiveness of solar equipment. Funds would be provided for retrofit installations wherever cost-effectiveness was established. The Administration should be instructed to determine the circumstances under which existing appropriations to subsidize operating costs of federally owned buildings and buildings operated with Federal subsidies could be diverted to capitalize solar equipment under current legislation and regulations.

5. The Adminstration should be required to examine the following grant programs to determine what funds appropriated in these areas can be used to subsidize the purchase of solar equipment (see Issue 4 for details):

   - –The community development block grants.
   - – Housing rehabilitation programs (Section 21 3).
   - – Homeowner grants (Section 302).
   - — Homeowners incentive demonstration programs (Title IV).
   - — Housing finance interest subsidies.
   - – Funds allocated by the Energy Conservation and Production Act for renewable technologies.
   - –Grants administered for energy conservation by the Administration on Aging (HE W).
   - —Grants administered for energy conservation by the Social Services Administration.
   - — FmHA grants for improving rural homes so that they can meet code requirements.
   - – Grants made under the Public Works and Economic Development Act.
   - –Any other grant programs which the Administration feels might be used to purchase solar equipment.

Incentives for Manufacturers

1. Allow qualifying manufacturers of solar equipment a 20-percent tax credit and 3-year depreciation allowances on machinery used in producing solar energy equipment. These incentives would apply to equipment purchased during the next 5 years.

2 Require the administration to conduct a study that would evaluate the desirability of a variety of alternative cost-sharing programs which would be effective in subsidizing manufacturers' relevant research in solar energy, which could be made available to the public

in some form, and yet at the same time protect the patentability of devices developed in part with private funds.

3. Measure cost sharing in terms of the fraction of a company's total assets which it is willing to make available for Federal cost sharing (instead of requiring small companies to compete directly with larger concerns in total dollars available for cost sharing).
4 Subsidize the development of a computer model which would facilitate the analysis of the detailed performance of a variety of different onsite solar devices attached to realistic building and industrial loads. Ensure that the widest possible group of system designers and engineers have access to the program, (An attempt should be made to ensure that existing work in this area is not duplicated. The Canadian Government, for example, has apparently developed a similar program for use by Canadian designers).

Research, Development, and Demonstration (RD&D)

A balanced program of research, development, and demonstration should be developed and carefully integrated with the requirements of the industries which will manufacture, install, and support the equipment developed. The program should include the following areas:

PASSIVE HEATING AND COOLING

Work needs to be done to design and make instrumented tests of buildings matched to a large variety of climatic conditions Other research topics in this area which would benefit from additional work include:

- Computer simulations of passive building designs.
- Studies of retrofit potential of passive buildings,
- Demonstration of passive facilities for livestock, storage, and other nonresidential application

ACTIVE SPACE-HEATING SYSTEMS AND SOLAR WATER HEATING

A number of advanced collector designs (used both for heating and air-conditioning) remain in preliminary stages of development. Devices include improved plastics for inexpensive collectors, air-inflated collectors, nontracking concentrators, tubular collectors with and without simple concentrators, simple booster devices, one-axis tracking devices using mirrors or lenses, and a variety of other systems.

SOLAR COOLING

Solar cooling is not a commercial technology but a number of different concepts are ready, or nearly ready for demonstration. These include advanced absorption, adsorption, and Rankine cycle devices and integrated total energy systems with fossil fuel used as a backup.

AGRICULTURAL AND INDUSTRIAL PROCESS HEATING

A number of commercial products are available in the lower and intermediate temperature ranges.

Demonstrations in this area should include:

— Drying for agricultural products;

— Desalinization;

– Process water for washing, textiles, paper, food processing, and other low-temperature applications; and

— Irrigation pumping,

Research work would include the development of inexpensive collectors for low (150° to 250° F) temperature, intermediate temperature (250° to 500°F) and high temperature (greater than 5000 F) applications.

THERMAL STORAGE

A variety of techniques have the theoretical potential for providing large amounts of thermal storage at very low cost. Development of such technologies would remove

many of the problems faced in providing backup power for solar energy devices. It should be possible, for example, to build systems capable of providing 100 percent of the heating and hot water requirements of apartment buildings or clusters of houses using large tanks of water (with earth providing the principal insulation), ponds, trenches full of hot rock, aquifer storage of hot water, storage in in-situ rock, and other techniques. Research in more advanced thermal storage systems (multiple tank, salt gradient, phase change, organic and inorganic chemical reaction devices, etc.) is also needed and much work remains incomplete.

SOLAR THERMAL ELECTRIC

work needs to be done on development of collectors, integration of solar devices with end-use equipment, improved heat-transfer systems, receivers, heat engines, and many other components which would increase design flexibility and reduce costs.

Development of low-temperature Rankine engines, high-temperature Stirling and Brayton cycle engines, and improved small steam cycle systems is needed. Research in advanced materials (particularly ceramics) would be useful for both collector and engine designs.

Work on systems integration needs to be done to identify promising concepts in a broad range of potential applications of small and intermediate size.

Research on electric storage systems is a critical factor. Work is needed on a number of advanced lead-acid, high-temperature, aqueous, and REDOX batteries, as well as in mechanical storage concepts such as flywheels, underground pumped hydro, and others. Thermochemical storage systems could greatly reduce the cost of storing and transporting solar energy for use in thermoelectric systems and in direct high-temperature process applications.

PHOTOVOLTAICS

Areas **where research would be useful include:**

–Advanced research on amorphous silicon, thin film materials (e. g., CdS, III-IV heterojunctions, organic substances and dyes), amorphous silicon, polycrystalline silicon, concentrator cells (GAA1As, multifunction cells, high efficiency silicon thermophotovoltaic devices, interdigitated back contact cells, vertical multifunction cells, etc.). Basic research on semiconductor properties of interesting materials.

–Systems analysis and engineering of control systems for practical application, installation problems, mounting racks, cleaning, cogeneration studies and designs, heat exchange designs, plumbing, etc.

–Silicon solar array technology (pilot plant for polysilicon production, full-scale demonstration of advanced crystal growing and slicing machinery, subs idizing design of large-scale fabrication and production facilities, advanced encapsulation, etc),

—Concentrator development (unique problems associated with cell attachment, cogeneration, heat rejection) for a range of concentrators including: dye concentrators, lens, and mirror systems.

DISSEMINATION OF RESULTS

Ensure that results of Federal RD&D programs exploring technology for heat engines, thermal and electric storage, collector designs, and other subsystems which can be **used in onsite solar energy equipment are widely disseminated to the diverse community of institutions and individuals working on onsite solar equipment.**

DEMONSTRATION AND RESEARCH STRATEGY

Develop and propose a program for the demonstration of a comprehensive spectrum of onsite solar energy systems. This would include (but not be limited to) the following:

— A detailed plan for the demonstration of the range of solar thermal and solar

electric facilities from existing simple hot-water and heating systems to larger, more complex, and perhaps more experimental devices

—A systematic program for developing and demonstrating a large number of subsystem technologies which are applicable to small onsite units but which could be enlarged or aggregated for larger systems. For example, concentrating collectors developed for onsite applications could provide valuable information on designs that would be useful in larger facilities Smaller demonstrations would permit a greater variety of technologies to be tried.

– A strategy for identifying intermediate and long-term markets for onsite solar energy systems. The plan should examine a variety of potential applications, the significance of regional variations in climate, energy prices, and other factors.

A fixed sum should be set aside with the single purpose of funding innovative small-scale energy technologies that show promise These monies would be distributed as direct prizes or grants to all types of inventors in typical amounts of $50,000 to $100,000 The selection of these projects should be performed by panels of qualified experts drawn from a broad cross-section of equipment developers and designers, including, among others, independent inventors, manufacturing firm researchers, university engineering and science staffs, consulting engineers, and personnel from Government laboratories Application procedures should be as simple as possible to encourage broad participation; the program should be widely advertised; and winners should be announced with fanfare,

Develop a system to subsidize proposals made by small organization. This might include a procedure by which brief submlssions from qualifylng small businesses would be screened for initial technical merit. Small grants might then be awarded to assist them in developing the proposal.

Underwrite the testing of solar equipment developed by small companies, such testing to be conducted in Federal or private laboratories.

Foreign Assistance

1. Ensure that programs developing priorities for Government-supported research and federally sponsored studies include an assessment of the potential for overseas sales.
2. Encourage the development of skills related to solar energy in developing nations by providing fellowships as a part of an economic assistance program,
3. Encourage and expand joint research ventures with other governments and international organizations engaged in solar energy research.
4. Augment U.S. contributions to international lending institutions with the objective of encouraging onsite solar energy facilities in developing nations.
5. Provide foreign aid in the form of technical assistance for demonstrating onsite solar systems in less-developed countries
6. Any proposal for foreign economic assistance involving energy must consider onsite solar equipment on an equitable basis. Training should be provided for United Nations, Agency for Internation Development, and Peace Corps officials planning such programs. Outside experts in this area should be utilized to facilitate a review of proposals.

Policies Affecting Public Utilities

Assuming that involvement in regulation of public utilities by the Federal Government has been established as a legitlmate activity under the "interstate commerce clause" of the Constitution, the following policies could be established by Federal legislation.

1. No organization which generates less

than 5 MW of thermal or electric energy will be regulated as a public utility unless this status is desired by the organization, In the latter instance, conventional regulatory procedures would apply. The nonregulated organization would be permitted to generate and sell energy to all consumers in its immediate area, without limitations on' the prices charged or income earned. A study should be commissioned to determine if this size threshold should be increased.

2. No organization which generates less than 5 MW of thermal or electric energy shall be required to obtain a certificate of convenience and necessity from local utility regulatory commissions in order to construct a plant (unless it has asked to be regulated under existing utility statutes).
3. The Administration should be instructed to examine the Sherman and Clayton Antitrust Acts and the Public Utility Holding Company Act to determine whether they prevent utilities from owning onsite energy equipment. If they do so, amendments should be proposed which would remove such barriers.
4. Any studies conducted by utilities to determine fair pricing policies for selling electricity and for purchasing electricity from industrial "cogenerators" must be expanded to include an analysis of the costs of supplying backup power to a variety of types of onsite solar electric generating facilities.

Effectiveness

It is always somewhat perilous to forecast the impact of any program for providing tax subsidies since consumer behavior can be unpredictable. Table III-1 indicates the effect of a 20-percent tax credit on the perceived cost of solar energy provided by a variety of different types of solar equipment, assuming that consumers utilize a life cycle costing technique to determine average energy costs. It can be seen that the tax credit would have the effect of reducing the cost of solar energy by 0.5¢ to 3¢/kWh. The more the solar system costs, the greater the tax credit and the greater the effective Federal subsidy. The table also shows the cost of the subsidies to the Government as a result of loss of tax revenues. The direct costs shown, however, significantly overestimate the net cost of the subsidies because extra tax revenues will result from production in-

Table 111-1 .—The Effective Cost of Solar Energy in Omaha, Nebr., for 20 Percent Investment Tax Credit [¢/kWh]

	No incentives	20 percent Investment Tax credit	Direct Federal subsidy •
Solar hot water	2,0- 4.2	1.4-3.3	0.6-0.9
Solar heating and hot water	3.0- 7.7	2.0-6.6	1.0- 1.1
Heating and hot water with seasonal storage	3.8- 6.9	2.5-4.7	1.3-2.2
Solar heating hot water and cooling	6.0	4.0	2.0
Solar Photovoltaic electricity	3.8-11.8	2.8-9.1	1.0-2.7

'This is the effective cost of the subsidy to the Government rellting from the tax revenues because of the tax credits It is calculated assuming that the Government applies a 10 Percent discount rate to future costs (See text)

Assumptions 1985 startup of equipment
The price ranges reflect the cost differences expected in the variety of residential equipment see Volume II Chapter IV

creases by businesses manufacturing and installing solar equipment, and from increased sales in supporting industries, such as the manufacture of glass and primary metals. This revenue would at least partially offset the direct revenues lost because of the credits I t a dollar is spent on solar equipment manufactured in the United States rather than on imported oil, the U.S. gross national product (GNP) could be increased by $2 to $5 Since the average Federal tax revenue per dollar of GNP is about 20 percent, an incentive which encouraged a dollar Investment in solar equipment could yield as much as $().40 to $1.00 in added Federal tax revenue Since this revenue would be obtained close to the time when the subsidy was granted, its "present value" to the Government would be high.

Reducing the price of solar equipment also would be expected to expand sales and thereby encourage the introduction of mass product ion equipment in technologies where such equipment can be used effectively.

PERSPECTIVE C

A third perspective is an extension of the view just discussed (Perspective B). It contends that the cost of energy could soon climb rapidly because of increasing competition for limited supplies. In this view, the virtues of solar energy — notably its benign impact on the environment, its desirable impact on labor, its impact on reducing competition on world energy supplies, its ability to avoid monopoly ownership of energy sources, and its potential for reducing the risks of climatic change and nuclear proliferatlon — merit an aggressive promotional program, even if the technology is not expected to become fully competitive in conventional economic terms.

POLICY OPTIONS FOR PERSPECTIVE C

An example of the policies which would be added under this perspective include:

1. All of the policies discussed under Perspective A and B except as strengthened below.
2. All owners would be given an investment tax credit of 20 percent on qualifying solar equipment (including heating, cooling, process heat, mechanical drive, and electric generating devices) and would be permitted to depreciate solar equipment over a 5-year interval, These incentives would continue until Congress determined that they were no longer required to ensure the competitiveness of solar equipment.
3, The income from all loans made for solar equipment would be exempt from Federal taxation.
4. All manufacturers of solar equipment would be given an investment tax credit of 20 percent on qualifying manufacturing equipment over a period of 5 years. These incentives would continue until Congress determined that they were no longer required to ensure the competitiveness of solar equipment.
5. Federal purchases of onsite solar energy equipment would be required for existing and new Federal buildings constructed with Federal support, in all cases when it could be shown that the technology would be cost-effective based on a low discount rate (e. g., 3 percent) and a high assumed increase in the cost of conventional energy,
6. FHA minimum property standards would be required to include onsite solar equipment whenever an analysis demonstrated that the equipment would be cost-effective on the basis of approved analytical techniques discussed previously. (As a possible variant of this approach there might be a provision for subsidized interest rates to cover the incremental cost of solar equipment.)
7. Utilities would be required to inform all residential and small industrial and commercial customers of the savings

they might realize by installing a variety of different types of onsite solar equipment. The utilities also would be required to provide installers and financing for any projects selected by the owners of the buildings. The utility would be reimbursed with charges added to the owner's bill over a 10-year period. (This is similar to the program for insulating buildings proposed in the National Energy Plan.)

8. The price of electricity would be raised to a rate which reflects the marginal cost of providing electricity from the most recent plant placed online. And the price of oil would be raised to reflect the cost of adding additional oil supplies. The funds generated by the taxes required to do this would be redistributed in the manner proposed by the National Energy Plan.

9 It would be determined that the development of low-cost solar collection, conversion, and storage equipment is a major national priority. An aggressive research and marketing program with ambitious goals for cost reductions and installed capacity would be funded at a rate which would reflect the urgency of the priority given

10, A separate section of the Small Business Administration would be established solely to guarantee loans made for manufacturing equipment used to produce solar equipment.

11. Environmental legislation would be strictly enforced, conventional powerplants held to strict safety standards, and proposals for nuclear waste disposal be subjected to exhaustive examinations.

Research and Development

The development of solar energy equipment under this approach would be aggressively pursued as a major national priority. The basic categories of projects receiving support would be the same as those discussed under Perspective B, but funding would be given to a broad range of projects, marketing programs would be accelerated, and emphasis placed on both near-term and long-term approaches Part of the price of an accelerated program, judged to be acceptable because of the priority given the undertaking, would be an increase in funds wasted on designs which are eventually overtaken by better approaches. Proponents of this point of view argue that if the United States were willing to make a multi bill ion dollar commitment to a project to put man on the moon, a commitment of similar size would be justified to develop safe and reliable solar energy equipment.

Analysis

The incentives discussed in this perspective will, as expected, have a greater effect in reducing the cost of solar energy perceived by solar equipment owners, and will cost the Government more to implement. Table I I I-2 indicates the impact of a group of policies which consist of:

– A 20-percent investment tax credit,

–A 5-year depreciation allowed for all solar equipment, and

– Exemption from property taxes

It can be seen that these credits reduce the effective cost of residential solar energy by 1.5¢ to 6¢/kWh

ISSUES

ISSUE 1

What changes in the Federal tax laws would be the most effective in encouraging private investment in solar equipment?

How much would such policies cost the taxpayers?

The tax laws can provide powerful incentives for the use of solar equipment without

Table ill-2.—The Effective Cost of Solar Energy in Residential Buildings in Omaha, Nebr., [¢/kWh] With a High Level of Incentives

	No Incentives	Incentives*	Direct Federal subsidy**
Solar hot water	2.0- 4.2	0.8-2.0	1.6-2.2
Solar heating and hot water	3.0- 7.7	1.1-4.1	1.9-3,6
Solar heating and hot water with seasonal storage. . .			
Solar heating and hot water with seasonal storage. . .	3.8- 6.9	1.3-2.9	2.5-4.0
Solar heating, cooling, and hot water	6.0	2.2	3.8
Solar photovoltaic electricity	3.8-11.8	1.2-5.7	2.6-6.1

. FullIncentives consist of a 20 percent investment tax credit, an allowed 5 year depreciation schedule, and exemption from property tax

"" This is the effective cost of the subsidy to the Government resulting from the tax revenues because of the tax credits It is calculated assuming that the Government applies a 10 percent discount rate to future costs (See caveat in text)

Assumptions 1985 startup of equipment
See volume II for details of systems analyzed

the need for major Federal intervention in the operations of the free market. Several alternatives are possible:

1. **A direct income tax credit. Such credits would allow the taxpayer to subtract a fixed fraction of the initial installed cost of solar equipment from his income tax Since these credits are deductions from taxes rather than from income, they would apply equally to al l applicants provisions must also be made so this program is fair to low income families who are not now required to file tax returns and to families whose tax credits exceed the taxes they owe The effect of different types of tax credits is illustrated in figure III-1.**

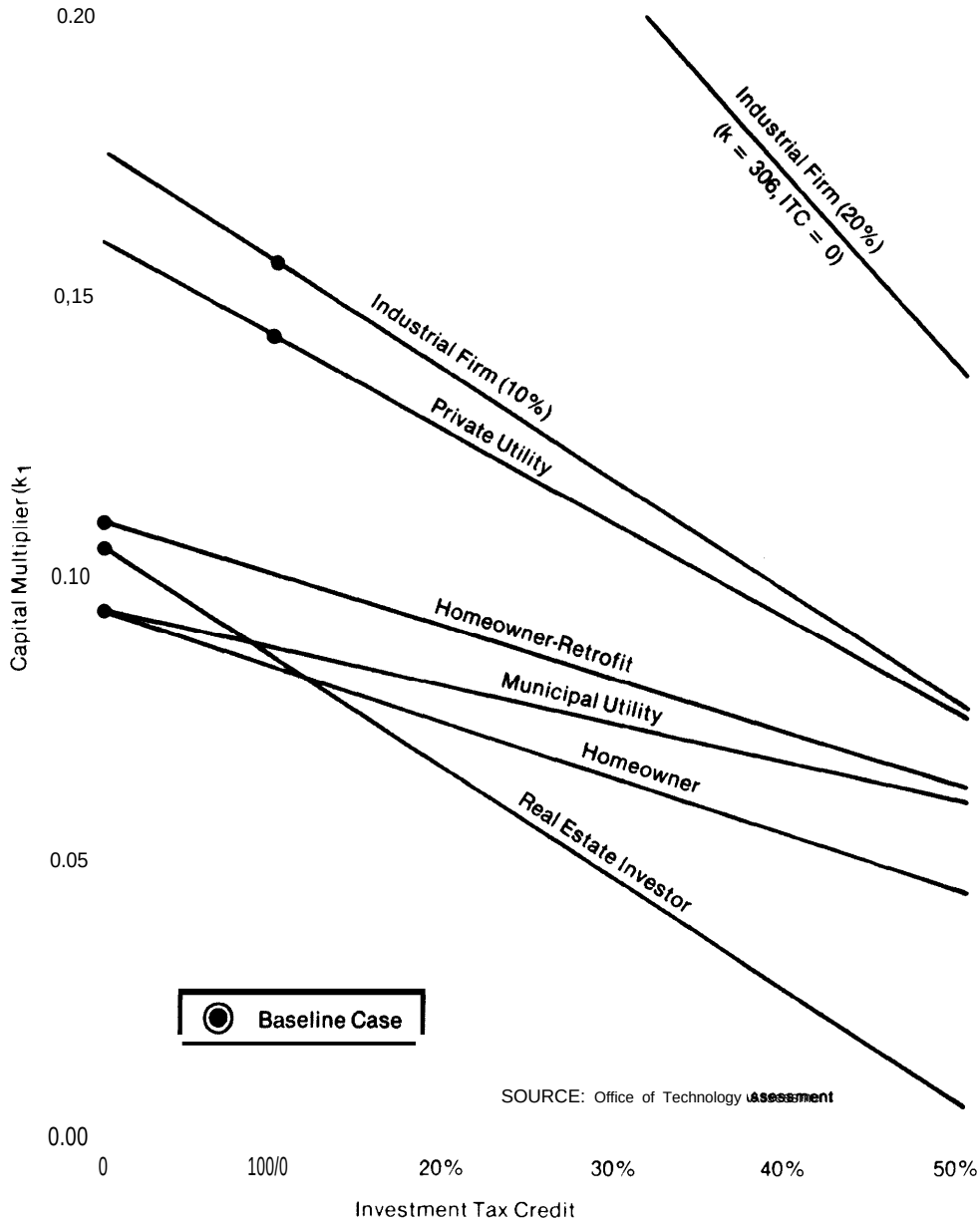
   Under existing laws, tax credits are permitted for some commercial and industrial equiprment, but not for investments in buildings, Nor are they allowed for heatlng, cooling, or other energy-generating equipment i nstalled in buildings However, a company that install such equipment in a building it does not own — and then sells the energy produced –- would probably qualify **for** a **tax credit under present laws**

2. **Accelerated depreciation allowances. Accelerated depreciation allowances would be of greatest interest to corporations, utilities, and individuals in high tax brackets. No individual is presently permitted to depreciate equipment in his own home, although equipment installed in the home by a company which sells energy could depreciate the equipment.**

The effect of different types of depreciation schedules is illustrated in figure ıı I-2, Several observations can be made immediate y:

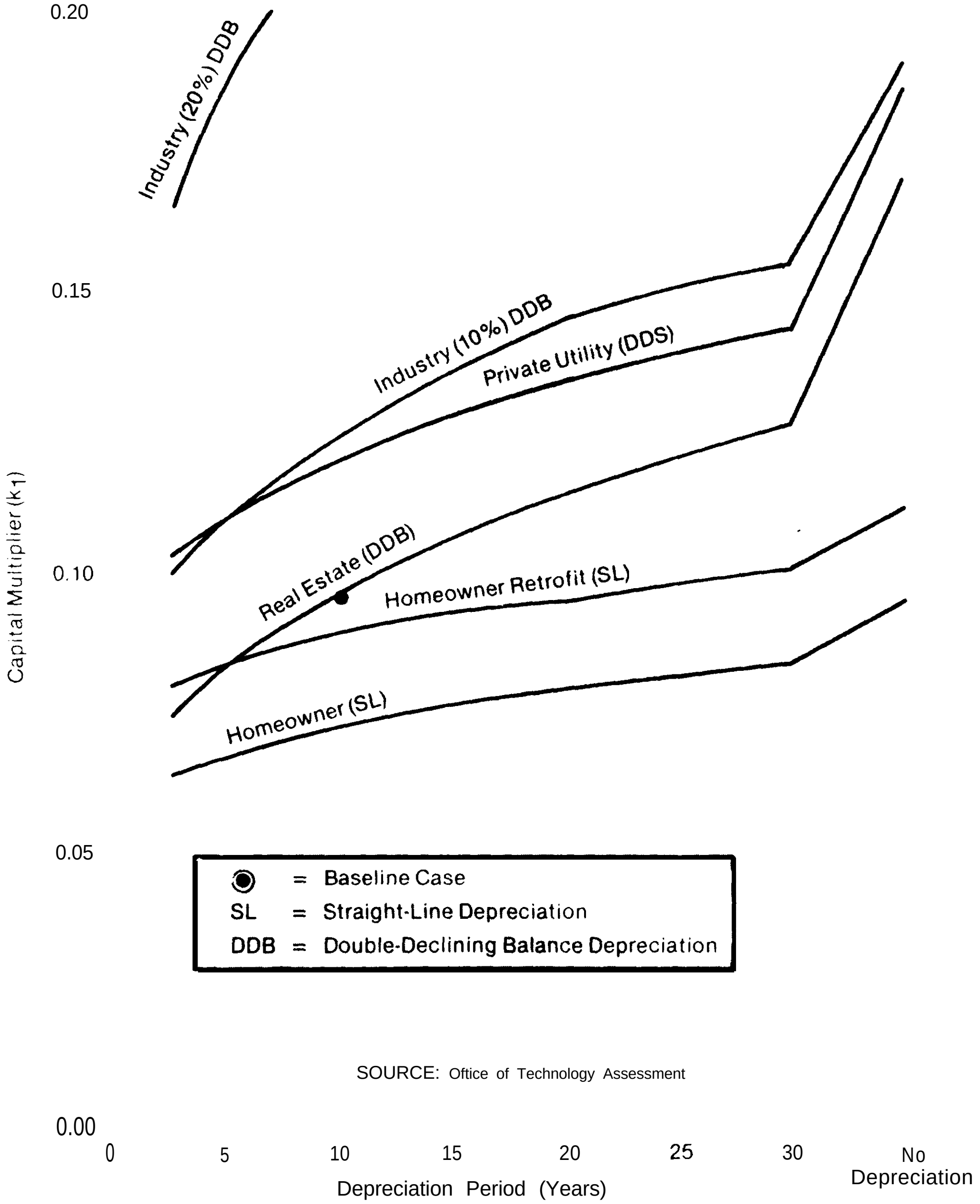
1. **Permitting a homeowner to depreciate the capital he invested in solar equipment over a period of 3 to 5 years would reduce his effective capital charges by about one-third Since institutional owners of energy-generating equipment are permitted to depreciate their equipment, the current tax policy forbidding homeowners to do this has the effect, if not the intention, of discriminating against the ownership of such equipment by the homeowner. (This incentive would be of greatest benefit to owners in high tax brackets)**

Figure III-1 .— Effective Capital Costs as a Function of Investment Tax Credit



NOTES
(1) The "effective interest rate paid on capital" shown here is the ratio between the capital-related component of the price perceived by the consumer and the total initial installed cost of the energy equipment in question. Capital-related expenses include return on debt, return on equity (unless the equipment is owned by the homeowner), taxes (with allowances for depreciation and other write-offs) and insurance.
(2) The baseline assumptions and the techniques used to compute the data shown on this figure are discussed in detail in the chapter on "Analytical Methods."

Figure III-2.– Effective Capital Costs as a Function of Depreciation Schedules



SOURCE: Office of Technology Assessment

NOTES

(1) The effective interest rate paid on capital shown here is the ratio between the capital related component of the price perceived by the consumer and the total initial installed cost of the energy equipment in question. Capital related expenses include return on debt, return on equity (unless the equipment is owned by the homeowner), taxes (with allowances for depreciation and other write offs) and insurance.

(2) The baseline assumptions and the techniques used to compute the data shown on this figure are discussed in detail in the chapter on Analytical Methods.

2. **Commercial, industrial, and utility owners can also be strongly influenced by altering policies on deductions for depreciation. In the cases shown in figure III-2, real estate investors, who expect a 10-percent return on their capital after taxes can reduce their capital-related costs by over one-third if they are permitted to depreciate equipment rapidly. The effect is even greater for an industrial owner expecting a 20-percent rate of return.**

PROPERTY TAXES

Property taxes can add as much as 10 to 25 percent to the cost of solar energy. The taxes, of course, are imposed entirely by States and municipalities and vary greatly around the country (see table 11 1-3). I n some urban areas in the northeast, for example, taxes are so high that an investment in on-site solar equipment would be prohibitively expensive for many individuals and companies. Figure I I I-3 illustrates the substantial effect of removing a "typical" property tax since, in most cases, the tax increases the effective investment cost by nearly 10 percent.

Some problems may arise concerning the property taxes paid by utilities and other organizations if they own solar equipment. Because in many cases these organizations pay taxes at much higher rates than those paid by individuals, there would be a disincentive to invest in solar equipment. Whether this is desirable must be decided. Another decision is whether to exempt companies which manufacture solar equipment from property taxes. There might also be some confusion about charging the property taxes in a case where a utility or other private concern places equipment on a house or building and charges the building owner for the energy produced.

Property taxes are not imposed by the Federal Government and therefore cannot be removed with Federal legislation. It may be possible to use Federal programs to encourage local governments to remove property taxes, perhaps by agreeing to compensate them in some way for lost revenues attributable to solar property tax exemptions or to penalize States which do not reduce property taxes by withholding Federal solar subsidies. The National Energy Plan proposed by the Administration states that it

Table III-3.—Property Tax Rates in Selected U.S. Cities

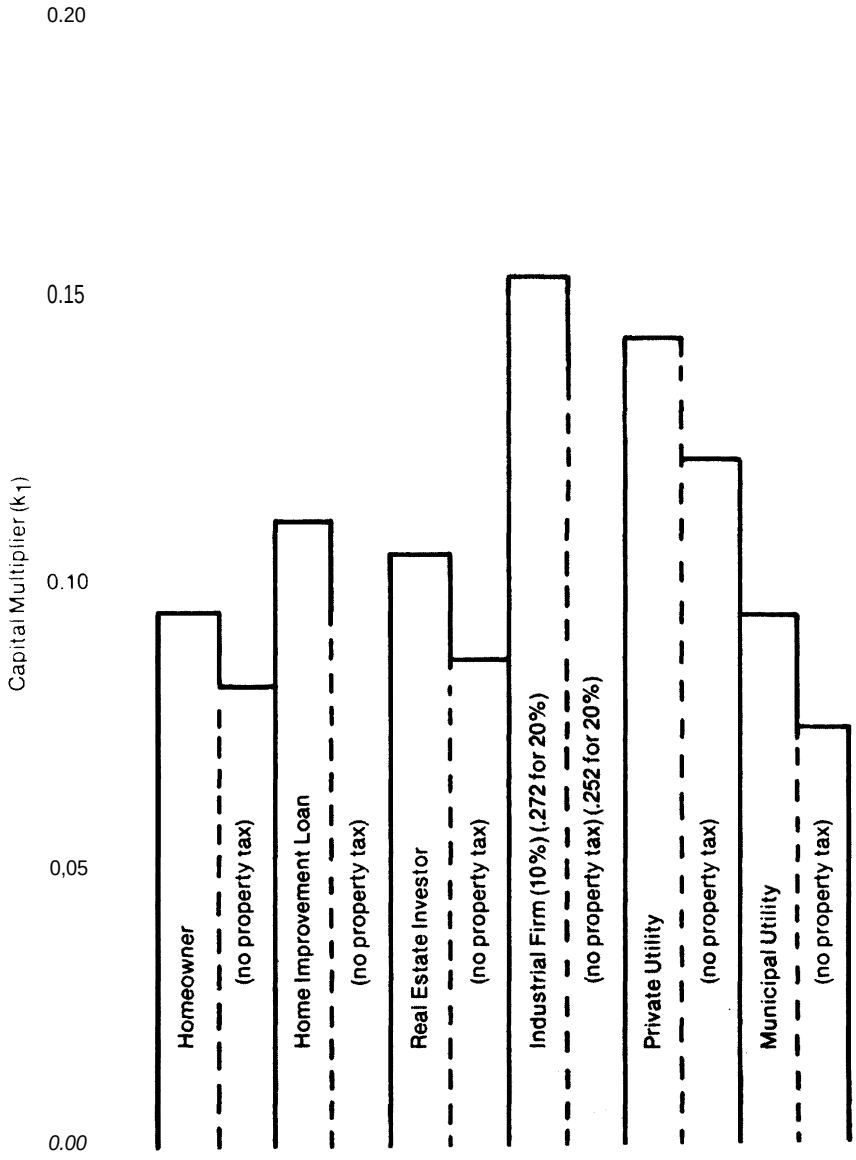
Residential Property Tax **Rates in Selected Large Cities: 1974**

City	Effective Tax Rate per $100 Rank	Rate	City	Effective Tax Rate per $100 Rank	Rate
Boston	1	$5.94	New York City	16	$2.18
Buffalo	2	4.31	San Francisco	17	2.13
Milwaukee	3	3.63	Cleveland	18	1 88
Los Angeles	4	3.43	Seattle	19	1.82
San Antonio	5	3.43	St. Louis	20	1.80
Indianapolis	6	3.29	Memphis	21	1 77
Baltimore	7	3,24	Denver	22	1,71
Pittsburgh	8	2.82	Jacksonville	23	1. 69
Philadelphia	9	2.80	New Orleans	24	1,69
Chicago	10	2.75	Kansas City	25	1,57
Detroit	11	2.73	Phoenix	26	1.55
Dallas	12	2.60	Washington, D.C.	27	1.54
Houston	13	2.38	Nashville	28	1 39
Atlanta	14	2.24	Cincinnati	29	1.31
San Diego	15	2.23	Columbus	30	1.17

,– OTA Baseline assumption **$200**

SOURCE: Government of the District of Columbia, Department of Finance and Revenue, *Tax Burdens in Washington D C Compared with Ma/or State and Local Tax Burdens in the Nation's Thirty Largest Cities 1974.*

Figure III-3.— Effective Capital Costs With and Without Property Taxes



NOTES

(1) The 'effective interest rate paid on capital' shown here is the ratio between the capital related component of the price perceived by the consumer and the total initial installed cost of the energy equipment in question. Capital related expenses include return on debt return on equity (unless the equipment is owned by the homeowner) taxes (with allowances for depreciation and other write offs) and insurance.

(2) The baseline assumptions and the techniques used to compute the data shown in this figure are discussed in detail in the chapter on Analytical Methods.

SOURCE: Office of Technology Assessment

would be desirable for the States to exempt solar devices from property taxes, and several have already done so.[23]

SALES TAXES

Sales taxes also lie beyond the Federal sphere, but they, too, can present an impediment to the installation of solar equipment. Here again, the rates for sales taxes vary from State to State. In Connecticut it is 7 percent, in Nebraska it is 2.5 percent, in New Hampshire there is none.[4] Removing the tax from sales of solar equipment would be of some benefit in reducing initial costs. However, an exemption would not have as great an effect as the property tax exemption which must be paid each year.

The Cost of Tax Incentives to the Government

The cost to the Government of changes in tax policy can be computed from the data in figures II l-l and II l-2 if it assumed that the Government and the private investor use the same discount rate (see volume 11, chapter I). This is done by finding the difference between the "effective cost of capital" which would apply with and without the change in policy. For example, if the effective interest rate paid on capital applied to a real-estate investor is 10.6 percent without a tax credit and 8.6 percent with a 20-percent credit, the average annual loss of revenues to the Government during the life of the equipment is simply 2 percent of the initial cost.

ISSUE 2

Will difficulties in obtaining loans hinder the installation of onsite solar-energy equipment? If so, can Federal authority to regulate the mortgage reduce such problems?

'The National Energy Plan, p 76

'National Bureau of Standards, Survey of State Legislation in Solar Energy

'The World Almanac and Book of Facts 1977, Newspaper Enterprise Association, Inc , Cleveland & New York, p 105

SUMMARY

The short answer to the first question is: probably, at least for a while. Banks and other lending institutions are understandably reluctant to invest in mortgages for residential buildings that plan to use costly new energy equipment with unproven market value, since they might not be able to recover the value of such loans i n a foreclosure sale. They are similarly reluctant to provide funding for commercial and industrial equipment if the owner cannot convince them that the system will produce a favorable cash flow during the period of the loan. Present statistics about the marketability and performance of most types of solar energy equipment are inadequate to support actuarially sound decisions, and few prospective lenders appear to have seen what little information is now available. Although solar devices with proven characteristics can be expected to gain gradual acceptance in the lending industry, the question of whether the Government can or should accelerate this process has not been resolved.

The Government has successfully used loan guarantee and mortgage insurance programs in the past to induce private lending institutions to provide funds for projects deemed socially desirable; Federal Housing Administration (FHA) and Veterans Administration (VA) have made loans available to prospective homebuyers for decades. The Government is also in a position to alter current banking practices through the great variety of regulatory and secondary mortgage institutions which operate under Federal charter, The potential for using these organizations to stimulate loans for solar programs is discussed below,

THE PROBLEM

In the absence of adequate information on the reliability, lifetimes, and marketability of solar equipment, many banks are reluctant to include solar devices in the value of mortgages made on residential buildings. In a recent survey by Regional and Urban Planning Implementation, Inc. (R UP I), 63

percent of the lending institutions interviewed Indicated that they would "exclude the excess cost (of solar equipment) from the appraised value of the house" for loan-making purposes, and an additional 22 percent indicated that they would lower the loan-to-value ratio of the loan. [5] The average loan actually issued by the institutions interviewed covered 55 percent of the value of the solar devices. ' (However, the institutions felt that it solar devices were deemed to be an actuarially sound investment, they would lend funds for the devices at the same rates they charged for other types of building loans.) Most of the solar loans were issued for expensive custom-built homes, and in many cases the owners or builders had an established relationship with the lender. [7]

This reluctance to issue loans for solar devices is accentuated both by the fact that most banks are simply unaware of the informat ion gathered about solar equipment, and by the tact that very few lending institutions take energy costs into account when determining the ability of a prospective borrower to meet mortgage payments.

Most lending institutions do not include an applicant's projected energy bills in an assessment of his ability to meet mortgage payments But this practice is changing. Forty percent of the lending institutions interviewed in the RUPI study indicated that since 1973 energy considerations had influenced lending decisions "a great deal" or had become "critical" in lending decisions, and 50 percent stated that the importance of energy in these decisions would increase.[8] Most banks rely primarily on the principal, interest, taxes, and insurance (PIT I) evaluation technique, which compares a prospective borrower's income before taxes to the PIT I costs which he must bear to support his investment in a home. Since the borrower is equally committed to carrying the energy costs of his home, there has been speculation that the PIT I formula may be expanded to include energy costs (although this is not now a common practice).

Lack of information about home energy consumption and the value of solar equipment makes it difficult for institutions to evaluate energy costs, even if they have a desire to do so. Only 9 percent of the lenders interviewed in the RUPI study had seen estimates of solar energy savings, only 4 percent had seen cost benefit analysis for solar equipment, and only 9 percent had seen an installed solar device or plans for an operational system. [9]

THE EFFECT OF MORTGAGE POLICY ON SOLAR COSTS

The availability of financing can present a major barrier to rapid introduction of solar equipment. The effects of loan-to-value ratios on overall capital costs are shown in figure III-4 and the effect of changing interest rates is shown in figure III-5. The results require some interpretation:

— From the perspective of a present value analysis, the fraction borrowed has relatively little effect on the capital costs perceived by the homeowner, given the assumption that the owner uses a 10-percent discount rate to evaluate future costs. This is because the discount rate chosen in the calculation is close to the interest rate charged for the loan. The fraction borrowed can have a much greater effect than figure III-4 indicates, however, since the requirement for a large downpayment can be a prohibitive barrier.

–The fraction borrowed strongly affects the prices which must be charged by industrial firms and, to a lesser extent, the prices charged by the hypothetical real estate investor. This is simply due to the fact that the investors expect a much

[5] Regional and Urban Planning Implementation Inc (R UP I), Home *Mortgage Lending and Solar Energy,* February 1977, p 13 (Prepared for the Division of Energy, Building Technology and Standards, Office of Policy Development and Research, HUD)

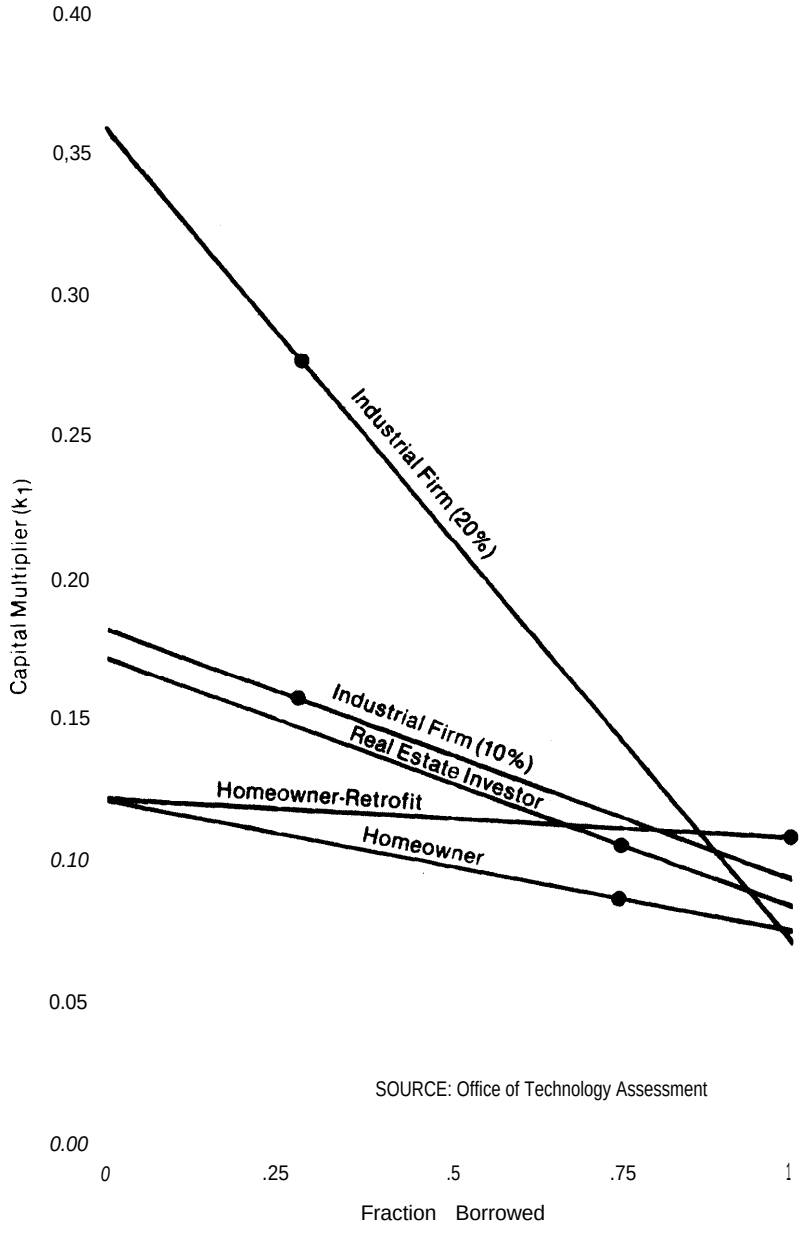
[6] Ibid , p 99

[7] Ibid

[8] RUPI, p 52

[9] RUPI, p 61

Figure ill-4.—The Effect of Loan-To-Value Ratios on Overall Capital Costs

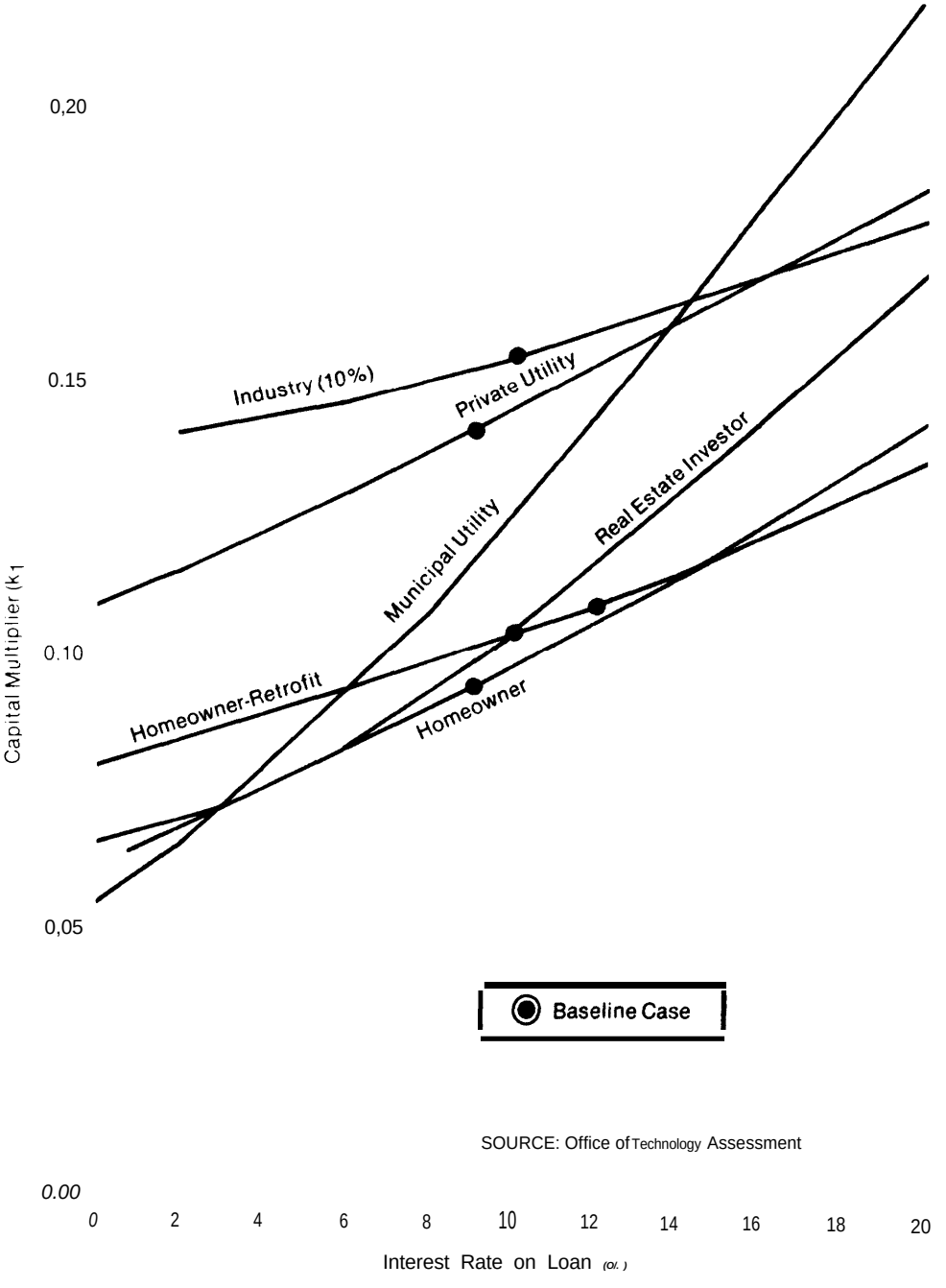


SOURCE: Office of Technology Assessment

P.U. = .142
M.U. = .095

NOTE
The baseline assumptions and the techniques used to compute the data shown on this figure are discussed In detail In the chapter on "Analytical Methods "

Figure ill-5.—The Effect of Interest Rates on Overall Capital Costs



SOURCE: Office of Technology Assessment

NOTES
(1) The "effective interest rate paid on capital" shown here is the ratio between the capital-related component of the price perceived by the consumer and the total initial installed cost of the energy equipment in question. Capital-related expenses include return on debt, return on equity (unless the equipment is owned by the homeowner), taxes (with allowances for depreciation and other write-offs) and insurance.
(2) The baseline assumptions and the techniques used to compute the data shown on this figure are discussed in detail in the chapter on "Analytical Methods."

higher return on their capital than the interest rates assumed for the loan.

— Interpretation of the effect of interest rates on loans is straightforward. The policy issue raised here is one of finding a way to persuade lending institutions to risk investments in solar equipment.

Figure I I I-6 shows the results of a recent survey of the reaction of a number of lending institutions to a number of proposed policies. It is apparent that the lenders are not interested in tax incentives which assist potential owners. They are much more interested in performance certification of the devices and in Federal insurance and secondary markets for mortgages.

Many existing Federal programs insure or subsidize loans to promote objectives deemed socially desirable. These programs are discussed in the following section. How-. ever, one difficulty with a policy that creates such distortions in the loan market is that the implicit subsidies are extremely difficult to calculate, Encouraging the use of capital in one area necessarily removes the capital from other applications; thus, it is never clear who, if anyone, suffers as a result.

Another option for encouraging lending institutions to make financing available to potential owners of solar equipment would be to find some way of requiring lending institutions to include estimates of the borrower's ability to cover utility costs in the process of estimating the borrower's ability to pay back the loan. This type of analysis might often benefit solar equipment owners. Several techniques for doing this are discussed.

A SOLAR LOAN PROGRAM

A program which made loans more attractive to potential solar customers would have several generic advantages over tax incentives:

1, They avoid complicating the tax laws. Recent tax reforms have attempted to separate Government incentives programs from the revenue-raising function of the Internal Revenue Service.

2. The benefits of a subsidized loan may be easier for a prospective buyer to understand and its impact is more immediate. It is apparent that consumers of solar energy equipment must be persuaded to make purchases on the basis that their net monthly payments for energy will be lower if they install solar energy equipment. It is easier to make comparisons between conventional and solar billing when loan incentives are provided.

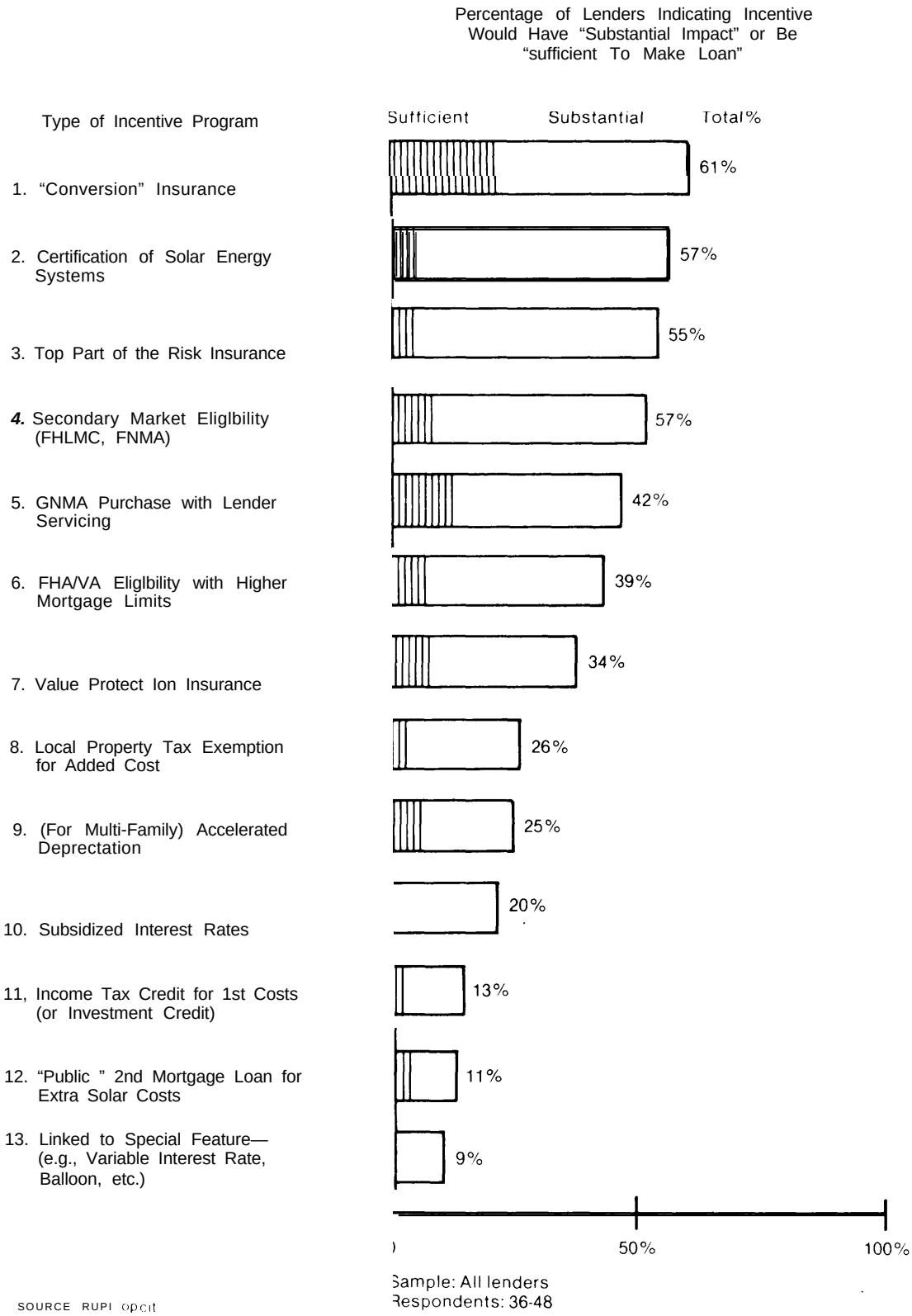
   A tax rebate requires owners to tie up their own capital while waiting for a refund. This wait can create real financial difficulty and the delayed gratification can have a psychological impact reducing the attractiveness of the incentive.

3. It may be easier for low-income families to take advantage of a loan program which requires a relatively small downpayment, for example, than a program which requires negotiating loans from conventional sources. It is interesting to notice that loan incentives may be more attractive to low-income homeowners than to homeowners with large incomes. Families in high-income tax brackets pay a lower effective interest rate since interest is deductible, and would therefore not benefit as greatly from an incentive which lowered the interest rates and hence their deduction.

4. If it is possible to place the loan as a part of a mortgage package used to finance an entire building or house, it may be possible to reduce the cost of administering the program and appraising the solar equipment. If tax programs are used, the IRS must presumably find a way to make independent audits of the projects.

Loan programs, of course, are not without problems. They can be complex and costly to administer, particularly if it is necessary to establish a separate bureaucracy to over-

Figure III-6.— Lender Perceptions of Likely Impact of Incentive Options on Loan Decisions



SOURCE RUPI opcit

see the operation of the program. Lending institutions constantly complain about the amount of paperwork required by Federal regulatory authorities and this paperwork can contribute significantly to the cost of a loan. Since the costs of paperwork are nearly Independent of the size of the loan, loan subsidies may not be an detractive technique for encouraging the installation of solar equipment costing less than $1,000 to $1,500. In these cases, it is much more likely that the purchaser will be able to make a single payment for the equipment and a direct grant or tax credit would be easier to administer.

There has also been some concern about loan support programs which commit the Government to administering programs over a term of many years.

The significance of all of the problems cited here depend on the details of how the loan program is administered. Concern about long-term Federal commitments can be reduced, for example, by simply having the Government make a single payment to a lending institution which would administer the loan, to cover the difference between the return received from a subsidized and a commercial loan.

If the Government uses an 8-percent discount rate (roughly the current cost of long-term Government bonds) a 3-percent loan covering 95 percent of the cost of a solar system owned by an individual homeowner has roughly the same effect on average monthly costs as an investment tax credit of 34 percent. If the system is owned by the owners of an apartment building, the loan would be equivalent to a credit of about 62 percent. The Government cost associated with the loan program for homeowners would be about the same as that for an investment tax credit of 29 percent (assuming no loan placement fee).

EXISTING FEDERAL LOAN PROGRAMS

The Federal Government has a great variety of programs for subsidizing and regulating the U.S. financial community. These fall into the following categories:

1. Direct Federal loans and programs which subsidize the interest paid to private lending institutions;
2. Programs which "guarantee" loans with a contract in which the Government agrees to purchase a mortgage offered by a private investment company if the borrower defaults (typically the debtor is then still liable to the Government for the outstanding funds and must either sell the property or permit the Government to sell it for him);
3. Loan "insurance" programs, in which the Government charges the borrower a small annual fee and agrees to reimburse the lender in the event of a default;
4. Federally chartered but privately owned "secondary mortgage" institutions, which purchase mortgages from primary lenders in order to free the funds of these lenders for further mortgages; the Federal National Mortgage Association can borrow funds directly from the Federal Treasury; and
5. Regulatory institutions which oversee the operations of banks, savings and loan institutions, and other lending organizations,

Each of these programs and organizations could retard the installation of solar equipment or, if Federal leverage is applied, accelerate it.

Direct Federal Loan Guarantees for Buildings

Most direct Federal loans are issued to projects designed to serve low-income groups–urban housing projects, hospitals, homes for the aging–although some funds are available for experimental communities and new energy equipment. Any direct loans for solar equipment will have to compete with their use for urgent social programs. It may make sense to increase funding in these direct-loan programs to reduce dependence on long-term Federal support for operating

costs (see discussion in the previous issue), The major direct-loan programs are:

Programs Administered by the Department of Housing and Urban Development (HUD).– 1) Public *Housing:* The Housing Act of 1937 (section 5) permits the Federal Government to directly finance housing for low-income families and the elderly through federally guaranteed municipal bonds. Additional funds are allocated each year to allow "modern i z at ion" of existing structures These programs do not have specific goals for energy conservation, although the properties must meet certain minimum HUD standards. Energy conservation features could be included in these standards.

(2) *Housing for the Elderly and the Handicapped:* **Section 202 of the Housing Act of 1959 provides loans for nonprofit sponsors of new or substantially rehabilitated rental housing for the elderly or the handicapped. The program also has no standards specifically designed for energy conservation. The projects constructed under this section, however, tend to be initiated by experienced and sophisticated managers, contractors, and architects, who are more likely to be attracted to novel energy systems than are the builders of public housing projects, which have been plagued by cost overruns, defaults, and tenant problems,**

Programs Administered by the U.S. Department of Agriculture (USDA). — The Department of Agriculture has two large Federal loan programs for low- and moderate-income rural families that could have applications for solar technology.

The first is a new conservation program under the Farmers Home Administration (FmHA), a $500 million to $1 billion project announced on February 28, 1977. Under this program, customers of electric cooperatives can receive 8 percent loans, repayable through their monthly electric bills, for such conservation measures as weatherization, storm window and door installation, and installation of attic cans, to a maximum expenditure of $1,500 a family. No new Federal appropriations or authorizations were necessary for this program; the money is left over from the FmHA's Section 502 home-construction loan program. But the conservation guidelines do not permit structural work, thus precluding solar installations. No legislation would be necessary to change the regulations; it could be done administratively within the Agriculture Department

The second large program is the Rural Electrification Administration (REA) loan program to electric cooperatives. There are two parts to this program — a direct loan authority of $75 million to $900 million (in FY 76) to cooperatives for electric distribution and transmission facilities. This program would appear to have no solar applications. However, a second REA program would. It is an open-ended REA loan-guarantee program, again to co-ops, for construction of electric generating facilities.

These loans, at prevailing interest rates, are made by a commercial bank or, more commonly, through the Federal Financing Bank within the Treasury Department. In calendar 1976, such REA-guaranteed loans totaled $3.7 bill ion,

There are no restrictions, either under the law or under REA regulations, as to what type of electric generating facility may be made with the REA-guaranteed loans. Thus, a solar electric generating plant could qualify for such a loan – at least so far as REA is concerned — assuming that the lending institution and the local electric co- operative conclude that the solar installation would be cost-effective.

The two largest impediments to using this large Federal program to foster the solar market would seem to be (a) the need for a backup system (a small diesel generator could suffice) and (b) the problem of convincing banks and co-op officials that a solar generating facility would be practical (when it is possible to make such a case). REA officials stress that their agency's mission is not to experiment with new or novel technologies, but to provide electricity to rural customers at the cheapest possible rates.

Programs Administered by the Small Business Administration (SBA).– The SBA has funds available for subsidizing loans to qualifying small businesses. These funds might be useful to firms manufacturing or installing solar equipment, since such firms tend to be quite small.

Loan Guarantees

Veterans Administration (VA).– The Serviceman's Readjustment Act of 1944 allows the VA to guarantee loans to qualifying veterans for residential buildings with one to four units. The program guarantees about 350,000 units a year, The loans can be made for any amount and cover 100 percent of the value of the property. There are no energy-conservation requirements, although the VA will only insure property which meets "minimum property standards" established by the FHA.

Federal Energy Administration (FEA).–The Energy Conservation and Production Act provides loan guarantees for a wide range of conservation and solar energy equipment. Regulations governing the application of the funds were still being drafted in mid-1977.

HUD Loan Guarantee Programs.–Amendments to the Housing Act of 1968 authorize HUD to make loan guarantees for privately developed new towns and for a variety of community facilities. To date, the program has extended guarantees to 13 new towns, some of which have projects for solar heating and cooling funded under the ERDA/-HUD solar heating and cooling demonstration program.

Mortgage Insurance

The Housing Act of 1934 established the Federal Housing Administration (FHA) and the FHA Insurance Fund to allow families with low and moderate incomes to obtain mortgages at reasonable rates, The program has since expanded to include apartments, cooperatives, nursing homes, and group medical practice facilities, The insurance program collects premiums from borrowers and provides a fund to reimburse lenders in the case of defaults. The value of interest rates allowed for FHA-insured loans varies and has recently been below the rate charged by the private mortgage insurance companies. In 1977, home-purchase loans financed under Section 203b charged 8-percent interest; home-improvement loans under Title I charged 12 percent.

FHA's direct participation in the mortgage market is diminishing. It now insures only about 17 percent of the loans made on 1- to 4-unit nonfarm residential buildings. The program is still extremely influential, however, if only because of the standards it sets for residential structures. All older homes purchased with FHA insurance must be appraised by the FHA and receive a "Certificate of Reasonable Value, " which forms the basis of the loan amount. New homes can be insured only if they meet FHA's "minimum property standards, " As noted earlier, these standards form the basis for many other Federal loan programs. They are also widely used by private lending institutions as the standards of value. Builders designing low-cost housing have, in many cases, chosen to meet these standards, since housing quality that did not measure up to them would have reduced the avail a-bility of financing for potential buyers.

The FHA standards reflect both the quality of the construction and its marketability. No firm policy has been established for solar-energy devices, although a 1974 amendment to the FHA law permits the use of FHA loans for solar equipment (The amendment may have been unnecessary, as FHA loans were used during the 1930's to purchase solar water heaters in Florida.)

Current FHA solar standards of performance quality employ the National Bureau of Standards " Interim Performance Criteria" for solar devices. " The major difficulty,

[10] Public Law 94-385, Title IV, section D

[11] 'Title IV of the Housing Act of 1968, amended as Title VII of the Housing Act of 1970

[12] RUPI, p 133

[13] FHA document FPMC-FHA, dated February 19, 1976

however, will not be the quality of the equipment but whether it will contribute to the resale value of the house. FHA is particularly sensitive on this point, since it deals primarily with low- and middle-income families to whom initial housing costs are important, A recent FHA publication noted that in inspecting property with solar devices, "[the] field office must also determine that a ready market exists for the property with the increased cost of the solar equipment."[14] An applicant failing to obtain FHA certification for a solar device has the right to a hearing before the local FHA office The results are difficult to predict and wi ll doubtlessly depend on the officials' familiarity with costs and benefits of solar equipment. Failing to obtain a direct FHA loan, the applicant has the option of utilizing a H U D " Experimental Housing Program (Section 233). "

HUD's experimental housing program is designed to provide an incentive for the construction of innovative or unconventional housing systems that do not meet the conservative standards of the FH A certification processes. The program's larger purpose is to develop familiarity with experimental designs that will provide the basis for altering the FHA standards.[15] Unfortunately, influence of experimental programs on traditional housing has not been notable thus far,

Loans for home improvement and mobile homes insured under Title I do not require a preinspection, although FHA audits projects after loans are granted. Up to $7,500 can be obtained without security.

The proposed National Energy Act would amend the act establishing these loan guarantee programs in three ways:

1. Section 110 would add public utilities to the types of institutions which can place loans for energy-conservation equipment insurable by FHA.
2. Section 111 clarifies the definitions for energy-conserving equipment and solar-energy devices.
3. Section 112 provides an opportunity to use Title I funds for experimental energy equipment but at higher interest rates than those conventionlly charged for home improvements, Actual rates would be determined by a study conducted by the Secretary of HUD.

Federally Chartered Secondary. Mortgage Institutions

Many of the mortgages issued for residential buildings in the United States are not held by the primary lending institution for the full mortgage period. Instead, they are sold to organizations which are more interested in holding notes over a long period and which use the primary lenders as agents to acquire them. Selling mortgages to a secondary-mortgage institution frees the assets of the primary lender, who is then able to use these funds to issue further mortgages. The Federal Government sponsors two of the largest purchasers of secondary loans: the Federal National Mortgage Association (called "Fannie Mae" by generations of brokers unable to pronounce FNMA), and the Federal Home Loan Mortgage Corporation (alias "Freddie Mac").

Primary lenders are critically interested in ensuring that their loans will be repurchased by these organizations. If the secondary-mortgage institutions are negatively inclined toward solar equipment, this could affect the willingness of primary lenders to approve loans involving such equipment. According to the RUPI study cited earlier, both FHLMC and FNMA have indicated that "until solar systems achieve some degree of market acceptance, they may conclude that incremental first costs should be largely, perhaps even entirely, excluded from the mortgageable value for the purpose of their programs,'" The manager of FNMA appraisals was quoted as saying that if "people

[14] FPMC-FHA 76-8

[15] Orville Lee, Director of HUD's Section 233 programs, private communication, 1977

[16] Title 12 (Banks and Banking, subchapter I I 1, 171 6a)

wish to experiment they should do so with their own money, not someone else's."[17]

On the other hand, the quasi-public nature of these organizations makes them susceptible to public-policy guidance.

The Federal National Mortgage Association was established by Congress in 1934 to "provide supplementary assistance to the secondary market for home mortgages by providing a degree of liquidity for mortgage investments, thereby improving the distribution of investment capital available for home mortgage financing" and to provide special assistance for special purposes. It purchased about $7 billion in loans in 1974.[18] It raises funds by private subscription, but has "backstop" authority to borrow directly from the Federal Treasury. Five of its 15 board members are appointed directly by the President of the United States, Fannie Mae can purchase loans guaranteed by FHA or other institutions [section 1717(b.1)] at full value. It can also purchase conventional uninsured loans, subject to restrictions on the loan-to-value ratio and other limitations [section 1717(b.2)]. About 85 percent of its loans are purchased from mortgage bankers.

The FNMA tends to place great reliance on the judgment of primary lenders, and as a result, its lending policies tend to be determined by the values of the mortgage banking industry.

The Federal Home Loan Mortgage Corporation operates under the auspices of the Federal Home Loan Bank Board (FHLBB) and primarily serves savings and loan institutions. The Corporation purchased approximately $1.5 billion in loans in 1974. The members of the board of the FHLMC are appointed by the FHLBB, who in turn are appointed by the President. The Corporation acts under regulations established in the Federal Home Loan Bank Act, It raises funds, entirely by subscription, from the institutions it services. The FHLMC's regulations place more risk on the primary lenders. For example, the FHLMC can require the primary lender to take back a repurchased loan if irregularities are discovered.

The proposed National Energy Act would amend the charters of both the FHLMC and FNMA, to make it clear that funds can be used for loans for "energy-conserving improvements to residential real estate."[20] Solar devices are not explicity mentioned, but their inclusion may have been intended.

Regulatory Authority

Nearly 97 percent of all loans granted in the United States are issued by lending organizations subject to some kind of Federal regulation. Savings and loan associations, for example, are tightly controlled by the Federal Home Loan Bank Board. The Federal Deposit Insurance Corporation regulates mutual savings and commercial banks. Neither appear to have a specific policy for encouraging or discouraging energy-related loans.

ISSUE 3

Can purchases of solar equipment for Federal buildings be used to stimulate the solar industry?

A major program for installing solar equipment on Federal buildings could be one of the Government's most powerful tools for encouraging the development of mass production of solar equipment by private industry.

Consider the following:

- The Federal Government owns or leases approximately 446,000 buildings in the United States, with a combined floor area of nearly 3 billion square feet and was spending almost $1.7 bill ion annually by mid-1977 to heat and cool them. (That figure was expected to

[17] Barrett, Financing the Solar Home, NSF Grant APR 75-18360 (June 1976), p 141

[18] Barrett, *op cit.,* p 139

[19] Barrett, Financing the Solar Home, NSF Grant APR 75-18360 (June 1976), p 139

[20] Title 1, sections113 and 114

reach $1 9 billion by the end of 1977, and about $3.5 billion by 1985,) If 10 percent of the present heating/cooling costs were capitalized — used for debt payments for the purchase of solar equipment — the Government could purchase nearly 100 million square feet of solar collectors annually. *

- The Federal Government subsidizes operating expenses, including heating and cooling costs, of a large number of projects built with Federal assistance. The Department of Housing and Urban Development alone paid more than $575 million in 1977 to subsidize the operating and energy bills of the nearly 1 million units of public housing administered by subsidized local housing authorities If 10 percent of this were capitalized, the Government could support the purchase of nearly 30 million square feet of collectors annually.

Ž It would be difficult for the Government to encourage private concerns to install solar equipment if it is not using solar equipment on its own buildings.

In spite of the enormous potential, Federal programs for purchase of solar equipment have been proceeding quite slowly, largely because of concern about the cost effectiveness of solar devices. This concern is often magnified by the inability of program administrators to accurately evaluate the costs of solar techniques, I n some cases, required formulas for determining the worth of a Federal investment (i. e., fixed limits on building costs, and present value computations with high discount rates) have inhibited these programs.

The opportunity to use Federal buildings for experimental energy equipment raises three difficult but important questions:

1. What should the Government use as a "discount rate" to evaluate alternative investments?

There is a considerable amount of disagreement among analysts on this point Some argue that the Government should make decisions with the same expectations of return as private investors This view was formalized in a ruling by OMB, which held that the Government should only invest In equipment which would result in a 10-percent return on investment since this rate "represents an estimate of the average rate of return on private investment before taxes and after inflation."[21] Others argue, however, that the free market does not necessarily accurately assess the social costs of investments and that the Federal Government should therefore use investment criteria which better reflect social costs. Even if this basic principle is accepted, however, it becomes extremely difficult to determine what economic expectations are proper Investments must be assigned values based on concerns about the environment, social costs, benefits to labor, benefits to national security, the stability of resource supplies, and other criteria difficult to evaluate in conventional economic terms

When the Government makes an investment that pays less than the return which could be realized if invested in the free market, society is losing some of the value of that capital. This of course means that society is subsidizing the investment In some way. The exact amount of this subsidy, however, can be as difficult to quantify as the value society might realize from the investment.

Nonetheless, several discount rates can be used to evaluate Federal equipment purchases:

- 10 percent rate of return after taxes and before inflation: this technique would result in Federal investments in solar equipment which neither lead nor lag investments made by private industry.
- Use of a rate of return equal to the rate of the growth of the U.S. GNP: this

'Assuming $20 per square foot for an Installed system

"George P Shultz, "Discount Rates to Be Used in Evaluating Time-Dlstrlbuted Costs and Benefits, " OMB Circular A-94, Mar 27, 1972

would encourage Federal purchases of solar equipment and ensure that funds extracted from the economy by the Government were not affecting overall economic growth. (This would imply a real discount rate of 2 to 5 percent.)

- Require only that the Federal Government recapture its initial investment without earning a return on the funds: this would obviously be a stronger stimulus to Federal purchase of the equipment. (Zero percent discount rate.)

The effect of applying different Federal discount rates to prospective Federal investments is illustrated in figure III-7; the anticipated effects of three separate discount rates on Federal decisions to purchase energy equipment are shown in figure I I 1-8.

Figure ill-7.—The Effective Cost of Capital to the Government as a Function of the Discount Rate Used in Decisionmaking

(Assumptions methodology used in preparing this figure are discussed in detail in volume 11, chapter 1)

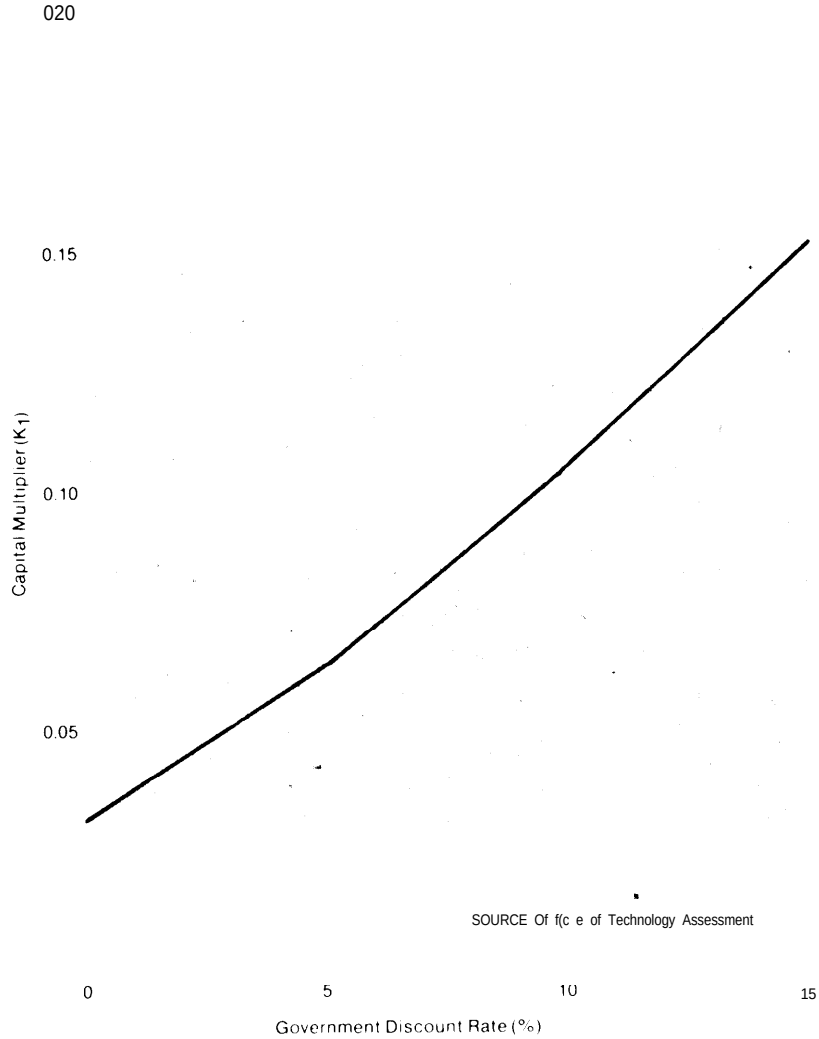
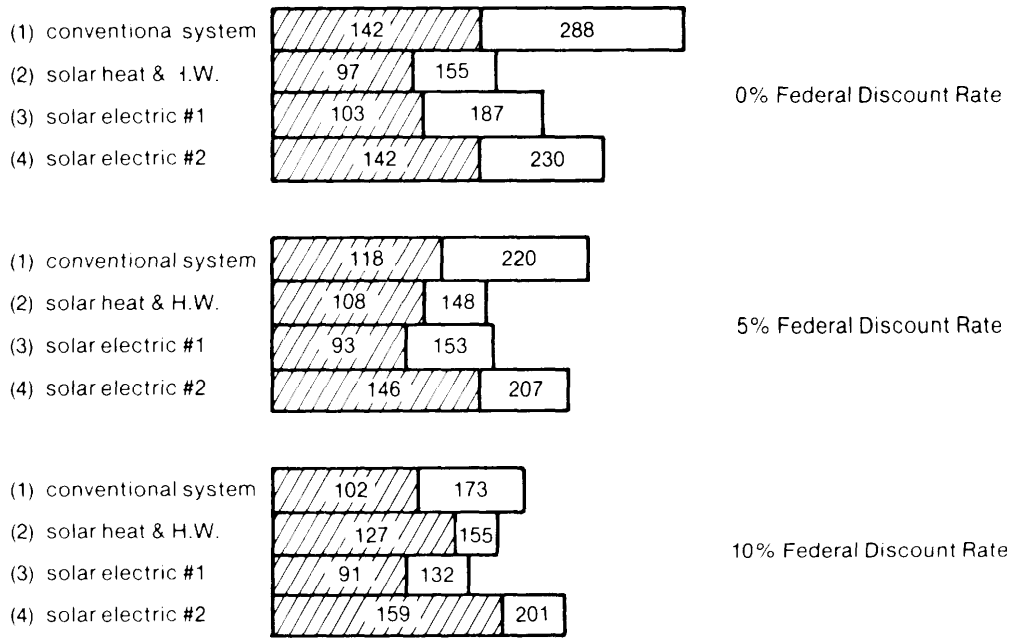


Figure III-8.—The Effect of Federal Discount Rate on the Perceived Cost of Federal Investments in Three Types of Solar Installations

(in $/month/unit in a 196 unit high rise apartment)



SOURCE: Office of Technology Assessment

ASSUMPTIONS

(1) conventional system is an all electric heating & cooling & hot water system using a two-pipe distribution system, central chilling units, and resistance heating elements in each unit

(2) solar heating & hot water system uses 4100 m^2 of flat plate collectors with cost 196 $\$/m^2$ installed (near term prices) and 1.2 million kwh low temperature thermal storage (seasonal in underground tanks

(3) solar electric #1 uses 2500 m^2 of two axis tracking collectors with GaAs photovoltaic cells. The collectors cost 102 $\$/m^2$ installed including collision optimistic estimate of future prices) 10000 kwh of low temperature thermal storage no batteries are used

(4) solar electric #2 uses 4263 m^2 of one axis tracking collectors with silicon photovoltaic cells. The collectors cost 300 $\$/m^2$ including the cost of the 15000 $/peak kW) the system has 17000 kwh of low temperature thermal storage and no batteries

assumes 1976 start up costs and electric prices increasing along BNL forecasts

assumes that electric prices increase by a factor of 5 over 60 = years (in constant dollars)

2. **If it is determined that the Government should subsidize the market in novel energy equipment, how should it select equipment?**

If it is assumed that the Government will **purchase equipment which cannot be justi**fied in traditional economic terms, values other than **those used by the free market must be applied This is a perilous undertaking since it runs the risk that the bureaucracy will select equipment which would not have been chosen by the market if it had been** given time **to develop along traditional lines, In extreme cases, mistakes might actually result in slowing the rate at** which solar equipment enters the market **if the Federal stimulus results in accelerating the installation of less desirable devices, thereby diminishing interest in** *promising* **alternatives. At a minimum, any Federal procurement program must be carefully integrated with an overall plan to promote a market for solar equipment as discussed** in the section reviewing overall policy alternatives.

3. What future fuel prices should the Government assume when evaluating the cost-effectiveness of solar technologies for specific applications?

THE POTENTIAL OF INDIVIDUAL AGENCIES

Department of Defense (DOD)

The Department of Defense operates 380,000 buildings with a total floor space of 2.5 billion square feet. " This includes 260,000 units of family housing in the United States. It recognizes that energy costs are becoming a major burden and a program is now underway to install a variety of solar-equipment designs on several typical DOD building types. Some of the projects are funded by DOE; some are funded internally. The projects include:

- –Shopping centers at Kirkland and Randolph Air Force Bases (heat and cool).
- –Administration building at Fort Hood (heat and cool).
- — High-temperature water from concentrating collectors at Fort Carson, Colo.
- —132 residential units on 16 Air Force, Navy, and Army bases (heat).
- –Three Army Reserve centers (heat and cool).
- — 50,000 square feet of classroom at Fort Huachuca, Ariz.
- –Air Force Academy housing (heat and cool, funded by USAF).
- – Refrigeration at the Navy regional medical center at Orlando, Fla.

According to a study conducted for DOD by the BDM Corporation, solar photovoltaic cells can compete with many generating devices now used to provide electricity to remote sites, (Standard DOD techniques were used to measure cost-effectiveness.) The study estimated that DOD could purchase over $100 million of silicon solar cells annually without subsidy if the current price of cells dropped by about 50 percent.[23] DOD is also testing the applicability of solar power in several new DOD construction projects and indications are that the results, if promising, will be phased quickly into other DOD construction and modernization projects.

Veterans Administration (VA)

Several solar projects have been proposed in the VA's 5-year plan:

- Retrofit of the San Diego VA Hospital for solar heating and cooling.
- A solar-assisted heat pump for a new VA hospital to be built in Palo Alto, Cal if.
- Solar hot water systems for three new hospitals under construction.
- 20 other projects were in the design stage for FY 77; 40 more were i n the preliminary design stage for FY 78,

The VA's 171 hospitals are built, operated, and maintained by the VA itself, rather than by the General Services Administration (GSA), which is responsible for acquisition and maintenance of the VA's non hospital facilities (these are discussed under the GSA program). Fuel expenditures for the 171 VA hospitals amounted to $23.5 million in FY 75.

VA officials have informally indicated that the agency's hospital system could accommodate 120 solar installations, at a cost of some $32 million. They estimate that retrofit would save $1.6 million annually in fuel costs and that this saving could be diverted into a principal/interest debt repayment fund for the solar equipment. " To accomplish this, the VA's 5-year Energy Plan would have to be revised. But apparently no legislation nor additional funding would be required.

"ERDA-76-6, pp 71, 75.

[23] "DOD Photovoltaic Energy Conversion Systems Market Inventory and Analyses, " Prepared for DOD and FEA, spring 1977

[24] Clark Granninger, VA, 1977

U.S. Postal Service (USPS)

An FEA-sponsored study found that **USPS "owns or operates approximately 75 million square feet of floor space in 36,000 buildings. " Of this floor space, approximately 80 percent is concentrated in *750* buildings. "**

The USPS has two solar demonstrations underway: a new post office building under construction in Ridley Park, Pa., and a retrofit project in Boulder, Colo A study is being made of the possibility of designing solar equipment for a standardized building design which the USPS could use in many parts of the country.

The USPS leases more than 80 percent of its buildings from the private sector, and the agency has the legislative authority and administrative flexibility to work any kind of variation on utility payment responsibility At present, however, it has no positive program for promoting the use of solar power in its leasing program. The agency has not developed a comparative cost analysis system, but USPS officials feel that regional USPS personnel are professionally competent, as well as definitely inclined, to solicit solar as part of its leasing program if encouraged to do so.

General Services Administration (GSA)

The General Services Administration has jurisdiction over all Federal office space, with the exception of post offices, DOD facilities, VA hospitals, and certain other specialized facilities It has installed solar equipment on only two Federal buildings — one In Saginaw, Mich , the other in Manchester, N.H. Planned projects include:

- **. Heating and cooling facilities i n a new Border Patrol building at Marfa, Tex.**
- **Ž Heating and cooling facilities at Federal office buildings in Denver, Colo , and Carbondale,** Ill,
- **Solar heating and cooling facilities at a Forest Service building in Arizona**
- **Regional GSA adminstrators are soon to make recommendations for solar energy projects for one or two GSA buildings in each region of the country,**

GSA's ability to install solar equipment is limited by the fact that in recent years it has often chosen to lease buildings rather than to purchase them.

Health, Education, and Welfare (HEW)

The Department of Health, Education, and Welfare is charged with demonstrating solar heating and cooling in Federal and private hospitals and other health-care facilities as part of DOE commercial demonstration program. An interagency agreement between DOE and HEW authorized HEW to solicit proposals for such projects, it calls for an "open" solicitation; that is, solar contractors are to be invited to make proposals for heating and cooling demonstrations at certain health care facilities Five or six projects are anticipated under the proposal, and about $1 million in DOE funds is involved.

In addition, DOE has funded a $300,000 project for a solar installation at an Indian health-care facility in New Mexico and a project at a Public Health Service hospital,[26]

BUILDINGS OPERATED FULLY, OR IN PART, UNDER REGULATIONS ESTABLISHED BY THE FEDERAL GOVERNMENT

The Federal Government, in addition to the buildings it owns or leases, supervises the operation of many buildlngs that receive Federal loans or operating subsidies The Government could use Its leverage to encourage the use of solar-energy equipment on such projects. In the case of buildings which receive operating subsidles partially attributable to energy costs, the Government might directly benefit from diverting annual subsidy funds to programs designed to capitalize solar devices.

The largest number of federally sponsored residential units have been con-

"Sola r Energy Government Bui Id ings Project, MITRE Corporation, p 4

[26] Carl Conner, ERDA, private communication, 1977

structed under public housing programs. Over 1 million units of low-cost housing have been constructed with federally subsidized municipal bonds since 1937. Projects covered under Section 8 of the Housing Act also receive annual payments to ensure that tenants are charged no more than 15 to 25 percent of their annual income for rent,

Unfortunately, current accounting procedures make it difficult to determine the fraction of annual subsidies attributable to energy costs. HUD officials estimate that **energy costs currently account for 20 to 30 percent of the subsidy payments.**

Public Housing

The Public Housing Program has funds for modernizing existing structures (the approximately $20 mill ion available in FY 77 was capitalized by local developers into about $200 million in project funding). Energy conservation is considered a major objective of recent modernization investments. However, HUD has no program-wide conservation goals. There are no real incentives for local housing officials to invest in conservation equipment, largely for the following reasons:

–There is a general feeling that **the Federal** Government will have to continue to subsidize energy costs, and local officials therefore apply all available funds to other modernization projects.

–There is much less glamour **in retrofitting older establishments with conservation equipment than in overseeing innovative new projects. The effectiveness of area personnel tends to be judged on the basis of their performance on newer projects.**

Until late 1974, HUD's legal staff had ruled that operating subsidies for public housing could not be used to capitalize investments in energy-conservation equipment. A more recent ruling changed that opinion, and there are now judged to be no legal barriers to using operating funds for solar and other energy equipment. However, there has been little attempt to use operating funds for solar equipment, since HUD officials are skeptical that solar devices could be economically attractive on their projects without additional Federal subsidies.

Acquired Housing

In addition to public housing, the Federal Government acquires a substantial number of residential **units because of foreclosures on VA, FHA, and FmHA loans (HUD currently owns approximately 90,000 such units). The current policy is simply to dispose of this property as rapidly as possible without making modifications to the structures. It might be desirable, however, to require that the Federal Government provide certain of these houses with energy-conserving equipment before they are resold.**

ISSUE 4

Could any existing Federal grant program be used to subsidize the purchase of solar- energy equipment?

Yes; many of them could, Some direct-grant programs already have energy conservation as an explicit objective; others, though initially designed for other purposes, could be used to administer funds for solar insta l l at ions,

Taken together, funding for such programs totaled over a billion dollars in FY 77 and thus could be used to provide substantial subsidies for solar equipment—even if only a small fraction of the funds could be justified for this purpose. However, it will be difficult to divert funds from many existing programs because they are already oversubscribed for their primary purposes; in these cases, solar equipment would have to be paid for through additional funding. To have solar grant money administered through existing programs would have the advantage of avoiding the addition of still another separate program to what is already a bewildering array.

If an attempt were to be made to coordinate these diverse and frequently overlap-

ping programs in the interests of accelerating the commercialization of solar energy, it would probably be desirable to use the services of the Federal Regional Councils in each of the 10 Federal regions nationwide. Councils are headquartered in Atlanta, Boston, Chicago, Dallas, Denver, Kansas City, New York, Philadelphia, San Francisco, and Seattle These councils can use personnel from several different agencies to coordinate programs across jurisdictional lines and which receive funding from several different sources.

FEDERAL GRANT PROGRAMS

It will not be possible to summarize all Federal grant programs which could be used to subsidize solar energy systems. A few of the programs which seem most immediately relevant are:

Programs Administered by HUD

Community Development Block Grants are provided under the Housing and Community Development Act for a variety of urban renewal and community improvement activities which may include the rehabilitation of housing. About $250 million was spent during FY 76 to secure loans totaling about $500 million Energy conservation was not a major priority of these programs since most of the funds were needed simply to make buildings habitable.

Housing Rehabilitation Programs are funded under Section 312 of the same Act. Their purpose is to rehabilitate housing and to ensure that housing meets the requirements of local building codes. Use of these funds for conservation is improbable because the program's success tends to be measured by the number of units completed. Solar installations would reduce this number.

Homeowner Grants are provided by Section 302 of the Housing and Community Development Act to assist persons needing funds for housing repairs.

Homeowners Incentive Demonstration Programs, authorized under the FEA extension act (Title IV), are designed to evaluate the effectiveness of incentives for encouraging homeowners to install energy-conservation or solar energy devices, Two hundred million dollars were authorized for the program in FY 77.

Housing Finance Interest Subsidies are provided under the 1974 Housing and Community Development Act. This Act allows HUD to make grants to State housing finance agencies that use the money to cover interest payments on bonds sold for rehabilitating housing. Buildings must be examined by HUD before such grants are made. They must meet HUD's minimum property standards. (See Issue 2 for a discussion of the impact of these HUD standards.)

Programs Administered by the Department of Energy

The Energy Conservation and Production Act (P. L. 94-385) established a 3-year program in which $200 million would be given to people with low incomes for the purpose of insulating and "weatherizing" their residences. The funds are to be administered at the local level by community action agencies Standards for allowable improvements will be established by the National Bureau of Standards.

Programs Administered by the Department of Health, Education, and Welfare

The Administration on Aging oversees a program which gives emergency relief to elderly persons finding themselves unable to meet rising fuel bills. Grants also are made to State agencies which provide direct assistance in insulating and weatherizing residences.[27] The program is very modest; its budget is approximately $1.5 million.

The Social Services Administration provides up to $500 for winterization to families qualifying for Aid to Families with Dependent Children. " The program requires the recipients to match the amount of the Federal grant

[27] Older Americans Act, Title III
[28] Social Security Act, Section 403

Programs Administered by the U.S. Department of Agriculture

The Farmers Home Administration may make loans or grants in amounts up to $5,000 to low-income rural residents for the purpose of improving their homes to meet local code standards. [z9] The funds can also be used to purchase insulation. Its applicability to solar equipment is uncertain.

Programs Administered by the U.S. Department of Commerce

The Economic Development Administration is authorized by both the Public Works and Economic Development Act of 1965 and by the Public Works and Capital Development and Investment Act to make grants to communities with the central objective of stimulating employment in regions with severe unemployment problems. Annual expenditures are typically in the order of $200 million, although a special "one-shot" infusion of $2 billion was granted in 1976 because of severe unemployment problems.

It may be easier to use this program for solar and conservation investments than any other Federal grant program. This is because money used for these purposes would not have to compete with other, critical uses of the Federal grant funds (e. g., housing rehabilitation). The object of the program is to stimulate employment and, as shown elsewhere in this paper, solar energy is a labor-intensive industry which requires skills in job areas currently suffering serious unemployment. Funds from the CD I program, however, are typically used for "public works" projects which have high visibility.

FEDERAL INFORMATION PROGRAMS

In addition to the major grant programs described above, a series of activities which provide grants and/or technical services exist within the various Federal agencies. These include such things as the Extension Service of the U.S. Department of Agriculture, the Product Dissemination Program of HUD, the Comprehensive Employment and Training Act administered by the Department of Labor, the Community Services Administration, and Action. Some of these programs are bringing energy conservation Into their activities through various means. These include grants for weatherization, providing labor for performing this weatherization, and information services on reducing energy costs to homeowners.

These programs appear to have the flexibility to incorporate solar energy in their activities. As such, their contact with a large portion of the American population could serve to accelerate the penetration of solar **energy. A similar course is being proposed with regard to the Energy Extension Service now being developed by DOE.**

ISSUE 5

When private companies are subsidized with Federal funds to develop equipment for the commercial market, how can a balance be struck between the company's need to retain a useful proprietary interest in the technologies developed and the Nation's right to have complete disclosure of the results of federally sponsored research?

There is no easy answer to this question. But it raises what is likely to be a central problem for all federally sponsored efforts to develop small, commercially viable energy technology.

On the one hand, the public has a clear interest in ensuring the widest possible dissemination of research and development work conducted under Federal auspices. This is particularly important with onsite solar equipment because many of the manufacturers are small, having neither large research staffs nor easy access to information about a rapidly changing technology.

On the other hand, a company which is not permitted to retain any proprietary information concerning the equipment it de-

[z9] Housing Act of 1949, Sect Ion 504

velops with Federal funds may conclude that it has no commercial interest in the development. Without patent protection and without any advantage of advanced design knowledge, the company may determine that it cannot risk manufacturing the equipment. The company would undoubtedly enjoy some competitive advantage as a result of its research, if only because of the experience and ideas it obtained. The Federal grant would have placed the firm on the edge of the "state-of-the-art" in at least one area of technology— a position that would leave the company in a uniquely favorable position to make further progress with its own funds. Most of the commercial technologies which have "spun off" from research sponsored by the Department of Defense and by NASA have resulted from such situations. Even in situations where the complete results of research work were published, the companies involved retained valuable experience in the practical difficulties associated with manufacturing and design which might be difficult or impossible to publish. (A machinist who d is covers that a drill works best if you spit on it before making a critical hole, for example, may hold the key to a problem which would require another company months to resolve.)

At present, the Government does not have much flexibility in adjusting its policies in this area Only NASA is now able to grant exclusive license protection to products developed with Federal support. Several innovative approaches have been proposed, however, and DOE is funding the development of a new heat-engine design in an experimental arrangement with the Sunstrand Corporation. In this program, the Government is acting very much like a private source of "venture capita l," giving partial development funding and retaining a partial interest in the result

A major effort should be made to explore alternative approaches to Federal support for commercial products, and to determine their utllitv and jiustice to the taxpayer.

ISSUE 6

Should the Federal Solar Program include a major effort to encourage competitiveness in solar energy and promote small solar business?

The relatively small investments associated with onsite solar energy devices have made it possible for many small businesses to enter the market. Indeed, much of the innovative work now being done in the area has emerged from firms with very limited assets. This unique feature of the onsite solar energy field presents a difficult choice for the policy maker. A program for supporting small, relatively simple technologies will have many more firms to choose from than a program for developing large energy technologies, which require large capital investments in individual projects. Supporting some of the small solar energy firms offers an opportunity to explore a rich variety of concepts without a massive investment in any one approach, as well as a better opportunity to foster competition in the energy market. Apart from any such pragmatic advantages, promoting small business has always been considered a desirable objective in and of itself; the small, independent competitive firm is still a cherished ideal of the American economic system.

On the other hand, small firms are likely to have limited marketing experience, no nationwide representatives and contacts, and limited research funds. Some may be inefficiently managed and others have limited experience with the difficulties associated with taking a good engineering concept, developing a marketable product, constructing equipment for mass production of comparable products, and developing sales and advertising policy. The policy options offered in this paper do not resolve this dilemma; they give encouragement to small enterprises but do not include requirements which ensure that small enterprises get a specified share of Federal funding.

The Small Business Administration (SBA) has played a very limited role in promoting small solar energy businesses, although it

has begun to investigate the field as the result of congressional prodding. SBA will participate in DOE's program to finance selected energy-related inventions.

A separate but related issue concerns Federal policy on restraint of trade. It is apparent that solar energy systems, particularly onsite devices, will increase competition in the energy supply industry. A substantial fraction of the cost of smaller solar systems (particularly and virtually the entire cost of passive solar systems) results from onsite construction work which would be performed by local building contractors. The building industry is one of the most competitive industries in the country, The diversity of approaches, the fact that different climates will call for different systems, and the relatively small investments required to manufacture many simple types of solar devices will almost certainly maintain the competitive nature of the solar manufacturing industry. There will, of course, be items which can only be produced economically in very large quantities. Production of sit i-con solar cells, for example, probably must take place in facilities capable of producing 5 to 50 MWe annually if low cell costs are to be achieved.

The Federal Trade Commission is monitoring the solar industry to insure that existing oil companies and utilities do not dominate the field to the point of restraint of competition in the area. Both utilities and major oil companies are entering the solar industry. A majority of the photovoltaic devices manufactured in the United States for example, are produced in subsidiaries of major oil companies. Both the Electric Power Research Institute and American Gas Association have sponsored projects in solar energy and a number of utilities have undertaken projects on their own. (For example, the Southern California Gas Company has been involved in a large-scale program for demonstrating solar hot water in California since 1973.) The Pennsylvania Gas and Water Company acts as a manufacturer's representative for solar collectors, and Gasco Inc. of Honolulu has a direct merchandise arm which sells collectors as well as gas appliances.[30] The advantages and difficulties of utility participation in ownership of onsite solar energy equipment is discussed in some detail in chapters V and VI. It will be extremely difficult for any organization to monopolize the solar industry because of the inherent diversity of approaches; there will probably always be intense competition between different designs. Probably the most serious danger to competitiveness in the solar industry is the Federal Government itself. The potential for competition between different organizations and different engineering concepts could be distorted if Federal funding is unwisely allocated.

ISSUE 7

What sort of consumer protection is required in solar energy products?

The central problem, not surprisingly, is the novelty of the equipment. Homeowners, builders, architects, and the financial industry share these fears:

1, Will the system work as advertised?

2. How long will it last?

3. Will operational costs be prohibitive?

4. Will a solar unit hurt the resale value of property on which it is installed?

5. Will the technology change so rapidly that the equipment now available will soon be obsolete?

These anxieties are intensified because: (a) there are no standard techniques for presenting performance data on the variety of different systems for sale, and (b) many systems are offered by small organizations without substantial assets or wide experience in manufacturing. Indeed, many of the firms now producing solar collectors, for example, are likely to vanish during the next 10 years, leaving their customers with equip-

[30] J H Williams, "Solar Energy and the Gas Utility, " February 1977 (Distributed by the American Gas Association)

ment no one else is qualified to repair. That part of the problem will get even worse, because potential buyers will be faced with an ever-widening array of equipment and advertising c laims.

To be sure, any new technology undergoes such growing pains. And in due course certain manufacturers will establish reputations for high-quality products and for backing their systems with attractive maintenance contracts. Unfortunately, it could take years for this to happen — and in the meantime some unscrupulous dealers are likely to enter the field.

Can the Government help to remove most of these concerns? It will be extremely difficult the way things look now — the Government itself is uncertain about the best technical approaches to support, and it should not be dogmatic anyway. However, standards have been established for the equipment the Government buys, and this could provide some guidance for prospective purchasers. A process for developing standards for solar heating and solar hot water equipment has been underway for some time, and plans are being made to certify a national testing laboratory which can assure that tests are properly administered. Progress on both fronts, however, has been frustratingly slow Great care is needed to make sure that such standards do not inadvertently eliminate novel approaches.

At a minimum, it will be necessary to develop mechanisms to ensure that standards are updated to take account systematically of advances in solar technology. It will not be an easy matter to work out standards for another reason: each subtechnology will require its own set of standards, which must be arranged in such a way that they are applicable to a variety of building sites Some such work has already been done The National Bureau of Standards has developed interim standards for solar heating and hot-water systems, and NASA-Lewis has developed preliminary standards for the photoelectrlc systems which will be purchased for electric generation.

The Government could also help by requiring that all systems sold bear performance ratings conducted under procedures prescribed by Federal law.

Another major problem has been the shortage of building inspectors trained to recognize mistakes made in installing solar equipment. Installation costs often represent a significant fraction of the total cost of a solar system, and a large fraction of the problems encountered with solar equipment is attributable to improper installation. Federal support of training programs for inspectors could provide useful assistance in this area.

However, none of these approaches can eliminate the basic fear which surrounds a novel technology. The most powerful influence on the public's reaction to onsite equipment will be the behavior of the solar industry itself. Because of its strong self-interest in policing itself, the industry may well be the best source of advice for ways in which the Government might assist in building consumer confidence

ISSUE 8

What are the objectives of the solar demonstration program, and what criteria should be applied to the systems demonstrated?

There has been considerable confusion in both areas. On the one hand, demonstration projects are presumably not a part of a research program since the systems demonstrated are presumably commercially available. On the other hand, there is little point i n demonstrating that commercial systems work if a market for them already exists or i n demonstrating that they are too expensive if there is no market. The program could be used to reduce costs only if the program purchased so many units of a given type [halt manufacturers could justify installing mass-production equipment, This course seems undesirable, however, since funds used for this purpose could probably be better used to support tax incentives and loan assistance.

Passively heated and cooled buildings are perhaps a unique case, however. A large number of concepts are possible, and it is frequently difficult to predict how designs will work or how much they add to construction cost without field demonstrations. A large number of demonstrations is needed since it is necessary to carefully tailor designs to each climate (perhaps to each microclimate). Another possible objective of the program is to provide information about the lifetime, reliability, operating costs, and unexpected problems associated with installations operated by inexperienced owners. While information in this area is needed, the use of expensive demonstration programs to gather it must be justified carefully. At a minimum, the demonstration programs should be integrated with an effort to obtain data in these areas using laboratory testing equipment. An effort should be made to publish the results of instrumented analysis of the demonstration units in many different climatic regions as soon as possible and to communicate this information to building designers in the area.

Information gathered about the cost of the units purchased in connection with the demonstration program must be treated with great caution and cost data prepared with considerable care. It is important, for example, to separate costs incurred in the demonstration unit which would not have been incurred if the device were built without Federal support (the cost of instrumentation, for example, must be separated from other costs). Interpretation of cost data is difficult since, if the demonstration program is choosing its sites properly, the demonstration solar device will be among the first of its kind in the region. It is to be expected that installers charge more for installing the demonstration units than they would charge once such installations become routine. Mistakes encountered in the first-of-a-kind installation can be avoided as experience is gained.

Perhaps the most useful function of the demonstration program is simply one of propaganda: bringing solar energy systems to the attention of the local population and providing an example of a real, functioning unit which can be visited by interested building contractors, potential investors, and other interested parties,

THE EXISTING MARKETING PLAN

There is a great deal of confusion in the current program about which technologies should be demonstrated, when they should be demonstrated, and the size of the applications which should be chosen for demonstrations. The lack of a coordinated plan has resulted in the following:

1. A consistent underemphasis on retrofit applications when the retrofit market is much larger than the market for new construction.
2. Underemphasis on combining solar and conservation demonstrations, Passive solar buildings have received little attention as a result.
3. Lack of planning to extend demonstration into electric generation and cogeneration equipment and into industrial and commercial markets.

A lack of a systematic approach to these technologies has resulted in many a situation where systems intermediate between residential and large utility applications have been given much too little attention. Part of this distortion, of course, is inherent in the unevenness of congressional support for different kinds of programs.

Commercial and industrial facilities and multifamily residential units are attractive initial markets for solar equipment for a number of reasons:

1. It should be easier to retrofit solar equipment on commercial buildings than on residential buildings since running pipes from collectors to the heating and cooling equipment would disrupt a proportionately smaller part of the building.
2. The owners of commercial buildings tend to be more sophisticated at anal-

yzing life-cycle costing than **owners of single family residences.**

3. **Systems on** commercial buildings may **have** greater visibility than systems **in residential neighborhoods, and businesses would frequently advertise their use of solar energy.**

4 **Cooling technology and some heat engine technology which is not ready for residential demonstrations is now available for commercial demonstration.**

5. **Single commercial systems would have a much greater impact on fuel consumption than an individual residence, and would be easier to manage with a small staff than numerous installations on different types of residences.**

ISSUE 9

Which Federal agencies are conducting solar research programs, and how well are these programs coordinated?

Those agencies with major responsibilities in solar **energy are DOE (which has been given responsibility for al l solar research programs and is developing programs to accelerate the commercialization of solar technologies which are ready for market) and HUD (which is managing the residential heating and cooling demonstration pro**grams). I n addition to these major activities, however, there are solar programs **in the Department of Health, Education, and Welfare, the National Science Foundation (which retains a small solar-energy staff even though the bulk of research has been transferred to DOE), the National Oceanic and Atmospheric Administration [which collects such climatic data as sunlight intensities and wind-speeds for use in the evaluation of solar technology), the Defense Department (which is going to install a variety of solar devices on military property, including electric systems for remote facilities], NASA (which has great institutional interest in the development of an orbiting solar photovoltaic system — and is reportedly investing heavily in designs for such systems out of internal funds — as well as using solar cells to power spacecraft), the Department of Agriculture (which is developing solar heating for barns and other farm buildings, along with equipment for agricultural process heat, irrigation pumps, etc.), and the National Bureau of Standards (which is developing standards and testing procedures for solar equipment following initial work by NASA). The Department of the Interior and many other agencies have smaller programs, most of them for the installation of a solar hot water or heating system at one of the agency's buildings.**

Still other Federal agencies are in a position to implement regulations affecting solar energy systems. For example, the Federal Energy Regulatory Commissin(FERC) in DOE (formerly the Federal Power Commission) is helping to develop design requirements for solar electric commercialization projects. The Veterans Administration is examining the feasibility of allowing VA loans to be used for solar equipment and is planning to use solar equipment at some of its hospitals. The section of HUD charged with administering FHA loans is examining the possibility of changing minimum property standards to permit funding of solar equipment. The Council *on* **Environmental Quality is conducting an independent study of solar heating and cooling for single family houses, The list could be extended.**

To some extent, of course, duplication between agencies in solar research and development produces healthy competition. It can prevent the development of a monolithic approach to solar-technology research which could lock out innovative concepts.

On the whole, officials interviewed agree that duplication exists, But they argue that most work is complementary and that it is coordinated with administration-wide solar policy. **They contend that each agency should carry out its unique responsibility in this area. Some say that funding solar development through a number of agencies probably results in a larger total solar budget because it is easier for each of two depart-**

ments to get a $2-million solar project than it is for one department to get a single $4-mill ion project.

There are, however, areas where confusion in management could create difficulties:

— Plans to change FHA and VA loans are proceeding without any clear guidance from DOE, which has a clear mandate to commercialize solar energy technology.

– In the meantime, HUD has proceeded to fulfill its mandate in the demonstration of residential units and is developing technical expertise and management experience in demonstrating novel solar technologies

–There have been some misunderstandings between NOAA and DOE over which agency's funds should be used to maintain installations for developing a data base on insolation, wind speed, and ocean temperatures.

— Total energy studies are proceeding in HUD and the National Bureau of Standards, as well as in DOE Coordination between these programs could be improved

— Research in advanced heat engine technology relevant to solar energy is being funded by DOD, NBS, the Department of Transportation, and NASA, as well as by DOE In some cases duplication has occurred. Coordination could be improved,

– Heavy NASA support of orbiting photovoltaic systems, not well coordinated with DOE, could greatly distort the overall photovoltaic development program.

ISSUE 10

Does the present Federal program for developing solar electric generating equipment overemphasize large, central station approaches at the expense of smaller, onsite approaches?

In spite of recent changes that have upgraded research on electric generating systems for nonutil ty appl cations, the bulk of DOE's solar electric research program is directed at technologies designed exclusively for large, central generating facilities This strategy has several difficulties:

1. There is no clear indication that large solar electric plants are more efficient or produce less costly energy than smaller, onsite facilities

2 The large-scale projects being examined are very unlikely to make a contribution to commercial energy supplies before the 1990's; smaller devices may have greater potential for making contributions in the near future

3 The very large solar electric system being contemplated will require simultaneous development of several novel types of technologies (collectors, receivers, storage devices, etc.) These systems will be required to operate on a large scale in the proposed multi-megawatt systems. It may be better to test and evaluate components on a smaller scale, or to develop components which could be used on a variety of systems of different sizes.

4, Concentration on large systems requires that difficult choices be made between many competing approaches before any of the alternatives have been adequately tested. Funding smaller projects would permit greater numbers of concepts to be tested at much lower risk.

DOE officials recognize that there are numerous total energy concepts and proposals for generating electricity for specialized agricultural and industrial applications, where available technology could be used in an expanded demonstration program, But they also note that additional funding would require additional staffing, which remains as the Office of Solar & Geothermal Energy Program's largest problem. The solar program does project a number of experimental projects, which could include agricultural process heat, small community applications, agricultural and industrial centers,

and several other projects in thermal electric generation. At least one project of each type of total energy could be built to research problems and demonstrate potential. Programs to develop heat engines and storage apparatus compatible with onsite electric equipment also appear to be supported at much lower levels than is warranted by the equipment's potential.

ISSUE 11

What kinds of research need increased emphasis in the Federal solar program?

COLLECTORS

Supporting the development of advanced collector design presents special difficulties since there are a large number of devices being developed independent of Federal funding and the number of possible designs is extremely large. The development of reliable, inexpensive collectors is, however, probably the single most important technical problem faced by the solar community.

Federal support has concentrated in four areas: 1) improving the design of flat-plate collectors used in connection with the heating and coollng demonstration program; 2) developing heliostats for the central receiver demonstration projects; 3) developing and testing materials for use in collectors (e.g. , low-cost plastics for covers and receivers), and 4) developing a series of distributed collector designs in connection with the total energy program While the last program has been effectlve in testing a variety of collectors, an even greater variety must remain withiout serious Federal support. For example, relatively little attention has been paid to the development of Inexpensive pond collector and simple, lightweight two-axis concentrators for use with small heat engines and photovoitaic devices designed for use in high-intensity sunlight One major difficulty with many federally sponsored designs has been the temptation to "over-engineer" devices rather than to emphasize techniques for simplicity, low material requirements, and low cost.

HEAT ENGINES

An enormous range of technical possibilities for heat engines is relevant to solar applications. While heat engines currently available can be used in near-term solar energy designs, few of the engines have been designed especially for solar applications — modifications of engines produced for some other application will be used. Additionally, most near-term applications of solar energy will utilize smaller heat engines than those typically used in utility operations, and the technology for small heat engines which can operate from an external heat source is frequently not as advanced as the technology used for large central powerplants, in many cases, the only small heat engines available are based on European designs.

The development of improved heat engines would unquestionably lower the cost of solar energy for applications requiring a high ratio of electrical to thermal energy New devices which could make efficient use of low-temperature solar heat sources could reduce the complexity of solar collectors required for power generation. More efficient heat engines can reduce total system costs by reducing the size of the collector field needed to provide a given amount of electrical or mechanical energy since collector costs tend to dominate overall system costs. Development of a high-performance Stirling, Ericsson, or closed-cycle Brayton device would open many attractive options for solar electric generation. Development of improved cogenerating systems would improve the overall utilization of the solar energy received in applications where there is a requirement for thermal energy,

Most federally supported work on advanced heat engines, however, is relevant only for large central powerplants and the funds available for engines designed for solar, transportation, and industrial applica - tions are very limited,

Background on Federal Programs

Most other work on advanced heat engines in DOE is being funded by the Office

of Conservation. Projects are funded in three categories:

1. Heat engine research in the Division of Transportation Energy Conservation.[31]

Development of new heat engines for automobiles and other road vehicles is being coordinated with major U.S. automobile manufacturers who apparently are unwilling to fund development of advanced engines without Federal prompting.

Three projects are of particular interest for solar applications:

- A program is underway to develop an efficient Brayton-cycle (gas turbine) engine. In the past years, tests have accumulated the equivalent of over 150,000 road-miles on some designs. Work is also underway to develop ceramic engine components capable of withstanding very high temperatures (2,500" F). The government will purchase seven General Motors Brayton engines during FY 78 for $500,000. The engines will be used for road tests.
- The Government is also contributing to the Ford/Philips program to develop a Stirling engine for road vehicles. This work will include continuing tests on the current 170 hp design and development of a smaller (80 to 100 hp) design. Work next year will include completing engine performance and emission tests and improvements on the difficult "heater" heat exchanger which has plagued the Philips design. DOE is contributing about $1.6 million to this project in a cost-sharing program during FY 78.33
- Development of an organic Rankine device to increase the efficiency of a truck diesel engine is also being supported. This combined-cycle design would replace the truck's muffler with a boiler for the organic fluid,

2. About $12 million will be spent on new heat engines during FY 78 by the "heat utilization" section of the Office of Conservation.[34] Projects funded in this area will include support for two high-temperature expanders which might be used for combined cycles, support for designs which will increase the pumping efficiency of engines .35 Research on small devices will include the development of efficient steam turbine systems in the 2 to 6 MW range and studies of Stirling engine applications. The Stirling work will include studies of designs suitable for solar applications as well as designs compatible with total 500 to 2,000 horsepower energy systems in residences and industry. It is hoped that a Stirling device for utility applications could be produced commercially by 1982.[36] Work on Stirling engines is also underway in DOE's Office of Nuclear Energy Programs, DOD, NASA, and the National Bureau of Standards, but conservation and solar applications officials claim there is little duplication. 37
3. Work is also being supported which will examine engines for topping or bottoming cycles for utilities and for industrial processes. Therm ionic devices for high-temperature topping is being supported with the objective of actually operating a device in a boiler by 1980.[38] Three different designs for organic Rankine cycle devices are being supported for use with medium-temperature waste heat streams. Work on low-temperature systems is beginning, although its exact structure seems somewhat vague.

Work on advanced heat engine designs is also being supported by the Fossil and Nuclear Energy Office of DOE. These de-

[31] ERDA Budget Estimates (Amended FY 78), Book 1, p 57

[32] Ibid , p 96

[33] Division of Transportation, Office of Conservation, DOE

[34] ERDA Budget Estimates (Amended FY 78), p 80

[35] Ibid., p 82

"John Belding, Research and Technology Division, Office of Conservation, DOE, private communication, 1977

[37] George Pezdirtz, Off Ice of Conservation, private communication, 1977

"ERDA Budget, p 86

signs are, almost without exception, applicable only to large central power applications. The fossil energy coal program has requested $25.5 million in FY 78 budget authority to develop advanced power systems including combined cycle and Brayton cycle devices. 39 The Nuclear Research and Applications Office of DOE is financing two studies into Stirling engines, one totaling almost $5 million to develop a Stirling isotope power system, contracted with General Electric, and the other with Mechanical Technologies, Inc., totaling more than $1.5 million.

In addition, Nuclear Research and Applications is funding a $2-million-a-year study by Garrett Air Research, Inc., of Phoenix to develop a 1.3 kilowatt Brayton isotope power system, as well as a similarly financed study by Sunstrand Corp to develop an organic Rankine device, also for a 1.3 kilowatt system. Both are due to be demonstrated during 1978; Nuclear Research and Applications officials say the choice will then be made between the two systems 40

PHOTOVOLTAICS

A well-designed photovoltaic program must maintain a careful balance between basic research, development improvements to current manufacturing processes, and engineering work on practical system designs. This is a difficult task since the field is changing very rapidly It would be tempting to delay major decisions in the area until research work has sorted itself out, but it should be possible to design a balanced program, supporting production and demonstration work in areas where prospects of success seem particularly high while continuing to give support to advanced concepts. (At a minimum, there seems to be no point in waiting for "research breakthrough" from arty of these devices without supporting a vigorous research program,)

There is room for a considerable amount of research on the basic physics and chemistry of photovoltaic devices. Serious work in the area of developing materials for terrestrial solar cells has been underway for only about 5 years. Work on the crystallography, electrical, and optical properties of silicon and other photovoltaic materials could be extremely useful. The properties of amorphous materials, which may have applications in photovoltaic devices, are still largely unknown,

The variety of cell designs which have been proposed for use in inexpensive flat arrays and in various types of concentrators is discussed in detail in chapter X. Many advanced cell concepts are receiving minimal Federal support.

Finally, a number of fundamental questions about the most effective use of photovoltaic equipment must be resolved. Detailed system design work will need to be done on the following topics:

- Mounting and support (e. g., should low-cost cells be used as a building material ?).
- What kind of cell cooling should be used ?
- How should the systems best be integrated into existing utility systems? Should onsite or utility storage be used? Should the system sell as well as buy from an electric utility? Should an electric backup or onsite generator burning fossil fuel be used when solar resources are not available?
- How often should the devices be cleaned ?

In the near term, it will be necessary to design practical and reliable systems for remote (often unattended) installations

STORAGE

The present DOE storage program is dominated by two objectives 1) developing very large storage systems capable of operating in electric utilities to "level" the loads met by these utilities, and 2) the development of

[39] Fossil Energy, ERDA Budget, p 45
[40] Robert Morrow, NRA, 1977

batteries for electric vehicles. Relatively little work is being conducted expressly for solar energy or for other onsite applications. There is, for example, presently no technique for adequately evaluating the complex issues of load management, transmission, and economies of scale for an integrated energy system.

Simple systems for storing relatively low-temperature thermal energy or chilled liquids in tanks, ponds, and aquifers — systems which appear very promising in the analysis conducted in this report — have received relatively little support or interest, An enormous amount of fundamental work in thermochemical storage systems remains to be done, and a number of known reactions have been characterized well enough to merit accelerated engineering development work, A number of simple systems for storing high-temperature energy in latent and specific sensible and latent heat have never received serious engineering design work. A number of other advanced storage systems (batteries, flywheels, and other devices) could also profit from greater attention.

Background on Federal Storage Programs

In the Division of Energy Storage Systems of DOE, a program has been developed to investigate a variety of thermal and chemical storage techniques. The main objective of these studies is to examine the feasibility of storing heat or electricity in order to level the loads of major utilities, although the technologies developed will probably be directly applicable to solar energy systetms for which the storage requirements are similar. Research will be required, however, to adapt such systems to solar applications. Adaptation may be particularly difficult for onsite systems which may have storage requirements many times smaller than the smallest utility units tested under this program.

The storage program has an objective of developing batteries with an overall efficiency of 75 percent, and a 10-year installed lifetime (approximately 2,500 deep cycles), at a cost of less than $30 per kWh of storage capacity. This program is also supporting research to develop inexpensive and efficient inverters for turning d.c. into a.c. power; such systems are needed to make efficient use of batteries. Again, the primary objective is the development of technology for utility load leveling.

The electric vehicle storage program in the Division of Energy Storage Systems is examining a number of advanced batteries which have low cost and low weight, and which last 4 years. In normal use the technology which DOE apparently feels has most promise in this area is the lithium/iron sulfide battery, although different pairs of reactors are being sought. Three firms fabricated such devices and delivered them to DOE for testing in FY 7841 DOE's utility battery program has the objective of producing batteries capable of 75-percent efficiency and 10-year lifetimes in normal utility applications. Work on a large battery storage test facility in New Jersey financed jointly with the Electric Power Research Institute began in FY 77.[42] The first batteries in this realistic utility environment will be lead acid batteries, but advanced batteries (probably zinc-chloride and sodium-sulphur batteries) will be tested in the next phase. Lithium/iron sulfide devices may be installed by FY 81. DOE is officially optimistic about the potential of these batteries and believes that the goal of $30 per kWh of capacity can be achieved.

Solar technology could also make profitable use of the variety of advanced energy storage techniques being considered in the Division of Energy Storage Systems. Hydrogen production and storage, underground pumped hydroelectric storage, underground compressed air storage, flywheels, and magnetic storage are all receiving at least some attention in the current program. Many of the secondary objectives of the energy storage program are also directly relevant to solar technologies. For example, the pro-

[41] ERDA Conservation Budget FY 78, revised p 22ff
[42] Ibid

gram to increase the efficiency of building space-conditioning **and the use of industrial process heat through the judicious use of thermal storage techniques has clear relevance to solar programs. Major field tests of seasonal and load-leveling storage for buildings are being conducted with the objective of improving the efficiency of conventional heating and cooling systems by 10** percent, and a major portion of the FY 77 funds for thermal storage **were used to start work on seasonal storage and structural materials with thermal storage properties for use in buildings.**

ISSUE 12

Should funding levels in DOE programs correlate to relative estimated contribution of different technologies?

Tables I II-4 and I II-5 compare the percentage of DOE solar funding given to three major solar energy applications with projections of the potential energy contribution of each solar application in the year 2000. No clear correlation is apparent. Electricity generated by solar systems, for example, is expected to represent only about 34 percent of the total contribution of solar equipment in the year 2000 but is receiving 64 percent of the funding, while industrial process heat is expected to provide 52 percent of the energy generated **by solar equipment while receiving only 4 percent of the funding.**

DOE has given solar electric power "highest priority" in its planning because of its potential as an "inexhaustible resource" and, it is claimed, it will "be given priority comparable to fusion and the breeder reactors."[43] Solar thermal systems, however, are relegated to a lower priority and characterized only as technologies which should be pursued only to "provide an energy 'margin' in the event of an **R&D failure in other areas."[44]**

[43] ERDA-76
[44] Ibid

Table ill-4.—Authorizing Appropriations for the Energy Research and Development Administration, U.S. House of Representatives, 95th Congress {1st Session], Conference Report No. 95-671

Demand sector	Total U.S. demand for primary energy in 2000		ERDA goals for energy provided from solar energy* sources in 2000	FY78 Budget Authority (millions of dollars)
	high demand estimate	low demand estimate		
Residential and commercial heating, cooling and hot water	31(29%)	23(40%)	2(18%)	96.4(30%)
Industrial & agricultural process	34(31%)	22(40%)	3(27%)	10.3(3.1%)
Electricity	68(63%)	47(81%)	0.5(4.5%)	216.1(67%)
Total energy in sectors listed above**	108(100%)	58(100%)	11(100%)	322.8(100%)

SOURCES: High demand estimate from ERDA 48 Vol1 pB 11
Low demand estimate based on a 1000 demand scenario constructed by the Institute for Energy Analysis
FY78 Budget Authority from U S House of Representatives Conference Report Authorizing Appropriations for the Energy Research and Development Administration October 6 1977 p 61 E R DA solar production goals collected and reported in Solar Energy Applications — A Comparative Analysis to the year 2020 Summary Report Draft July 1977 prepared by the Mitre Corporation Metrek Division

Table 111.5.—Authorizing Appropriations for the Energy Research and Development Administration, U.S. House of Representatives, 95th Congress [1st session], Conference Report No. 95-671

	Operating expenses	Capital equipment	Plant	Total
Heating and cooling of buildings	**94.4**	2.0		96.4
Agricultural and industrial process	10.3	0		10,3
Solar electric	210.7	5.4	41	216.1
Heating & coolng	**94.4**	2.0	**0**	96.4
Agricultural and industrial process	10.3	0	**0**	10.3
Solar thermal	61.1	3.0	41.0	105.1
Photovoltaics	76.2	0.3	0	76,5
Wind	35.3	1.4	0	36.5
Ocean thermal	2.8	0	0	2,8
Satellite power systems	2.8	0	0	2.8
TOTAL SOLAR ELECTRIC	210.7	5.4	41	256.9
Biomass	20.5	0.5	0	21.0

It is difficult to evaluate those arguments since a comprehensive plan for integrating Federal and industrial investments in solar research has not been developed, and there is no clear technique for determining when the time has arrived for Federal research support to be phased out and other types of nontechnical support initiated. I n addition, there has never been a comprehensive examination by DOE of either the economies and diseconomies of scale in solar technology or the relative merits of direct-thermal, electric, and combined electric and thermal operations.

ISSUE 13

The Solar Energy Research Institute, in its present operating relationship with DOE, may not be sufficiently independent of DOE to effectively meet its responsibilities in reaching the objectives set forth by Congress in the Solar Energy Research, Development, and Demonstration Act of 1974.

In the Solar Energy Research, Development, and Demonstration Act of 1974, Congress found that "it is in the Nation's interest to expedite the long-term development of solar energy, " and ". that the Nation undertake an intensive research, development, and demonstration program" in solar energy, As a consequence, Congress declared that it was the policy of the Federal Government to "pursue a vigorous and viable program of research of solar energy .; and provide for the development and demonstration of practicable means to employ solar energy on a commercial scale. " To enable the Nation to fulfill this policy, Congress established, in the same Act, the Solar Energy Research Institute (SE RI) to "perform such research, development, and related functions" as determined by the DOE, "or to be otherwise in furtherance of the purpose and objectives of this Act. " In other words, it was the intent of Congress that SE RI, while providing support to DOE, should also be able to provide independent direction and assessment of the Nation's effort to develop solar energy. This was reiterated at oversight hearings held a year after the passage of the Act. There it was stated that Congress intended that SERI be "highly visible" and be an institute symbolic of the "national will and the national effort"

toward solar energy, It is clear, therefore, that the Congress did not want SERI to be completely dominated by any other organization responsible for portions of the Federal solar energy program.

Since the startup of SERI nearly 1 year ago, however, it appears this intent is not being met. I n particular, the present method of funding SERI is to enact a "tax" on other programs under the Assistant Secretary of Research and Technology. No separate line item for SE RI appears in the budget; this severely limits the ability of Congress to directly evaluate the effectiveness of SERI through the budget process. Furthermore, it is not clear whether SERI can report directly to Congress without DOE approval and c learance.

SERI must maintain an ability to fairly assess and, if necessary, criticize the direction DOE takes on developing solar energy, if it is to fulfill the original intent of the Act. A clear congressional reaffirmation of SERI's responsibility and mission and separate funding status within the DOE budget, would contribute significantly to SERI's independence In addition, it may be desirable to establish a more direct link between Congress and SERI to emphasize the intent of Congress that SERI be a "visible" and "symbolic" institute of the Federal policy toward development of solar energy and not simply another group to carry out current DOE pollcy

ISSUE 14

Staffing Limitations

A persistent shortage of professional staff has been a major constraint on DOE's ability to adequately manage the rapidly changing and growing solar program. The FY 76 solar budget, for example, was $116 million, but only 46 staff professional positions were allowed. This amounted to just over $2.5 mill ion per professional. The problem became even worse in FY 77, with a budget of $290 million to be spent by 54 professionals — amounting to nearly $5.5 million per professional. The management of such large amounts of funding is particularly difficult in solar energy technologies, where the typical contract is much smaller than the average contract grant made by other sections of DOE.

The staffing shortage can create two types of problems:

1. It makes it difficult for DOE to react to a large number of innovative ideas and increases the temptation to spend funds in a small number of major and predictable projects rather than in a larger number of smaller projects some of which may have a higher risk.

2. It necessitates transfer of the detailed management responsibility to organizations outside the DOE's Solar Energy Division.

The problem associated with short staffing have been aggravated by demands placed on staff by the continuing, extensive public and congressional interest in solar energy which is floodin, DOE with inquiries, Much of this difficulty has been relieved under a grant to Franklin Institute, which has set up a toll-free number (800-523-2929) to answer inquiries about solar energy.