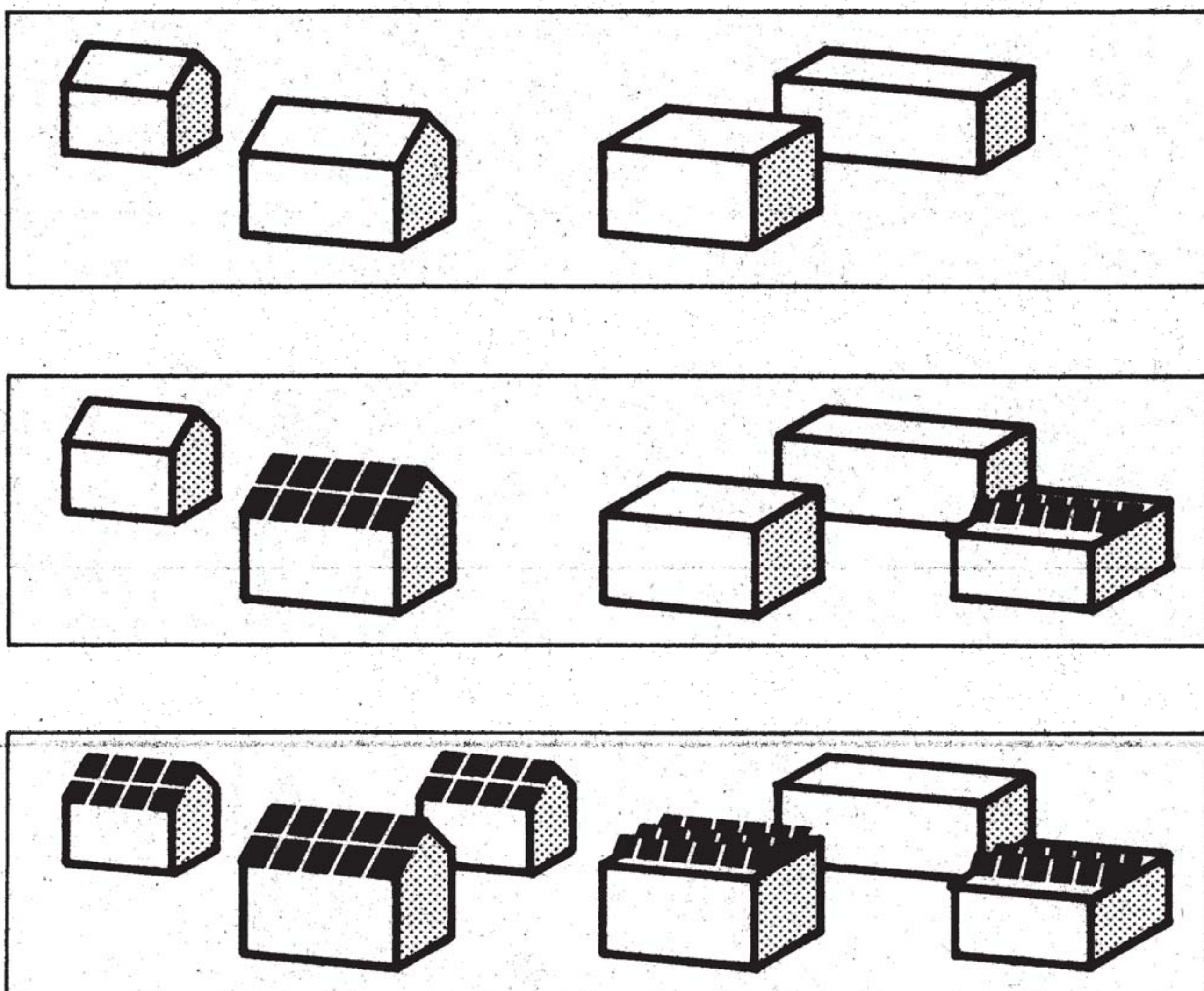
SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB)

Commercialization Report

PART A

Volume II - Technical Report



Federal Energy Administration
Task Force on Solar Energy Commercialization

SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB) COMMERCIALIZATION REPORT

OPTIONS AND STRATEGIES

PART A

VOLUME II - TECHNICAL REPORT

FINAL REPORT

July 15, 1977

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PREFACE

The Energy Conservation and Production Act (PL 94-385) authorizes the Federal Energy Administration (FEA) to "provide overall coordination of federal solar energy commercialization activities" and "to carry out a program to develop the policies, plans, implementation strategies, and program definitions for promoting the accelerated utilization and widespread commercialization of solar energy." The Congressional conference report listed several specific actions desired by the Congress including (among others):

- Develop a national plan for the accelerated commercialization of solar energy to include workable options for achieving on the order of 1 million barrels per day of oil equivalency in energy savings by 1985 from a combined total of all solar technologies;*

- Develop commercialization plans for each major solar technology;

- Conduct studies and analyses addressing mitigation of economic, legal, environmental, and institutional constraints;

In essence, the "National Plan. . .for all solar technologies" will be comprised of the combination of "commercialization plans for each major solar technology." Analyses of costs, benefits, and strategy options for each of the technologies can be placed in context, coordinated and optimized into an overall commercialization plan for solar energy.

The SHACOB Commercialization Report (PARTS A and B) is the first step toward development of a SHACOB Commercialization Plan. PART A addresses qualitatively the potential barriers to and incentives for the accelerated commercialization of SHACOB in the residential and commercial sectors. It represents a summary and synthesis of a large amount of recently completed research on all aspects of the market development of solar heating and cooling. PART B, prepared by Arthur D. Little, Inc., under FEA Contract No. CR-05-70066, contains quantitative analyses of the market penetration and the costs and benefits to the government associated with some of the incentives examined in PART A.

The SHACOB Commercialization Report relates closely to the President's proposed National Energy Plan (NEP) in that it analyzes a large number of incentives in terms of their impact on barriers to commercialization, their impact on income and interest groups, and possible administrative mechanisms. The impacts of incentives contained in the NEP are analyzed and compared to the present research, development and demonstration programs, an expanded NEP, and new initiatives.

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* Major solar technologies include: solar heating (including hot water) and cooling of buildings--SHACOB, agricultural and industrial process heat, wind energy conversion systems, photovoltaics, fuels from biomass, solar thermal, and ocean thermal energy conversion.

PART A is divided into three volumes. Volume I is the executive summary. The technical report is presented in Volume II. Volume III contains appendices which support the technical discussions in Volume II.

PART A was prepared by Midwest Research Institute under FEA Contract No. CR-05-70065-00. The principal authors were Mr. Dennis Costello (Project Leader) and Mr. David Posner. They were assisted by Mr. Carl Bingham and Mr. Michael Scott. Consultants on the project were Dr. Ronal Larson, Georgia Institute of Technology, Mr. Jerry Bradley, Desert Research Institute, and Dr. Harold Orel, University of Kansas. The original draft material was partly supplied by members of the Federal Energy Administration's Task Force on Solar Energy Commercialization. Mr. Norman W. Lutkefedder is the Director of the Task Force. Other Task Force members are: Samuel J. Taylor (Deputy Director), LaVerne P. Johnson, Robert Grubermann, I-Ling Chow, Stanly Stephenson Edward Downey, Mike Kutsch, Elaine Smith, Howard L. Walton, Richard D. Stoll, Howard Magnas, Charles Allen, Robert Jordan, Jeffrey Milstein, Margaret Sibley, Sally Mott, Ned Dearborn, James H. Berry, Mary Liebert, and Jack Koser.

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CHAPTER 1

BACKGROUND

SUMMARY

The SHACOB Commercialization Report (PARTS A and B) deals with the accelerated commercialization of solar heating and cooling of buildings in the residential and commercial sectors. Specifically, the two objectives of PART A are to: (1) analyze the potential barriers to SHACOB commercialization and (2) investigate government incentives that could accelerate the commercialization process.

Solar hot water and space heating are among the possible solar technologies that offer the most promise for widespread, near-term commercialization. Further research and development and increases in the real price of electricity are necessary to make solar cooling systems economically feasible. Commercialization of all solar technologies will have to occur in conjunction with increased emphasis on conservation.

The U.S. consumed the equivalent of about 34 million barrels of oil per day (mmb/d) in 1975. About 22% of that total (or 8 mmb/d) was used for heating and cooling of buildings and for domestic hot water. The Congress, in the Energy Conservation and Production Act of 1976 (P.L. 94-385), asked FEA to analyze commercialization incentives and options which could achieve "on the order of 1 million barrels of oil equivalent per day in energy savings by 1985 with a combined total of all solar technologies." The SHACOB Commercialization Report (PARTS A and B) represents a partial response to that request.

The national benefits of SHACOB are that it is a renewable, environmentally benign, domestically available and abundant means of energy production. The value of these attributes to society make the societal benefits of SHACOB utilization greater than the economic value of the fossil fuel displaced. In any case, the future economic value of fossil fuels (reflected by their prices) is uncertain but will probably increase. The benefits of SHACOB vary regionally depending on heating and cooling demand, solar insolation availability and regional fuel prices.

The federal government, state and local governments, the companies in the solar industry and utilities have been participants in the development of the SHACOB commerical market to date and they will continue to play important roles in the future. All levels of government have already passed some type of solar related legislation. Data on the collector manufacturing activities of the solar industry have been compiled by the federal government for the past 3 years. From January 1974 to June 1976, approximately 11 million square feet of collectors have been produced. This represents a fuel savings of about 1,300 barrels of oil equivalent per day.

CHAPTER 1

BACKGROUND

A. Introduction

The realities of the U.S. energy crisis are growing harsher every year. Rising fuel costs, uncertainty about future supplies, increasing dependence on imported energy, and increasing volatility in U.S. and world-wide business cycles characterize our current energy dilemma. Conservation and alternative energy sources are gaining more importance as elements in the solution of U.S. energy problems. Solar energy is at the forefront of these alternatives and is the subject of this report.

The term "solar energy" encompasses a wide variety of energy technologies. These generally include solar hot water, space heating and space cooling, solar industrial and agricultural process heat, photovoltaics, solar-thermal power generation, wind energy conversion, fuels from biomass, and ocean-thermal energy conversion. This report deals only with solar heating (including water heating) and cooling of buildings. Furthermore, the report deals primarily with the accelerated commercialization of Solar Heating and Cooling of Buildings (SHACOB) in the residential and commercial sectors. Subsequent FEA reports will deal with accelerated commercialization of the other solar technologies as part of an overall national plan for accelerated commercialization of solar energy.

Accelerated commercialization of SHACOB is distinct from commercialization in that the former is a joint government-private sector process. The objective of accelerated commercialization is to increase the rate, level, and breadth of both acceptance and utilization of this technology through government actions. Commercialization, on the other hand, is undertaken only by the non-government sector. Commercialization is the process by which the private sector moves a technology from the availability status to the status of marketplace acceptance, consumption and profitability.

Solar hot water and space heating are among the possible solar energy technologies that offer the most promise for widespread, near-term commercialization. Technologically, all of the necessary elements are available and no substantially new techniques are needed to produce a variety of working systems. However, additional research and development, and increases in the real prices of electricity and fossil fuels are necessary to make solar cooling systems economically competitive with conventional equipment. Increases in the prices of electricity and fossil fuels will also improve the economic competitiveness of solar water and space heating systems.

A small market for solar heating and cooling of buildings (SHACOB) has already developed in the United States. A much more significant SHACOB market could develop in the future. However, there are a wide variety of potential barriers that could stop or at least slow that development. These barriers are similar to the barriers that confront the introduction of any new technology into the building industry. Without government action, it is uncertain whether the SHACOB market will develop quickly enough or to the extent required to meet the expectations and needs of the nation.

This SHACOB Commercialization Report (PARTS A and B) has been prepared to discuss possible options and strategies for federal government action for accelerating the commercialization of SHACOB. The two primary purposes of the report are to (1) analyze the potential barriers to SHACOB and (2) estimate the costs and benefits of potential federal economic incentives which could be instituted to:

- Stimulate accelerated development of market demand for SHACOB, and
- Stimulate development of a SHACOB industry infrastructure capable of meeting an accelerated market demand.

The secondary purpose of this report is to discuss other actions which could be (and in some cases are being) taken to accelerate SHACOB commercialization. These actions include, among others:

- State and local government actions which have been proposed and/or enacted to allow SHACOB to reach full potential in the near-term.
- Cross-impacts of SHACOB with the gas and electric utilities and possible actions that utilities could take to address these impacts and accelerate SHACOB commercialization.

There are no major technical obstacles to the use of solar energy for space heating and hot water applications. In "active" SHACOB systems, a liquid or air is circulated through solar collectors angled toward the sun. Solar energy heats up the fluid, which then is usually moved by pumps or fans through pipes or ducts to a storage unit--which might be a water tank, or a bin full of warm rocks. The heat is then delivered from the storage unit when needed. In "passive" SHACOB systems, similar results are attained with creative building design and materials choices instead of separate mechanical devices.

Most residential solar heating systems today are being designed to supply from 1/2 to 3/4 of the space heating or hot water needs over a year's time. Enough heat is usually stored during the day to handle nighttime energy demands. The storage is often large enough to last for 1 or 2 days if cloudy weather persists. Auxiliary heaters take over when stored energy is depleted.

As is true with other forms of energy, it is important to coordinate the use of solar energy with energy conservation measures. Conservation will have to play an increasing role in U.S. energy policy until alternatives to the depletable fossil fuels can be developed. Therefore, widespread usage of SHACOB will occur in conjunction with increased emphasis on the more efficient utilization of energy. Coordination of solar energy and conservation will have to be considered when incentive actions are examined.

Given current energy prices, numerous conservation measures are usually closer to economic feasibility than SHACOB. In the residential sector, for example, insulation, storm doors and windows, automatic thermostats, furnace modifications, and reductions in infiltration (weather stripping and caulking) represent more economically feasible energy investments than solar water and space conditioning systems.

If residential and commercial building owners perceive conservation and SHACOB as mutually exclusive alternatives, SHACOB could face a major barrier to commercialization. When building owners have limited capital funds for energy investments, conservation alternatives will quite properly obtain the bulk of the funds. It may often be desirable, however, to install a SHACOB system in addition to energy conservation measures. This is the case when both SHACOB and conservation are competitive with conventional energy sources.

B. Organization of the Report

PART A of the SHACOB Commercialization Report is organized into three separately bound volumes. Volume 1 is the executive summary. It briefly summarizes the major findings and conclusions of the report. Volume 2 is the technical report. Volume 3 contains the appendices that support the technical report.

The technical report (Volume 2) is further divided into five chapters. The background is discussed in Chapter 1. After an introductory section, the national and regional perspectives for SHACOB are presented. The chapter ends with an overview of the participants in SHACOB commercialization.

Chapter 2 defines the problem of SHACOB commercialization. Discussions of economic, institutional, legal and other barriers constraining SHACOB commercialization are contained in this chapter.

Chapter 3 deals with the analysis procedure and the baseline case. Various analytical models are examined which project the future extent of SHACOB use (or SHACOB market penetration) and future SHACOB contributions to U.S. energy supplies under alternative government policies. The model used in PART B of the SHACOB Commercialization Report, which provides quantitative analyses of the policy options examined in this report, is then described in more detail. Finally, the results for the baseline case (i.e., assuming no further government actions for accelerating SHACOB are implemented) of several market penetration models are presented.

Chapter 4 is organized to parallel Chapter 2. Chapter 4 presents possible ways to overcome each of the barriers presented in Chapter 2. A wide range of individual federal and state incentives that might accelerate SHACOB commercialization are examined. Qualitative analyses are presented on incentives such as public education programs, financial education programs, the development of codes and standards, electric and gas utility programs, and state incentives. Qualitative analyses are also presented for residential and non-residential user incentives (grants, tax credits, subsidized loans, loan guarantees, and accelerated depreciation) and producer incentives such as the solar energy government buildings program. Each incentive is examined to assess its impact on barriers to SHACOB commercialization and its impact on various income and interest groups. Possible administrative mechanisms are identified for each incentive.

Chapter 5 compares individual incentives and combines them into alternative policy strategies and options. The combination of incentives contained in the President's National Energy Plan is examined first. Next, an expanded version of the National Energy Plan is discussed. Finally, a program containing new solar initiatives is addressed.

A glossary of technical terms and abbreviations used in the report is provided at the end of Volume II.

C. National Perspective for SHACOB

As mentioned earlier, energy problems in the United States are continuing to grow more severe. According to the Federal Energy Administration's (FEA) projections in the 1976 National Energy Outlook, the nation's total energy demand in 1975 was equivalent to about 34 million barrels of oil per day (mmb/d).[1/] This demand is expected to grow to about 47 mmb/d by 1985 and 55 mmb/d by 1990. At the same time, domestic energy production has declined and both domestic and imported energy prices have increased drastically.

1/ Superintendant of Documents, U.S. Government Printing Office, Washington D.C., 20402.

The integral role that energy plays in the U.S. economy makes energy of vital interest to policymakers and the nation. SHACOB represents a possible partial solution to our current energy problems. However, the costs and benefits of SHACOB must be compared with alternative energy supply sources when national investments are being considered.

Comparisons of solar energy to other energy technologies can be achieved at two levels. First, investment decisions can be made on the basis of economic factors as viewed by the private sector. If policymakers use these decision criteria, they should arrive at results similar to those reached by the private sector.

The second level of comparison is based on more broadly defined social factors. That is, energy decisions can be made on the basis of overall societal benefits and costs rather than just the costs and benefits as perceived by the private sector. Factors entering this broader decision framework include: environmental costs and benefits of the technologies, balance of trade implications, national security factors, impacts on the nation's economy, impacts on conservation of domestic resources and the societal value of conventional fuel savings (i.e., the price of the fuel if all existing and historic subsidies were removed). This broader decision framework more accurately reflects the interests of the nation as a whole than does the purely private sector economic decision framework.

1. Energy consumption in buildings: As stated previously, the equivalent of about 34 million barrels of oil per day (mmb/d) were consumed in the U.S. in 1975. About 22% of that total demand (or 8 mmb/d) was for heating and cooling of buildings and for domestic hot water.

In 1975, all solar technologies combined contributed to the U.S. energy supply by providing fossil fuel savings of approximately 0.18 mmb/d (primarily from the use of forestry residues as fuel in lumbermills).[1/] The contribution by solar energy to the nation's overall supply was about 0.5% in 1975. The Congress asked FEA to analyze commercialization incentives and options which could achieve "on the order of 1 million barrels per day of oil equivalent in energy savings by 1985 from a combined total of all solar technologies."[2/] The percentage of the total solar contribution that can be expected from SHACOB in the residential and commercial sectors depends on a wide variety of factors--including what SHACOB incentives are instituted by the government.

1/ Stanford Research Institute report for the National Science Foundation, entitled "An Evaluation of the Use of Agricultural Residues as an Energy Feed Stock," March 1976.

2/ Energy Conservation and Production Act of 1976 (PL 94-385), Conference Report to accompany H.R. 12169, August 5, 1976, p. 66--discussed later in Chapter 1.

To get a better understanding of the requirements of the Congressional target, a review of the U.S. binding inventory is useful. Table 1 presents U.S. residential and commercial building inventories for 1975 and projects them through 1990. The total number of residential housing units (three stories or less) was 66.9 million units in 1975. By 1985, that total is projected to reach 77.6 million units with 82.9 million units being contained in the inventory by 1990. In the commercial and institutional sectors, approximately 27.1 billion sq ft of floor space was in place in 1975. That total is projected to reach 39.8 billion sq ft by 1985 and 48.3 billion sq ft in 1990.

Figure 1 presents the relationship between the U.S. building inventory and the 1 mmb/d Congressional solar target. A large number of assumptions must be made to relate the Congressional target to the required penetration of SHACOB into the residential and commercial building sectors. Figure 1 explicitly states those assumptions. First, it is assumed, merely for explanatory reasons, that SHACOB will contribute 25% of the 1 mmb/d energy savings target. Assuming average generation losses of 0.5 implies that solar collectors must produce the equivalent of approximately 125,000 barrels of oil per day in order to save 250,000 barrels of oil equivalent per day by 1975. This output requires a collector area of about 1.5 billion sq ft.* This collector area is then distributed across the residential and commercial sectors as shown in Figure 1. Following the logic of Figure 1, the net result is that 18% of the 1985 residential building inventory will have to use solar hot water heaters and 1.1% of that inventory will have to use combined hot water and heating systems. Only 0.1% of the residential inventory will have to utilize combined solar heating and cooling systems.

In the commercial sector, Figure 1 shows that 20% of the available commercial floor space will have to be served by solar hot water systems, 0.9% served by combined hot water and heating systems, and only 0.3% served by combined heating and cooling systems. Of course, this result only represents one of many alternative scenarios.

On April 20, President Carter presented an alternative solar target of 2.5 million residences with solar energy systems by 1985. Using the same assumptions presented in Figure 1, this goal is approximately equivalent to 25,000 barrels of oil equivalent per day (if all homes just used solar hot water systems) and 120,000 barrels of oil equivalent per day saved if all homes used combined hot water and heating systems. As mentioned previously, these estimates assume average conventional generation losses of 0.5.

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* This result assumes (1) 50% of the collector area will be used for hot water, 45% for combined hot water and heating, and 5% for combined heating and cooling systems, (2) average collector performance of 210,000 Btus/ft^2/year for hot water systems, 128,000 Btus/ft^2/year for combined hot water and heating systems, and 204,000 Btus/ft^2/year for combined heating and cooling systems, and (3) 5.8 million Btus per barrel of oil (See Volume III, Appendix A, for further details).

TABLE 1

U.S. RESIDENTIAL AND COMMERCIAL BUILDING INVENTORIES AND PROJECTIONS TO 1990

	Inventory 1975	New Construction 1975-1980	Removals 1975-1980	Inventory 1980	New Construction 1980-1985	Removals 1980-1985	Inventory 1985	New Construction 1985-1990	Removals 1985-1990	Inventory 1990
Residential Inventory (Thousand Units)										
Single Family b/	48,133	6,798	3,165	51,763	6,389	2,782	55,370	5,855	1,864	59,361
Multifamily Low c/	17,422	3,298	2,362	18,358	3,121	2,308	19,171	2,483	2,120	19,534
Condominium d/	1,345	855	a/	2,200	855	a/	3,055	1,000	a/	4,055
Total (Thousand Units)	66,900	10,948	5,527	72,321	10,365	5,090	77,596	9,338	3,984	82,950
Commercial and Institutional Inventory (Million Square Feet)										
Commercial	18,325	5,000	842	22,483	7,130	1,352	28,261	8,723	1,680	35,304
Institutional	8,808	1,815	461	10,162	2,025	613	11,574	2,167	695	13,046
Total (Million Square Feet)	27,133	6,815	1,303	32,645	9,155	1,965	39,835	10,890	2,375	48,350

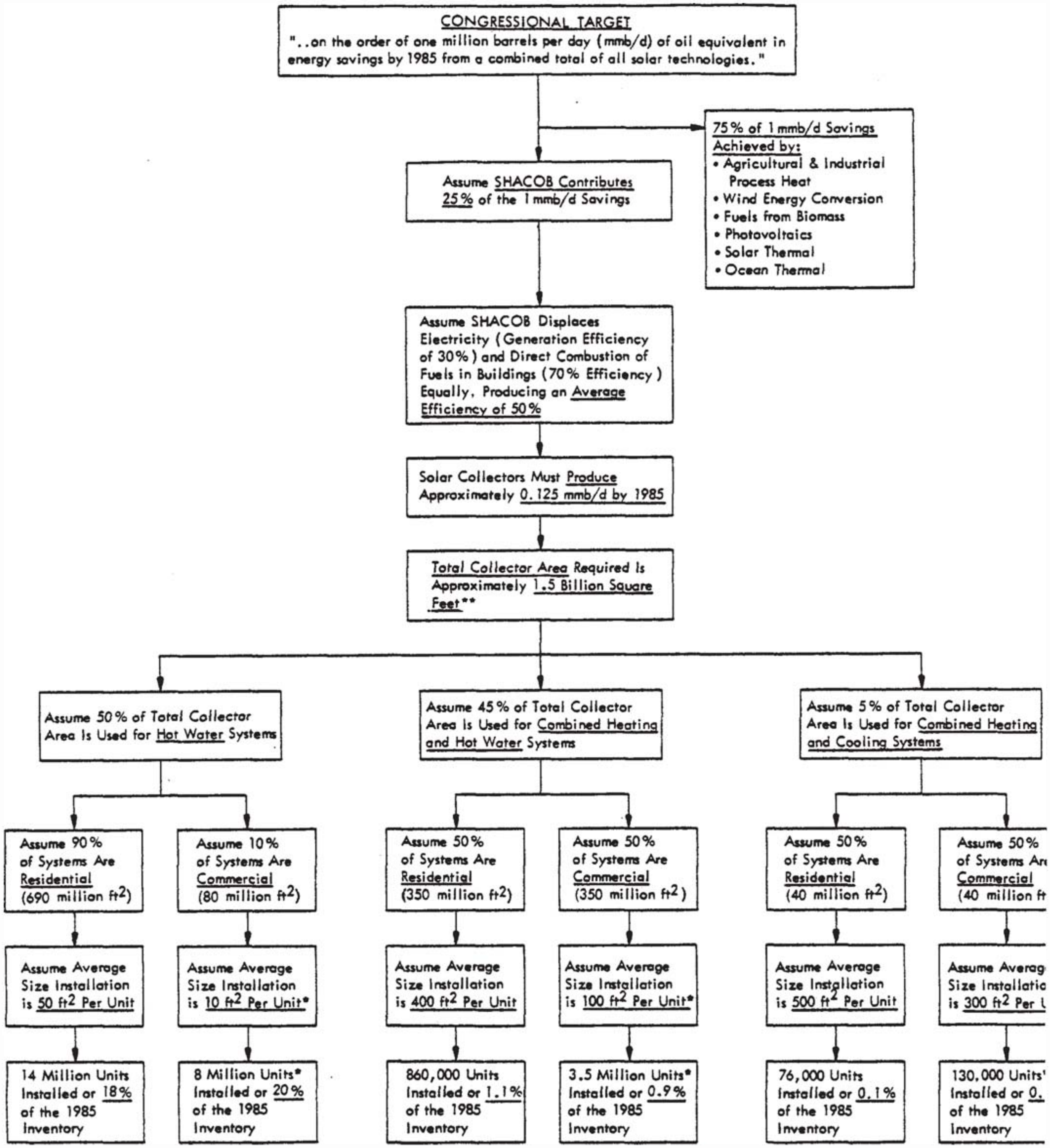
Source: 1975 inventory estimated from the 1970 Census of Housing and from the Annual Housing Survey:1973, U.S. Census Bureau and the Department of Housing and Urban Development. Projections to 1990 by A. D. Little, Inc., in "An Analysis of the Market Development of Dispersed Usage Solar Energy Systems 1976-1985," Draft Report to Federal Energy Administration, pp. II-19 and II-24, March 1976.

a/ Condominium conversions are assumed to be approximately equal to removals.

b/ Denotes one-unit detached structures.

c/ Denotes owner occupied units in one-unit attached structures and two or more unit structure, but with three stories or less.

d/ Denotes renter occupied units in one-unit attached structures and two or more unit structures with three stories or less.



* Commercial "Units" Are 1000 ft^2 of Floor Space.

** Assumes: Average Collector Performance of 210,000 BTU/ft^2-Year for Hot Water Systems, 128,000 BTU/ft^2-Year for Heating and Hot Water Systems, and 204,000 BTU/ft^2-Year for Heating and Cooling Systems; and 5.8×10^6 BTU per Barrel of Oil.

Source: Midwest Research Institute

Figure 1 - Possible Relationships Between SHACOB Penetration and the Congressional Target

2. National benefits of SHACOB: Solar energy is a renewable, environmentally benign, domestically available and abundant resource. Although these benefits are obvious, they have important national and regional implications.

The benefits of solar energy utilization include:

- Social (i.e., national) value of not depleting finite energy resources in the production of energy;
- Social value of long-term availability;
- Social value of not polluting the environment as a by-product of energy production;
- Social value of insurance against foreign energy curtailments, restrictions, or price increases;
- Social value of solar technology for exportation to other nations;
- Social value of information gained that could be transferred to other energy problems (e.g., the development of practical energy storage systems);
- Any improvement in national employment or economic conditions due to the RD&D program or the growth of a new industry; and
- Value of any subsidies on displaced conventional energy sources.

These benefits, which have been termed Total National Value (TNV),1/ are a major justification for government efforts to accelerate solar energy commercialization.

One of the most significant national benefits of SHACOB is as a substitute (or displacer) for conventional fuels. In most cases, each Btu of energy that can be supplied by solar energy in the residential and commercial sectors displaces at least 1 Btu of fossil fuel, except in cases where heat pumps are employed or waste heat utilization is practiced. If fossil-fuel generated electric heat is being displaced, the savings are approximately 3 Btus of fossil energy per Btu of solar. This additional energy savings results from energy losses that occur in the generation and transmission of electrical power, and the subsequent conversion of that electricity to usable heat in the buildings. The value to the nation of utilizing solar energy to displace conventional fuels depends on both the type of fuel that is being displaced, the value of that resource to society, and auxiliary benefits such as reduced adverse environmental impacts.

1/ MITRE/Metrek, "Solar Energy Government Building's Program: Policy and Implementation Plan," Report for FEA, Contract No. CR-05-60704-00, January 1977, pp. 4-28 - 4-29.

The potential benefit of solar energy as a displacer of fossil fuels will increase in the future. Energy consumption in the residential and commercial sectors is expected to increase to 9.3 mmb/d in 1985 and 10.1 mmb/d in 1990, as forecast in the 1976 National Energy Outlook (NEO). Growing demand for limited supplies of fossil fuels increases the need for alternative energy sources.

As mentioned earlier, the benefits of conserving fossil fuels depend in part on the amount of fuel saved and its economic value to society. The most widely used measure of economic value is the market price of the fuel. The National Energy Outlook includes projections of future fuel price trends.[1/] The price of natural gas in the residential sector is projected to increase 3.1% per year over the rate of inflation between 1975 and 1985 and 4.5% per year in the 1985 to 1990 period. Uninflated electricity prices are expected to increase at a 1.2% annual rate between 1975 and 1985, while heating oil is expected to escalate 2.4% per year over the same period. From 1985 to 1990, both electricity and fuel oil are not expected to escalate faster than the general rate inflation. Although projections of future conventional fuel prices are highly uncertain, one can reasonably conclude that the value to the nation of SHACOB in displacing electricity and fossil fuels will increase substantially in the future.

Another important benefit of solar heating and cooling of buildings is its long-term availability. Although the amount of solar radiation striking the collectors varies daily, the annual radiation is predictable. Furthermore, solar radiation will continue to be available in the future. The availability of conventional fuels is much more questionable and future availability of natural gas is particularly uncertain. Natural gas currently provides about 30% of the total U.S. energy supply and 44% of nontransportation direct uses.[2/] Forty million residences and 3.4 million commercial establishments consumed natural gas in 1974. Residential use of natural gas is predominately for space heating (70%) and water heating (20%).[3/] However, since 1968, natural gas consumption on the continental U.S. has exceeded additions to reserves. Interstate gas pipeline companies have not been able to meet their gas delivery contracts. In 1974, for example, governments in 33 states placed moratoria on new additions of residential customers. The outlook for natural gas will continue to include some restrictions on additional customers and curtailments to existing customers.

D. Regional Perspective for SHACOB

The potential benefits of utilizing solar energy for heating and cooling of buildings vary across geographic regions. The contribution of SHACOB to the energy supply of any given region (and the economic feasibility

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1/ Federal Energy Administration, 1976, op. cit.
2/ National Energy Outlook, op. cit, p. 111, 1976.
3/ Ibid.

of SHACOB) will generally vary with the amount of solar radiation, the size of the heating and cooling requirements, price escalations of conventional fuels, regional differences in collector prices, the stock of buildings, new housing starts, and population and income growth rates.

Weather variability in terms of degree days* of heating is shown in Figure 2. Figure 3 presents regional variability information concerning cooling. The wide variability in heating demand is illustrated by a comparison of the middle Florida (500 degree days) and parts of Montana (10,000 degree days). Solar radiation differences are presented in Figure 4. There is a range of about 300 to 500 langleys/day (on a horizontal surface) across the U.S.** However, the amount of usable solar energy on a tilted surface is greater than the values indicated in the figure, especially in the northern latitudes of the U.S. Regional variations in weather and solar insolation influence the performance of different types of SHACOB systems in different regions.

Regional variability in fuel price growth rates in real terms (uninflated) are presented in Table 2. In the Southwest (Region 6), real electricity prices in the residential sector are forecast to increase at a 4.0% real rate. In contrast, nominal electricity prices in New York/New Jersey (Region 2) are expected to increase slower than the inflation rate, resulting in a 0.9% decrease in real terms. Natural gas and oil prices exhibit a similar regional variability. Regional fuel price variations have a major impact on the economic competitiveness of SHACOB in different regions.

The total demand for energy also varies between geographic regions. Regional demand for energy in the residential and commercial sectors is forecasted to the year 1985 in Table 3. The 1975 to 1985 growth rates are also presented. The demand for energy will generally correspond closely to population growth and economic activity. In areas of greater population growth, it will be particularly important to incorporate solar energy into new buildings, whereas in other areas SHACOB will primarily be directed to retrofit existing buildings.

E. Participants in SHACOB Commercialization

The federal government, state and local governments, the solar industry, and utilities have been primary participants in the development of the SHACOB market to date and will continue to play important roles in future commercialization. The activities of each of these four groups are discussed in more detail below.

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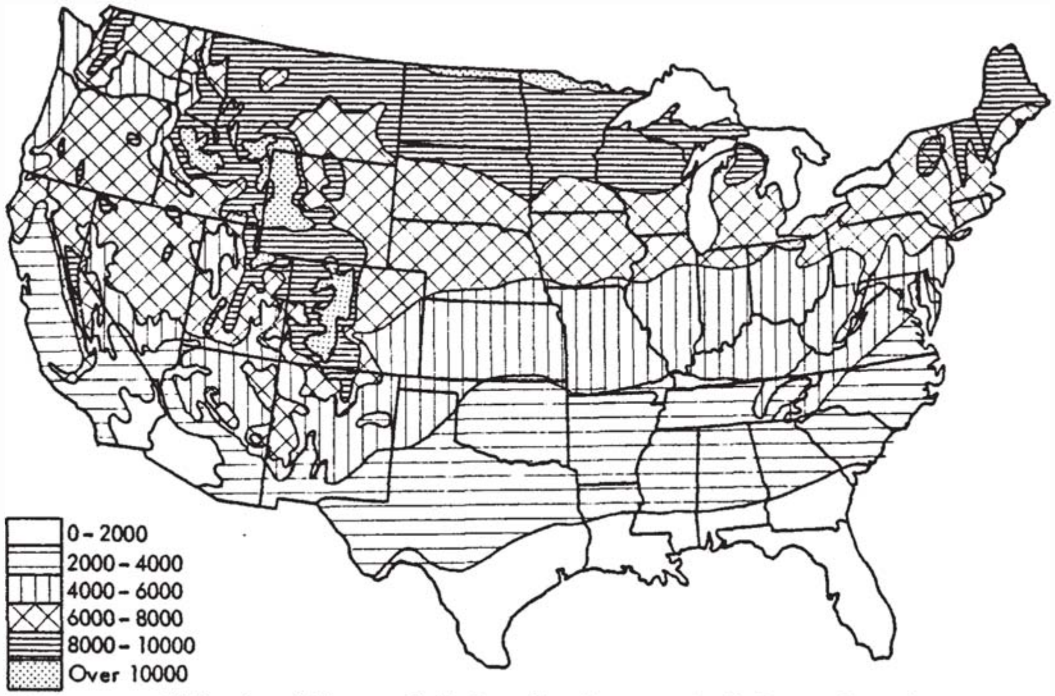
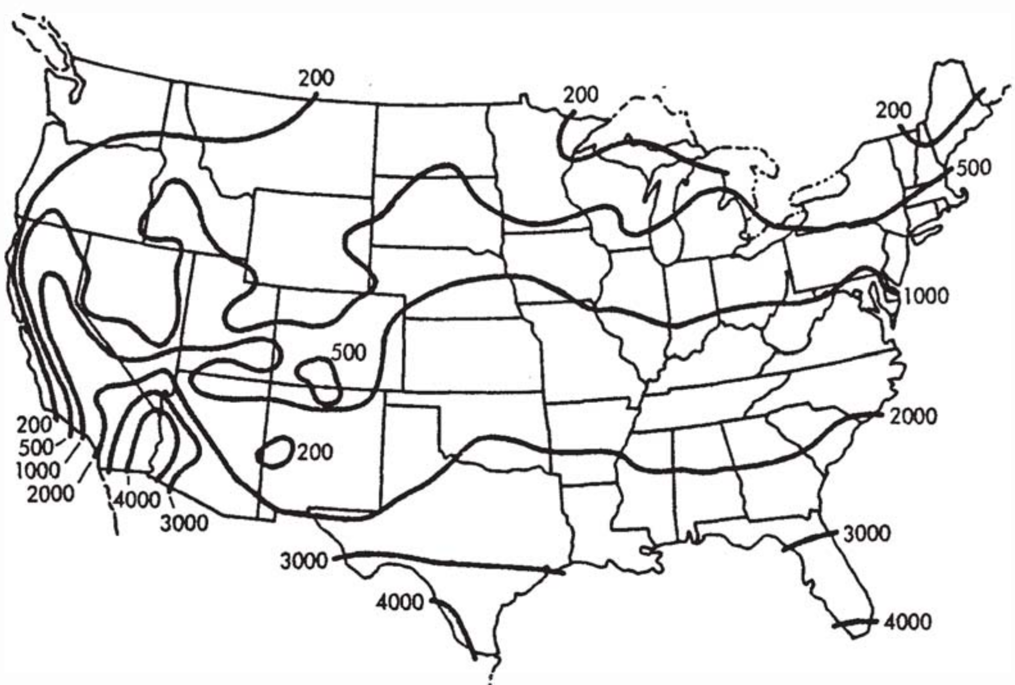
* A degree day of heating is defined as the temperature difference between the daily mean temperature and 65°F.

** A langley is a measure of the intensity of solar radiation. 1 langley equals 1 calorie per square centimeter or 0.271 Btus/sq ft.



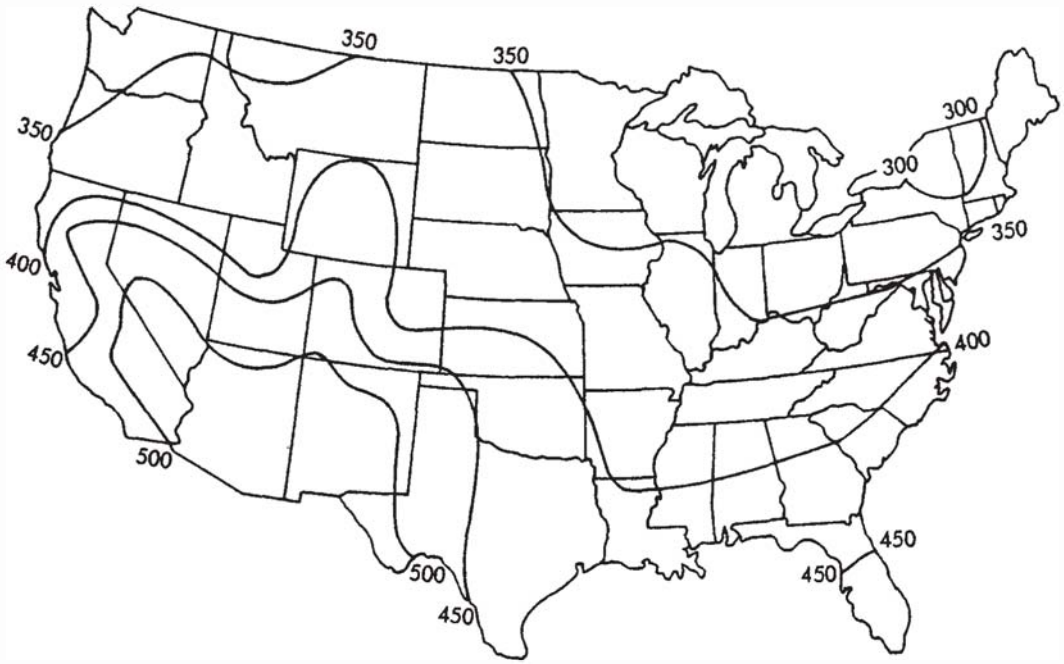
Source: <u>Climate Atlas of U.S., Environmental Data Service,</u>
U.S. Department of Commerce, June 1968.

Figure 2 - Regional Distribution of Annual Degree Days of Heating



Source: <u>Climatic Atlas of U.S., Environmental Data Service</u>
U.S. Department of Commerce, June 1968.

Figure 3 - Regional Distribution of Annual Degree Days of Cooling



Source: Climatic Atlas of U.S., Environmental Data Service, U.S. Department of Commerce, June 1968.

Figure 4 - Mean Daily Solar Radiation Distribution (Langleys on a Horizontal Surface)

TABLE 2

PROJECTED GROWTH IN RESIDENTIAL FUEL PRICES

FEA REGIONS
(1975-1985)

FEA Region	Annual Growth Rate* (%) Electricity	Natural Gas	Oil
1 - New England	-0.2	2.1	0.7
2 - New York/New Jersey	-0.9	2.8	1.9
3 - Mid-Atlantic	1.6	4.3	2.6
4 - South Atlantic	0.7	5.7	2.7
5 - Midwest	0.7	5.0	2.1
6 - Southwest	4.0	3.3	2.2
7 - Central	1.3	1.9	1.7
8 - North Central	0.1	3.2	1.8
9 - West	1.9	7.9	1.2
10 - Northwest	3.4	3.9	1.4
Nation	1.2	4.5	1.9

Source: Project Independence Evaluation System, Reference Case.
* Real price increases, net of inflation.

TABLE 3

ENERGY DEMAND IN THE RESIDENTIAL AND COMMERCIAL SECTORS

FEA Region	1975 Demand (Trillion Btus)		1985 Demand (Trillion Btus)		Growth Rates (%) 1975-1985	
	Residential	Commercial	Residential	Commercial	Residential	Commercial
1 - New England	626	551	782	616	2.2	1.1
2 - New York/New Jersey	1,225	989	1,201	869	-0.2	-1.3
3 - Mid-Atlantic	1,051	719	1,247	684	1.7	-0.5
4 - South Atlantic	1,119	847	1,456	1,047	2.6	2.1
5 - Midwest	2,788	1,766	3,366	1,748	1.9	-0.1
6 - Southwest	907	741	1,295	828	3.5	1.1
7 - Central	584	427	686	383	1.6	-1.1
8 - North Central	348	303	405	353	1.5	1.5
9 - West	930	667	978	738	0.5	1.0
10 - Northwest	286	291	380	342	2.8	1.6
Nation	9,864	7,301	11,797	7,608	1.8	0.4

Source: National Energy Outlook, Op. Cit., 1976, Reference Case.

1. The federal government: The federal government has been active in accelerating the commercialization of solar energy for a number of years. Several key legislative actions have already been taken by Congress. The Energy Conservation and Production Act of 1976 (PL 94-385) is the legislative action most relevant to this report. The law authorizes the FEA:

> "to carry out a program to develop the policies, plans, implementation strategies, and program definitions for promoting accelerated utilization and widespread commercialization of solar energy and to provide overall coordination of federal solar energy commercialization activities."

This mandate specifies that FEA shall develop:

- A "national plan for the accelerated commercialization of solar energy" to include workable options for achieving on the order of 1 mmb/d of oil equivalency in energy savings by 1985 from a combined total of all solar technologies;
- Commercialization plans for each major solar technology;
- State solar energy commercialization programs;
- Major commercialization projects including the "Solar Energy Government Buildings Project" and the "Southwest Project"; and
- Studies and analyses addressing mitigation of economic, legal, environmental, and institutional constraints.

On October 1, 1976, FEA established the Task Force on Solar Energy Commercialization to develop the solar policies and plans as called for in the act. To assure the necessary "multi-agency coordination," FEA has been working with the Energy Research and Development Administration (ERDA) and other agencies, as well as the White House Energy Policy and Planning Office.

A multi-agency approach is necessary because solar energy--with several distinctively different energy technologies--is a complex set of alternative energy sources. No single federal agency encompasses all the expertise, insight, and working relationships with the private sector that are essential for accelerating solar commercialization. Effective action at the federal level therefore requires: (1) a central policy focus, and (2) assuring that all affected agencies participate in areas where they can contribute.

Under the present multiple energy-agency structure, the key federal energy agencies are FEA, ERDA, and the energy-related parts of the Department of Interior (DOI). Concurrent with coordination of solar energy commercialization within the federal energy structure, the "non-energy agencies" (especially the Department of Housing and Urban Development (HUD), Department of Commerce National Bureau of Standards, and Department of Treasury) will also play significant roles. Even under a projected Department of Energy, these "non-energy agencies" would still be involved in various aspects of an accelerated commercialization program for solar energy.

The federal government is involved in accelerated commercialization of solar energy because the overall benefits derived from the widespread use of solar energy go beyond the directly calculable economic factors. As stated in the Energy Reorganization Act of 1974 (PL 93-438), Section 2(e):

> "Determination of priorities which are warranted should be based on such considerations as power-related values of an energy source, preservation of material resources, reduction of pollutants, export market potential (including reduction of imports), among others. On such a basis, energy sources warranting priority might include, but not be limited to, the various methods of utilizing solar energy."

These benefits are often referred to as Total National Value. They have been studied by economists for many years. They have not, however, been analyzed in a comprehensive, quantitative manner as they apply to solar energy. Quantification of the Total National Value of SHACOB is beyond the scope of this report. Quantification of these benefits, to the degree possible, is planned for subsequent analysis as a necessary part of the National Plan for Accelerated Commercialization of Solar Energy.

Congressional legislation has designated ERDA as the coordinator of solar energy, research, development and demonstration activities. Legislation authorizing ERDA's solar programs includes:

- Solar Heating and Cooling Demonstration Act of 1974, PL 93-409, which provides for the early development and commercial demonstration of the technology of solar heating and combined solar heating and cooling.

- Energy Reorganization Act of 1974, PL 93-438, which establishes the Energy Research and Development Administration.

- Solar Energy Research, Development, and Demonstration Act, 1974, PL 93-473, which authorizes a program of research, development, and demonstration to promote the utilization of solar energy.

- Non-Nuclear Energy Research and Development Act of 1974, PL 93-577, which establishes a national program of basic and applied research and development addressing all potentially beneficial energy sources and utilization technologies.

The federal demonstration activities, initiated under PL 93-409, have continued to expand. The Energy Research and Development Administration (ERDA) has been managing the commercial demonstration program for non-federal buildings since 1976. Locations of the first and second cycles of the program (which included 32 projects in cycle 1 and 80 projects in cycle 2) are shown in Figure 5. ERDA also has lead responsibility for commercial SHACOB demonstrations in federal buildings. Currently Department of Defense (DOD), Government Services Administration (GSA), Tennessee Valley Authority (TVA), and United States Postal Service (USPS) are participating in this program.1/

In the residential sector, the Department of Housing and Urban Development (HUD), in cooperation with ERDA, is managing the non-federal demonstrations. The first cycle of the HUD demonstration program resulted in projects serving 143 housing units at a total cost of almost $1 million. The second cycle involves 1,411 dwelling units at a total cost of $4 million. The third cycle involves 3,468 units at a total cost of over $6 million. The locations of the dwelling units of first, second and third cycle HUD demonstrations are shown in Figure 5. The federal residential demonstration program is being managed by the Department of Defense (DOD). Various military facilities are participating in the program (see Figure 5).

The solar heating and cooling residential demonstration program has been expanded into a grant program to put solar hot water systems in 10,867 homes and thereby induce manufacturers to step up equipment production. The funds will be allocated to 11 states where homeowners paid the highest electric heating bills in 1976 (see Figure 5). The states will then distribute the funds to homeowners and builder-developers who want to install solar hot water systems.

The commercial demonstration program has also been expanded to offer grants for the installation of solar water heating systems in hotels and motels. The commercial hot water initiative is expected to result in grants totalling approximately $5 million in 1977.

Another important federal solar energy program is the establishment of the national Solar Energy Research Institute (SERI). The national SERI was awarded to Midwest Research Institute, with SERI facilities in Golden, Colorado. The national SERI, in conjunction with regional SERI facilities to be established in the near future, will serve as the focal point for solar energy research and information dissemination throughout the nation.

2. State and local government activities: State and local governments have played and will continue to play a key role in accelerating the commercialization of solar energy in the United States. Their roles have

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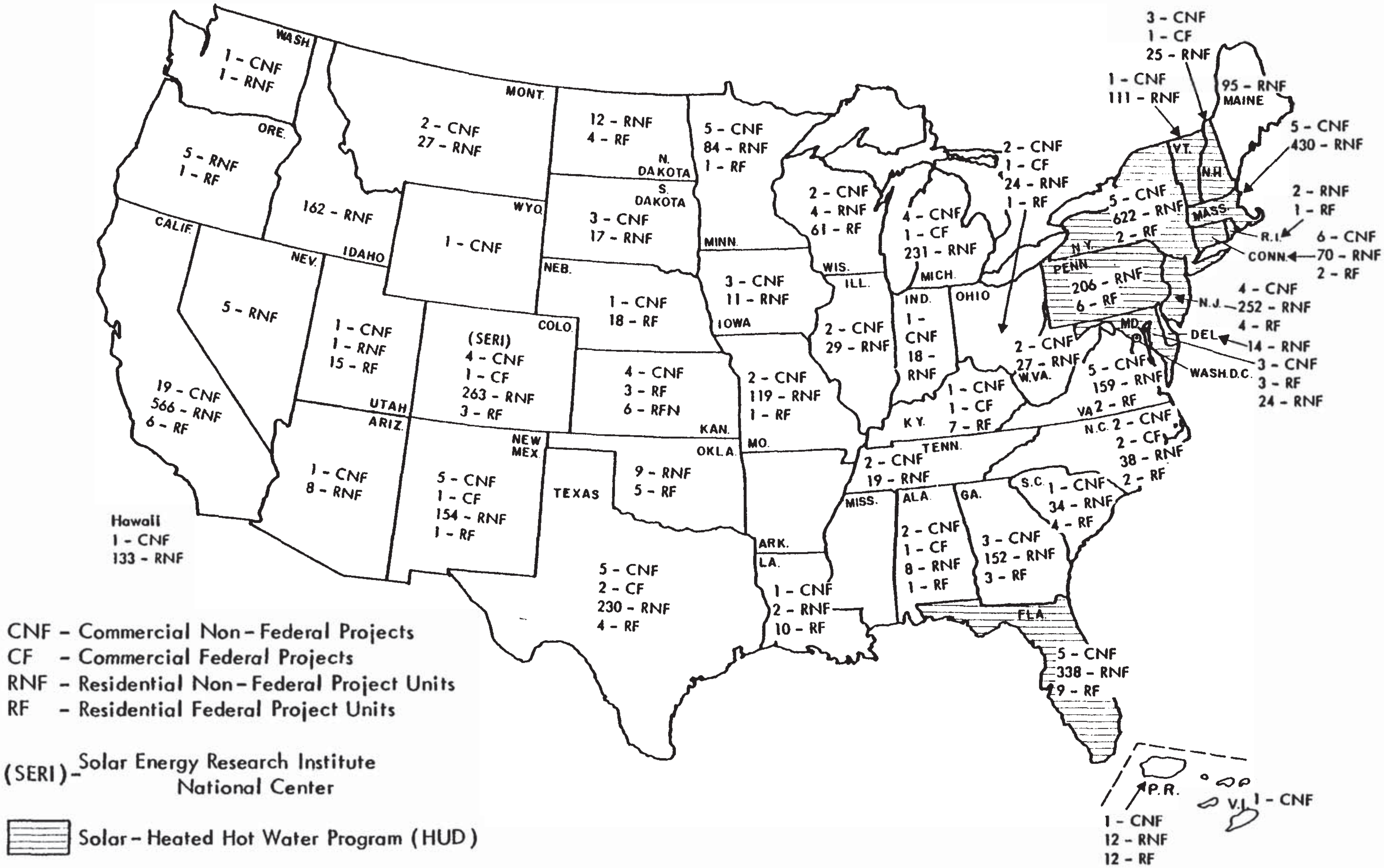
1/ National Program for Solar Heating and Cooling of Buildings, Project Data Summaries, Vol. 1 Commercial and Residential Demonstration, Energy Research and Development Administration (ERDA 76-127), August 1976, p. vii.



Source: National Program for Solar Heating and Cooling of Buildings - Project Data Summaries, ERDA 76-127, Vol. 1, August 1976 (updated to include HUD Cycles 2 and 3 RNF Grants and ERDA Cycle 2 CNF Grants).

focused on their ability to encourage research and development, power to regulate production and distribution of energy, control over regulations affecting energy usage as in building codes, land use controls, and zoning ordinances, educational responsibilities, and policies as consumers of energy themselves.

Many state and local governments have been active in implementing policies affecting SHACOB through legislation and other programs. Legislation introduced in the past 3 years by various state and local governments includes tax incentives, building code modifications, easements and zoning, and state funding for research, development and promotional activities. Of all legislation that has been enacted or proposed, tax incentives have received the greatest attention. Examples of such incentives include property tax exemptions, sales tax exemptions, state income tax deductions and income tax credits. Table 4 presents state acts relating to solar energy which have been passed between 1974 and 1976. Legislation still in the proposal phase cover measures such as life-cycle costing, utility rate restructuring, loan programs and public information programs. This legislation is discussed in further detail in Chapter 4 and Appendix B.

In the administrative realm, various state energy offices share responsibility of solar activities with other state offices including the Governor's office, the public service/utility commissions, corporation commissions and fiannce offices.* Most states also have public information programs. Many have sponsored workshops or seminars largely comprised of participants involved in engineering, contracting, building and manufacturing. Funds for these activities usually come from state education offices or universities.

The federal government has also interacted closely with the states in accelerating solar commercialization. In addition to the demonstration programs, the federal government has begun to establish an Energy Extension Service. Pilot programs in 10 states (to be chosen competitively) will be initiated in 1977. The primary objective of the service will be to encourage energy consumers such as homeowners, small businesses, schools, and state and local governments to adopt measures which save energy or utilize non-depletable energy sources, such as solar energy.

The federal government also expects to work cooperatively with the states in developing solar energy policies and a wide variety of other programs aimed at accelerated commercialization. The types of programs anticipated include:

- Joint state/utility planning projects designed to achieve maximum utilization of solar systems and consistency with gas and electric utility operations;

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* See Appendix B, "State and Local Activities" for further details.

TABLE 4

STATE ACTS RELATING TO SOLAR ENERGY

State Acts Relating to Solar Energy (1974-1976)	Tax Incentives			Easements and Zoning	Standards and/or Certification	Code Provisions	Provide State Promotion, Investigation or R&D	State Buildings to Use Solar
	Real Property	Income	Sales					
Alabama								
Alaska								
Arizona	●	●					●	
Arkansas							●	
California		●					●	
Colorado	●			●			●	●
Connecticut	●				●			
Delaware								
Florida					●	●	●	
Georgia	●		●					
Hawaii	●	●					●	
Idaho		●						
Illinois	●							
Indiana	●							
Iowa							●	●
Kansas	●	●						
Kentucky								
Louisiana								
Maine							●	
Maryland	●						●	
Massachusetts	●							
Michigan	●		●				●	
Minnesota					●		●	
Mississippi								
Missouri								
Montana	●						●	
Nebraska							●	
Nevada								●
New Hampshire	●							
New Jersey								
New Mexico		●					●	●
New York							●	
North Carolina							●	
North Dakota	●							
Ohio							●	
Oklahoma								
Oregon	●			●				
Pennsylvania								
Rhode Island								
South Carolina								
South Dakota	●							
Tennessee								
Texas			●					
Utah								
Vermont	●						●	
Virginia							●	
Washington								
West Virginia								
Wisconsin								
Wyoming								

Source: National Bureau of Standards, Interim Report 76-1082, "A Survey of State Legislation Relating to Solar Energy."

- Programs to utilize solar energy in state and local public buildings;

- State solar energy quality assurance programs to assure that solar equipment sold or manufactured in a state meets appropriate criteria;

- Educational/training programs for builders and homeowners;

- State participation in federal/state/utility comprehensive regional commercialization strategies for large-scale solar electric power generation, such as the Southwest Project;1/

- Economic incentives; and

- Revisions of state/local regulations where necessary (e.g., building codes, land-use planning, solar access, etc.).

FEA has already begun to work cooperatively with Florida in the development of commercialization programs in the State.2/

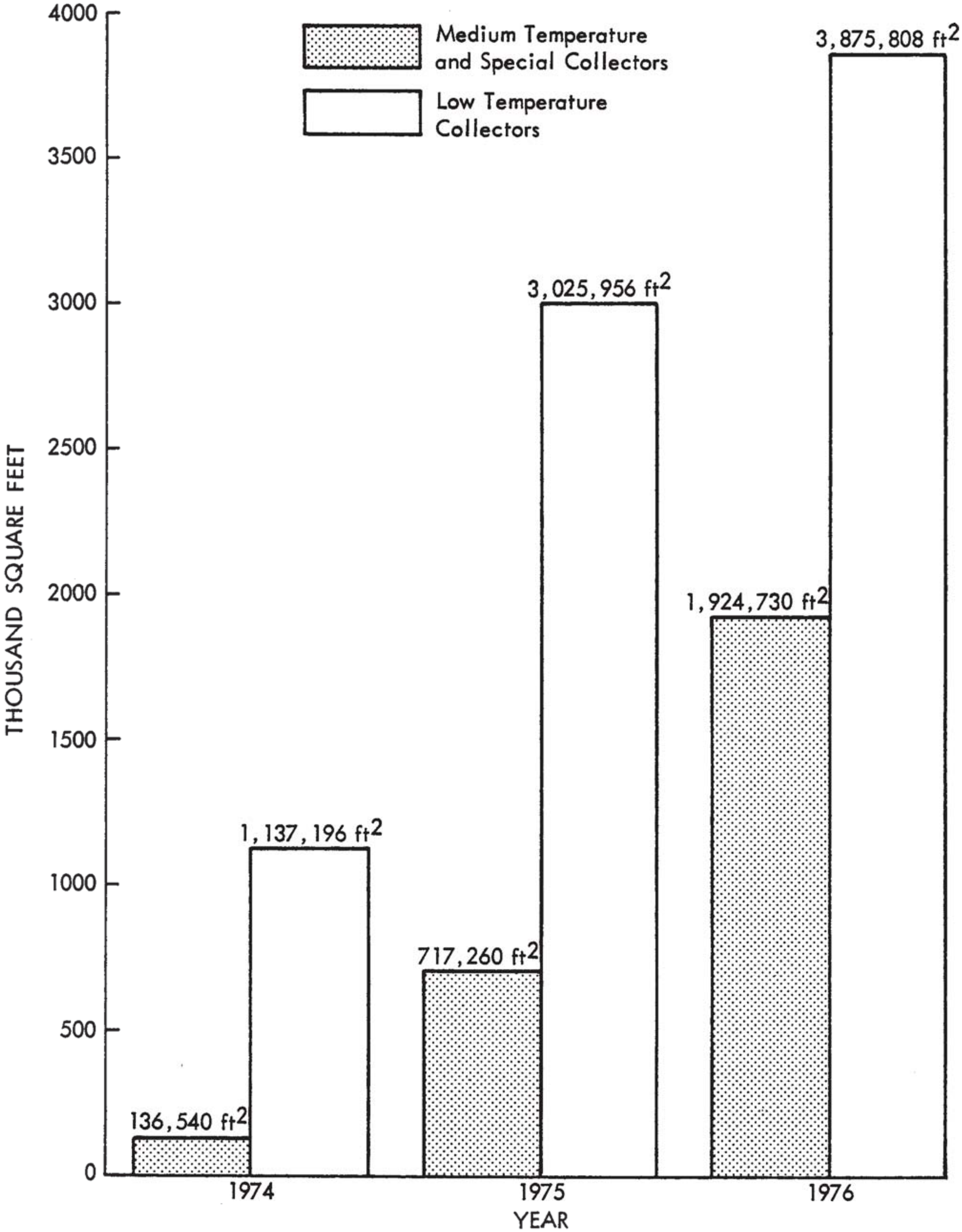
3. The solar energy industry: A viable, although small, solar energy industry has developed in recent years as the demand for solar heating for swimming pools and SHACOB has expanded. The solar collector is the major new component in the solar energy heating, ventilating and air conditioning (HVAC) industry. Collector manufacturing is therefore a primary indicator of the industry state of development.

Figure 6 and Table 5 summarize collector manufacturing activities during the past 3 years. The production rates during those years for medium temperature collectors and low temperature collectors are shown in Figure 6. The cumulative production of all types of collectors from January 1974 to June 1976 was approximately 11 million sq ft. Medium temperature and special collectors accounted for approximately 26% of this production while low temperature collectors accounted for 74%.

Medium temperature (140° to 250°F) and special collectors (i.e., evacuated tube and concentrating) are used primarily for SHACOB applications. Low temperature collectors (60° to 90°F) are currently used almost exclusively for heating swimming pools.

1/ "Southwest Project-Resource/Institutional Requirements Analysis," an FEA study being funded by FEA, ERDA and DOI, conducted by Stone and Webster Engineering Corporation and eleven utilities and involving the state governments in the eight southwestern states.

2/ Florida Solar Energy Center, "Solar Energy Commercialization at the State Level," Prepared for the Federal Energy Administration and the State of Florida, March 1977.



Source: "Solar Collector Activity, June through December 1976," Federal Energy Administration, April 1977.

Figure 6 - Solar Collector Annual Production Rate

TABLE 5

SOLAR COLLECTOR MANUFACTURING ACTIVITY 1974-1976

Solar Collector Annual Production Rate (square feet)	Total 1974		1975				1976			
			January-June		July-December		January-June		July-December	
	Number of Manufacturers	Percent of Production	Number of Manufacturers	Percent of Production	Number of Manufacturers	Percent of Production	Number of Manufacturers	Percent of Production	Number of Manufacturers	Percent of Production
Medium temperature and special collectors										
Greater than 50,000	*	*	*	*	*	*	5	30.9	12	44.5
10,000-50,000	*	*	*	*	*	*	25	40.8	46	41.3
Greater than 10,000	1	40.3	14	78.5	21	74.5	(30) 1/	(71.7) 1/	(58) 1/	(85.8) 1/
2,000-10,000	12	42.0	21	18.9	37	21.0	65	24.9	68	12.3
1,000-1,999	12	11.8	10	2.6	17	3.0	20	2.2	22	1.2
Less than 1,000	14	5.9	24	2.0	25	1.5	27	7.2	29	0.7
Total	39	100.0	69	100.0	100	100.0	142	100.0	177	100.0
Low Temperature Collectors	6	--	6	--	13	--	14	--	15	--

Source: "Solar Collector Manufacturing Activity, June through December 1976," Federal Energy Administration, April 1977.

* Not shown separately before 1976.

1/ Numbers in parenthesis are total of two preceding numbers in same column but not added for final total.

Assuming that all collectors manufactured are currently used for a mix of domestic hot water heating, space heating and pool heating based on industry statistics and collector characteristics, it has been estimated that the current energy savings from solar systems is approximately 1,300 barrels of oil per day.*

Table 5 shows that there are currently 177 companies manufacturing medium temperature and special collectors. Of these, only 12 have an annual production rate of over 50,000 sq ft. The fragmentation of the current industry, in conjunction with its small volume output, reflects the early stage of industry development. Industry growth, however, both in terms of collector production and number of companies manufacturing collectors, has been phenomenal.

The geographic locations of the companies manufacturing different types of solar collectors are shown in Figure 7. The collector industry is at the present concentrated in the Northeast, Florida, and California.

The collector industry is currently dominated by small manufacturers, the majority of which are new companies established to pursue the collector industry. There are, however, a significant number of large corporations involved in collector manufacturing. Large corporations in the solar industry include companies whose major business activities are materials manufacturing, appliance manufacturing, HVAC component manufacturing, chemical processing and aerospace equipment.

In 1974, the Solar Energy Industries Association (SEIA) was established to serve the collector manufacturers, manufacturers of other system components, and service sectors of the industry. The association has grown from six members in 1974 to 570 members as of May 1977. The association acts as a spokesman for the industry and plays an active role in the solar industry's development.

4. Utilities: Electric and gas utility companies have played and will continue to play a role in the commercialization of SHACOB. Utility involvement in SHACOB usually takes the form of providing backup energy. Backup energy is required because it is not economical to size the solar array and storage system large enough to provide 100% of the building energy requirements at all times.

Electric and gas utilities are aware of their roles in SHACOB commercialization and are active in the field. A recently completed survey of electric utilities in the U.S.1/ shows that a significant number of utility companies are undertaking special solar energy related projects. Table 6 summarizes the extent of electric utility solar energy projects.

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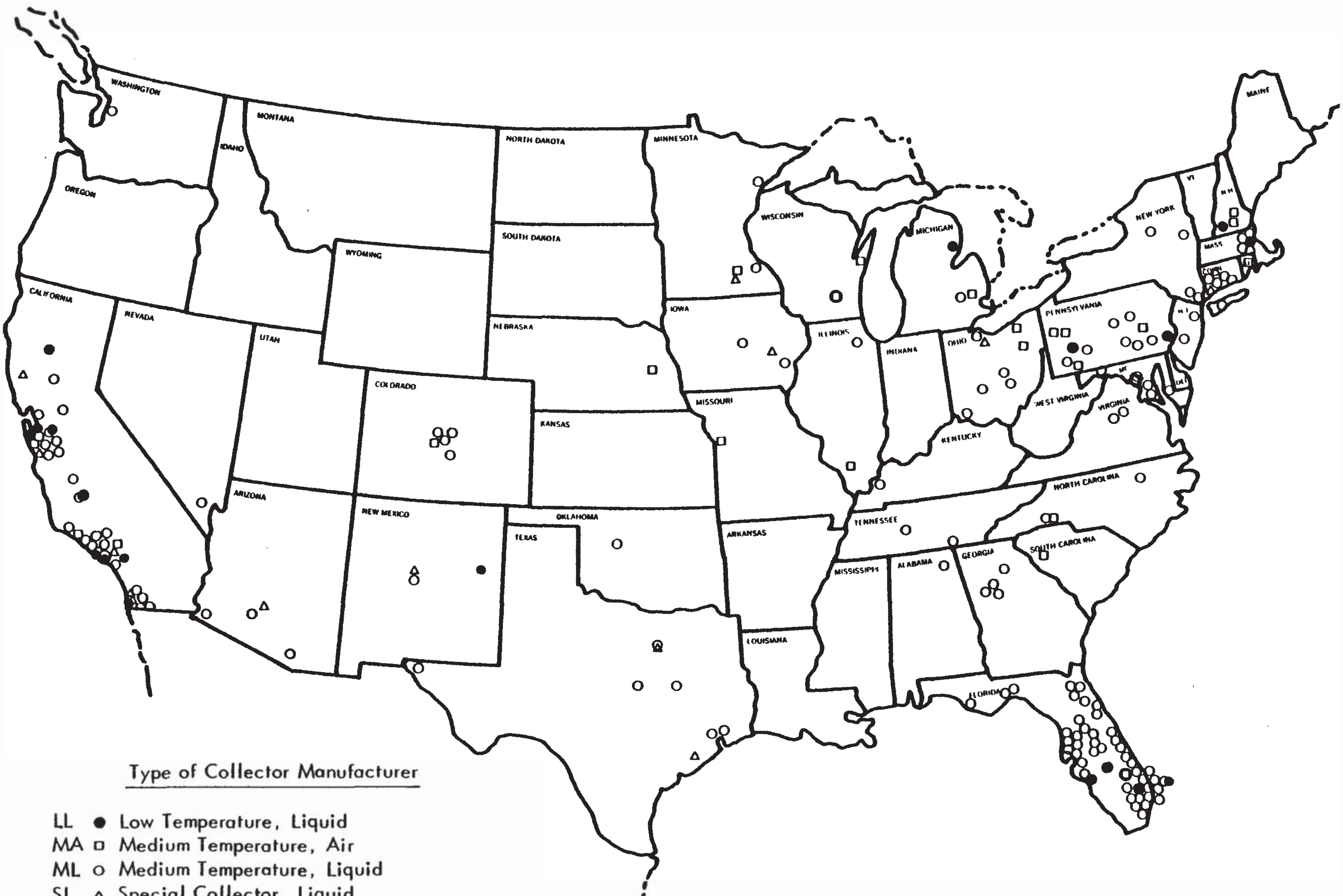
* For an explanation of this calculation, see Volume III, Appendix A.

1/ Electric Utility Solar Energy Activities - 1976 Survey, prepared by Louis D. Cleary, Electric Power Research Institute (ER-321-SR), January 1977.



Source: "Solar Collector Activity, January through June 1976," Federal Energy Administration, National Energy Information Center.

Figure 7 - Geographic Location of Collector Manufacturers

TABLE 6

SUMMARY OF ELECTRIC UTILITIES' SOLAR ENERGY PROJECTS

Category	Utilities Participating In Solar Area	Active and Planned Projects Number	Active and Planned Projects % of Total
SHACOB and Related Projects	98	216	73
Wind	20	29	10
Solar Data Collection	15	17	6
Solar-Thermal Central Power	8	11	4
Photovoltaics	5	5	1
Other	10	17	6

Source: Electric Utility Solar Energy Activities - 1976 Survey, prepared by Louise D. Cleary, Electric Power Research Institute (ER-321-SR), January 1977.

Table 6 shows that the bulk of electric utility solar projects (73%) are directed toward SHACOB. Ninety-eight different utility companies are currently participating in 216 SHACOB-related projects.

A wide variety of SHACOB projects have been sponsored by electric utilities. Some projects are purely informational, as for example a project sponsored by the Long Island Lighting Company (Mineola, NY) to disseminate information to homeowners about SHACOB. Another type of project commonly sponsored by electric utilities is the provision of instrumentation for monitoring the performance of solar buildings. General Public Utilities (Parsippany, NJ), in conjunction with Pennsylvania Electric Company (Philadelphia, PA), provided instrumentation on a solar heating system installed in a private residence. Some utilities have provided complete financing for the construction of SHACOB demonstration projects. The Georgia Power Company (Atlanta, GA), for example, designed and constructed a house with a 1-1/2 ton solar augmented heat pump. Another type of project undertaken by several electric utilities is to sponsor SHACOB research projects in universities. The Iowa Public Service Company (Sioux City, IA) has developed such a relationship with Iowa State University.

A final type of project sponsored by several electric utilities is the project that addresses the specific problem of the SHACOB-electric utility interface. The Electric Power Research Institute (EPRI), in conjunction with two utility companies, the Public Service Company of New Mexico and The Long Island Lighting Company, is sponsoring a project entitled "Individual Load Centers--Solar Heating and Cooling Residential Project." The objective of the project is, by constructing prototypes and using computer simulations, to examine SHACOB designs in these two regions that are preferred from both the user and utility points of view. In another EPRI project, in conjunction with the New Bedford Gas and Edison Light Company, a solar assisted heat pump and off-peak power storage system are being evaluated. Some electric utilities, for example, the Kansas Gas and Electric Company (Wichita, KS), are working to develop special rates for off-peak energy use that would be applicable to SHACOB users. Appendix C contains a more detailed examination of the role of electric utilities in SHACOB. The potential barriers in the solar/utility interface are discussed in Chapter 2.

Gas utilities have also been active in exploring the potential of SHACOB. In fact, many of the programs discussed above are being undertaken by joint electric and gas utilities. One particularly important project being undertaken solely by gas utilities is the solar assisted gas energy (SAGE) experiment. The experiment was initiated in 1973 by Caltech Environmental Quality Laboratory, in cooperation with Caltech Jet Propulsion Laboratory and the Southern California Gas Company (partially funded by the National Science Foundation). The objective of the SAGE experiment is to explore the potential for commercializing gas-supplemented solar water heating systems in new multi-family dwellings in Southern California.

The significant interest in SHACOB on the part of the electric and gas utilities to date indicates that these utilities are interested in SHACOB's future potential. Utility participation in the early use of SHACOB is the first step toward a complementary relationship between SHACOB and the utilities.

CHAPTER 2

PROBLEM DEFINITION AND BARRIERS TO COMMERCIALIZATION

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CHAPTER 2

PROBLEM DEFINITION AND BARRIERS TO COMMERCIALIZATION

SUMMARY

The crucial problem facing the nation is how to use solar energy extensively in those applications which are now technically feasible. In other words, the problem is to motivate homeowners, businesses and institutions to utilize SHACOB systems to meet at least part of their building energy demands.

There are a variety of barriers to the accelerated commercialization of SHACOB. The federal government must first understand these barriers and then take actions to overcome them. The first type of barrier is economic. Consumers often use inappropriate economic decision criteria to determine whether an energy investment is worth the cost. Consumers often use non-economic criteria to make those decisions. Another economic barrier is the separation that often exists between the person who makes the decisions to install a SHACOB system and the person who pays the utility bills (i.e., receives the benefits of SHACOB). SHACOB systems have higher initial costs than conventional systems that must be financed. Some SHACOB systems also have higher life-cycle costs than conventional systems. Another economic barrier is that SHACOB must compete with subsidized conventional energy sources.

There are six major institutional barriers that solar heating and cooling faces. First, traditional practices of financial institutions and the risk associated with a SHACOB investment often produce problems in the cost and availability of financing. The SHACOB industry is in its formative stages and the industry infrastructure has not yet fully developed. Conservative attitudes of the building industry make the situation more difficult. Next, adequate building codes and standards for SHACOB have not yet become widely accepted. Electric and gas utilities may attempt to slow the commercialization of SHACOB if it adversely affects utility operation and, hence, profits. Finally, if consumer attitudes became unfavorable toward SHACOB, a serious barrier to commercialization would arise.

The major potential legal barriers facing SHACOB concern insuring solar access of collectors, overcoming zoning restrictions, and an assortment of less significant legal problems such as patent policies and antitrust laws. Finally, some technological and environmental problems still confront SHACOB.

CHAPTER 2

PROBLEM DEFINITION AND BARRIERS TO COMMERCIALIZATION

Direct utilization of the sun's energy to provide hot water, heating, and cooling energy to residential and commercial buildings could constitute a significant new U.S. energy resource by 1985. Although the potential for solar energy is significant, so are the barriers. The problems facing the federal government are to first analyze the barriers to the accelerated commercialization of SHACOB and then develop policies that overcome these barriers and realize the potential benefits.

This chapter is divided into five sections. The problem is stated in Section A. The remaining four sections describe the barriers to SHACOB commercialization. Economic barriers are addressed in Section B. Section C describes institutional barriers. Legal barriers are examined in Section D. Section E discusses other barriers to SHACOB commercialization.

These barrier categories are chosen primarily for convenience in presentation. It is important to realize that many of the barriers discussed have economic, institutional, and legal aspects. For example, electric utility attitudes toward supplying backup energy, classified here as an institutional barrier, have economic implications because higher costs for backup energy increase the total cost of solar utilization. There are legal aspects of the backup energy problem that need to be considered, such as changes in regulatory policy. Many of the other barriers discussed in this chapter can also be placed into more than one of the defined categories. Throughout these discussions of SHACOB barriers, references are made to the relationship of individual barriers to the other barriers examined.

A. Statement of the Problem

There are no major technological obstacles to using the thermal energy from the sun for heating potable water and for space heating buildings in the residential and commercial sectors. Space cooling applications, while somewhat more complex, are also within the range of current technology. There are, however, a number of technical problems that confront SHACOB, but these deal primarily with improving system performance and reducing costs.

The crucial problem facing the nation is how to use solar energy extensively in those applications which are technically feasible. In other words, the problem is to motivate homeowners, businesses, and institutions to utilize SHACOB systems to meet at least part of their building energy demands. Since solar heating and cooling of buildings is primarily a problem of commercialization, the efforts of the federal government should be directed toward analyzing the economic, institutional, and legal barriers confronting SHACOB and designing cost effective and socially acceptable programs to overcome these barriers.

The decision to implement specific government programs to accelerate the commercialization of SHACOB should ideally be made by comparing the benefits of the widespread use of SHACOB to the proposed program costs. This report is not intended to provide a comprehensive evaluation of the appropriate level of government investment in SHACOB. Rather, the report compares alternative government policies for accelerating SHACOB commercialization. In determining the appropriate level of government investment in SHACOB, it would be desirable to compare the total social benefits of SHACOB commercialization to the total social cost of a commercialization program. The basic elements of such an analysis are described in Appendix E.

B. Economic Barriers

Economic barriers to the commercialization of SHACOB are widely accepted as the most critical. This discussion of economic barriers first addresses consumer economic decision criteria in Section 1. Section 2 examines the impact of ownership on the economic attractiveness of SHACOB. Cost barriers such as high initial and life-cycle costs are discussed next in Section 3. The high initial cost of SHACOB creates financing problems. Financing problems are the subject of Section 4. Finally, the barrier of competition with subsidized energy alternatives is addressed in Section 5.

1. Consumer economic decision criteria: The consumer's economic decision criteria refers to the method a potential solar energy buyer uses to determine whether the investment is worth the cost. Currently, residential, commercial and institutional building owners and developers use a wide variety of decision criteria. These techniques range from choosing the energy alternative with the lowest initial cost to detailed after-tax life-cycle cost approaches.[1/] Other criteria often used (at least in the solar literature) include years to payback and years to positive savings.[2/]

1/ See, for example, (a) "Solar Heating and Cooling of Buildings: Methods of Economic Evaluation," by Rosalie T. Ruegg, National Bureau of Standards, U.S. Department of Commerce, July 1975 and (b) "Evaluating the Total Cost of an On-Site Solar Energy System: by D. Costello and J. Bradley, in Proceedings of the 2nd Annual UMR-MEC Conference on Energy, Western Periodical, North Hollywood, California (1975).

2/ See, for example, An Economic Analysis of Solar Water and Space Heating, Energy Research and Development Administration, Division of Solar Energy, November 1976.

The major differences among these approaches are the number of cost factors considered. Comparing only initial costs ignores all future savings in operating expenses. Calculations of the payback period and years to positive savings usually (although not always) ignore tax considerations and the time value of money.* The life-cycle cost approach considers taxes and tax benefits, all operating and maintenance costs, system and component lifetimes, and the time value of money. A life-cycle approach also requires the projection of the future cost and availability of backup energy which are highly uncertain. This uncertainty is particularly severe, given the possibility of modifications to existing utility rate structures. Utility rate structures, and their implications for SHACOB, are discussed in Section C.

Because life-cycle costing is a complex calculation, it therefore may not be the basis upon which a consumer decision is made. Presently, life-cycle cost analysis is for the most part restricted to the institutional and parts of the commercial sectors, with the majority of homeowners, residential developers and businesses using less sophisticated first cost or payback techniques.

The number of cost factors considered in an energy investment decision has a major impact on which alternative is chosen. This impact is even more important when the flow of costs and benefits of the alternative systems are significantly different. A comparison of a solar energy system and a conventional heating system illustrates this problem.

Figure 8 presents a hypothetical example of the cash flows associated with both a solar and conventional residential heating system. The horizontal axis represents time. The first cash outlays occur before the investment decision is made and are associated with gathering information. Information on solar designs is not as readily available as information on conventional systems. Therefore, the cost of gathering solar information is higher. After the investment decision is made, the installation costs of capital equipment for the solar system are higher than conventional systems. After the system begins operation, the operating expenses, primarily fuel costs, are incurred. The conventional system uses high-priced fuels and is, therefore, more expensive to operate than the solar alternative. As fuel prices escalate, the cost of operating the conventional system increases.**

Given this cash flow pattern, it is evident that comparisons of capital costs alone would prevent any investment in solar energy. On the other hand, if only operating costs are considered, solar energy would gain widespread acceptance.

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* One exception is the ERDA Document, "An Economic Analysis of Solar Water and Space Heating," November 1976.

** The cost of operating the solar unit also increases because some fossil fuel is still used as backup.

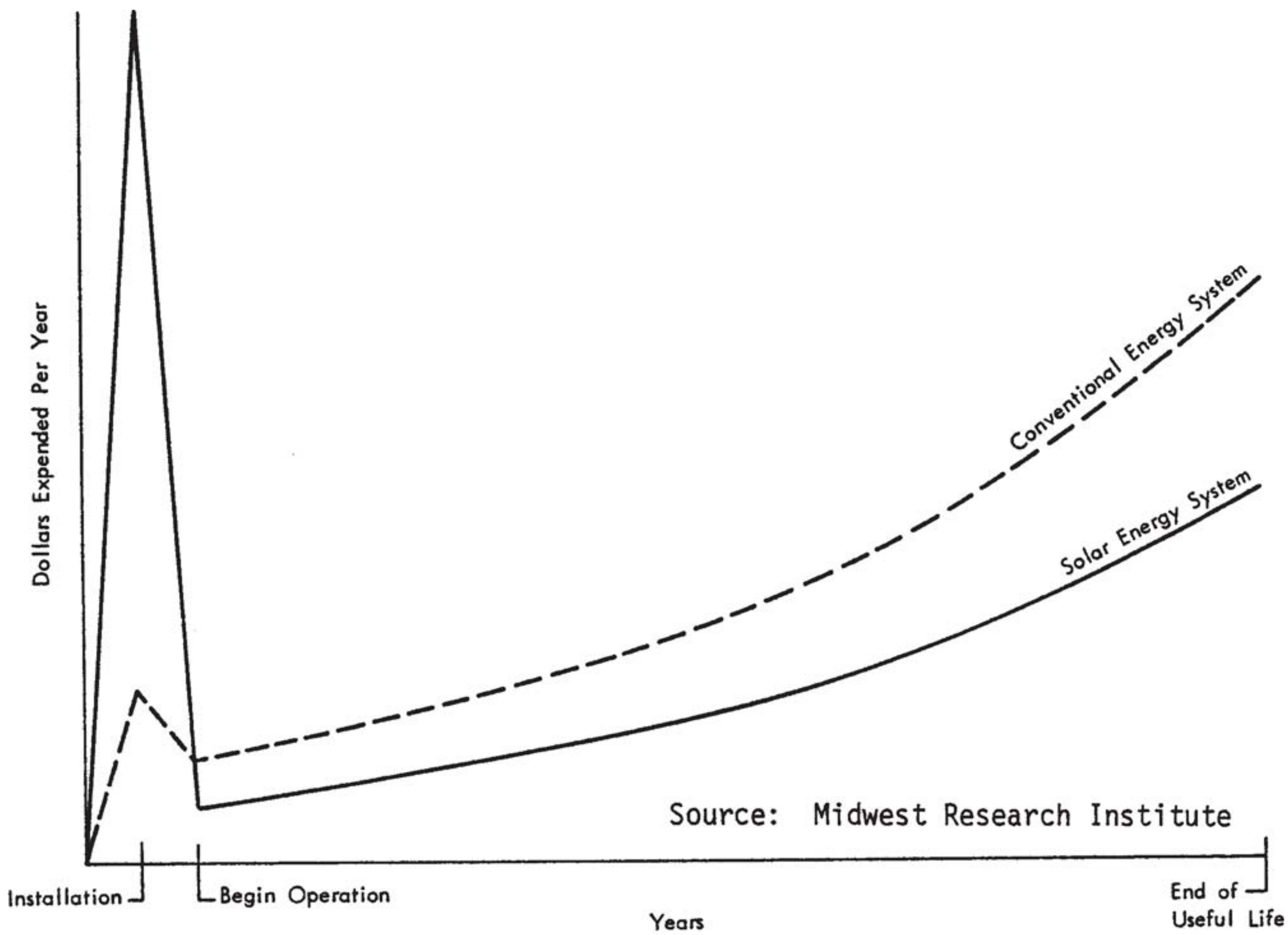

Figure 8 - Cash Flow Patterns

Rather than considering only initial or operating costs, some decision criteria compare these two components of the total cost. The comparison can be done in a number of ways. The most common method is called "payback" or "years to payback." Figure 9 illustrates this method. The cash flows illustrated in Figure 8 are shown as cumulative costs in Figure 9. A comparison of Figures 8 and 9 shows that while the initial costs of the SHACOB system are greater than the conventional system, the cumulative costs of SHACOB over the life of the system are less than the conventional system. The point where the cumulative costs of the conventional system equal the cumulative costs of the solar unit defines the payback year (Point A in Figure 9). In other words, it will take "A" years for the solar alternative to "pay back" its higher initial cost in operating cost savings.

Another method of comparing capital and operating costs is called life-cycle costing. The life-cycle cost method usually includes all capital costs, operation and maintenance costs, taxes, tax benefits and the value of time. The tax effects of the investment are sometimes also incorporated into the payback approach. However, the time value of money (or the opportunity cost of money) is usually included only in the life-cycle cost approach.

The time value of money reflects the investment opportunities given up by the investor when he spends his money now rather than in the future. Taking account of this cost is termed "discounting" the future.

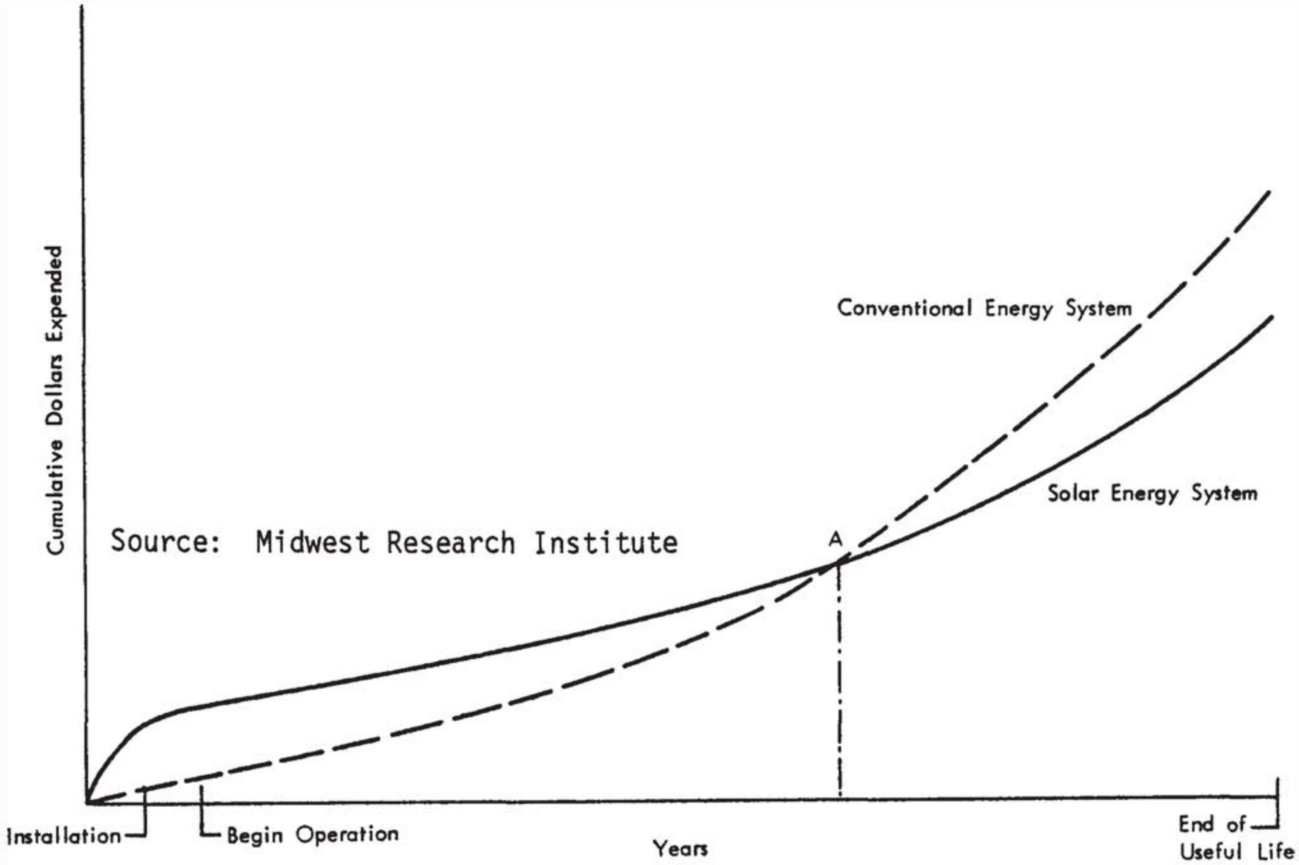

Figure 9 - Cumulative Expenditures

Discounting implies that future costs (or benefits) are less valuable than equal dollar costs (or benefits) in the present. The future is less valuable for two major reasons: (1) inflation will make future dollars less valuable, and (2) if one receives a fixed amount of money in the future instead of the present, he gives up the opportunity to gain interest on those dollars between now and the future.

Figure 10 illustrates how discounting affects energy investment decisions. The same cash flow pattern shown in Figure 9 is repeated in Figure 10. In addition, a 10% rate of discount (or interest) is applied to the cash flows and graphed separately. The year of installation is considered the present and all costs are discounted to that date. Note that as one moves into the future, the effect of discounting increases. In this hypothetical example, discounting completely counteracts the escalations in fuel prices and results in relatively constant cash outlays over the system's lifetime.

The example in Figure 10 demonstrates how the time value of money reduces the effect of future benefits on an energy investment decision. The higher the discount rate, the lower future benefits are valued. Discounting, therefore, tends to have a negative influence on a solar energy investment decision because it makes future benefits less valuable and current outlays more valuable. Nonetheless, time has economic value and the use of discounting should be part of rational economic decision making.

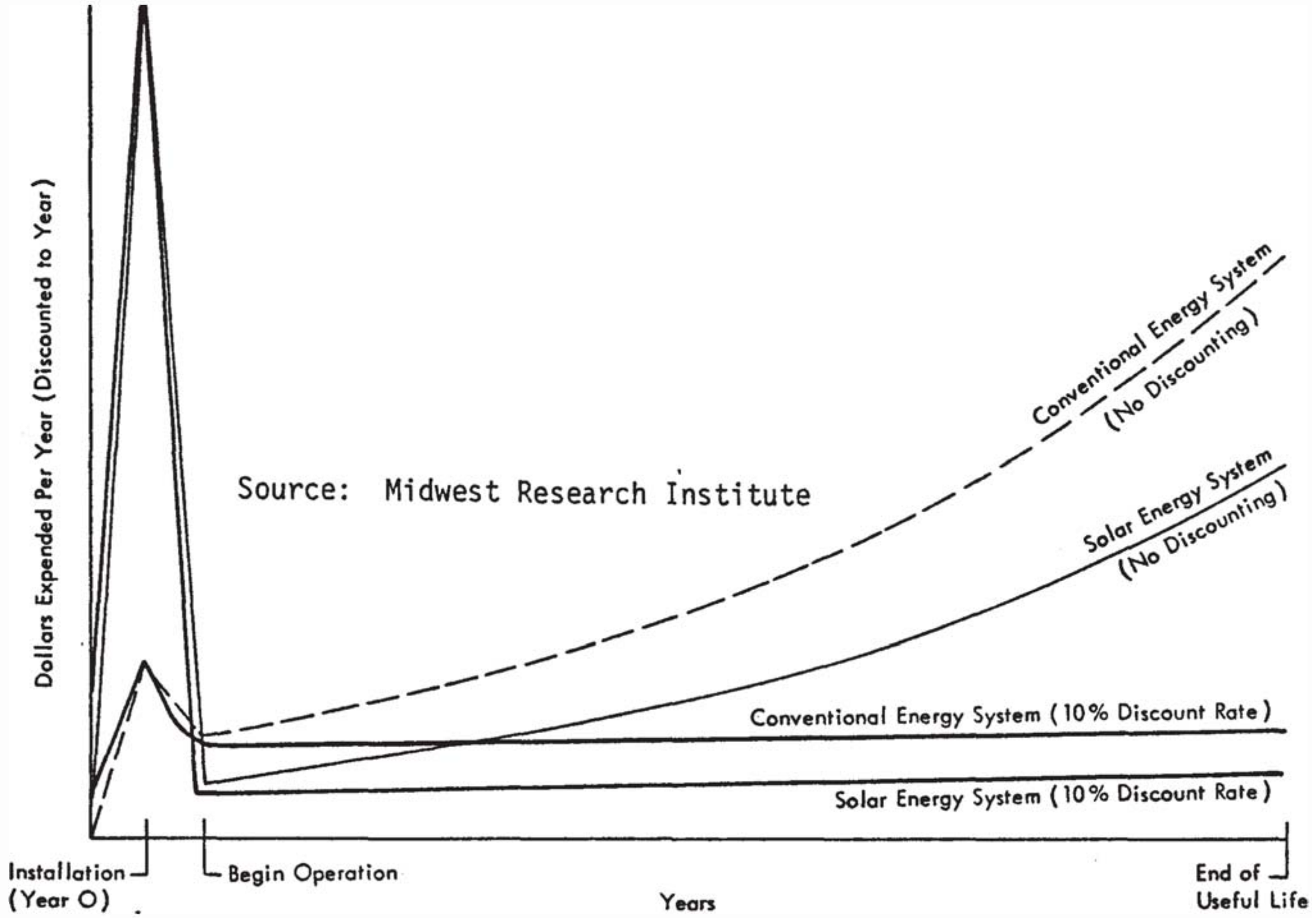

Figure 10 - The Effect of Discounting on Energy Systems, Cash Flow Patterns

In summary, the decision criterion used to determine the economic feasibility of a solar energy system has a profound impact on the result. If the predominant decision criteria in an important economic sector methodically ignore future fuel costs savings, then SHACOB will face an overwhelming barrier to commercialization.

Methods to combat the use of inappropriate decision criteria for evaluating an investment in SHACOB include public information programs and financial education programs promoting the payback and life-cycle cost concepts. Public and financial education programs are described in Chapter 4, Section C. Another alternative is to mandate the use of life-cycle cost analysis in government buildings, as described in Chapter 4.

While the method of economic analysis is an important factor in the consumer decision to buy or not to buy a solar system, there are, however, a number of other factors which influence this decision. The adequacy of the warranty on the solar equipment or the consumer confidence in the projections of system performance, for example, may have considerable influence on the solar purchase decision. Noneconomic decision factors are addressed in the discussion of consumer attitudes contained in Section C of this chapter.

2. Ownership: A second economic barrier to SHACOB commercialization is the separation that often exists between the person who makes the decision whether or not to install a SHACOB system and the person who pays the utility bills. Because purchase of a SHACOB system requires an additional initial investment in return for lower operating costs, it is important that the SHACOB decision maker somehow be able to realize these savings.

Figure 11 presents a matrix of several building situations and the possible SHACOB decision makers and utility bill payers. For each building situation, the primary SHACOB decision maker is denoted by a "D." The bill payer is denoted by a "B." Residential buildings are divided into single family and multifamily, and classified by whether the building is speculatively built, custom built, or a potential retrofit project. Multifamily buildings are further classified according to whether the building has only one utility meter for the entire building (master metered) or whether it has a meter for each unit (individually metered). Commercial buildings are divided first into those which are rental buildings and those that are owner occupied, and then classified by the same categories as residential buildings.

When the primary decision maker is the same person as the utility bill payer, the decision maker is assured that he will realize the benefits of the solar system through lower utility bills. From Figure 11, it can be seen that there are several situations where this is the case. For example, in a single family home that is custom built, the prospective owner is both the primary decision maker and the utility bill payer. The owner (or someone he directs) may assess the value of a solar system based on one of the consumer decision criteria discussed previously. If the owner is convinced that the SHACOB system is worth the initial investment, he can instruct the builder to install the system. The same situation occurs in residential, single family retrofit, custom built master metered apartments, and retrofit master metered apartments. As shown in Figure 11, there are four similar situations in the commercial building sector. In each case where the D and B appear in the same cell, the solar system will potentially be evaluated on its economic merits.

Figure 11 shows that there are a number of situations in which the primary decision maker and the utility bill payer are not the same person. The speculative, single family home is an example of this case. The builder is the decision maker in a speculative house, while the owner ultimately pays the utility bills. The owner plays no direct role in making the decision whether or not to install a solar system. This occurs because the speculative house is constructed with no previously identified owner. The builder of the speculative house, having no responsibility for the utility bills, has no direct motivation to consider a SHACOB system.

Possible SHACOB Decision Makers and Utility Bill Payers	BUILDING DESCRIPTION																	
	RESIDENTIAL									COMMERCIAL								
	Multifamily						Single Family			Rental						Owner-Occupied		
	Speculative Built		Custom* Built		Retrofit					Speculative Built		Custom Built		Retrofit				
	Master Metered	Individually Metered	Master Metered	Individually Metered	Master Metered	Individually Metered	Speculative Built	Custom Built	Retrofit	Master Metered	Individually Metered	Master Metered	Individually Metered	Master Metered	Individually Metered	Speculative Built	Custom Built	Retrofit
Builder/Developer	D	D					D			D	D					D		
Building Owner	B		DB	D	DB	D	B	DB	DB	B		DB	D	DB	D	B	DB	DB
Rental Occupant		B		B		B	B**	B**	B**		B		B		B			

Source: Midwest Research Institute

D - Primary Decision Maker on SHACOB
B - Utility Bill Payer
* Speculative built includes those new buildings that are built before a purchaser has been identified. Custom built includes those buildings that were built for a specific prospective owner.
** The rental occupant is the bill payer in the case where the single family home is rental property.

Figure 11 - Matrix of SHACOB Decision Makers and Utility Bill Payers for Alternative Buildings

The major concern of the speculative builder is that the house can be sold. Speculative builders traditionally try to minimize first costs, and therefore, may have a negative attitude toward SHACOB. It appears that in the case of the speculative house, the dichotomy between the SHACOB decision maker and the owner acts to discourage the consideration of a solar system.

It is probable that if the speculative builder were confident that the solar house could be sold at an appropriate price, he would be willing to build solar homes. This would remove the barrier to SHACOB commercialization presented by the decision maker-bill payer separation. A clear consumer demand for solar homes will have to be evident before speculative builders are likely to be willing to take the risk of constructing a large number of solar homes. In isolated cases, builders are finding that a demand for solar homes now exists. Figure 11 shows that there are a number of other situations with a similar separation between decision maker and bill payer.

Speculative, individually metered apartment buildings and rental commercial buildings present another set of circumstances. In these buildings, the builder is responsible for the SHACOB decision while the renter pays the utility bills. Neither the builder nor the owner is concerned with operating costs. This situation also discourages the consideration of a SHACOB system. When speculative builders and owners are convinced that there is a demand for the lower utility bills experienced in a solar apartment building, this problem will be resolved.

In the cases of individually metered, custom and retrofit apartment and rental commercial buildings, the building owner is the SHACOB decision maker, while the renter is the bill payer. The owner may not be motivated to install a SHACOB system unless he can pass on the additional costs of the system to the tenants through increased rental charges.

In summary, different building situations present different degrees of motivation to install SHACOB systems. Even if a SHACOB system is economically attractive based on one of the consumer decision criteria discussed in Section 1, it is possible that the person responsible for making the SHACOB decision will not be motivated to consider SHACOB. This may present a substantial barrier to SHACOB commercialization in some markets.

3. <u>Cost barriers</u>: Another economic barrier to SHACOB commercialization is that, even if a comprehensive economic decision criterion, such as payback and life cycle cost analyses is used, many solar heating and cooling systems are currently too expensive. When the first cost criterion is used, SHACOB is even further from economic feasibility. The cost barriers discussed in this section are divided into two categories, high initial costs and high life-cycle costs.

Solar water heating is generally the SHACOB technology closest to being economically feasible. Solar space heating is usually next and solar cooling is the SHACOB technology furthest from economic feasibility. Combining hot water heating, space heating, and space cooling often leads to better utilization of capital equipment.

In general, installed solar hot water and space heating systems currently range in price from $20 to $35/sq ft of collection area. Some systems, however, are currently being installed at prices below this range. Optimal sized collectors for residential water heating may range in size from 50 to 100 sq ft (depending on the building load, solar insolation, and fuel prices). At $25/sq ft, the capital cost of the hot water system would be between $1,250 and $2,500. For residential space heating, collector sizes in the order of 300 sq ft may be required to provide a significant portion of the heating load. At $25/sq ft, the capital cost of this system would be approximately $7,500.

High initial costs lead to a variety of problems for the purchaser. Capital costs must be financed from savings or with a loan. If debt is used, added costs of financing must be borne, and there may be problems in obtaining the funds from financial institutions. Barriers related to financial institutions are discussed more fully in Section 4 below.

Life-cycle costs are much more difficult to estimate than initial costs. Calculating the life-cycle cost of an energy system requires prediction of future conventional fuel prices. The dynamic nature of the current U.S. energy situation does not facilitate reliable predictions. With this degree of uncertainty concerning future fuel prices, many variations in predictions can be defended. The economic feasibility of SHACOB is directly dependent on the price of the conventional fuel being displaced. Therefore, assumptions about future fuel price can be altered to get almost any desired result. Careful selection of the consumer decision criteria can be used in the same manner. Combining the appropriate fuel price escalation rate and consumer decision criteria can insure a result of either economic feasibility or nonfeasibility of SHACOB by a wide margin.

Economic feasibility analyses can provide some insights into the relative cost of solar energy. However, the sensitivity of the analyses to variations in assumptions may lead to inconclusive results. Nonetheless, most economic studies of SHACOB do agree that system costs will have to be reduced and conventional fuel prices increased in order to achieve widespread commercialization. Policy options which reduce cost barriers include a number of federal economic incentives. These incentives are described in Chapter 4.

4. Financing problems: The high initial cost of SHACOB technologies creates additional financing problems for SHACOB owners. The purchase of a solar heating and cooling system can be visualized as equivalent to buying most of the fuel required for a conventional system at the time it is installed. The only way for most building owners to obtain the needed funds is by borrowing from a financial institution. Two financing problems appear to be the most serious barriers to the SHACOB owner. The first is securing the loan for a new and uncertain product. Second, the amount of interest charged on the loan is an added cost to the solar energy investor.

Including interest costs in the consumer's economic decision criteria gives a better indication of the total cost of SHACOB.* Rather than considering the initial cost of SHACOB as a single period outlay, some cost methods assume a loan is granted. These methods then calculate the monthly interest and principal payment to the owner. Comparison of the monthly loan payment with the savings in fuel cost constitutes another possible consumer decision criterion. If the solar energy system is economically feasible, the net monthly or annual benefit in fuel savings will exceed the loan payment at some point in time. The year in which the benefits exceed the loan payment is termed "years to positive savings."

A number of barriers are associated with financing the capital cost of SHACOB systems. These barriers are described in detail in the discussion of financial institutions, located in Section C of this chapter.

5. Competition with alternative fuels: No matter which consumer decision criterion is utilized, the value of the conventional fuel being displaced by SHACOB is derived from current and future fuel prices. However, the value to the nation of displacing conventional fuels is not necessarily reflected in current market prices. In fact, the large number of special tax benefits, direct subsidies, research and development subsidies, and regulations concerning pricing and operation of conventional fuel supplies insure that current prices do not reflect either the costs of production or the fuel's value to the consumer. These subsidies to conventional fuels are described in Appendix E.**

The debate concerning regulation and subsidization of all forms of energy has been going on for years and will undoubtedly continue. It is well outside the scope of this report to pass judgement on the equity or propriety of these practices. Nonetheless, it is clear that current market prices for energy do not reflect the true value (in terms of total costs of production and value to consumers) of these fuels to the society. Therefore, it would be desirable not to base decisions about solar energy development merely on economic feasibility arguments that use current fuel prices. A broader view of the value of SHACOB must be taken.

While public policy analysis may evaluate solar energy based on the real costs of alternative fuels, the individual consumer or investor will take a much narrower view of the costs and benefits associated with SHACOB. SHACOB must attain economic feasibility compared to conventional

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* Discounting future cash flows, as used in the life-cycle cost calculations, is one method of including interest costs (if the discount rate is equal to the interest rate on the loan).

** For other analyses of government subsidies to conventional energy sources and government regulatory policies, see: (1) Gerald M. Brannon, Studies in Energy Tax Policy, Energy Policy Project of the Ford Foundation, Ballinger, 1975; and (2) Steve Frank and Eric Rauth, Federal Energy Tax Policies and Their Impacts, Office of Special Projects, Federal Energy Administration, 1976.

fuel costs as perceived by the decision maker before widespread commercialization will be achieved. Any part of the total cost of conventional fuels that are shared by all sectors of the society (such as pollution costs or tax subsidy distortions) are ignored by the investor. In most cases, utility policies of average cost pricing, as opposed to marginal cost pricing, also tend to distort the real value of SHACOB. The effects of utility rate policies on the economic viability of SHACOB are discussed in Section C of this chapter.

The consumer's or investor's view of energy decisions is justified by, and is a basic component of our contemporary economic system. However, subsidies and pricing policies which distort the true cost of competing energy sources constitute a significant barrier to SHACOB commercialization.

The President's proposed National Energy Plan contains several modifications of existing energy tax and regulatory policies. The impact of these proposals on the economic competitiveness of SHACOB is discussed in Chapter 5, Section C.

C. Institutional Barriers

A number of potentially serious institutional barriers to SHACOB have surfaced in recent solar research and early SHACOB installations. The discussion below deals first with financial institutions in Section 1. The solar market infrastructure (manufacturers, builders, installers, maintenance services, etc.) is addressed next in Section 2. Building codes and standards are examined in Section 3. Interface problems between electric utilities and SHACOB and between gas utilities and SHACOB are addressed in Sections 4 and 5, respectively. Section 6 discusses the potential barrier resulting from consumer attitudes toward SHACOB.

1. Financial institutions: Traditional financial institutions, which currently play a major role in providing both construction and permanent* financing for the building industry, will play a similar role in the development of the SHACOB industry. For SHACOB to achieve substantial market success, financial institutions must be willing to finance the cost of SHACOB systems under reasonable terms. Financial institutions, for the reasons discussed below, may initially be hesitant to provide adequate financing for the SHACOB industry.

Mortgage and construction financing in the residential and commercial sectors is provided by seven types of financial institutions: (1) savings and loan associations, (2) mutual savings banks, (3) commercial banks, (4) life insurance companies, (5) mortgage companies, (6) real estate investment trusts (REITS), and (7) federal government agencies. The attitudes of these institutions toward SHACOB will have a major impact on the SHACOB's market success.

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* Construction financing refers to temporary financing provided to cover the cost of constructing a building before it is transferred to the ultimate purchaser or owner. At the time that the owner gains control of the building, he obtains permanent financing, usually in the term of a mortgage.

There is some variation in the importance of these financial institutions in providing construction and permanent financing for residential and commerical buildings. In the residential sector, commercial banks, savings and loan associations and mortgage companies provide the bulk of the construction financing for single family homes. In addition to these construction financers of single family homes, REITs are a significant source of construction financing for multifamily residential buildings. Construction financing for commercial buildings is provided by the same mix of lenders that finance multifamily residential buildings.

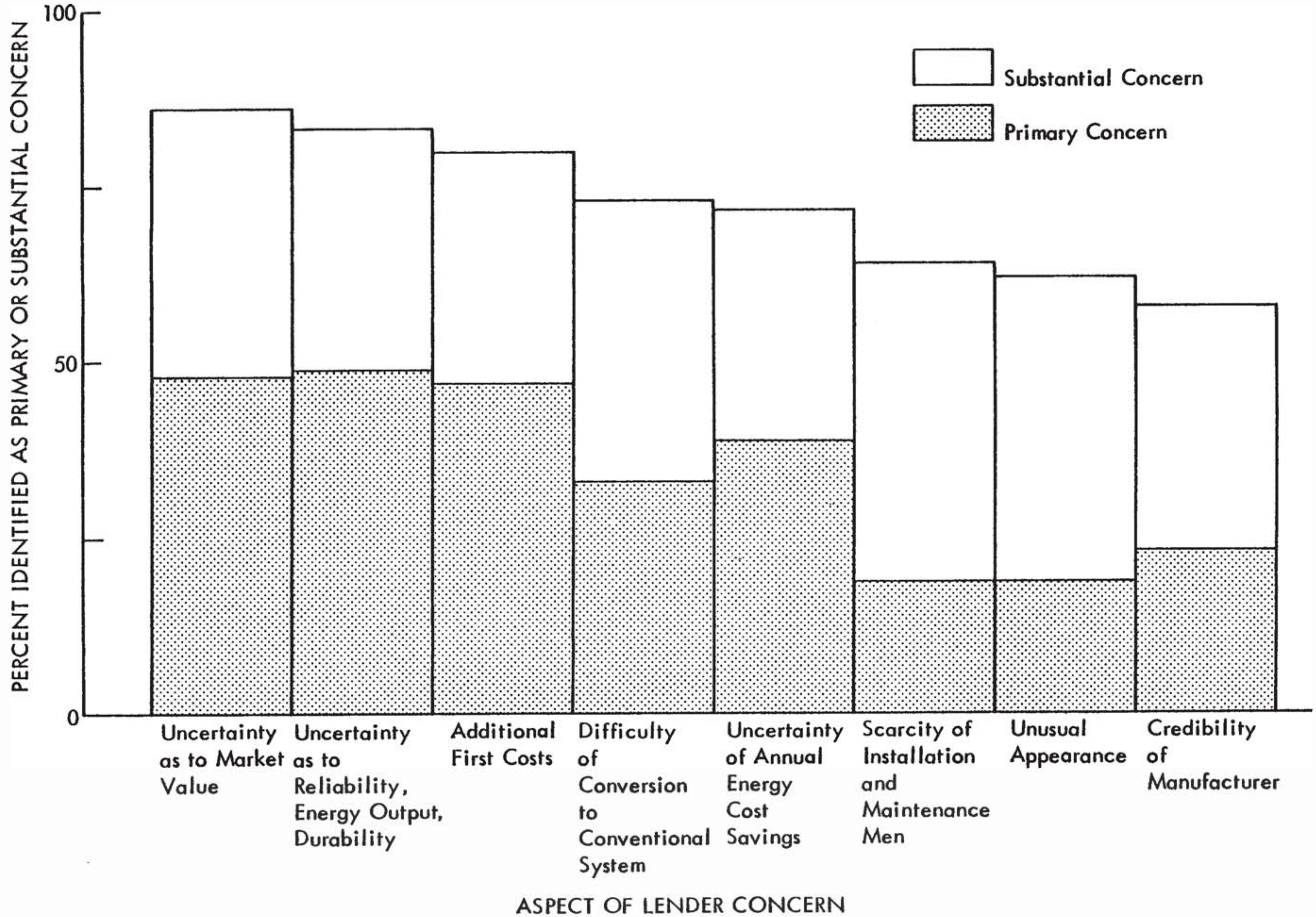
Permanent financing for both single family homes and multifamily residential buildings is dominated by savings and loan associations. Commercial banks, mutual savings banks, and federal agencies play secondary roles in permanent finance for the residential sector. Life insurance companies are another source of permanent financing for multifamily buildings. Permanent finance for the commercial sector is dominated by commercial banks, with life insurance companies, savings and loan associations, and mutual banks playing secondary roles.

In addition to institutions that provide construction and permanent financing for buildings, there are two other important participants in the finance process. These are the appraiser and the mortgage insurer. The appraiser estimates the market value of a given property. This appraisal is used by the lender in determining the size of the loan. The mortgage insurer provides insurance for the lender to reduce the lender's risk in the event of foreclosure.

Of the several participants in the finance process, the permanent lender plays the dominant role. Construction financing for a project is rarely granted unless the project meets the requirements of elegibility for permanent finance. The appraiser, when estimating the market value of a project, is primarily concerned with the market value from the permanent lender's point of view. Only the mortgage insurer remains somewhat independent from the permanent lender. But both the insurer and the lender have similar concerns about the risk involved in financing or insuring a project. It is therefore essential that SHACOB systems meet the requirements of the permanent lender. Without adequate financing, it is unlikely that SHACOB can achieve significant market success.

A study conducted by Regional and Urban Planning Implementation, Inc. (RUPI) for the National Science Foundation examined in detail the problem of financing the solar energy home.[1/] As part of the study, RUPI interviewed approximately 50 representatives of the major institutions involved in permanent residential financing. The major concerns of the lenders interviewed in the RUPI study are summarized in Figure 12.

1/ Barret, D., P. Epstein and C. Haar, Financing the Solar Home: Understanding and Improving Mortgage Market Receptivity to Energy Generation and Housing Innovation, Regional and Urban Planning Implementation, Inc., Report to the National Science Foundation, June 1976.



Source: Regional and Urban Planning Implementation, Inc., Financing the Solar Home, Report to the National Science Foundation, p. 73, June 1976.

Figure 12 - Percentage of Lenders Identifying Selected Aspects of Solar Heating Systems as Primary or Substantial Concerns in Lending Decisions

It is evident from Figure 12 that the primary concern of lenders is the impact of the solar system on the value of the property. The other lender concerns shown in Figure 12 emphasize the lender's lack of confidence in SHACOB at the present time. The uncertainty of system performance, the lack of sales data on the market response to solar homes, the small amount of experience of the solar industry, and the mortgage analyst's inability to assess the quality of solar systems currently make it difficult for financial institutions to finance a significant number of solar homes. These factors also present difficulties for obtaining home insurance, which again acts to discourage financial institutions. Until lenders become convinced that the market value of a solar system is equal to the cost, it is likely that they will be hesitant to finance the total cost of the system. The lack of experience and stated policies toward solar homes on the part of secondary mortgage institutions such as the FHLMC, FNMA and GNMA programs* further reduce the willingness of primary financial institutions to make loans for solar homes.

At the same time that financial institutions are likely to be initially hesitant to provide mortgages for a significant number of solar homes, current emphasis on initial costs in granting mortgages may discourage the construction of a solar house. The amount of financing a bank is willing to provide a prospective new home builder is currently almost exclusively based on the ratio of monthly housing costs to before-tax income. This ratio is referred to as the PITI ratio because the housing costs taken into account are Principal and Interest payments on the mortgage and property Taxes and Insurance. Most lenders require that the PITI ratio not exceed 25%. The additional first costs of a SHACOB system could disqualify many homebuyers for mortgages on the quality of house they wish to purchase.

Inclusion of the energy costs in the PITI ratio (PITI + Energy) would take into account the value of the reduced conventional energy costs of a solar house and make the financing of SHACOB systems more feasible from the lender's point of view. Such an approach would also provide the lender and borrower with a complete calculation of the cost of housing. One problem with including energy costs in the mortgage decision calculation is that energy costs have increased so dramatically over the past several years that many prospective homeowners would be disqualified because the PITI + E to income ratio would exceed the traditional 25%.1/ Under these circumstances, perhaps the traditional lender guidelines will be adjusted to consider the importance of the energy component of housing costs.

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* The Federal Home Loan Mortgage Corporation (FHLMC) and Federal National Mortgage Association (FNMA) are the two major secondary mortgage institutions. The Government National Mortgage Association (GNMA) is a secondary mortgage institution that provides interest rate subsidies.

1/ Ibid., pp. 53-55.

The terms under which a SHACOB system is financed will have a major impact on the attractiveness of the system to the consumer. Table 7, which presents monthly financing costs for a $6,000 SHACOB system under alternative financing terms, illustrates this fact. In the case of a new home (or apartment building), the additional cost of the SHACOB system will probably be included in the original mortgage. As shown in Table 7, depending on the loan/value ratio, interest rates for conventional mortgages may be 8.5 to 9.0%, with an average term of 27 years.* Mortgages with 80% and 90% loan/value ratios have an additional charge for mortgage insurance. The federal government FHA and VA mortgages have 30-year terms and, slightly lower total interest and insurance costs than conventional mortgages, in addition to offering higher loan/value ratios. Should a SHACOB system be financed through a second mortgage, the term is typically 10 years with a 13.5% interest rate.

Retrofit of a SHACOB system in the residential sector would be subject to very different terms. Retrofit solar systems would for the most part be financed by personal, home improvement loans.1/ While the home improvement loan for a SHACOB system may not be vulnerable to the same obstacles as the mortgage (because these loans are usually granted based solely on the individuals credit and ability to pay), the terms of this type of loan are less attractive. Conventional home improvement loans usually have an interest rate of 12.5% and a term of 5 years. Thus, financing for retrofit will result in a higher annual debt cost but will be for a shorter period than an installation financed under a mortgage. The higher interest rate and short amortization period for a home improvement loan is due to the small amount of such loans and the high origination and service costs. Mortgages are typically for larger amounts which serves to spread the cost of origination and servicing.

Some home improvement loans are available through the FHA Title I home improvement loan program. Table 7 shows that Title 1 loans offer somewhat more lenient terms than a conventional home improvement loan, with a term of 12 years and interest rate of 11.5%. It is worthwhile to note that solar water heaters are now eligible for loans under Title 1.

The effect of financing terms on the monthly carrying cost of a $6,000 solar system can be seen by examining rows A, B and C in Table 7. Row A shows the monthly carrying cost of the loan. Because the values in Row A do not reflect the monthly cost of the down payment, they are somewhat misleading. Rows B and C provide a more realistic comparison. Row B divides the cost of the down payment over 10 years, and adds this cost to the monthly

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* It should be noted that no conventional mortgages have a 27-year term. They usually carry a 25- or 30-year term; 27 years represents an average term.

1/ Ibid., pp. 124-131.

TABLE 7

COMPARATIVE INITIAL AND MONTHLY FINANCING COSTS OF RESIDENTIAL SOLAR ENERGY SYSTEM, FOR SELECTED FIRST COSTS, UNDER PRIVATE LENDER FINANCING ALTERNATIVES*

			First Mortgage					Second Mortgage	Home Improvement	
		Loan Type	Conventional			FHA	VA	Conventional	Title I	Conventional
LOAN TERMS**		Loan/Value Ratio	70%	80%	90%	93%	100%	75%	100%	100%
		Interest Rate	8.5%	8.75%	9.0%	8.25%	9.0%	13.5%	11.5%	12.5%
		Term (years)	27	27	27	30	30	10	12	5
		Mortgage Insurance	--	0.15%	0.25%	0.5%	--	--	0.5%	--
		Downpayment on $6,000 solar system	1,800	1,200	600	420	0	1,500	0	0
Monthly Carrying Cost	A	Monthly carrying cost of loan	33.11	39.18	45.40	43.90	48.28	68.52	78.81	134.99
	B	Monthly carrying cost of loan plus straight line amortization of downpayment over 10 years	48.11	49.18	50.40	47.40	48.28	81.02	78.81	134.99
	C	Monthly carrying cost of loan plus straight line amortization of downpayment over 10 years plus 7.5% return on outstanding downpayment	54.48	53.42	52.52	48,89	48.28	86.33	78,81	134.99

Source: Adapted from Regional and Urban Planning Implementation, Inc., Financing the Solar Home, pp. 34,36.

* Table assumes appraised value equal to first costs.

** The terms specified in this table are estimates of the typical terms for various types of loans.

costs. Row C is the same as Row B, except that it also adds a 7.5% annual finance charge to the outstanding down payment. Comparing the monthly carrying costs of the $6,000 solar system in Rows B and C, it is evident that the variation in terms of conventional mortgages have a relatively minor impact on monthly carrying cost. The major variations are between first mortgages, second mortgages, and home improvement loans. Clearly, the first mortgage offers the most lenient financing terms. When solar can be financed as part of a first mortgage, the monthly cost to the consumer is significantly lower than when financed under a second mortgage or home improvement loan. The high monthly carrying costs of a SHACOB system financed through a second mortgage or a home improvement loan may present a significant barrier to SHACOB commercialization.

This discussion has dealt primarily with the single family house. There are a number of differences in lending practices for multifamily residential and commercial buildings. The major difference is that loans for multifamily and commercial buildings are usually made based on the income producing capability of the property. The determination of eligibility for a loan is therefore a more sophisticated calculation than a loan for a single family home, taking into account operating costs, energy costs, and income tax effects, in addition to principal and interest payments, property taxes, and insurance (PITI).

Policies aimed at improving the terms and increasing the availability of financing for SHACOB are discussed in Chapter 4.

2. SHACOB industry infrastructure: Accelerated commercialization of SHACOB must be accompanied by the development of an industry infrastructure able to meet SHACOB demand. The manufacture, distribution, installation, and financing of a SHACOB system represent individual steps in the delivery of the final product. For SHACOB to achieve widespread use, it is essential that all participants in this delivery process have an aggressive interest in SHACOB commercialization. Policies of financial institutions as they affect SHACOB were discussed in the previous section. This section focuses on the problems in the manufacture, distribution and installation steps. Government policies aimed at the accelerated commercialization of SHACOB must be formulated with a clear understanding of the attitudes and methods of operation of each member of the industry infrastructure if a vital SHACOB industry is to result.

Historical analyses of the introduction of past innovations in the building industry show that there exist forces within the building industry which act to resist change.[1] The major explanation for these forces is that the complex network of defined roles and interrelationships of industry members is not easily modified and adapted to meet the requirements of new building technologies.

1/ Schoen, R., A. S. Hirshberg, J. M. Weingart, New Energy Technologies for Buildings: A Report to the Energy Policy Project of the Ford Foundation, Ballinger Publishing Company, Cambridge, Mass. (1975).

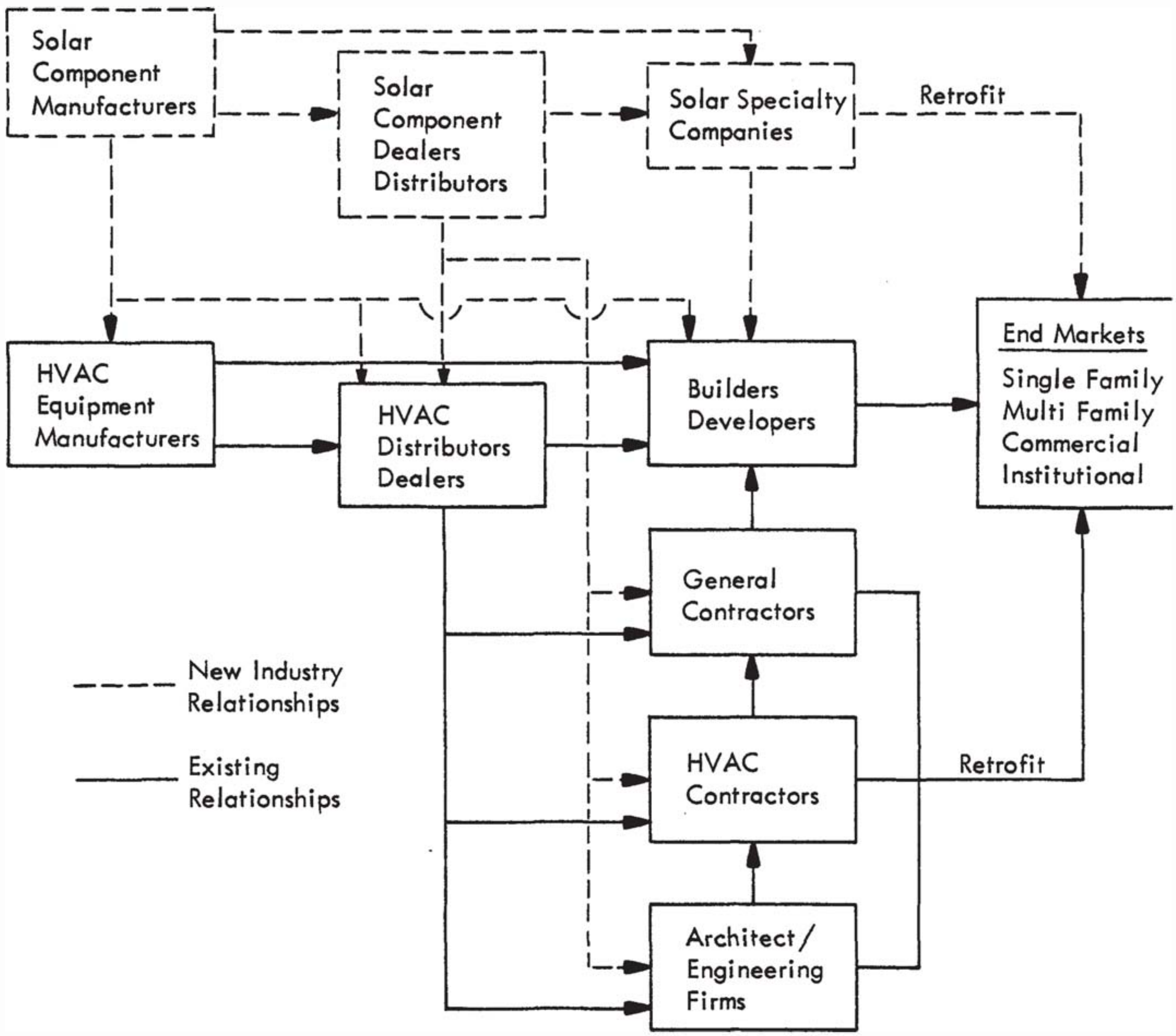
The first indication of the complexity of the construction industry is the industry's fragmentation. There are approximately 300,000 builders working in the residential sector. Ninety percent of these builders produce less than 100 units/year. The largest single builder is responsible for less than 1% of the annual construction volume. The extreme horizontal stratification of the construction industry is another indication of the industry's complexity. There is a high degree of separation between related tasks, with one company rarely being responsible for the design and construction of the building itself and the building HVAC system. Industry fragmentation and stratification make a rapid penetration of SHACOB difficult.[1/]

Figure 13 is a schematic diagram of the relationships that are likely to exist in a mature SHACOB industry. The figure shows the existing HVAC industry participants and their interrelationships in solid lines, and the new SHACOB entities and their predicted interrelationships in broken lines. Given the fact that this network of relationships will necessarily be established on a region by region, company by company basis, it is likely to take some time before a mature industry evolves. In some isolated cases, the industry infrastructure is already developing.

The lack of industry experience in installing solar systems is likely to act as a barrier to early SHACOB market success. The threat of delay associated with this inexperience, and inflated costs resulting from uncertainty on the part of industry participants, act to reduce the attractiveness of SHACOB to prospective purchasers. In particular, the builder-developer, a key decision maker in the new construction market, may not be willing to absorb the risk of implementing SHACOB in the early market stages. The lack of a developed marketing mechanism for SHACOB, and of a group of companies with experience working together in various aspects of the SHACOB delivery system, will act to slow SHACOB penetration in the retrofit market as well.

Most interrelationships in the SHACOB industry infrastructure are likely to evolve routinely as the industry gains experience. It is very possible that the industry will evolve differently than shown in Figure 13. One possibility, not shown in Figure 13, is that utilities could eventually play a role in the infrastructure. Utilities, for example, might act as a coordinator for the distribution and installation of SHACOB, effectively shortcutting many of the steps in the delivery system presented. Utility involvement in the SHACOB industry is described in Chapter 4, Section C. The roles of various participants in the industry infrastructure is described in greater detail in Appendix A.

1/ Hirshberg, Alan S., "Public Policy for Solar Heating and Cooling," in the Bulletin of the Atomic Scientists, Vol. 32, No. 8, p. 39, October 1976.



Source: Midwest Research Institute, adapted from work by Robert Shaw, Booz, Allen, and Hamilton.

Figure 13 - Schematic Diagram of SHACOB Industry Infrastructure.

One problem that could arise in the development of the SHACOB industry is a problem of jurisdiction between the various trades involved in SHACOB installation. SHACOB system installation encompasses several trades--roofers, plumbers, glaziers, electricians, carpenters, etc. Because of the requirement for these numerous skills, overlap and competition between unions representing different trades may result.1/ This has not been a problem to date, and several unions are working to resolve potential disputes. As the industry expands, however, the consequences of disputes, and therefore their intensity, could increase.

Evaluations of the development of the SHACOB industry infrastructure suggest that the skills needed to design, install and market SHACOB systems will result as a by-product of the evolution of the solar collector manufacturing industry.2/ If a sizeable number of solar collectors are sold, the relationships and skills needed to develop a viable SHACOB industry infrastructure should develop concurrently. This is the reason why the solar collector is looked upon as the central element and primary indicator of development in the SHACOB industry.

It is important to realize, however, that the collector manufacturer cannot accelerate the development of the industry infrastructure by merely manufacturing a large quantity of collectors. A demand for the collector must exist at the consumer level in order for the relationships and skills of the industry infrastructure to emerge. In other words, consumer demand for SHACOB systems must stimulate the development of the collector manufacturing industry which, in turn, must stimulate the installation and service sectors.

Because the collector is the major new component in the SHACOB industry, and the primary indicator of the industry state of development, it is important to understand the problems confronting companies which are now entering the industry. As was described in Chapter 1, the collector industry is still in an early stage of development.

A major problem presently confronting the collector manufacturing industry is how to reduce the cost of collectors. Mass production techniques might reduce medium temperature collector costs substantially. One study of the collector industry found that to achieve cost reductions on the order of 50% for medium temperature collectors, single plant volume would have to be approximately 1 million sq ft/year.3/ For higher

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1/ American Bar Foundation, Legal Issues Related to the Use of Solar Energy Systems, pp. 26-30, August 1976.

2/ METREK Division, Mitre Corporation, "Solar Energy Government Building Program: Policy and Implementation Plan," Prepared for the Federal Energy Administration, January 1977.

3/ Intertechnology Corporation, "Industry-Market Infrastructure Analysis," Report to the Federal Energy Administration, June 1976.

temperature special collectors, such as evacuated tube collectors, the same study found plant volumes would need to be in the range of 20 to 30 million sq ft/year.1/ Clearly, both of these figures are currently in excess of the market for solar collectors, unless there emerges a high degree of market concentration.

A part of the current demand for SHACOB is not based on the economic feasibility of the system, but results from purchases both by the government demonstration programs and by individuals choosing solar for non-economic reasons. The solar heating and cooling demonstration program accounted for approximately 10% of the collectors sold in 1976. It is unlikely that companies in the solar collector manufacturing business will be able to significantly reduce collector costs without a stable and much larger market for SHACOB systems than currently exists.

The cost of the collector is only a part of the total cost of a completed solar system. The material costs of system controls, piping or duct work, and storage units add to the cost of a solar system. The cost of labor for system design and installation must also be included in the total system cost. While collector costs alone are now approximately $10/sq ft, the installed costs for solar heating and hot water systems are in the range of $20 to $35/sq ft.*

If the SHACOB industry is to overcome the cost barrier, the cost of system design and installation as well as the cost of the collector itself must be reduced. Reductions in design and installation costs will occur as those participants in the infrastructure involved in these activities gain experience. A projection of the reductions in system costs as a function of time and industry volume is provided in Appendix A. Specific incentives, aimed at accelerating the development of the industry infrastructure, are described in Chapter 4.

3. Building codes and standards: Standards for SHACOB systems are at the present time addressed in only a few existing building codes. Current research indicates that building codes have not yet posed a major problem in the SHACOB systems installed to date.2/ Building codes, however, are developed and administered on a fragmented basis. Therefore, as the number of SHACOB systems increases significantly, testing and approval of SHACOB technologies at the local jurisdictional level could retard future commercialization. Historically, building codes have acted to slow down the introduction of new technologies into the building industry.3/

1/ Ibid.

2/ See, Rivkin, Steven, in Proceedings of the Workshop on Solar Energy and the Law, funded by NSF in conjunction with "Legal Issues Related to the Utilization of Solar Energy," February 10, 1975, and AIA Research Corporation, Early Use of Solar Energy in Buildings, Technical Report to NSF, Section II, p. 30-31, August 1976.

3/ Schoen, Hirshberg, Weingart, op. cit. pp. 171-200.

* A few solar companies are currently installing systems for substantially less than $20/sq ft.

The federal government has already taken steps to reduce the barrier posed by the lack of standards for SHACOB. The Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409) required that Interim Performance Criteria (IPC) and Definitive Performance Criteria (DPC) be prepared for use in conjunction with both the residential and commercial demonstration programs. In 1975, HUD, in cooperation with NBS, published IPC for the residential demonstrations.[1/] In 1976, ERDA, in cooperation with NBS, published IPC for the commercial demonstrations.[2/] According to PL 93-409, DPC would be required within 3 years for solar heating and hot water systems and within 5 years for solar cooling.

In addition to the requirements of the government demonstration programs, a need for accelerated standards development was recognized. Standards were needed for use in the expanding private market for SHACOB, and for use in conjunction with HUD/FHA mortgage insurance and federal incentives for SHACOB. As a result of this need, FEA initiated in April 1975 a concurrent, two-pronged government/industry approach: (1) to develop Intermediate Minimum Property Standards (IMPS) for solar heating and hot water systems for adoption by HUD, and (2) to encourage industry organizations to establish voluntary consensus standards for solar systems.

The solar IMPS have been completed by HUD and NBS[3/] and were formally announced in the Federal Register on July 1, 1977. The solar standards parallel the HUD Minimum Property Standards, which cover all aspects of residential building construction. Minimum Property Standards set the guidelines for residences eligible for coverage by FHA mortgage insurance. The Minimum Property Standards are often used as guidelines by private mortgage insurers and lending institutions. NBS is currently developing model code language based on the IMPS for solar sections of the model building codes.

Solar standards now being developed by the federal government receive ongoing review by interested private organizations, including the American National Standards Institute (ANSI), the American Society for

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1/ Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems in Dwellings, prepared by the National Bureau of Standards for HUD, Washington, D.C., January 1975 (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.).

2/ Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities, prepared by the National Bureau of Standards for ERDA, February 1976.

3/ Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems, prepared by the National Bureau of Standards for HUD, July 1977.

Testing and Materials (ASTM), the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), the American Society of Mechanical Engineers (ASME), the American Refrigeration Institute (ARI), and the Solar Energy Industry Association (SEIA). The participation of these organizations is expected to lead to a set of voluntary, consensus standards for SHACOB systems. The standards of these organizations have a substantial impact on the operations of the building industry. In some cases, industry consensus standards have already been established. ASHRAE, for example, has already formulated voluntary consensus standards for rating the thermal performance of solar collectors (Standard 93-77) and thermal storage systems (Standard 94-77). These standards are based on standards originally developed by NBS.

While the federal government has already taken the initiative to remove the building code barrier, it will probably require a considerable amount of time for these standards to be implemented at the local level. The severe fragmentation of building codes necessitates that any SHACOB standards be easily applied by a large number of administering organizations without the technical knowledge to carefully evaluate SHACOB systems. Because of this lack of technical skill, it may be necessary to certify the compliance of SHACOB systems and components with established standards. Certification will require that an appropriate mechanism for evaluating SHACOB equipment be established either within the government or within private organizations. Policies directed at the SHACOB standards problem are discussed in Chapter 4.

In addition to the code problem, land use controls and zoning ordinances may inhibit SHACOB development by regulating building height, bulk, aesthetic appearance, and location. These restrictions may prohibit the use of solar collectors, or force the SHACOB purchasers to choose a less than optimal location for the collector array, reducing the economic viability of the system.

4. SHACOB-Electric utility interface: SHACOB systems are rarely designed to supply 100% of a given load. Variations in the availability of solar radiation and building loads, and the high capital cost of SHACOB systems make such a self sufficient system uneconomical. It is essential, therefore, that a backup supply of energy be available to the SHACOB user. If a SHACOB system depends on electrical backup system, uncertainty in the supply and cost of backup electricity could be a significant barrier to SHACOB.

Historically, electricity rates have been designed with the objective of providing adequate revenues to the utility and at the same time charging electricity consumers fair and equitable rates. Ideally, electricity rates have attempted to be cost responsive--that is each customer is charged a rate that reflects the cost of serving that customer. The complexity of determining the actual cost of service for a large number of customers with different consumption patterns has led electric utilities to develop rate structures which approximate the cost of service. Most existing rate structures, however, do not track the cost of service for each customer.

Most electric utilities use the declining block rate structure. Under this structure, the customer is charged a different rate for each quantity or block of electricity he consumes in a given billing period. For the first block, the customer is charged a certain fixed amount that covers a portion of the utilities fixed costs in serving the customer (i.e., generating, transmission, and distribution costs), a portion of the utilities demand costs (i.e., the cost of having the generating capacity, transmission and distribution systems that will meet the customers peak demand), and the actual fuel costs of generating the electricity used by the customer in the first block. The next blocks in the declining block rate structure include the balance of the utilities demand costs, and the fuel costs of the electricity consumed in these blocks. The last block includes charges only for the cost of fuel to supply the electricity consumed in this block.

The specific parameters of a declining block rate are determined by individual utilities for an average customer in each rate class. A residential, all electric home in a given region, for example, has a total energy use and load factor* that can be predicted by the utility. The utility establishes the charges in each block to reflect the cost of serving this average all electric home customer.

If a customer in this electric home rate class installed a solar heating system, it is likely that the revenues received from this customer would not cover the utility's cost of service. The solar home will use less energy than the all electric home, and may not consume electricity in all blocks which include demand charges. In periods of bad weather, the solar home will depend on the electric backup heating system, and will therefore have a peak demand similar to the electric home. Because the solar home exhibits approximately the same peak demand as the all electric home, but does not consume enough electricity to pay all the demand charges, the utility in effect subsidizes the solar customer.1/

This example is perhaps an oversimplification of the interface between a solar home and the electric utility, under existing rate policies. Studies of the interface problem indicate that the actual interaction between solar systems and electric utilities is extremely complicated. There is some disagreement in the studies conducted to date concerning the impact of solar systems on the electric utility. One study supports the concept

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* Load factor is the ratio of the customer's average load to his peak load during the day.

1/ Energy Rate Initiatives: Study of the Interface Between Solar and Wind Energy Systems and Electric Utilities, Federal Energy Administration, Contract No. P05-77-4242-0, March 31, 1977.

that the peak demands of a solar and conventional system are nearly identical, and therefore, under a declining block rate, revenues collected from the solar customer do not cover utility costs.[1/] Another study implies that solar and conventional peaks may not be identical.[2/] As these studies are based on computer simulations of complex interactions, and employ different assumptions and data inputs, the lack of a conclusive understanding of the interface problem is not surprising. Clearly, more detailed research will be needed before a final understanding of the interface problem emerges.

Given the possibility that existing rate structures do not reflect the actual cost of service to the utility for solar customers, utilities will probably act to develop revised rates which do cover their costs. One possibility is a special demand rate (often referred to as a Hopkinson rate) for solar customers. Under a demand rate, a customer is charged a special rate based on his peak demand over a specified period. The Public Service Company of Colorado introduced a special demand rate in 1976. This type of rate can substantially reduce the economic value of a SHACOB system because the SHACOB user will pay a high utility rate for a small amount of electricity consumption. This effectively eliminates the economic value of the system.

Another rate option being evaluated by a number of utilities is a time-of-day rate. Under the time-of-day rate, the utility charges a different rate for electricity consumed during utility periods of peak and off-peak demand. The time-of-day rate concept is an attempt at implementing marginal cost pricing, because electricity is more costly to produce at peak periods than off-peak periods.* Time-of-day rates may not have a direct adverse impact on the economic feasibility of SHACOB systems. The SHACOB system could be designed with a thermal storage unit to use electricity primarily during the off-peak period, and thus realize some benefits from the rate strucutre. Under a time-of-day rate structure, the concept of a thermal energy storage system alone, utilizing off-peak electricity, may be attractive. SHACOB would then have to be competitive with a storage only system.

1/ Feldman, Steven and Bruce Anderson, Utility Pricing and Solar Energy Design, Clark University, report to NSF Grant No. APR-75-18006, p. 118, September 1976.

2/ Lorsch, Harold, Implications of Residential Space Conditioning on Electric Utilities, Franklin Institute Report to NSF, Grant No. AER-75-18220, September 1976.

* Peak electricity is more costly for two major reasons: (1) generating equipment used to meet peak loads is sometimes less efficient than base load equipment and usually uses more expensive fuel, and (2) peak generating capacity is used during only a small amount of time.

Until the complexities of the SHACOB-electric utility interface problem are resolved, it is unclear what barriers to widespread SHACOB use this problem will pose or what opportunities will arise. As the number of SHACOB systems utilizing electricity backup increases, and the implications for the utilities become more severe, the utilities and regulatory authorities will be forced to act on this problem. The current uncertainty as to how this problem will be resolved casts a significant amount of doubt on the cost effectiveness of SHACOB systems with electricity backup which are being installed today. Under different rate structures, the practicality of various SHACOB system concepts and specific designs may be radically different. This uncertainty itself may act as a barrier to SHACOB commercialization. Clearly, if the policies which are ultimately adopted contain high SHACOB demand rates without provisions to use off peak power, the effect on the economics of SHACOB systems would be devastating.

The SHACOB-electric utility interface is discussed in greater detail in Appendix C. Policies which might lead to the resolution of this problem are described in Chapter 4, Section C.

5. SHACOB-gas utility interface: The barriers to SHACOB commercialization posed by the SHACOB-gas utility interface are somewhat different from those posed by the electric utility interface. One important difference is that natural gas can be stored more efficiently than electricity. There is some capital cost of storage that does potentially represent an additional system cost associated with solar induced demand changes. This storage capability can reduce the consequences of any peak loading problems that are likely to be caused by SHACOB systems utilizing a gas backup. However, the allowable variation in pipeline deliveries, the availability of peak shaving supplies such as synthesized natural gas, and other system characteristics will affect the overall ability of the gas utility to economically integrate solar. While the peak loading problem is less severe, there still exist problems related to the gas utilities which could discourage the use of SHACOB systems.

The major barrier to SHACOB posed by the gas utility industry is that the current federal and state pricing policies for gas utilities require that the retail price of gas be based on the average wholesale cost of gas to the utility company. Under this pricing mechanism, the price of old gas and new gas are averaged together based on the percentage that each contributes to a given utility's gas supply. The result of this pricing policy is that the price charged to a consumer of natural gas does not reflect the true marginal cost of service. The implications of this price averaging on the consumer decision to purchase a SHACOB system can best be understood by the following example.1/

1/ This example is derived from work by E. S. Davis, in "Commercializing Solar Energy: The Case for Gas Utility Ownership," Systems Analysis Section Working Paper, Jet Propulsion Laboratory, p. 3, May 1976.

The wholesale cost for new gas is in the range of $1.40 to $5.00 per million Btus, while most old gas carries a wholesale price of $0.25 to $0.50 per million Btus. Assuming: (1) the higher end prices for both new and old gas, (2) a $0.60 per million Btus charge for taxes, operation, maintenance and capital, and (3) that a given utility purchases new gas to satisfy 10% of its demand due to additional consumption, the price charged to the consumer would be $1.55 per million Btus. This compares with a price of $1.10 per million Btus before the new gas was needed. The cost of supplying the additional gas is distributed evenly among all customers, regardless of whether or not the customer is responsible for the added demand.

Next, examine the case of an individual customer, serviced by this hypothetical gas utility, who purchases a solar water heater. The consumer's investment in a solar water heater reduces his gas bill by $1.55 for every million Btus saved. The consumer's investment reduces the utilities need to purchase new gas and, therefore, saves the utility $5.00 per million Btus. Clearly, if the individual customer received savings equal to the savings realized by the utility, the attractiveness of the solar water heater investment would be enhanced. However, the savings attributable to the individual's solar investment are distributed among all consumers served by the utility. Under this average pricing policy, the individual consumer, the primary actor in a solar investment decision, does not receive the true value of the energy savings derived from SHACOB. This fact has a negative impact on the ability of SHACOB systems to compete with natural gas, and could therefore be a barrier to commercialization. Even without averaging, it may be difficult for SHACOB to compete with natural gas (assuming gas is available) because of other regulatory policies.

SHACOB systems are not likely to compete effectively with natural gas at the consumer level, until the gas price to the consumer increases. Policies which might remove the barriers to SHACOB presented by the gas utility interface, are discussed in Chapter 4, Section C.

6. <u>Consumer attitudes</u>: Consumer attitudes toward SHACOB are likely to have a significant impact on SHACOB commercialization. Economic aspects of the consumer decision process were already discussed in Section B of this chapter. There are, however, a number of other factors that affect the solar purchase decision.

Because SHACOB represents a new approach to energy production requiring a substantial investment in equipment, the consumer must be willing to adapt to this new approach if SHACOB is to achieve significant market success. For SHACOB to achieve widespread commercialization, it is likely that, in addition to improvements in SHACOB system performance and reliability, lower system costs, and increased availability of SHACOB financing, public understanding of the energy crisis in general will need to be improved.

Current market research on public attitudes towards energy conservation[1] shows that the majority of Americans have a fairly good understanding of the need to conserve energy in the home. When it comes to actual conservation actions, however, people tend only to take conservation actions which require minimal inconvenience, such as turning off lights. Research shows that consumers have a somewhat cynical view of the energy crisis, with one-third believing that the crisis was caused by big business, and another third believing that it was caused by politicians and government.[2] The extent to which consumers are actually willing to conserve is probably related to how seriously they view the energy crisis. Recent polls show that President Carter's energy efforts are improving public understanding of the problem.[3] While consumers may to some extent be motivated to conserve by informational efforts, government exhortation, and feedback on how much energy they are actually consuming, research shows the primary motivation for energy conservation is cost.[4]

Given these public attitudes to the energy situation and conservation in general, it seems unlikely that the public will make more than a verbal commitment to SHACOB until the severity of the energy crisis is more completely understood. This understanding must somehow be communicated in terms of cost. Comparative economics of SHACOB and conventional systems must act as the primary signal to the public that energy conservation through the use of SHACOB is desirable. Whether this signal is transmitted via actual energy prices or government incentives is probably less important. As discussed in the earlier section on consumer economic decision criteria, it is difficult to determine exactly what comparative costs between SHACOB and conventional systems are required for a consumer to choose the solar alternative.

While cost may be expected to be the dominate consumer concern in using solar systems, other considerations may have a significant impact on the solar purchase decision. Table 8 contains a list of some factors that could affect a consumer decision to purchase a SHACOB system. This list is not intended to be all inclusive, but rather representative of items of potential concern to consumers.

1/ Milstein, Jeffry S., "Attitudes, Knowledge and Behavior of American Consumers Regarding Energy Conservation with Some Implications for Government Action," Office of Energy Conservation and Environment, Federal Energy Administration, October 1976.

2/ Ibid.

3/ Newsweek, Gallup Organization Poll after Carter Energy Message to Congress, p. 15, May 2, 1977.

4/ Milstein, op. cit.

TABLE 8

LIST OF FACTORS AFFECTING CONSUMER DECISION TO PURCHASE SHACOB SYSTEM

Resale value of house or property
Operating, maintenance, and repair costs
Reliability of equipment
Adequacy of equipment guarantees
Reputation of manufacturer and dealer
Uncertainty of estimates of fuel savings
Uncertainty over future fuel costs and utility rates
Vulnerability of system to vandalism
Aesthetic appearance of SHACOB system
Expectation of lower equipment costs in future

Other than cost, the lack of consumer information on system operation, durability and reliability, the lack of adequate guarantees, and the uncertainty of future fuel costs, are likely to be the most significant attitudinal barriers to SHACOB commercialization. Some literature aimed at the general public is now available,[1/] but the extent of public understanding of SHACOB systems is probably still low. Another factor that is likely to be important in consumer attitudes toward SHACOB is consumer experience. For example, an historical study of the solar water heater industry in Florida[2/] showed that leaky storage tanks had a large negative effect on public attitudes toward solar water heaters in the 1940s and 1950s.

Consumer attitudes toward SHACOB are likely to improve as the SHACOB industry gains experience. However, negative consumer attitudes could develop if a number of consumers are disappointed by the quality and performance of SHACOB systems. Positive consumer attitudes are essential to the widespread acceptance of SHACOB. The significance of noneconomic factors in the formulation of consumer attitudes should not be underestimated. Specific programs aimed at improving consumer acceptance of SHACOB are described in Chapter 4, Section C.

1/ For example: Dawson, Joe, Buying Solar, Department of Health, Education and Welfare, Office of Consumer Affairs, Published by The Federal Energy Administration, June 1976 and two ERDA brochures, Solar Energy and Solar Energy for Space and Hot Water Heating.

2/ Scott, Jerome E., "The Solar Water Heater Industry in South Florida: History and Projections," in Solar Energy, Volume 18, No. 5, pp. 387-394, 1976.

D. Legal Barriers

The successful commercialization of solar energy could possibly be hampered by a multitude of legal questions. In 1974, the National Science Foundation granted funds to the American Bar Foundation, an independent research affiliate of the American Bar Association, to study how laws and institutions could be made more receptive to solar energy. This report1/ and several subsequent reports have dealt with potential legal problems such as: (1) solar access, (2) zoning restrictions, and (3) other legal barriers.

1. Solar access: Access to sunlight is one legal issue that has received considerable attention in the last few years. Empirical studies of the issue to date indicate that sun rights have yet to cause actual problems. An American Institute of Architects Research Corporation survey of architects that have built solar houses reported no problems of solar shading.2/ Another study which used aerial photography techniques to analyze the solar shading problem in a Colorado Springs residential area, indicated that nearly all of the rooftops in the area were not shaded during the important solar collection hours.3/ Despite this evidence, it is possible that sun rights may present some constraints to SHACOB development in the future, particularly in areas of high density construction.

Two specific case studies are important to the issue of solar access. The "Doctrine of Ancient Lights" is an English doctrine from the 16th century in which the property owner is entitled to receive light across neighboring land to the extent needed for "reasonable use and enjoyment." Laws in the United States establish the right of the landowner to receive light from directly above his property but no right to receive light across neighboring land.4/ One state ruling on this subject came in Miami Beach, Florida, in 1959. The Fountainbleu Hotel built an addition which shaded the Eden Roc Hotel swimming pool after about 2 PM in the winter. Arguments by the Eden Roc based on the English Doctrine of Ancient Lights were rejected by the court, and access to the sun was not granted.5/ This ruling, however, does not establish any binding precedents for other states. In most states, no precedents for sun rights have been established.

1/ Legal Issues Related to Use of Solar Energy Systems, American Bar Foundation, August 1976.

2/ Early Use of Solar Energy in Buildings, A Study of Barriers and Incentives to the Widespread Use of Solar Heating and Cooling Systems, AIA Research Corporation, Report to NSF, August 1976.

3/ Robbins, Richard L., "Law and Solar Energy Systems: Legal Impediments to Solar Energy Systems," in Solar Energy, Vol. 5, pp. 371-379, 1976.

4/ Legal Issues Related to Use of Solar Energy Systems, American Bar Foundation, August 1976.

5/ "Solar Energy and Land Use in Colorado: Legal, Institutional and Policy Perspectives," Environmental Law Institute, Report to NSF, April 1976.

Easements to light and air are now available in a few states. An easement for unobstructed light grants the holder the right to the light coming across adjacent property. By obtaining such an easement from a neighbor, which can be created for any length of time, an owner of a solar collector could guarantee his access to sunlight.

The legislative level most appropriate for the administration of these policies appears to be state and local governments. Over the past several decades, land use controls have been implemented by most state and local governments. Most studies to date recommend that the sun rights problem be approached at the same level. The American Bar Foundation's evaluation of the solar access problem has developed model zoning and land use statutes that could be used. The study conducted by the Environmental Law Institute examines in detail how land use controls and zoning ordinances in the state of Colorado could be modified to resolve the sun rights problem.[1/] Under support from NSF, Richard Robbins has also examined the sun rights problem and prepared recommendations for corrective legislation.[2/] Because the problem does not appear to pose an immediate constraint to SHACOB commercialization, the consensus of most studies seems to be that the federal government should encourage state and local governments to carefully adapt existing controls to accommodate the future use of SHACOB.

Some caution should be taken as to the effect of such legislative actions on the public attitude concerning solar energy. A premature sun rights law that does not allow for lot orientation, topography, climatic condition, energy needs, storage capability, efficiency of the collector, and the existing rights of surrounding property owners could be successfully challenged in the courts.[3/] A few adverse decisions regarding sun rights during the crucial period of market development could have a disastrous effect on consumer attitudes to the solar industry in general.

2. Land use and zoning problems: In addition to the solar access problem, land use controls and zoning ordinances may inhibit SHACOB development by regulating building height, bulk, aesthetic appearance, and location. These restrictions may prohibit the use of solar collectors, or force the SHACOB purchasers to choose a less than optimal location for the collector array, reducing the economic feasibility of the system. Retrofitting of solar energy systems could become a problem because zoning ordinances frequently limit changes to existing buildings.

1/ Ibid.

2/ Robbins, op. cit.

3/ "Another Perspective on the Sun Rights Issue," Alan S. Miller, Environmental Law Institute (unpublished manuscript) 1976.

Several specific examples of possible zoning restrictions adversely affecting solar energy are explained in the Environmental Law Institute's Report.[1/] They include: (1) height restrictions preventing location of collectors on the roof, (2) sideyard and setback provisions and lot size restrictions which could also prevent optimum location of collectors, (3) use classifications (e.g., residential) could prohibit equipment for power generation or energy storage, thus preventing the construction of solar systems, and (4) aesthetic controls affecting building appearance could require non-optimum location of collectors and storage.

Implementation of large-scale solar developments, such as shopping centers and residential subdivisions, may also face legal barriers. These structures are controlled by many other regulations as to the placement of buildings and their uses, style, and aesthetics. With proper planning and zoning regulations, these planned solar developments may evolve into attractive and energy efficient models for the building community.

3. Other legal barriers: Several other potential legal barriers have been identified in the areas of patent policies and antitrust laws, guarantees, health and safety considerations, and foreign trade laws.

Government assistance in stimulating the commercialization of a new technology often poses questions as to patent rights. Conflicts between public and proprietary information dealing with hardware developed under government contract could occur. Compulsory licensing with equitable fees could encourage more rapid development or use of solar energy systems. This could reduce monopolistic effects that might impede the use of solar energy. Small businesses may be discouraged from participation in the government solar energy program if non-exclusive or short-term exclusive licenses are offered.

Problems related to antitrust laws have also been cited as being a legal problem related to SHACOB development. The primary concern is that large corporations will use their power to inhibit SHACOB development, by monopoly pricing or monopoly marketing arrangements. Antitrust problems as they relate to SHACOB should not be any different than in other new industries, and should be overcome through enforcement of the current antitrust laws. The enforcement of Section 14 of the Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409), requiring significant participation by small businesses in federal solar programs should also facilitate the development of a competitive solar industry.

1/ Hillhouse, Karin H., et al., "Solar Energy and Land Use in Colorado: Legal, Institutional and Policy Perspectives," Environmental Law Institute for the National Science Foundation, August 1976.

As mentioned previously, mechanisms must be established to assure consumers that purchased solar systems are durable and perform as claimed by manufacturers. Performance warranties on SHACOB systems are probably the most effective method to reduce the risk to the consumer of purchasing SHACOB systems. One study has suggested that if comprehensive warranties are not initially provided by private entities, the government could provide subsidies to the SHACOB industry specifically for supplying these warranties.1/ Shoddy merchandise or installation practices will quickly frighten away the potential solar market. A lack of such guarantees could permanently inhibit SHACOB commercialization.

Health and safety hazards could be avoided by proper regulation of building codes and materials. The common use of poisonous heat transfer fluids such as ethylene glycol or other freeze retardants could pose health problems.

While these problems may seem remote, their possible impact on the commercialization of solar energy and the subsequent development of the solar manufacturing industry should be considered.

E. Other Barriers

A number of other barriers could slow SHACOB commercialization. Two types of barriers of significance are technological and environmental.

1. Technological barriers: The main technological barrier is one of system performance. Major areas of concern may be classified as SHACOB technological barriers: (a) collectors, (b) solar cooling, (c) energy storage, (d) system durability and reliability, and (e) modular systems.

a. Collectors: The performance of collectors could be improved to give higher efficiencies, leading to smaller system size and lower costs. The dissemination of standardized collector performance data and the development of uniform design practices would enable architects and engineers to optimize system designs more easily.

b. Solar cooling: Improvements in performance are needed in many areas with regard to solar cooling. Currently, lithium bromide absorption chillers require collector temperatures in the range of 240°F for optimum efficiency and cost effectiveness. These temperatures often require high technology collectors such as focusing collectors or evacuated tubes. Although focusing collectors such as the parabolic trough have been

1/ AIA Research Corporation, op. cit., pp. 61-82.

in operation for many years, evacuated tubes are just out of the development stage. Most available high temperature collectors use liquid as the transport fluid. High temperature air collectors are currently, for the most part, under development. Improvements could be made on both high temperature collectors and lithium bromide absorption chillers to achieve better performance and reduce current solar cooling costs. Solar dessicant systems also provide a promising answer to solar cooling problems.

c. Energy storage: In general, maximum performance of energy storage systems requires the capability of receiving and discharging energy at the maximum rate without excessive temperature differentials. The storage unit should also be capable of a large number of charge-discharge cycles without serious dimunition of capacity. While operable storage systems are widely available, energy losses and economics of storage systems could be improved. Both liquid and air storage processes, along with other technologies, such as phase-change energy storage, deserve further research and development to improve performance and economics.

d. System durability and reliability: Along with improvements in collector efficiencies and storage capabilities, solar economics could improve rapidly if system durability and reliability could be improved. As life-cycle costing becomes more popular, system life will be examined more carefully. Improved materials and manufacturing methods could increase the system durability and expected useful life of SHACOB systems. Reliability is also an important factor in producing economical solar systems. Troublefree, low maintenance systems are needed. System reliability is expected to improve as manufacturers and installers gain additional experience with SHACOB systems.

e. Modular systems: Installation is a major component of system cost. The development of modular systems, which may be installed efficiently by a contractor or the homeowner, could also accelerate SHACOB commercialization. The costs required for installation could be reduced significantly with the development of modular collectors, storage and controls.

2. Environmental impacts: Solar energy technology has been promoted as a "pollution free" energy technology, one for which there are no adverse environmental effects. This is not entirely true, of course, because any activity which requires raw materials, processing, manufacturing, construction activities, plant operations, and the employment of a labor force entails some degree of man-made contamination of the environment. But solar energy does not directly involve combustion or nuclear reactions, the two primary sources of environmental concern associated with energy production. Therefore, improvements in environmental quality are expected if solar energy is used to satisfy energy needs that would otherwise be filled by fossil fuels or nuclear energy.

While solar energy is not expected to directly produce pollution, there are some potentially negative environmental impacts associated with SHACOB use. Negative environmental impacts include land use, aesthetics, and safety problems. If a SHACOB system were not placed directly on the building, it could require a significant amount of land. Initially, there may be some negative responses to the appearance of solar buildings. Safety problems include toxicity of fluids and materials, and also glare resulting from sunlight reflecting off glass cover plates, which could be a problem for oncoming traffic. These problems may be resolved as a result of land use economics, architectural design techniques, and development of building codes.

CHAPTER 3

ANALYSIS PROCEDURE AND BASELINE CASES

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CHAPTER 3

ANALYSIS PROCEDURE AND BASELINE CASES

SUMMARY

Important questions concerning the future potential of SHACOB need to be answered so that government resources can be invested in SHACOB in an optimal manner. This need has led to the development of a number of analytical procedures (or models) to estimate the future energy potential of SHACOB.

There are common elements in all models that predict the future use of SHACOB. The elements or phases of the models usually include: (1) data grouping, (2) data collection and projection, (3) solar and conventional system design, (4) economic comparisons, (5) market penetration curve development, and (6) national impacts estimation.

There are a number of important limitations and uncertainties associated with modeling the future market penetration of SHACOB. The first is the uncertainty of projecting future values of a wide variety of variables. Next, problems arise in gathering the large amount of required data into meaningful groups. The development of realistic market penetration curves is also a major uncertainty of the models. These limitations emphasize the fact that results of these penetration models should be used with caution.

Arthur D. Little, Inc. is developing an extensive model of SHACOB market penetration for the FEA. The results of this model are contained in PART B of the SHACOB Commercialization Report. The model quantitatively investigates some of the incentives discussed in this report (PART A).

SHACOB market penetration estimates from other analytical models display wide variations in results. However, the results indicate that the future development of SHACOB is highly uncertain and, without further government involvement, the SHACOB market could remain insignificant in terms of total U.S. energy demand.

CHAPTER 3

ANALYSIS PROCEDURE AND BASELINE CASES

Solar heating and cooling of buildings (SHACOB) is recognized as an attractive energy source that should be developed. However, a number of questions should be addressed while government programs to accelerate SHACOB commercialization are pursued. How much energy can be produced by SHACOB in the future? What will this energy cost the nation and the federal government? Do the benefits of SHACOB justify the additional government investment required to achieve those benefits?

The need to answer these questions has led to the development of a number of analytical procedures (or models) to estimate the future energy potential of SHACOB. This chapter addresses those procedures with special attention to the model used in PART B of this report. Section A contains a general description of concepts of models and their major limitations. The section ends with a review of solar market penetration models. Section B focuses on the analytical procedure used in PART B. Section C presents the results of a variety of models under a set of baseline conditions that assume no additional government investment for SHACOB. Incentives contained in the proposed NEP are not included in the baseline conditions.

A. Modeling the Future Market Penetration of SHACOB

It is impossible to empirically determine the future rate of SHACOB market penetration until the events actually occur. However, predictions of market penetration need to be made now so that government funds can be invested in a timely and appropriate manner. To fill this need, a number of analytical models of solar energy market penetration have been developed. Each model developed is unique in its treatment of input variables and their relationships. However, most models are conceptually similar.

A significant amount of government funds may be invested in solar energy as a result of of one or more of these market penetration models. Therefore, it is important for policy makers to have a general understanding of how the models operate and, perhaps more importantly, their major drawbacks and limitations. Both of these subjects are discussed below.

1. Concepts of SHACOB modeling: Most models of SHACOB market penetration can be divided into six distinct components. These components or phases and their relationships are illustrated in Figure 14.

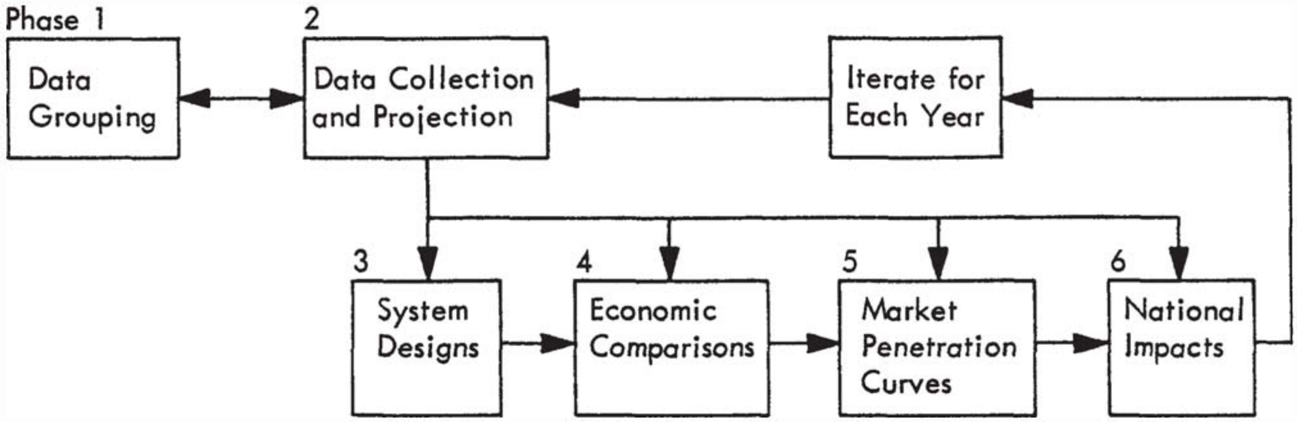

Figure 14 - Basic Components of all Solar Energy Market Penetration Models

The first phase in most solar penetration models is data grouping. This step is used to divide the universe of possible combinations of events and locations into manageable groups. One of the first variables to be grouped is geographic locations, which are usually grouped into regions. Once these regions are defined, average values for solar radiation, building heating and cooling loads, fuel prices, etc., are usually specified. Next, the wide variety of building types and characteristics must be simplified into a small number of groups. In most cases, the building types are grouped into two to ten categories. For each category, the total inventory is estimated and a single set of building characteristics are usually assigned to the entire group.

The next grouping in this first phase deals with the type of energy technologies that will be considered. Usually, less than five different solar applications are assumed (e.g., solar hot water, solar heating and hot water, solar heating alone, etc.). New and retrofit solar applications are usually treated separately. The number of competing energy systems is also reduced by grouping them into a small number of categories (e.g., electric water and space heating, electric hot water and gas heating, gas hot water and electric heat pumps, etc.).

The second phase of most solar market penetration models could be called the data collection and projection phase. This phase starts with the collection of current data (by the defined regions) on variables such as:

- regional prices of conventional fuels (i.e., natural gas, fuel oil, electricity),

- relative share of markets which will be penetrated by each of the conventional fuel types (termed "fuel shares"),

- climatic characteristics (i.e., degree days of heating and cooling),

- solar insolation,

- building inventories (e.g., number of each type of building and historical growth in those inventories), and

- local costs of collectors and other solar energy system components.

In order to make economic comparisons of the solar and conventional systems (Phase 4), future values of the regional data must be predicted. Predicting the future of almost any event is difficult and uncertain. However, predicting future fuel prices, fuel shares, population growth patterns, building inventory trends, solar component prices and future trends in building conservation practices is particularly difficult. Nonetheless, projections of each of the variables listed above must be assumed before penetration levels for each region can be estimated.

The next phase (Phase 3 in Figure 14) of most market penetration models is the design of the solar and conventional energy systems. Typically, a small number of idealized systems are designed for representative buildings in each regional division. The designs are usually not very detailed. However, they have to be accurate enough to determine (a) the amount of collector area needed, (b) the type and capacity of the storage subsystem, (c) the size and type of backup system, and (d) the percentage of annual heating and cooling load supplied by the solar energy system. Each of these factors is crucial to the economic comparisons made in Phase 4.

The methods used for system design are varied. Some models use previously developed design optimization algorithms such as FCHART or TRNSYS.[1/] Others use the judgment of engineers involved in the model

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1/ See Klein, S. A., Cooper, P. I., Beckman, W. A., and Duffie, J. A., "TRNSYS, A Transient Simulation Program," Madison, University of Wisconsin, Engineering Experiment Station, Report No. 38 (1974), and Klein, S. A., Beckman, W. A., and Duffie, J. A., "A Design Procedure for Solar Heating Systems," Solar Energy, 18, p. 113 (1976).

development and a variety of convenient "rules of thumb." Still others integrate the design phase and elements of the economic comparison phase to design the system based on cost minimization.

The methods used in the economic comparisons of the systems (Phase 4) also vary across penetration models. The least complex and the predominant approach is the payback period criterion discussed in Chapter 3. Other models use life-cycle costs for the economic comparisons. In either case, the comparison requires input from all the previous phases of the model. These inputs include:

- solar collector area,
- cost of collectors per square foot,
- storage volume,
- cost of storage per unit of volume,
- size and type of the backup system,
- cost of the backup system,
- total heating and cooling load percentage contribution by the solar system, and
- price of conventional fuels over the life of the system.

As previously mentioned, many of these input variables are region specific. Therefore, a large percentage of the time required for model calculation is spent calculating the economic feasibility of each specified energy system in each specified region. Comparisons are often made among three or four solar design alternatives and three or four conventional alternatives in each region for each building type.

One of the most crucial and uncertain phases of solar market penetration modeling is the formulation of penetration curves (Phase 5 in Figure 14). Basically, market penetration curves relate the results of the economic comparison to the percentage of market participants who will purchase the solar units. In other words, the penetration curves are supposed to indicate how buyers will react to the relative economic competitiveness of solar energy systems.

The most widely used form of market penetration curve is called the S-shaped logistic curve. The curve usually relates some type of ratio of the cost of solar energy and the cost of a conventional energy unit (either using payback or life-cycle cost) to the percent of the market penetrated. Figure 15 presents a typical logistic curve. The slope of the curve reflects the fact that when the cost comparisons do not favor a technology, only a few innovators will adopt it. The majority of adoptions comes when the technology reaches economic feasibility. The rate of penetration slows again as the saturation level is approached.

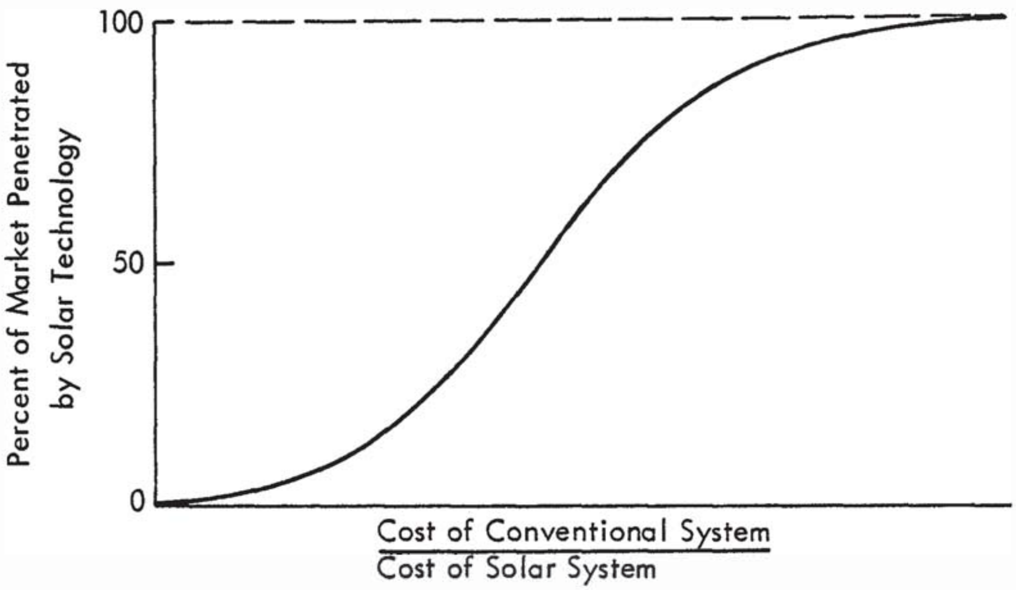


Figure 15 - Typical "S-Shaped" Logistic Curve

The S-shaped logistic curve is used because a number of studies have shown that the market development of most new technologies follow that pattern.1/ Although the shape of the logistic curve is regular, there is no regularity about the steepness or time span of the curve. Mansfield (1968)2/ and Schon (1969)3/ have shown that the adoption of new technologies by industrial firms varies from industry to industry. Fisher and Pry4/ have investigated the substitution of new commodities and found that the process took anywhere from 5 years (substitution of detergent for soap) to 58 years (substitution of synthetic rubber for natural rubber).

1/ See, for example, Fisher, J. C. and R. H. Pry, "A Simple Substitution Model of Technology Change" in M. H. Citron and C. H. Ralph, eds. Industrial Applications of Technology Forecasting (New York: Wiley and Sons, 1971).

2/ Mansfield, Edwin, Industrial Research and Technological Innovation, (New York: W. W. Norton and Company, Inc., 1968).

3/ Schon, Donald A., Technology and Change (New York: Dela Court Press, 1967).

4/ Fisher, J. C. and R. H. Pry, "A Simple Substitution Model of Technology Change," in M. H. Citron and C. H. Ralph, eds., Industrial Applications of Technology Forecasting (New York:John Wiley and Sons, 1971).

As expected, these differences result from variations in consumer preferences, expectations, discount rates, the availability of information, external economic conditions, etc. Penetration curve development is therefore one of the least reliable phases of the modeling effort. The discussion of drawbacks and limitations below expands on this problem.

The final phase of most penetration models (Phase 6 in Figure 14) deals with estimating the national impacts associated with any level of solar market penetration. The percent penetration of solar energy derived from the market penetration curves is multiplied by the building inventory estimates obtained in Phase 2 to calculate the number of solar buildings penetrated during the year. The energy savings resulting from that level of market penetration are then derived. The resulting equivalent oil imports saved, employment ramifications, materials demanded, etc., are sometimes also estimated. To estimate the market penetration in other years, the models usually reiterate Phases 2 through 6 (see Figure 14).

After base projections are made for each year, alternative policies can be investigated. The investigation of policies starts by entering the policy into the economic comparison phase of the model to see how costs are affected. If the simpler payback calculations are used, most policies enter the calculation merely as a subtraction from the initial cost component. The market penetration curves and national impacts are then recalculated. The difference between the baseline results and the recalculated values are attributed to the policy.

2. Major limitations and uncertainties: There are a large number of limitations and uncertainties surrounding solar market penetration models and, hence, market penetration estimates. The first uncertainty is the required projection of a large number of variables into the future. Basically, a relatively complete set of assumptions concerning the future economic and social environment for solar market development has to be specified.

The next limitation concerns how the needed input variables are grouped. There are unique qualities in buildings, solar insolation, and solar energy designs that are not easily adaptable to large scale models. To accommodate these models, information must be grouped into large and, hopefully, homogeneous groups. However, the number of potentially important factors contained in each group is so large that homogeneity is almost impossible. The problem is often compounded by the lack of detailed data sources. In addition, the available data sources are usually grouped differently than other sources being used. This often also forces the researcher to use larger aggregations than desirable.

Perhaps the most crucial uncertainty of the penetration models surrounds the specification of market penetration curves. The relationship between the economic feasibility of a product and the actual number of purchases is, at best, a complex process. In addition to the economic variables, numerous other factors enter the process. These factors include: perceptions, attitudes, effects of promotional campaigns, aesthetic qualities, etc. It is impossible to predict the effect of these qualitative factors on the actions of an individual. Aggregating all individuals and predicting their collective action are equally difficult. These problems make the development of market penetration curves highly uncertain. The sensitivity of the model results to these curves increases the severity of this limitation.

In addition to these major limitations, there are a number of less severe problems usually encountered in modeling solar market penetration. They include:

- The number of policies that can be directly analyzed is usually limited to economic incentives. Other policies can be analyzed only indirectly.
- Assumptions must be made concerning the relationship between collector production and collector costs. The true shape and nature of these curves (called experience curves) are uncertain.
- Technological advances and mass production could also significantly reduce the cost of other solar energy system components. These changes are impossible to predict and are usually ignored.
- The future impacts of conservation on energy consumption in buildings is not known but must be assumed for the models.
- The savings in conventional fuels attributable to the solar energy systems depends on the mix of fuels displaced in each building. If electricity is displaced, the savings depend on the fuel mix used by the utility. National or, at best, regional averages for fuel mixes are usually used in the models.
- Changes in electric and gas utility pricing policies could have a major impact on solar energy market penetration. Most existing penetration models assume no change in utility pricing.

- Technological advances may result in changes in the types of solar energy equipment which may be economically used for building end use applications.

In summary, the major limitations to modeling future SHACOB market penetration are: (1) uncertainty about future trends in fuel prices, conservation, building inventories and the socioeconomic setting for SHACOB development, (2) uncertainty about consumer behavior in the face of various economic relationships between solar and conventional energy costs (i.e., market penetration curves), and (3) problems in combining a large number of potentially important factors into manageable groups.

With these limitations and uncertainties in mind, it is easy to understand why different SHACOB penetration models produce different conclusions. A number of organizations are continuing to investigate these problems and the quality of results generated in the future will undoubtedly improve. However, no analytical technique will be able to eliminate the uncertainty associated with an unknown future. Therefore, the results of all market penetration models should be interpreted with reservation and an awareness of their basic limitations.

3. Review of market penetration models: The SHACOB penetration modeling concepts and limitations discussed above can best be illustrated with examples from existing penetration models. A brief review of three of the more prominent SHACOB penetration models is presented below to highlight their similarities and differences. The models reviewed are:

- Arthur D. Little, Inc., "An Analysis of the Market Development of the Dispersed Usage of Solar Energy Systems; 1976-1990, Draft Report to Federal Energy Administration, March 1976, and "Refined Analysis of Solar Market Development," FEA Contract No. CR-05-70066.

- Mitre Corporation, METREK Division, "Analysis and Planning Support for the Division of Solar Energy," Energy Research and Development Administration as described in "Detailed Analysis of Policy Options for Accelerated Commercialization of Solar Heating and Cooling Systems," George Washington University, Washington, DC, April 1977.

- H. Craig Petersen, "The Impact of Tax Incentives and Auxiliary Fuel Prices on the Utilization Rate of Solar Energy Space Conditioning," Report to NSF-RANN, Utah State University, Logan, Utah, January 1976.

The models first differ in how they group input variables. For example, the A. D. Little, Inc., approach divides the U.S. into 10 regions while the Mitre/METREK model uses 16 climatic regions. The Petersen model deals only with the Denver, Colorado, area and therefore contains only one region. The Mitre/METREK model groups buildings into nine categories while the A.D. Little model uses twelve groups.

Significant differences also occur in the projection of fuel prices into the future. For example, the Mitre/METREK model assumes an annual inflation rate of 5% and fuel price increases of 7% annually over the period of analysis. Petersen uses fuel price projections derived by Hudson and Jorgenson. Specifically, Petersen assumes natural gas will increase by 6.5% annually, 5.8% for refined petroleum products and 3.5% for electricity. The A. D. Little, Inc., model uses price projections generated by the Project Independence Evaluation System (PIES). Fuel escalation rates for 1975-1985 and 1985-1990 and the residential and commercial sectors are presented separately (see Section B below) in their approach.

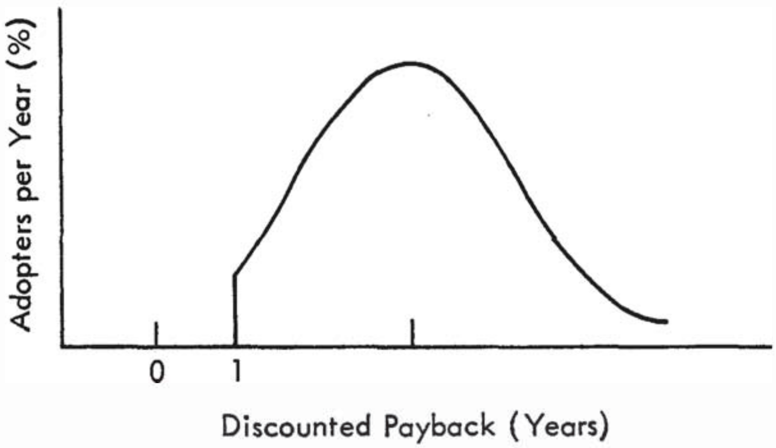
Methods used to design the solar energy systems also differ in the three models. Mitre/METREK uses the University of Wisconsin's FCHART method to derive preliminary designs. The results are then entered into an iterative procedure that selects the collector area which minimizes life-cycle costs of the system. Petersen begins the system design process by using the University of Wisconsin "TRNSYS" model. The design is optimized based on minimizing the discounted payback period. The A. D. Little, Inc., model uses the expert opinion of solar engineers to design the systems.

Economic comparisons of solar and conventional energy systems differ across the models. The A. D. Little, Inc., model uses a payback criterion without discounting the future or incorporating tax effects. The Petersen approach, on the other hand, uses a discounted payback criterion that includes tax impacts. The Mitre/METREK approach uses the ratio of life-cycle costs of solar and conventional systems.

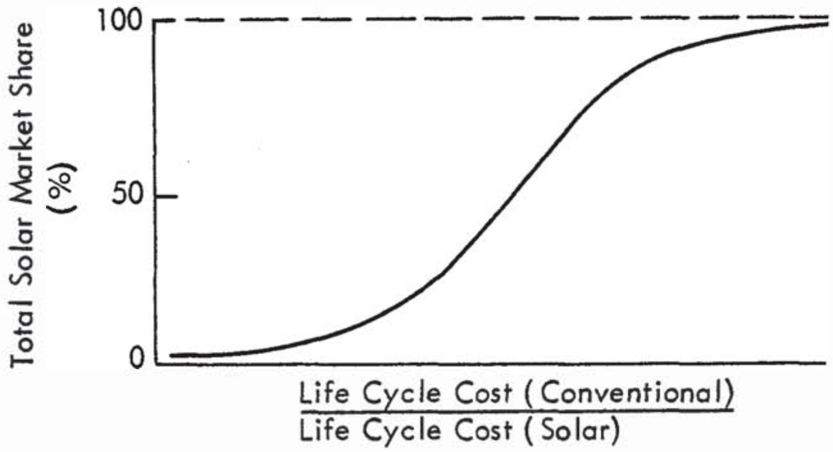
Each of these different economic decision criteria enter different market penetration curves. Figure 16 presents the general form of the Petersen, Mitre/METREK and A. D. Little, Inc., models. The Petersen model assumes solar penetration is related to the number of years until discounted conventional and solar costs are equal. The integral of the Petersen distribution yields the typical S-shaped logistic curve.

The Mitre/METREK penetration curve relates the ratio of life-cycle costs of conventional and solar systems to the share of the market captured by solar energy. A. D. Little, Inc., on the other hand, relates market penetration to zero interest payback periods for the solar energy systems.

PETERSEN MARKET PENETRATION CURVE



MITRE/METREK PENETRATION CURVE



A.D. LITTLE, INC. PENETRATION CURVE

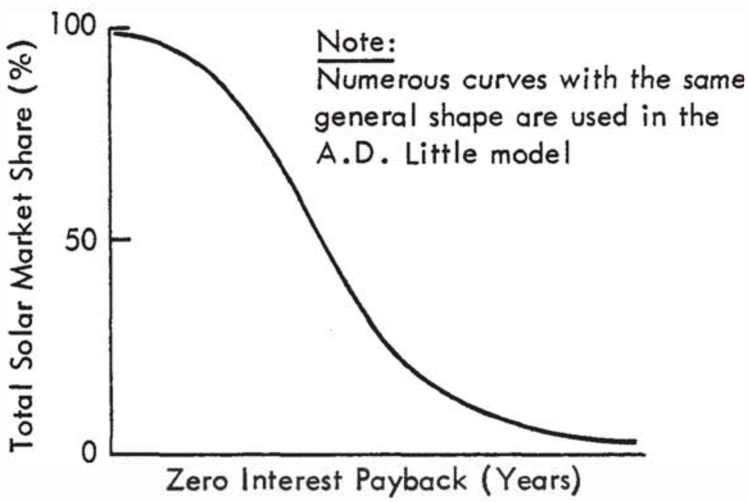


Figure 16 - Penetration Curves Used in Sample SHACOB Models

There are a number of other differences in these three market penetration models. However, the differences discussed above have the most significant effects on the model results. Each of these models is currently being developed and refined further. Further development of the A. D. Little, Inc., model serves as the basis for the quantitative analyses contained in PART B of this report. Details of the A. D. Little, Inc., method and input assumptions used are presented below.

B. Analysis Procedure

Arthur D. Little, Inc., under an FEA contract, have developed an analytical model for the future market penetration and energy production of SHACOB under alternative governmental policies.* The FEA/ADL model is described in Section 1. A more detailed description of the model may be found in Appendix D. The major assumptions incorporated into the model are explained in Section 2. Regional data for building inventory, new building construction, energy use, fuel shares and prices, weather and solar insolation, as used in the model, are displayed in Appendix D.

Results of the A. D. Little, Inc., model are contained in PART B of the SHACOB Commercialization Report. PART B quantifies some of the incentives examined in Chapters 4 and 5 of this report. The description presented below is intended to introduce the model and further emphasize the modeling concepts and limitations previously discussed.

1. Description of the FEA/ADL model: The FEA/ADL computer model attempts to capture the main features of the SHACOB market penetration process. A schematic diagram of the model is shown in Figure 17. Given information on weather, conventional fuel costs, building fuel shares, thermal loads, solar collector performances and costs, and penetration of energy conserving devices, the model simulates the responses of potential buyers, calculates the regional and national impact on the solar collector industry, and estimates conventional fuel savings. The model is disaggregated into decision modules, including 10 FEA regions and 10 building/market types for each of 14 decision years, 1977 to 1990. Data are being developed in all 10 regions for: building inventory, new building construction, fuel shares, fuel prices, building loads, and solar radiation.

For each module, energy consumption is specified by end-use through the interaction of two matrices: one containing the number of building units for each module, and the other containing the penetration of each of the primary fuels for each module, as well as the per-unit energy consumption by fuel for that module.

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* The contract is an extension of the previous work completed by A. D. Little, Inc., entitled "An Analysis of the Market Development of Dispersed Usage Solar Energy Systems; 1976-1990," Draft Report to the Federal Energy Administration, March 1976.

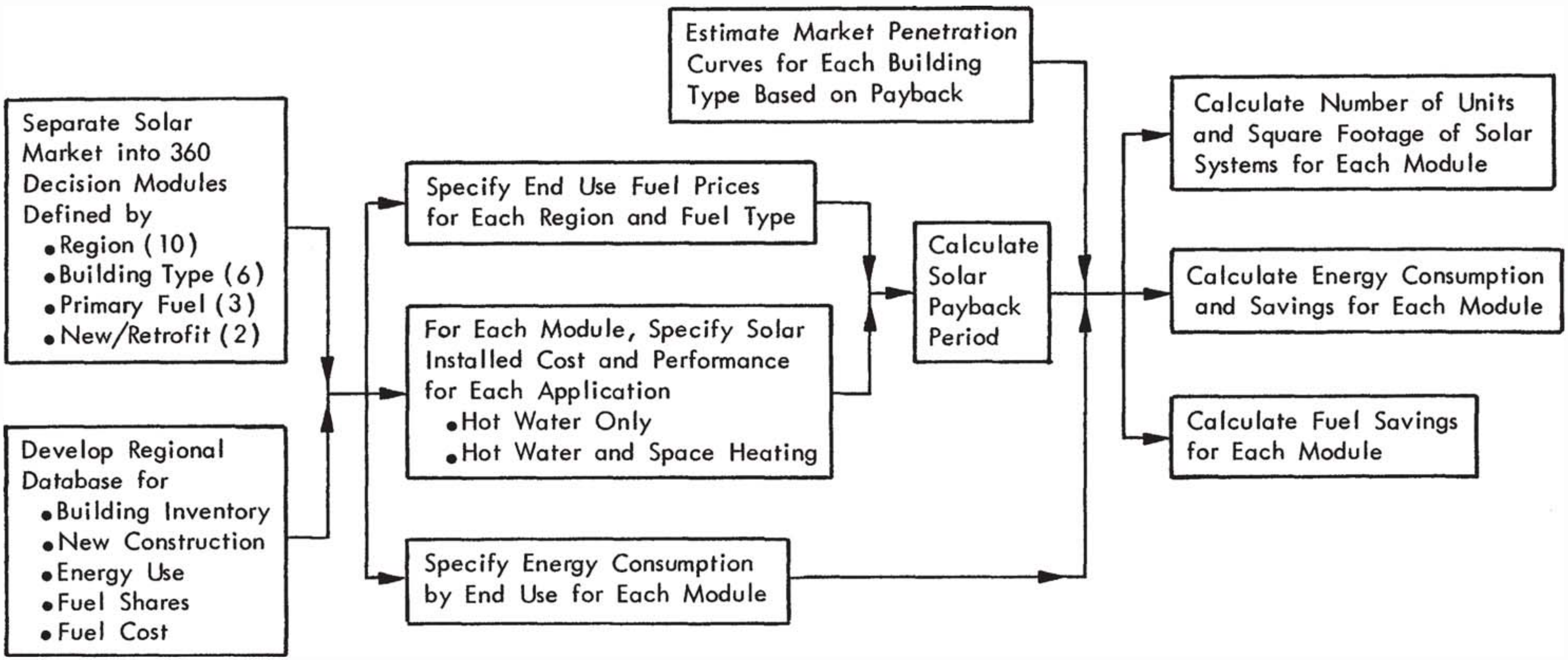

Figure 17 - Schematic Diagram of FEA/ADL Market Development Model

Two other matrices determine the performance of the collector system. One contains average energy costs by fuel and region, and the other contains the basic data on solar system cost and performance.

The model calculates, for each module, the economic performance of three different solar systems expressed in terms of a zero-interest payback period. The three systems examined are a hot water system, a combined space heating and hot water system, and a combined space heating and cooling and hot water system. These economic performances are then translated into expected market penetrations by means of the interaction with a non-linear function which relates various paybacks to expected market acceptance in each of the 10 basic building/market types. The three collector systems are treated independently, and if there is penetration for all three systems, the largest value is used.

Penetration rates are applied to the number of building units in each module, and Btus saved, system costs, etc., are aggregated to the regional and national level.

2. Major input assumptions: A major element of a SHACOB market penetration and energy production model has to do with the assumptions incorporated into the model. Section a describes the structural variables. Economic variables are described in Section b. All assumptions are specified for the baseline case. A more detailed discussion is presented in Appendix D.

a. Structural variables: The structural variables addressed in the model are collector system, regional solar insolation and energy load variations, and building inventories.

Three systems were analyzed for the purpose of simulation. The first system was designed to supply at least 50% of the hot water load. The second system was designed to supply at least 40% of the domestic hot water and space heating load. The third system was designed to supply at least 50% of the combined hot water and space heating and cooling loads. The percentage of the load supplied by solar is assumed to vary by region. All systems are assumed to be hydronic (i.e., they use liquid as the transfer medium instead of air).

As solar insolation availability varies considerably among the 10 regions, average insolation values of each region were derived from the Climatic Atlas[1/] (see Figure 4 in Chapter 1).

Data on heating loads were developed from detailed engineering pre-design of prototypical buildings for each type of building in each region.

1/ Climatic Atlas of the U.S., Environmental Data Service, U.S. Department of Commerce, June 1968.

Costs and collector areas for solar energy systems on new construction were developed through the use of a curve-fitting equation which related building load, solar flux, and collector efficiency to required system size. A collector area was computed, given insolation and building load characteristics, for each region and building type for both systems. A second equation was then used to calculate cost per square foot based on area and system type.

Effective life expectancy of both hot water systems and combined hot water and space heating systems was assumed to be 25 years.

One of the most sensitive variables in the economic feasibility analysis of solar energy systems is the projected cost of fuel. The price escalations used in this analysis were obtained from the Project Independence Evaluation System (PIES), Reference Case.[1/] Prices reflect regionalized inflation factors for the various fuels taken from PIES. Fuel price assumptions are summarized in Table 9.

Assumptions concerning the availability of fuels for the heating and cooling of buildings have a substantial impact on the economics of solar collector systems. In the current analysis framework, it is assumed that natural gas will be available to the residential sector in increasing quantities in some regions. Some natural gas will be made available from the commercial sectors as a result of fuel-burning conversions.

The concept of zero interest payback was used to integrate system economics and consumer behavior in the preparation of a market penetration curve. Basically, the method indicates how many years are required for the investment to pay itself off, with no discount rate considered, given the anticipated fuel savings for the unit. For example, a system costing $1,000 and having an annual fuel savings of $50, would have a zero interest payback period of 20 years. This payback period is adjusted for non-financial characteristics such as aesthetics, reliability and space requirements. Estimates may then be made of the responses of the various classes of consumers, which may be best visualized through a market penetration curve.

Several market penetration curves were developed for each of the 10 building/market types. An example curve is shown in Figure 16. Significant market penetration does not occur under these assumptions until adjusted paybacks reach approximately 5 years. Such a payback implies a discount rate attached to future savings by the consumer of nearly 20%. Low penetrations are achieved if the adjusted payback exceeds 10 years.

1/ 1977 National Energy Outlook, Federal Energy Administration.

Specific loads for different building types in various regions were derived with minor adjustments from Residential and Commercial Energy Use Patterns 1970-1990.[1/]

The residential housing inventory for 1975 was estimated from the 1970 Census of Housing[2/] and from the Annual Housing Survey, 1973.[3/] To derive forecasts for the 10 FEA regions, data were factored using regional population data.[4/] Thus, in cases where a region's population is projected to increase, that region's share of the housing stock is assumed to increase proportionately. The residential housing inventory, including projections for new construction and removals, is summarized in Table 1, Chapter 1.

The building inventory for the commercial and institutional sectors was derived from analysis of data on new construction since 1925.[5/] New construction was forecasted by means of single-variable regression techniques. For commercial buildings, forecasts of real personal income was used as the independent variable. For institutional buildings, the best correlation was with the historical time trend. Schools, however, have been adjusted for school age population trends.

b. Economic variables: The economic variables addressed in the model include system cost and useful life, fuel prices and availability, and consumer decision criteria and market penetration rates.

The cost of solar systems tends to be sensitive to system size (i.e., collector area). However, many system costs, such as those associated with controls, piping, and storage, tend to go up relatively slowly with increased collector area. Thus, as collector areas increase (due to greater loads placed on the systems), costs per square foot tend to be lower.

1/ Arthur D. Little, Inc., Residential and Commercial Energy Use Patterns 1970-1990, Report to the President's Council on Environmental Quality and the Federal Energy Administration, 1974.

2/ 1970 Census of Housing, U.S. Census Bureau.

3/ Annual Housing Survey, 1973, U.S. Department of Housing and Urban Development.

4/ Population Estimates and Projections, Current Population Reports, Series P-25, No. 477, U.S. Bureau of Census, March 1972.

5/ Statistical Abstract of the U.S., Compiled by F. W. Dodge Division of McGraw-Hill Information Systems, Co.

TABLE 9

ENERGY PRICE ASSUMPTIONS OF FEA/ADL MODEL OF SHACOB PENETRATION

Part A; Residential Energy Prices
(In 1977 Dollars Per Million BTUS)

	FEA Region*										
	1	2	3	4	5	6	7	8	9	10	
Year and Fuel Type	New England	New York/ New Jersey	Mid-Atlantic	South Atlantic	Midwest	Southwest	Central	North Central	Western	North Western	National Average
1975											
Electricity	14.53	16.32	12.24	9.01	10.66	8.70	9.79	9.02	10.83	4.66	10.34
Natural Gas	3.37	2.75	2.12	1.64	1.68	1.48	1.42	1.29	1.68	2.30	1.81
Fuel Oil	3.44	3.13	3.06	3.08	2.90	2.99	2.94	3.08	3.29	3.22	3.11
1980											
Electricity	14.43	15.60	11.94	10.40	11.05	13.70	11.27	9.25	13.92	6.64	11.72
Natural Gas	3.39	3.13	2.69	2.24	2.21	1.80	1.69	1.70	2.42	3.35	2.32
Fuel Oil	3.54	3.59	3.76	3.83	3.30	3.53	3.20	3.40	3.48	3.48	3.53
1985											
Electricity	14.25	14.86	12.37	10.51	11.48	12.89	11.18	8.97	13.11	6.51	11.65
Natural Gas	4.14	3.63	3.24	2.86	2.74	2.04	1.72	1.77	3.59	3.36	2.80
Fuel Oil	3.69	3.77	3.94	4.02	3.58	3.71	3.49	3.68	3.70	3.70	3.74

Part B; Commercial Energy Prices
(In 1977 Dollars Per Million BTUS)

	FEA Region*										
	1	2	3	4	5	6	7	8	9	10	
Year and Fuel Type	New England	New York/ New Jersey	Mid-Atlantic	South Atlantic	Midwest	Southwest	Central	North Central	Western	North Western	National Average
1975											
Electricity	14.15	16.41	11.38	9.44	10.43	7.60	9.09	7.58	9.12	4.88	10.17
Natural Gas	2.79	2.23	1.81	1.30	1.42	1.00	1.07	1.08	1.37	1.73	1.44
Fuel Oil	3.05	2.85	2.84	2.84	2.74	2.74	2.75	2.95	3.01	2.95	2.86
1980											
Electricity	14.19	16.48	11.24	10.68	10.92	12.87	10.42	8.13	12.62	6.74	11.79
Natural Gas	2.76	2.56	2.25	1.76	1.90	1.30	1.30	1.48	1.93	2.80	1.87
Fuel Oil	3.31	3.35	3.39	3.40	3.12	3.28	3.04	3.18	3.22	3.22	3.27
1985											
Electricity	14.16	16.53	11.83	10.63	11.46	12.32	10.93	8.17	12.23	6.49	11.78
Natural Gas	3.51	3.07	2.80	2.38	2.43	1.99	2.30	2.40	3.10	2.81	2.60
Fuel Oil	3.47	3.53	3.57	3.58	3.41	3.47	3.32	3.47	3.44	3.44	3.48

C. Baseline Cases

As mentioned previously, PART B of this report presents results of the FEA/ADL market penetration model. Results included predict the future penetration of SHACOB if no additional government support or incentives were implemented in the future (termed the baseline case).

Baseline cases have been included in almost all previous solar market penetration reports. Table 10 presents the results of some of these models. The Petersen model, mentioned in Section B above, only deals with the Denver, Colorado area and is therefore not presented in the table. Preliminary results from the Mitre/METREK model are presented. However, further model refinement is still underway and final results could be quite different than those shown in the table. The other results presented were completed in 1974 and 1976 by Arthur D. Little, Inc., and by the NSF contractors for the Phase "0" studies on solar heating and cooling.

The major conclusion that can be drawn from Table 10 is that without further government involvement, SHACOB market penetration will not grow rapidly. The additional model development being conducted by A. D. Little, Inc., and Mitre/METREK Corporation should give added insights into these conclusions. However, the major limitations and uncertainties of this type of model will not be overcome. Nevertheless, further research on models should substantially improve the market penetration predictions which are obtainable.

TABLE 10

ESTIMATES OF SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB) UTILIZATION
($Btu \times 10^{12}$/Year--Energy Produced)

	1980	1985	1990
Arthur D. Little, Inc., (1974)a/			
Business-as-usual, oil $11/bbl	11.7	280	550
Arthur D. Little, Inc., (1976)b/			
Business-as-usual	12	19.2	31.1
Mitre/METREK Corporation (1977)c/			
Base Case	0.7	7	33
General Electric (Phase "0" 1974)d/			
New Construction Applications	10	80	190
Westinghouse (Phase "0" 1974)e/			
Capture Potential	6	28	41
TRW Systems Group (Phase "0" 1974)f/			
Medium level estimate	270	--	2,030

a/ "Technology Assessment of Terrestrial Solar Energy Resource Development," A. D. Little, Inc., July 2, 1974.

b/ "An Analysis of the Market Development of Dispersed Usage Solar Energy Systems: 1976-1990," A. D. Little, Inc., Draft Report to FEA, March 1976. The same projections were used in the FEA National Energy Outlook, March 1976.

c/ As described in Bezdek, et al., "Detailed Analysis of Policy Options for Accelerating Commercialization of Solar Heating and Cooling Systems," The George Washington University, Washington, D.C., April 1977.

d/ Solar Heating and Cooling of Buildings, Phase 0, General Electric Co., Space Division, NSF-RA-N-74-021, May 1974.

e/ Solar Heating and Cooling of Buildings, Phase 0; Westinghouse Electric Corp., Special Systems, NSF-RA-N-74-022, May 1974.

f/ Solar Heating and Cooling of Buildings, Phase 0; TRW Systems Group, NSF-RA-N-74-022, May 31, 1974.

CHAPTER 4

EXAMINATION OF INDIVIDUAL INCENTIVES

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CHAPTER 4

EXAMINATION OF INDIVIDUAL INCENTIVES

SUMMARY

The purpose of this chapter is to examine a wide variety of incentives that might help accelerate the commercialization of SHACOB. A complete set of criteria to examine an incentive would include: (1) its impact on SHACOB barriers, (2) its impact on various income and interest groups, (3) the complexity and cost of administering the incentive, (4) the incentive's impact on cost and, hence, market penetration of SHACOB, and (5) its direct cost to the government. All the above criteria, except 4 and 5, are used to investigate incentives in this chapter.

Solar related incentives can be designed to influence SHACOB users, SHACOB producers, or both. Most incentives applicable to SHACOB users, such as grants, tax deductions, investment tax credits, low-interest loans, loan guarantees, etc., could also be applied to SHACOB producers.

Grant programs are effective in reducing the first cost barrier. The current ERDA, HUD, DOD solar demonstration program could be expanded into a more massive grant incentive program. Income tax credits also reduce the initial cost barrier but are applicable only to the individual SHACOB user. Investment tax credits represent a parallel incentive for commercial users and SHACOB producers. The impact of an individual income tax deduction incentive on SHACOB users depends on their levels of income and, therefore, favors middle and high income groups. Accelerated depreciation allowances favor commercial users and SHACOB producers by decreasing the life-cycle costs of systems or production equipment.

Low-interest loans also reduce cost barriers and could be administered in a variety of ways. Loan guarantees address the risk of the SHACOB investment rather than its initial cost. Property tax exemptions influence cost barriers but require coordination with non-federal government organizations.

Other incentives investigated include the Solar Energy Government Buildings Program, demonstration programs, consumer education programs, programs implementing SHACOB building codes and system/component certification procedures, utility programs, and government insurance programs.

CHAPTER 4

EXAMINATION OF INDIVIDUAL INCENTIVES

A large number of potential barriers to the commercialization of SHACOB have been discussed in Chapter 2. The analytical model results from the baseline cases of previous studies presented in Chapter 3 indicated that the market penetration of SHACOB will be uncertain and probably small if current government programs are the only incentives provided. The potential benefits of SHACOB suggest that some type of incentive legislation is justified for SHACOB. The purpose of this chapter is to examine a wide variety of incentives that might accelerate SHACOB commercialization.

The chapter is divided into five major sections. Section A discusses the criteria used to examine the incentives. Federal economic incentives are examined in Section B. These incentives include government actions that would have a direct impact on the cost of SHACOB. Section C examines federal noneconomic incentives. Noneconomic incentives are defined to include those incentives which primarily affect institutional, legal, and other barriers, but which may have an indirect effect on system costs. Incentives which could be implemented by state and local governments or which require joint federal, state, and local government support are examined in Section D.

Many of the incentives investigated in this chapter have unique costs and benefits to the government. Some incentives address one or two particular barriers to SHACOB commercialization. It may be useful, therefore, to combine these incentives to promote SHACOB. Chapter 5 addresses a selected number of possible incentive combinations and analyzes their impacts.

A. Examination Criteria

If SHACOB incentives are justifiable, the logical next step is to determine which incentives are most appropriate. The factors that determine whether an incentive is appropriate include: (1) the incentive's impact on SHACOB commercialization barriers, (2) its impact on various income and interest groups, (3) the complexity and cost of administering the incentive, (4) the incentive's impact on the economic feasibility of SHACOB and, hence, its effect on SHACOB market penetration, and (5) its direct cost to the government. The best incentives are those which provide the greatest amount of SHACOB penetration at the lowest cost to the society, with minimal impacts on the distribution of income. The cost of the incentive to the society includes direct and administrative costs to the government and other societal costs.

The first three factors mentioned above form the basis of the examinations of incentives in the following sections of this chapter. The fourth and fifth factors, the incentive's impact on SHACOB market penetration and its cost to the government, are addressed in PART B of the SHACOB Commercialization Report.

After a general description of each incentive, a matrix of the incentive and the SHACOB barriers described in Chapter 2 provides a qualitative assessment of the incentive's impact on SHACOB barriers. Impacts are described as major direct positive, moderate direct positive, indirect positive, no impact, and potentially negative impact.

Next, the equity impacts of the incentive are described by a qualitative assessment of the incentive's impact on various income groups, private corporations, utilities, and the SHACOB industry. Transfers of funds from one level of government to another required by the incentive are also noted in the equity analysis.

Possible administrative mechanisms for each incentive are then broadly described. The level or levels of government that are likely to administer the incentive is indicated. A qualitative assessment is made of whether the incentive could be administered by an existing agency or would require the establishment of a new organization.

B. Federal Economic Incentives

Most of the federal incentives discussed in this section deal with economic aspects of SHACOB. The incentives discussed were selected for their potential effectiveness in establishing a viable solar industry, and because they are construed as being acceptable to the user and capable of enactment. In addition, most of these incentive provisions, or similar provisions, are included in currently proposed or enacted Congressional legislation. Several of the incentives examined have been examined in previous reports.[1/] The group of incentives addressed below is not intended to be all inclusive but rather typical of various types of incentives.

The incentives examined in this section are divided into two groups, user incentives (Section 1) and producer incentives (Section 2). User incentives are intended to directly benefit those who install SHACOB systems. Producer incentives are intended to first benefit the SHACOB industry component manufacturers and service sectors and indirectly, through

1/ See, for example, "Interim Policy Options for Removing Barriers and Implementing Incentives to Accelerate Market Penetration of Solar Heating and Cooling Systems," ERDA, Division of Solar Energy, Unpublished Draft, February 17, 1977, and "Residential Solar Heating and Cooling Constraints and Incentives: A Review of the Literature," Arthur D. Little, Inc., Report to HUD, NTIS PB-258 238, May 1976.

lower costs, benefit SHACOB users. It is important to realize, as shown in Figure 18, that most user incentives could also be applied to producers. Figure 18 also shows that some user incentives are likely to apply only to individual users while others apply only to commercial users.*

INCENTIVE	POTENTIAL TARGET GROUPS		
	Individual Users	Commercial Users	Producers
Grants	●	●	●
Income Tax Credits	●		
Income Tax Deductions	●	●	●
Investment Tax Credits		●	●
Accelerated Depreciation		●	●
Low Interest Loans	●	●	●
Loan Guarantees	●	●	●
Property Tax Exemptions	●	●	●
Government Buildings Program			●

● Indicates Incentive Could Apply to the Target Group

Figure 18 - Matrix of Federal Economic Incentives and Potential Target Groups

Those incentives which apply to both users and producers are described in detail only in the section on user incentives. This is because most legislation proposed to date has directed these incentives toward SHACOB users. The application of these same incentives to SHACOB producers is, therefore, discussed only briefly in Section 2.

1. User incentives: Eight incentives which could benefit those who install SHACOB systems are examined in this section. These user incentives are: (a) grants, (b) income tax credits, (c) income tax deductions, (d) investment tax credits, (e) accelerated depreciation allowance, (f) low interest loans, (g) loan guarantees, and (h) property tax exemptions.

a. Grants: One obvious means to stimulate solar energy use in buildings is to provide grants to building owners for the purchase of SHACOB systems. These grants could equal the total value of the SHACOB system or some fraction of the total cost. The grants could also be applied to single components of a system such as collectors or storage units.

* Individual users implies an individually-owned residential building. Commercial users implies a corporate-owned residential or commercial building.

Figure 19 shows the impact that a grant program is expected to have on barriers to SHACOB commercialization. It is evident from this figure that the major advantages of federal grants are their impact on both high initial costs and high life cycle costs. Grants are easily understood by building owners and directly enhance the economic feasibility of SHACOB, no matter which consumer decision criterion is utilized.

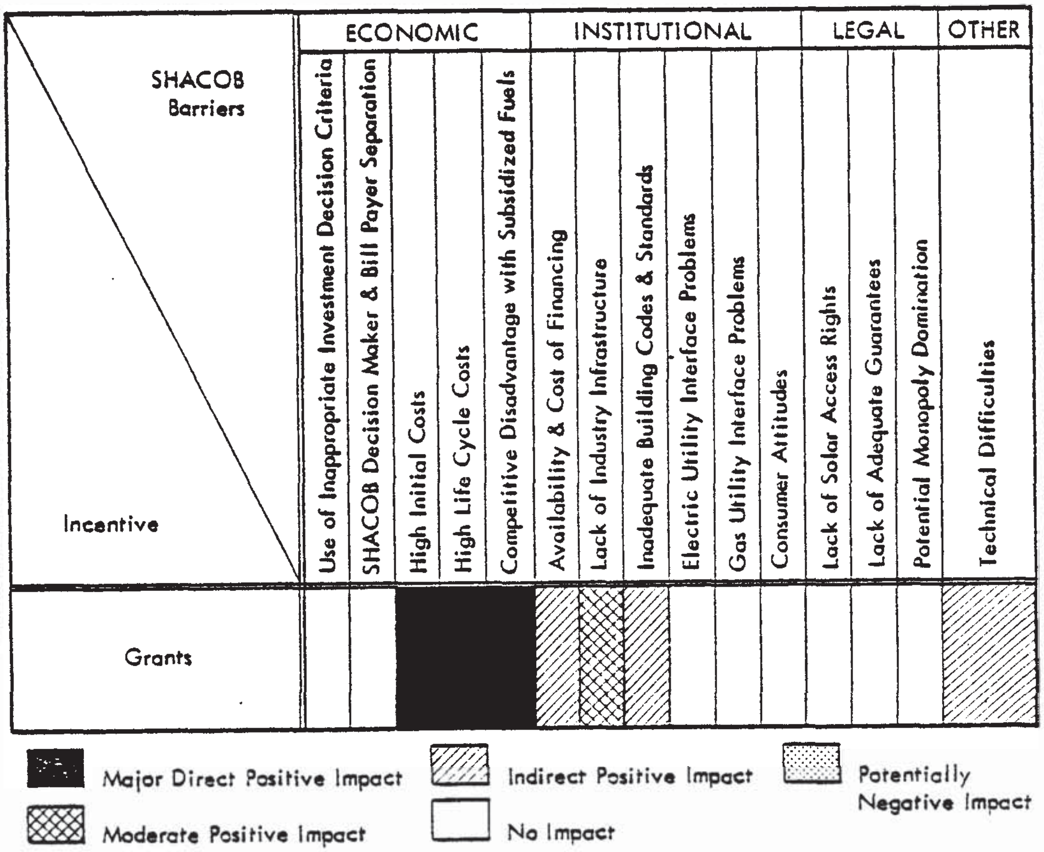

Figure 19 - Impact of Grant Incentive on SHACOB Barriers

By reducing or eliminating initial capital costs, grants are also likely to indirectly reduce or eliminate financing barriers. This reduction occurs because the reduced need for financing will significantly lower the size of any needed bank loan, and thereby, lower the risk to the bank.

A grant program is expected to have a direct positive impact on the SHACOB industry infrastructure and to indirectly reduce technical difficulties with SHACOB systems. Increased industry experience resulting from a grant program will accelerate industry development, leading to lower cost and higher quality systems. Greater experience with SHACOB systems is also expected to increase the local building code authorities' familiarity with SHACOB, indirectly reducing the code problem.

Figure 19 shows that a grant program is expected to have no impact or uncertain impact on the remaining SHACOB barriers. It is, of course, very possible that a grant program may have some impact on any one of these barriers. These impacts, however, are not easily predicted. Consumer attitudes toward SHACOB, for example, may either improve or become negative, depending on the experience of SHACOB users, and a number of other factors. One uncertain factor affecting consumer attitudes is the response of those prospective SHACOB purchasers who are unable to obtain a grant.

Figure 20 presents the impacts that a grant program is likely to have on different income and interest groups. The figure shows that a program could be designed to benefit either low, middle, or upper income groups. A program could, for example, restrict eligibility to low income homeowners. Essentially any elegibility restriction can be specified in a grant program in order to target the program to a specific group. The program could be designed to favor only homeowners, only businesses, or both groups.

A grant program would obviously provide direct benefits to SHACOB component manufacturers, installers, and service companies. No direct benefits are provided to utilities, and no significant amount of government funds will be transferred from the federal government to state or local governments.

The administrative costs of a grant program could be significant. Figure 21 shows that the grant program could be administered by an existing federal government agency, possibly in conjunction with a state agency. An expanded grant program, however, would probably require an expanded administrative mechanism to evaluate a large number of grant applications. The administering organizations will need to determine that a proposed solar energy system is technically operational, efficient, and that no fradulent applications are funded.

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Grants	Could by Design	Could by Design	Could by Design	No	Yes	No

Figure 20 - Equity Impact of Grant Program

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Grants	Federal State	Yes FEA, ERDA, HUD, and State Energy Offices	No

Figure 21 - Administrative Mechanism of Grant Program

An administrative advantage of grants is that they can have an immediate impact on SHACOB initial cost. This will allow the SHACOB purchaser to use them to pay for all or part of the system cost at the time of purchase, rather than having to wait for reimbursement at some later date. Another administrative advantage is that grant programs would require no changes in the federal income tax structure. For tax purposes, grants could be treated as additional gross income or be tax deductible, resulting in the need for a smaller grant.

A limited number of grant incentives have already been passed by federal and state legislatures. For example, the Energy Conservation and Production Act amended Title V of the Housing and Urban Development Act of 1970, to provide for solar equipment demonstration grants.[1/] The Act allows a grant or 25% of the cost of implementing the solar energy system. The Secretary of HUD may increase such percentages for certain low income families. Two hundred million dollars are authorized, but no funds were allocated to implement the Act.

1/ U.S. Congress, Energy Conservation and Production Act, P.L. 94-385, 94th Congress, 42 USC 6801, August 14, 1976, Title IV, Part C, Sec. 441.

HUD also has an interagency agreement with ERDA to provide annual funds for solar installations in single family homes and apartment buildings. In October 1976, HUD announced 102 grants totaling about $4 million compared to about $1 million in grants to 55 builders announced in January 1976. In June 1977, over $6 million was awarded by HUD for 169 projects cycle of the residential demonstration program. In March 1977, HUD announced the size of the residential demonstration program would be increased by $4.6 million to be used in 10,867 homes in 11 selected states. The grant is limited to $400 per unit for solar water heating systems.1/ This program will be administered by state agencies in the selected states. Many states have also passed limited grant programs. For example, Montana has established a fund to award grants to individuals, educational facilities or other organizations installing solar energy systems.2/ At least 10 other states have similar limited grant programs.3/ State incentives legislation is discussed in Section D of this chapter.

All the state and federal grant incentives to date have been very limited in scope and aimed primarily at demonstrating the technology.* Large scale grant programs aimed directly at SHACOB commercialization have not, as yet, been attempted.

b. Income tax credits: One of the important residential sector incentives is income tax credits. These credits directly offset the income tax liability of homeowners purchasing solar energy systems. Income tax credits have been discussed in a wide variety of solar energy research studies4/ and included in numerous Congressional bills.5/ An income tax credit for residential solar equipment is a key part of President Carter's proposed energy program. In general, the amount of the tax credit granted represents a pre-specified percentage of the solar energy system cost up to some maximum amount. The credit would be available to any homeowner who purchased a solar energy system. No application or other forms would have to be filed in advance.

1/ HUD News, No. 77-87, March 28, 1977.

2/ National Conference of State Legislatures Energy Task Force, Turning Towards the Sun, p. 16.

3/ Evaluating Incentives for Solar Heating, Rosalie Ruegg, National Bureau of Standards, September 1976, p. 9.

4/ See Residential Solar Heating and Cooling Constraints and Incentives: A Review of the Literature, Arthur D. Little, Inc., for Department of Housing and Urban Development (PB 258 238), May 1976, p. C-25.

5/ See for example, Solar Energy Legislation in the 94th Congress: A Compilation of Bills through February 7, 1977, Library of Congress (Unpublished). This document is continually updated.

* Demonstration programs are discussed further in Section C of this chapter.

The specific percentages and maximum amounts allowed in an income tax credit for SHACOB systems will have a significant effect on how the incentive works. For example, the NEP tax credit proposed by the President, which allows 40% of the first $1,000 and 25% of the next $6,400, up to a maximum of $2,000, would be a stronger incentive for solar water heating systems than for solar heating systems. This is because solar water heaters cost approximately $1,000 per unit and are, therefore, eligible for the 40% credit. Heating systems, however, cost significantly more than a water heater and would, therefore, be eligible for a smaller total percentage credit. In contrast, a tax credit specifying a straight credit equal to 20% of SHACOB system costs, up to a maximum credit of $2,000 would provide an equal total percentage credit to all SHACOB systems. However, because solar water heaters are the SHACOB system type nearest to economic feasibility, a percentage credit weighted to have a larger impact on small SHACOB systems (as proposed in the NEP), may lead to greater near term use of SHACOB systems than a straight 20% credit. The experience gained by the SHACOB industry from installation of large numbers of solar water heaters should indirectly reduce the cost of solar heating systems.

Figure 22 shows that income tax credits are similar to grant incentives in that both have a major direct impact on SHACOB high initial and life-cycle costs. The cash flow of income tax credits may be somewhat different from grants. The solar energy system purchaser would receive the tax credit at the end of the year in which he purchased the unit. From the consumer's viewpoint, he must first find the funds to purchase the system and then wait to be reimbursed after he files his income tax. Grants, however, could be structured so that the consumer receives the government funds before he purchases the solar equipment.

The impact of income tax credits on other SHACOB barriers is expected to be similar to that of grants. The availability of financing will be indirectly increased. The barriers of lack of industry infrastructure, inadequate codes, and technical difficulties will be reduced.

The impact of an income tax credit on various income and interest groups is shown in Figure 23. As the credit is primarily for residential users, businesses do not receive benefits from the credit. Middle and upper income groups will likely be able to realize the maximum benefits of the income tax credit. This is because the tax liability of these groups is large enough to allow for the full value of the credit.

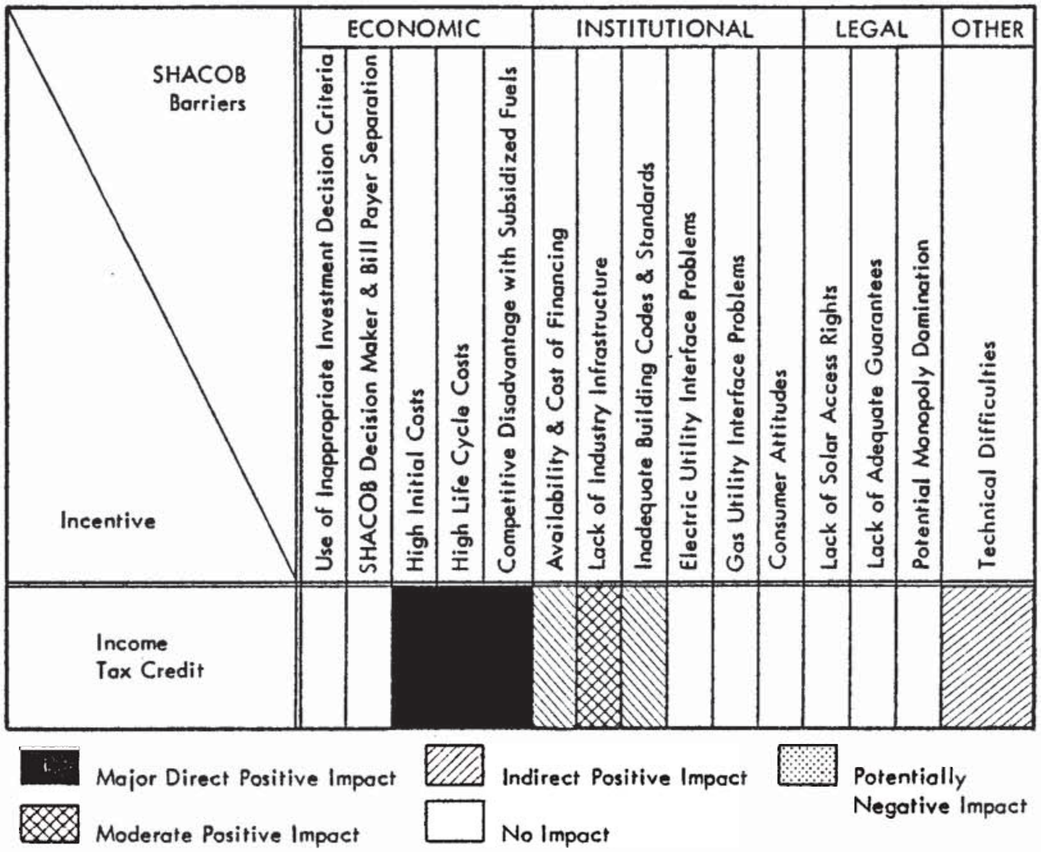

Figure 22 - Impact of Income Tax Credits on SHACOB Barriers

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Income Tax Credit	Could by Design	Yes	No	No	Yes	No

Figure 23 - Equity Impact of Income Tax Credit

The potency of income tax credits in stimulating SHACOB markets will be enhanced if the credit is designed not to be limited to the consumer's current annual tax liability. If the tax credit claimed exceeds the consumer's annual income tax liability (as would often be the case in the low income group), he could then: (1) be reimbursed for the difference between the tax liability and the tax credit in a lump sum, or (2) apply the remaining credit to future income tax liabilities. Both of these options have the advantage of not giving additional tax benefits to higher income homeowners. All taxpayers purchasing SHACOB would receive equal payment from the government.

An income tax credit, as shown in Figure 24, can be administered by the Internal Revenue Service. Therefore, a new administrative mechanism would not need to be established and the cost of administering this incentive may be low.

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Income Tax Credit	Federal	Yes (IRS)	No

Figure 24 - Administrative Mechanism for Income Tax Credit

Although the administrative costs of tax credits may be lower than some alternative incentive options, the direct costs to the government would probably be large. A large amount of lost tax revenue could be expected. However, the exact number of consumers using the credit would be hard to determine in advance. Furthermore, changes in existing federal tax law would be required. Provisions to phase out the tax credit after a few years would need to be formulated. The type of equipment eligible for the tax credit would have to be carefully specified (especially when passive solar energy systems are included).

c. <u>Income tax deductions</u>: The income tax deduction is another SHACOB incentive option. Under this incentive, an individual who installs a SHACOB system is allowed to deduct a specified percentage of the system cost from his taxable income in that year. An income tax deduction would probably be limited to individuals installing solar systems in residences. However, it could be expanded to also apply to corporate income taxes. The discussion below deals only with applications to individual income taxes.

Figure 25 shows the impact of an income tax deduction on SHACOB barriers. The tax deduction has essentially the same impact as the income tax credit discussed previously.

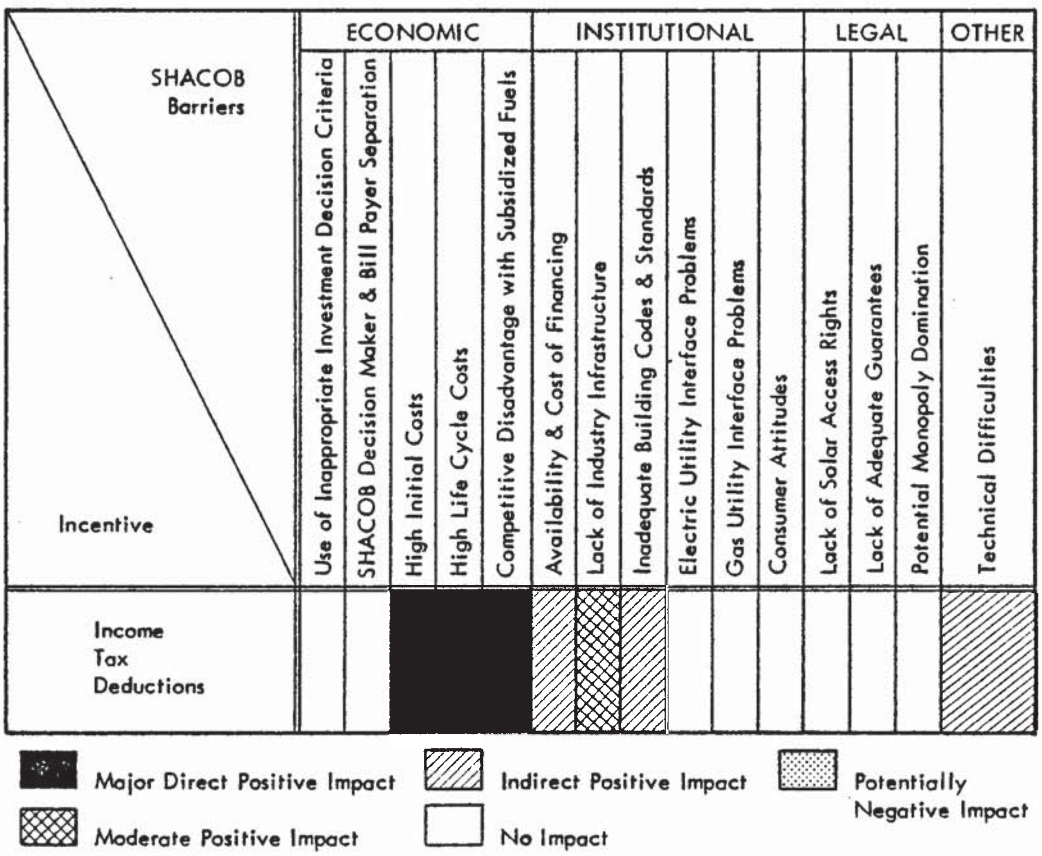

Figure 25 - Impact of Income Tax Deduction on SHACOB Barriers

The magnitude of the tax deduction's impact on system cost depends upon the income of the SHACOB purchaser. As shown in Figure 26, the tax deduction favors the middle and upper income groups. This is because these groups have a higher percentage tax rate, and therefore receive a greater savings from a deduction than the lower income group.

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governmen Entities
Income Tax Deductions	No	Yes	No	No	Yes	No

Figure 26 - Equity Impact of Income Tax Deduction

As in the case of the income tax credit, the tax deduction benefits the SHACOB industry because of the greater SHACOB system sales that are likely to result. The utilities receive no special benefits, and no funds are transferred from the federal government to state or local governments. As the incentive is assumed to be limited to individuals, businesses receive no benefit from the tax deduction.

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Income Tax Deductions	Federal	Yes (IRS)	No

Figure 27 - Administrative Mechanism of Income Tax Deduction

Figure 27 shows that the income tax deduction, like the income tax credit, would be administered through the Internal Revenue Service. The administrative costs of these two incentives are likely to be similar, both being relatively low in cost.

d. <u>Investment tax credit</u>: Investment tax credits form another potentially effective incentive program. Like the residential tax credits discussed earlier, the investment tax credit is designed to reduce the high initial investment costs of solar equipment installations. The investment tax credit, however, does not apply to individual SHACOB users. Instead, it applies to business users, and possibly to SHACOB component manufacturers (application to producers is duscussed below in Section 2). An investment tax credit for business users of SHACOB is included in the President's proposed National Energy Plan.

As shown in Figure 28, the investment tax credit and several incentives already discussed have similar impacts. Each acts to reduce both high initial and life-cycle SHACOB costs, as well as other barriers indicated in the figure. Like the income tax credit and deduction, the benefits from the investment tax credit are returned to the purchaser at the end of the first year in which the SHACOB unit was acquired. The grant, as mentioned previously, can be given to the SHACOB purchaser before he buys the system.

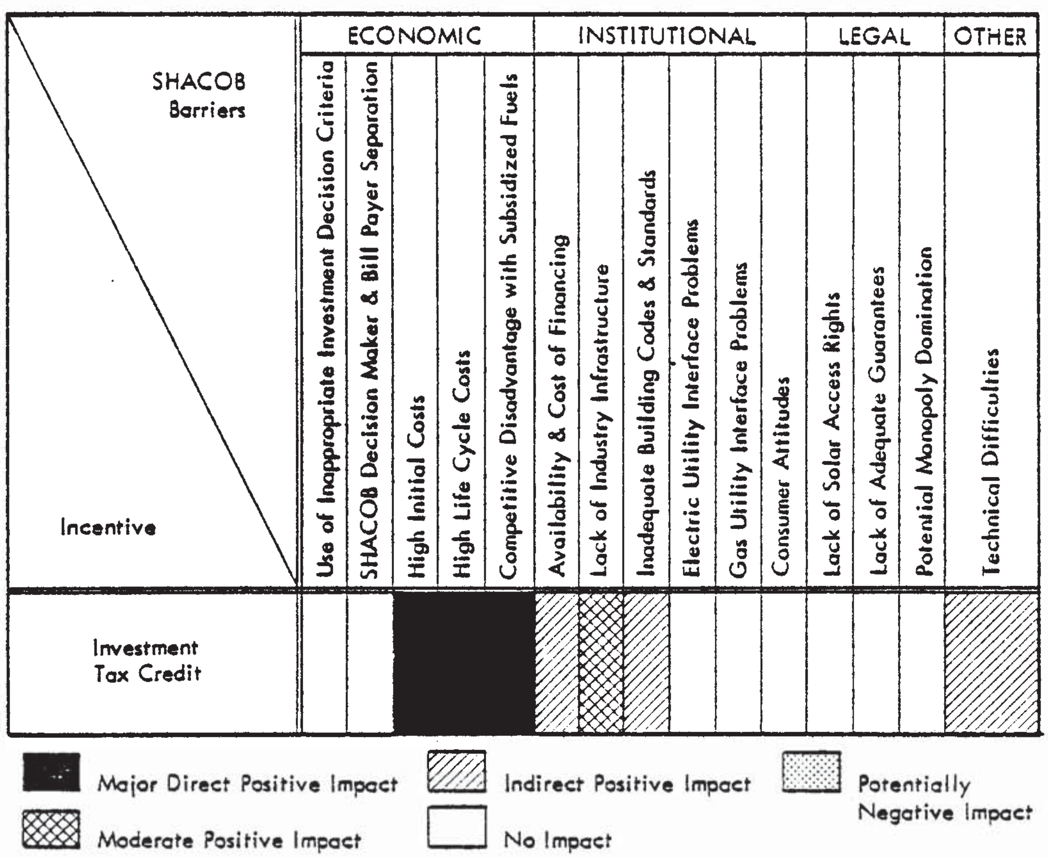

Figure 28 - Impact of Investment Tax Credit on SHACOB Barriers

The impact of the investment tax credit on various income and interest groups is shown in Figure 29. Business users receive benefits from this incentive, with no benefits to individual users. The SHACOB industry itself receives benefits in the form of increased industry sales. Utilities receive no special benefits, and no funds are transferred from the federal government to state and local governments.

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governmer Entities
Investment Tax Credit	No	No	Yes	No	Yes	No

Figure 29 - Equity Impact of Investment Tax Credit

The administrative mechanism for the investment tax credit, as shown in Figure 30, would be the same as for the two tax incentives discussed previously. Administration of the investment tax credit through the Internal Revenue Service (IRS) will probably result in low administrative costs for this incentive.

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Investment Tax Credit	Federal	Yes (IRS)	No

Figure 30 - Administrative Mechanism for Investment Tax Credit

e. Accelerated depreciation: An incentive designed to encourage the adoption of solar equipment by business users is the accelerated depreciation allowance. Proposed legislation1/ allows a taxpayer to amortize over a 60-month period solar heating and cooling equipment used in nonresidential buildings. This legislation is modeled after current federal laws permitting the 60-month amortization for costs of pollution-control facilities. It differs by allowing the use of both rapid amortization and the investment tax credit for qualified solar heating and cooling installations.

Historically, accelerated depreciation has provided a powerful incentive to promote desired commercial expansion (e.g., war-related plants) and could be effective in promoting the adoption of solar equipment. By lowering the overall cost of solar installation, it increases the 60-month (5 year) cash flow by the amount of excess depreciation over normal depreciation. The government's cost is equal to the lost tax revenue from the tax exempt excess depreciation.

Figure 31 shows that the accelerated depreciation incentive has a major impact on SHACOB life cycle costs. Lower life-cycle costs improve SHACOB's competitive position with other energy sources. The availability of financing for SHACOB is indirectly increased because of the reduced life-cycle costs resulting from accelerated depreciation. Lower life-cycle costs make the solar system more profitable and therefore make the bank more willing to finance its installation. Additional SHACOB sales that result from the incentive accelerate the development of the SHACOB industry infrastructure, indirectly leading to higher quality and less expensive systems. As was the case in the incentives discussed previously, the building code barrier is expected to be reduced as more systems are installed.

The impact of the accelerated depreciation incentive on various income and interest groups is shown in Figure 32. The incentive is restricted to business users, so individuals receive no direct benefits. No direct benefits are provided to utilities and no funds are transferred from the federal government to state or local governments. The increased SHACOB system sales that result from this incentive will directly benefit the SHACOB industry.

1/ U.S. Congress, House of Representatives, The Solar Heating and Cooling Tax Incentive Act of 1977, H.1167 (A bill introduced in the U.S. House of Representatives, January 4, 1977, now pending in the Committee on Ways and Means).

SHACOB Barriers / Incentive	ECONOMIC: Use of Inappropriate Investment Decision Criteria	ECONOMIC: SHACOB Decision Maker & Bill Payer Separation	ECONOMIC: High Initial Costs	ECONOMIC: High Life Cycle Costs	ECONOMIC: Competitive Disadvantage with Subsidized Fuels	INSTITUTIONAL: Availability & Cost of Financing	INSTITUTIONAL: Lack of Industry Infrastructure	INSTITUTIONAL: Inadequate Building Codes & Standards	INSTITUTIONAL: Electric Utility Interface Problems	INSTITUTIONAL: Gas Utility Interface Problems	INSTITUTIONAL: Consumer Attitudes	LEGAL: Lack of Solar Access Rights	LEGAL: Lack of Adequate Guarantees	LEGAL: Potential Monopoly Domination	OTHER: Technical Difficulties
Accelerated Depreciation	No Impact	No Impact	No Impact	Major Direct Positive Impact	Major Direct Positive Impact	Indirect Positive Impact	Moderate Positive Impact	Indirect Positive Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	Indirect Positive Impact

Major Direct Positive Impact; Indirect Positive Impact; Potentially Negative Impact; Moderate Positive Impact; No Impact

Figure 31 - Impact of Accelerated Depreciation on SHACOB Barriers

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governmer Entities
Accelerated Depreciation	No	No	Yes	No	Yes	No

Figure 32 - Equity Impact of Accelerated Depreciation

The administrative mechanism for the accelerated depreciation incentive, as shown in Figure 33, is similar to the other tax related incentives discussed previously. Administration of this incentive through the federal tax system should result in relatively low administrative costs.

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Accelerated Depreciation	Federal	Yes (IRS)	No

Figure 33 - Administrative Mechanism for Accelerated Depreciation

f. Low interest loans: A federal loan program is an incentive designed to reduce a primary barrier to investment in solar equipment--high life-cycle costs. The life-cycle cost barrier could be overcome by providing federally subsidized low-interest loans for SHACOB systems.

There are a number of different types of low-interest loan programs that could be used to accelerate SHACOB.[1/] The federal government could directly provide low-interest loans for SHACOB systems, offering the same interest rate as the United States government debt, plus a small percentage service charge. A lower interest rate could also be offered on a direct loan. Another option is for the government to subsidize the loans of private financial institutions by paying the difference between the market and incentive (or subsidized) interest rate.

1/ See "Digests and Solar Energy Legislation Identified in the 95th Congress," Congressional Research Service, February 1977, for a detailed description of various programs.

Another type of low-interest loan program that has been proposed would be modeled after the Government National Mortgage Association (GNMA) program. Under this program GNMA would purchase mortgages on solar homes at a subsidized interest rate and use approved lenders to sell and service the loans. GNMA currently conducts an interest rate subsidy program in conjunction with the Federal National Mortgage Association (FNMA) and the Federal Home Loan Mortgage Company to subsidize low income housing. This program is referred to as the FNMA - GNMA Tandem plan. The creation of a similar program for solar has been called the Solar Tandem Plan.[1/] Under the Solar Tandem Plan, a private lender would originate the loan at the subsidized interest rate and GNMA would either hold the loan itself or resell it to FNMA or FHLMC at the market rate, with GNMA paying the additional interest costs.

While there are many variations in specific low-interest loan programs, all of these programs are expected to have similar impacts on SHACOB barriers. The impact of a low-interest loan on SHACOB barriers is shown in Figure 34. Availability of low-interest loans will have a major positive impact on the life-cycle cost barrier. The initial cost barrier will also be reduced. Obviously, the availability of financing will be increased and financing costs will be reduced. Both of these impacts will improve the competitive position of SHACOB as compared with other energy sources. The increased use of SHACOB that results from this incentive will accelerate the development of the industry infrastructure, and indirectly reduce both technical difficulties and building code problems.

The impact of a low interest loan program on various income and interest groups is shown in Figure 35. The program would benefit all income groups. However, the low income group, which traditionally pays high interest rates because of lower benefits from income tax deductible finance costs, receives somewhat greater benefits than upper income groups. Low-interest loans could also be applied to business users, depending on the specific program structure. The loan program could also be designed to favor small businesses, if the program were administered through the Small Business Administration (SBA) and included a requirement for small business participation. As with all SHACOB incentives, the SHACOB industry itself receives benefits through increased industry activity.

Figure 36 shows that there are several possible mechanisms that could be used to administer a low-interest loan program. The program could be administered by one of several existing agencies, or a new agency could be established. In any case, it may be costly to administer. Administrative costs could probably be lower if the program could be administered through existing federal agencies and private mortgage institutions.

1/ Regional and Urban Planning Implementation, Inc., op. cit., pp. 207-11.

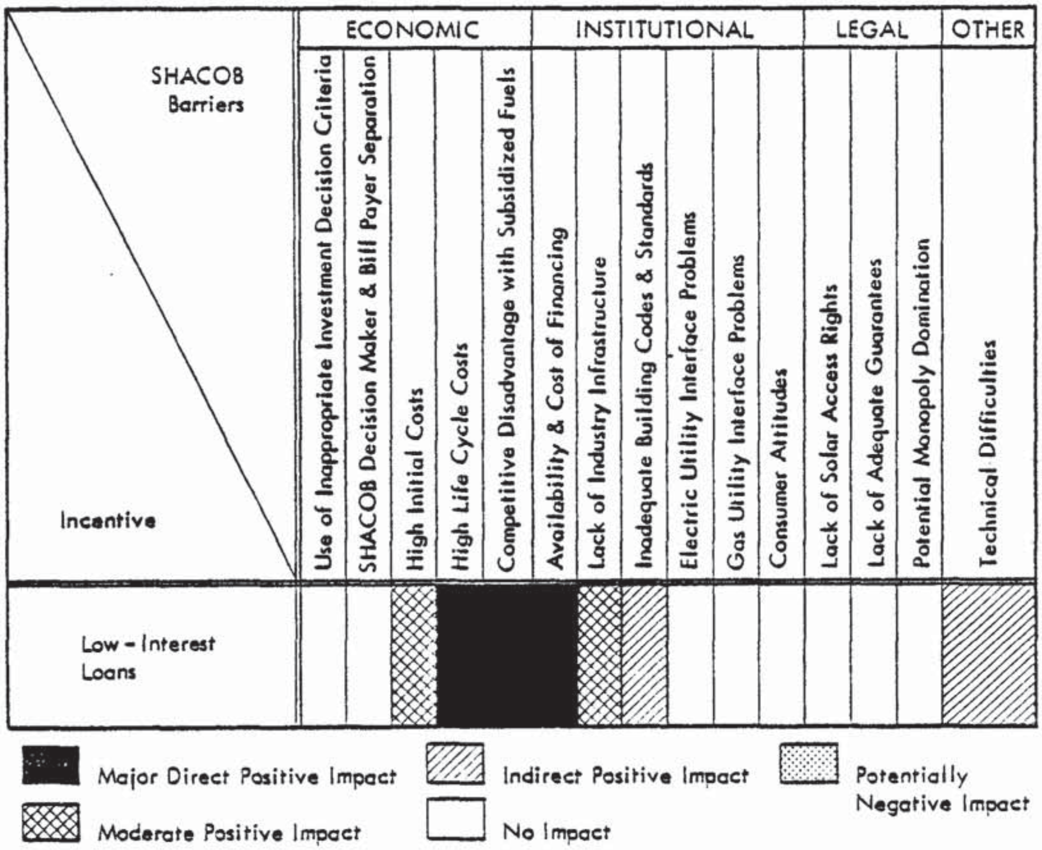

Figure 34 - Impact of Low Interest Loan Program on SHACOB Barriers

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Low - Interest Loans	Yes	Yes*	Could by Design	No	Yes	No

* Probably Less Impact than on Low Income Group, See Text

Figure 35 - Equity Impact of Low Interest Loan Program

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Low - Interest Loans	Federal	Maybe HUD, SBA, GNMA, FNMA, FHLMC	Maybe

Figure 36 - Administrative Mechanism for Low Interest Loan Program

g. Loan guarantees: The basic concept of a federal loan guarantee program is to place the credit of the federal government behind the borrower. A loan guarantee specifically aimed at SHACOB could take several different forms. The guarantee could be limited to only the cost of the SHACOB system, or it could cover the entire value of the loan. One idea, intended to limit the government insurance to cover only the additional risks of the SHACOB, would be a conversion guarantee.1/ In this type of program, the government would pay for SHACOB system repair, replacement, or conversion to conventional heating if, in the event of foreclosure, the system lowered the resale value of the property.

Figure 37 shows that the primary impact of a loan guarantee program would be to reduce lender undertainty and thereby make financing for SHACOB more available. Guaranteeing the repayment of financing for the solar building would also encourage lenders to include a larger portion of the value of the solar system in the loan, lowering the down payment required. Life-cycle costs may be reduced slightly because of the improved financing terms resulting from a loan guarantee program. As the program is likely to increase SHACOB market penetration, the development of the industry infrastructure will be accelerated, and the technical and code barriers will be reduced.

1/ Regional and Urban Planning Implementation, Inc., op. cit., pp. 199-203.

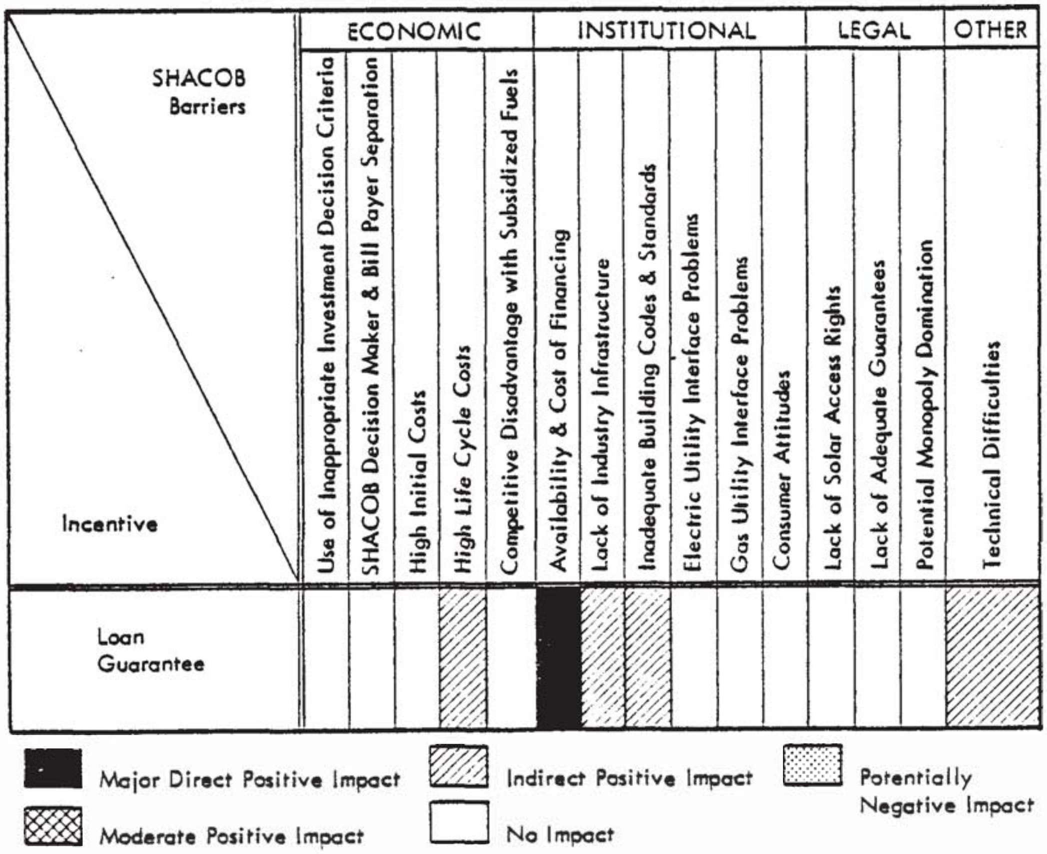

Figure 37 - Impact of Loan Guarantee Program on SHACOB Barriers

The impact of a loan guarantee program on various income and interest groups is shown in Figure 38. Individual SHACOB users in all income groups benefit from the incentive. The low income group may receive larger benefits because of the difficulty this group traditionally experiences in obtaining debt. There is some doubt, however, as to whether the low income group would be financially able to take advantage of this incentive. If the program was designed to service business users, then this group could also benefit. The program could also be designed to specifically benefit small business users and small companies in the industry infrastructure, by restricting part or all of the program funds to these companies. As with all SHACOB incentives, the industry itself receives benefits from the loan guarantee programs.

The administrative costs of a loan guarantee program will depend on the administrative structure of the program. Figure 39 shows that there are several alternative administrative mechanisms that could be used. If the program were administered through existing programs or in conjunction with private mortgage insurance companies, the administrative costs may be low. Establishment of a loan guarantee administrative mechanism is likely to be more costly.

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governme Entities
Loan Guarantee	Yes	Yes	Could by Design	No	Yes	No

Figure 38 - Equity Impact of Loan Guarantee Program

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Loan Guarantee	Federal	Maybe FEA, FHA, VA, SBA	Maybe

Figure 39 - Administrative Mechanism of Loan Guarantee Program

The actual cost of a loan guarantee program to the government depends on the type of program that is implemented. A program which offers a broad range of coverage (i.e., includes more than the value of the SHACOB system) and is not designed to discourage high risk loans, could experience a high rate of default. Such a program could be extremely costly. A program which offers coverage for only the cost of the SHACOB system and is based on sound lending principles, would have a comparatively low rate of default and low cost.

h. Property tax exemption: This federal incentive program is designed to encourage state and local governments to exempt solar energy hardware from increased incremental property taxes. Except in those states which have already passed property tax exemptions for SHACOB systems (see Appendix B), property taxes on SHACOB are a disincentive, hindering SHACOB commercialization prospects. Recent congressional efforts have proposed to exempt solar equipment from property taxes.* Another possibility is to use federal income tax credits to offset any increased local property tax assessments attributable to the installation of SHACOB systems. There exists considerable doubt as to whether a federal reimbursement for property tax exemption is necessary in light of the growing number of states that have implemented this incentive as their own.

The impact of a property tax exemption for solar equipment on SHACOB barriers is shown in Figure 40. The incentive's major impact is to reduce SHACOB life-cycle costs which, in turn, improves SHACOB's competitive position with other energy sources. The increased SHACOB market penetration that could result from the property tax exemption will accelerate the development of the SHACOB industry.

The impact of a property tax exemption on various interest groups is shown in Figure 41. The incentive benefits all income groups, business users, and the SHACOB industry. As indicated in the figure, funds might be transferred from the federal government to state or local governments. This would be the case if the state and local governments exempted solar equipment from property taxes and were then reimbursed for this lost revenue by the federal government.

There are two different mechanisms that could be used to administer a property tax exemption with federal reimbursement. Figure 42 shows that both of those mechanisms could be administered through existing federal, state, and local government departments of revenue. The first technique would be for state and local governments to waive property taxes on solar equipment and then be reimbursed for the lost revenue by the federal government. Alternatively, the federal government could allow all property taxes paid on solar equipment as a tax credit on federal income tax returns. The complexity of interacting with state departments of revenue could make it difficult to administer this incentive.

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* See, for example, House Congressional Resolution 47, which calls for state and local governments not to increase property taxes in instances of solar equipment installations.

Incentive \ SHACOB Barriers	ECONOMIC: Use of Inappropriate Investment Decision Criteria	ECONOMIC: SHACOB Decision Maker & Bill Payer Separation	ECONOMIC: High Initial Costs	ECONOMIC: High Life Cycle Costs	ECONOMIC: Competitive Disadvantage with Subsidized Fuels	INSTITUTIONAL: Availability & Cost of Financing	INSTITUTIONAL: Lack of Industry Infrastructure	INSTITUTIONAL: Inadequate Building Codes & Standards	INSTITUTIONAL: Electric Utility Interface Problems	INSTITUTIONAL: Gas Utility Interface Problems	INSTITUTIONAL: Consumer Attitudes	LEGAL: Lack of Solar Access Rights	LEGAL: Lack of Adequate Guarantees	LEGAL: Potential Monopoly Domination	OTHER: Technical Difficulties
Property Tax Exemption	No Impact	No Impact	No Impact	Moderate Positive Impact	Indirect Positive Impact	No Impact	Indirect Positive Impact	Indirect Positive Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	Indirect Positive Impact

Major Direct Positive Impact — Moderate Positive Impact — Indirect Positive Impact — No Impact — Potentially Negative Impact

Figure 40 - Impact of Property Tax Exemption on SHACOB Barriers

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governme Entities
Property Tax Exemption	Yes	Yes	Yes	No	Yes	Could by Design

Figure 41 - Equity Impact of Property Tax Exemption

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Property Tax Exemption	Federal State Local	Yes Federal, State, and Local Departments of Revenue	No

Figure 42 - Administrative Mechanism for Property Tax Exemption

One problem of adopting the property tax exemption financed by the federal government involves possible abuses. Because property taxes are administered on the state and local level, the lack of uniform property assessment rates could pose a problem. Property tax assessors may tend to assess solar hardware at an excessive rate, realizing the federal government would offset (i.e., subsidize) any increased incremental property taxes. This would allow local governments to obtain additional revenues at the expense of the federal government. Potential abuses reduce the attractiveness of a federally financed property tax exemption.

2. Producer incentives: While the incentives discussed in Section 1 above were directed primarily at the users of SHACOB systems, the incentives discussed in this section are those directed at producers of SHACOB equipment and other companies in the SHACOB industry infrastructure. An incentive designed to stimulate the development of the SHACOB industry infrastructure is described in Section a. Section b discusses the applicability of incentives to SHACOB producers which parallel the user incentives.

a. Solar Energy Government Buildings Program: As discussed in Chapter 2, an important barrier to the development of the solar industry lies in the fact that substantial markets are required to justify the establishment and capitalization of a solar energy industry infrastructure. In order to help remove this barrier, the Solar Energy Government Buildings Program (SEGBP) has been proposed.1/ A program to use SHACOB in government buildings is included in the President's proposed energy legislation. SEGBP is defined as a planned program of accelerated procurement and installation of SHACOB systems in federal buildings throughout the United States, using technically proven equipment. Its primary purpose is to help stimulate the growth and improved efficiency of the SHACOB industry and thereby to reduce the cost and increase public and private availability of solar energy systems.

The impact of a government buildings program on SHACOB barriers is shown in Figure 43. The major impact of the program is to accelerate the development of the SHACOB industry infrastructure. The development of the industry infrastructure is accelerated because the program requires the installation of a significant number of SHACOB systems in regions where SHACOB has potential. In these regions, companies involved in various aspects of the industry infrastructure will gain experience in the work required to deliver the system. A buildings program, by providing an additional market for solar collectors over the next several years, may stimulate larger volume collector manufacturing plants and thereby lower collector costs.

As shown in Figure 43, implementation of a government buildings program is expected to have an indirect impact on the cost of SHACOB systems to the individual consumer. The accelerated development of the SHACOB industry should result in lower collector costs, and the more efficient design, distribution, and installation of SHACOB systems, all of which should be reflected in lower final system costs.

One of the requirements of a government buildings program is that participating federal agencies consider the life-cycle costs of SHACOB as compared to other systems in all SHACOB proposals. This type of requirement will have a substantial impact on the barrier posed by using the inappropriate decision criteria in selecting HVAC systems in government buildings. There has been some discussion of mandating the life-cycle cost approach in all federal buildings, although this provision has not been included in the President's legislative proposals.

1/ Metrek Division, Mitre Corporation, Solar Government Buildings Program: Policy and Implementation Plan, Prepared for the Federal Energy Administration, January 1977.

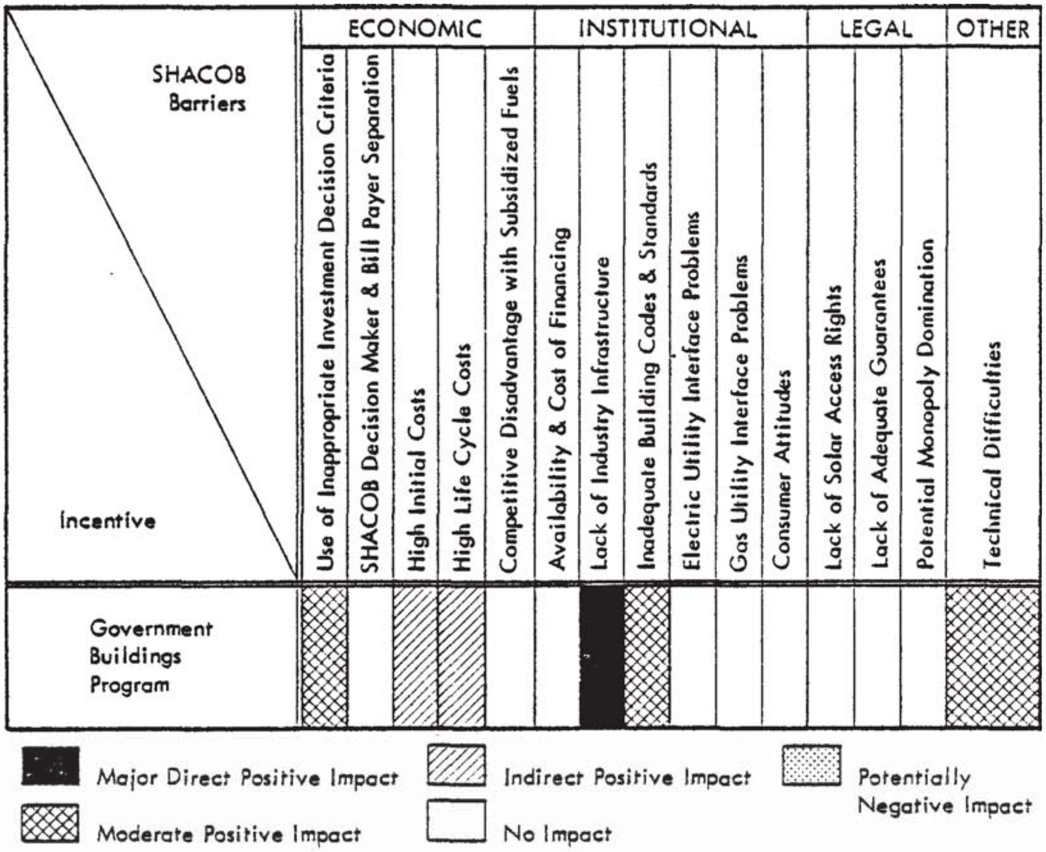

Figure 43 - Impact of Government Buildings Program on SHACOB Barriers

A government buildings program, particularly one that promotes the demonstration of a wide variety of SHACOB systems in different building types and locations, will help reduce any technical difficulties encountered by SHACOB systems as well as help reduce any code problems.

The impact of a government buildings program on various interest groups is shown in Figure 44. The only group to receive direct benefits is the SHACOB industry. Other SHACOB users, however, are expected to receive indirect benefits in the form of lower cost and higher quality systems. Government funds will be transferred from the federal administering agency to other federal agencies. If the program was expanded to include state government buildings, and the cost of SHACOB systems on these buildings was paid by the federal government, funds would be transferred from the federal to state governments.

The administrative mechansim for the government buildings program is described in Figure 45. The program, as proposed in the President's energy legislation, specified FEA as the primary administering agency. Other agencies, including ERDA and the Government Services Administration (GSA) as well as participating agencies, will also be involved in the program.

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governmen Entities
Government Buildings Program	Yes	Yes	Yes	No	Yes	Yes

Figure 44 - Equity Impacts of Government Buildings Program

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Government Buildings Program	Federal	Yes FEA	No

Figure 45 - Administrative Mechanism for Government Buildings Program

The President's proposed government buildings program is budgeted at $100 million through 1980. The actual costs of SEGBP incurred by the government will be made up of several components. These are: (1) administrative costs, (2) costs of assessing buildings for solar-system suitability, (3) extra costs of procuring and installing solar systems in cases of scheduled building or system renovation, (4) total costs of solar systems in cases where a hot water, heating or cooling system is replaced or supplemented by a solar system only for the purpose of meeting SEGBP requirements, and (5) operating and maintenance costs. A significant portion of the cost of SEGBP to the government would be offset by fuel savings resulting from the SHACOB systems that would be installed.

b. Other producer incentives: A key element of the successful commercialization of solar heating and cooling is the manufacture of solar collectors, storage subsystems, controls, etc. Many of the same incentives that apply to users can also be implemented to stimulate the solar energy industry itself. Income and investment tax credits or deductions could be offered to manufacturers whose major income results from the sale of solar hardware. Low interest loans and loan guarantees could be offered to all solar manufacturers, or only to smaller firms through the Small Business Administration. Accelerated depreciation could be allowed on manufacturing equipment specifically used for producing SHACOB components. Companies that are part of the SHACOB industry could have those facilities associated with the industry exempted from property taxes.

A portion of manufacturing costs of SHACOB components are the result of research and development (R&D) in support of a specific product. Research and development grants, already a part of the ERDA solar program, could be made more accessible to the SHACOB manufacturer. Increased R&D support to SHACOB component manufacturers could prove to be very promising in promoting novel concepts for solar systems, which might lead to higher quality systems and lower costs.

Policies directed at SHACOB producers could be extremely helpful to the solar energy industry, especially small businesses not able to bear costs of development and large scale production. These benefits, however, would require significant government investment. Incentives to the industry could bring component costs down, which, in turn, could accelerate market penetration in both the residential and commercial sectors.

One major problem associated with producer incentives is equity. When supplying incentives directly to a producer, it is difficult to insure that the producer's lower costs resulting from the incentive will be entirely reflected in lower costs to the purchaser. This possibility would be particularly severe in the event that SHACOB systems become cost-effective without incentives. In this situation, the producer would have no reason to reduce prices, because a demand for his products exists without price reductions.

Most incentive proposals to date have been directed at SHACOB users. This is probably a reflection of the problem of insuring that benefits to producers are passed on to users. Policies to accelerate the commercialization of SHACOB have also, for the most part, been formulated with the thought that stiumulating the demand for SHACOB systems will be sufficient incentive to stimulate the production of SHACOB components.

C. Federal Noneconomic Incentives

To this point, federal economic incentives have been the focus of attention. There are, however, a number of other types of federally initiated programs which, although having no direct economic impacts, could accelerate SHACOB commercialization. As was discussed in Chapter 2, there are, in addition to economic barriers, several institutional and legal barriers to SHACOB commercialization. This section examines programs which could act as incentives to remove these noneconomic barriers.

Six general program concepts are examined separately in this section. These are: (1) demonstration programs, (2) consumer education programs, (3) financial education programs, (4) programs implementing SHACOB building codes and system and component certification procedures, (5) utility programs, and (6) government insurance programs.

1. Demonstration programs: The federal government is providing considerable cost sharing of SHACOB systems in the form of residential and commercial demonstration programs. The residential program, administered by HUD, is designed to "encourage the use of solar energy in residential applications by the builder and the consumer, to identify the potential constraints to this use on the part of the many participants in the industry, and to develop approaches to remove these constraints."[1/] The commercial demonstration program, as administered by ERDA, is similar in purpose to the residential program except that more emphasis is put on cooling technology. Another key aspect of the demonstration programs is the collection of data on the technical and economic performance characteristics of SHACOB systems and the acceptance of SHACOB by industry and consumers. The long-term goal of the demonstrations is to provide necessary experience to industry and regulatory bodies to enable continuing use of solar energy in residential and commercial buildings after the termination of the program.

The first demonstration cycle of the program was initiated during FY76 with the issuance of solicitations by ERDA and HUD for commercial and residential demonstration projects, as well as for solar heating, cooling,

1/ National Program for Solar Heating and Cooling (Residential and Commercial Applications) ERDA-23A, October 1975.

hot water, and combined systems for use in the demonstrations. Following evaluations, HUD announced $1 million in grants for the installation of 143 residential solar energy units and ERDA announced the selection of 34 commercial projects, costing $7.5 million for the solar portion. In addition, ERDA announced the identification of 36 solar conversion systems that are technically acceptable for use in the demonstration program.[1/] In October 1976, HUD announced the second in its series of five rounds of grants, amounting to nearly $4 million, to be distributed among 102 grantees. A total of 1,411 dwelling units are involved in this second round. ERDA announced $7.2 million in awards for 80 commercial demonstration projects in the second cycle of awards. In June 1977, HUD announced the third cycle of grant awards for housing units at a total cost of over $6 million.

The expected impact of a demonstration program on SHACOB barriers is shown in Figure 46. The program gives a wide range of participants in the industry an opportunity for early experiences with SHACOB, thereby accelerating the development of the industry infrastructure. The program provides valuable information on system performance and durability in a large number of situations, greatly reducing any technical problems with SHACOB systems. All of these functions should result in lower system costs. The program is also a vehicle for consumer education and improving consumer attitudes toward SHACOB. The experience with SHACOB systems by local code authorities is expected to reduce the building code barrier.

A demonstration program could be designed to directly address the problems of the SHACOB utility interface. This could be done through individual demonstrations of the effect of various system designs on utility load profiles, as well as demonstrations of the impact of different rate structures on system design and economics. Addressing the utility interface problem through a demonstration program could have a substantial positive impact on this barrier.

As shown in Figure 47, all potential SHACOB user groups receive indirect benefits from a demonstration program. These benefits are in the form of lower cost and higher quality systems that are expected to be a byproduct of the demonstration program. Obviously, those user groups that are direct recipients of demonstration funds receive large, direct benefits. The SHACOB industry itself also receives direct benefits from a demonstration program. If the demonstration program is designed to obtain information on the interface between solar systems and the utilities, then the utilities also receive benefits.

1/ ERDA News Release No. 76-30.

Incentive \ SHACOB Barriers	ECONOMIC					INSTITUTIONAL						LEGAL			OTHER
	Use of Inappropriate Investment Decision Criteria	SHACOB Decision Maker & Bill Payer Separation	High Initial Costs	High Life Cycle Costs	Competitive Disadvantage with Subsidized Fuels	Availability & Cost of Financing	Lack of Industry Infrastructure	Inadequate Building Codes & Standards	Electric Utility Interface Problems	Gas Utility Interface Problems	Consumer Attitudes	Lack of Solar Access Rights	Lack of Adequate Guarantees	Potential Monopoly Domination	Technical Difficulties
Demonstration Program	No Impact	No Impact	Indirect Positive Impact	Indirect Positive Impact	No Impact	Indirect Positive Impact	Moderate Positive Impact	Moderate Positive Impact	Indirect Positive Impact	Indirect Positive Impact	Indirect Positive Impact	No Impact	No Impact	No Impact	Major Direct Positive Impact

Major Direct Positive Impact — Indirect Positive Impact — Potentially Negative Impact — Moderate Positive Impact — No Impact

Figure 46 - Impact of Demonstration Program on SHACOB Barriers

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governme Entities
Demonstration Program	Yes	Yes	Yes	Could by Design	Yes	No

Figure 47 - Equity Impact of Demonstration Program

The administrative mechanism for the demonstration program is shown in Figure 48. ERDA, HUD and DOD have already established mechanisms to administer demonstration programs.

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Demonstration Program	Federal	Yes ERDA, HUD, DOD	No

Figure 48 - Administrative Mechanism for Demonstration Program

2. Consumer education program: The function of a consumer education program is to provide the general public, builders, developers and various special interest groups with information on SHACOB systems. A consumer education program could inform the public concerning the costs, benefits, operation, reliability and financing of SHACOB systems. The program could be used to encourage prospective SHACOB users to make choices between alternative systems based on the life-cycle cost or payback decision criteria as opposed to the first cost criterion. A consumer education program might also publicize any incentives which are made available for SHACOB.

The federal government has already initiated a general public information program on a small scale. Materials, developed for the general public, addressing SHACOB systems, are now available. A National Solar Heating and Cooling Information Center has been established as part of the national solar demonstration program. This center is equipped to answer a wide range of requests for information by mail or by toll free telephone. These initial efforts could be expanded into a more aggressive consumer education program. A federally funded joint federal and state consumer education program is proposed in the NEP.

Figure 49 shows the impact of a consumer education program on SHACOB barriers. The program would have a major impact on consumer attitudes toward SHACOB. A successful program would provide a large number of potential SHACOB purchasers with the information necessary to intelligently evaluate the applicability of SHACOB to their own situations. This would require information on how to evaluate the cost and benefits of solar as compared to conventional systems, how to finance the solar system, and where to purchase it. The program could have a major impact on the decision criteria used to evaluate SHACOB by encouraging consumers to evaluate SHACOB based on life-cycle costs.

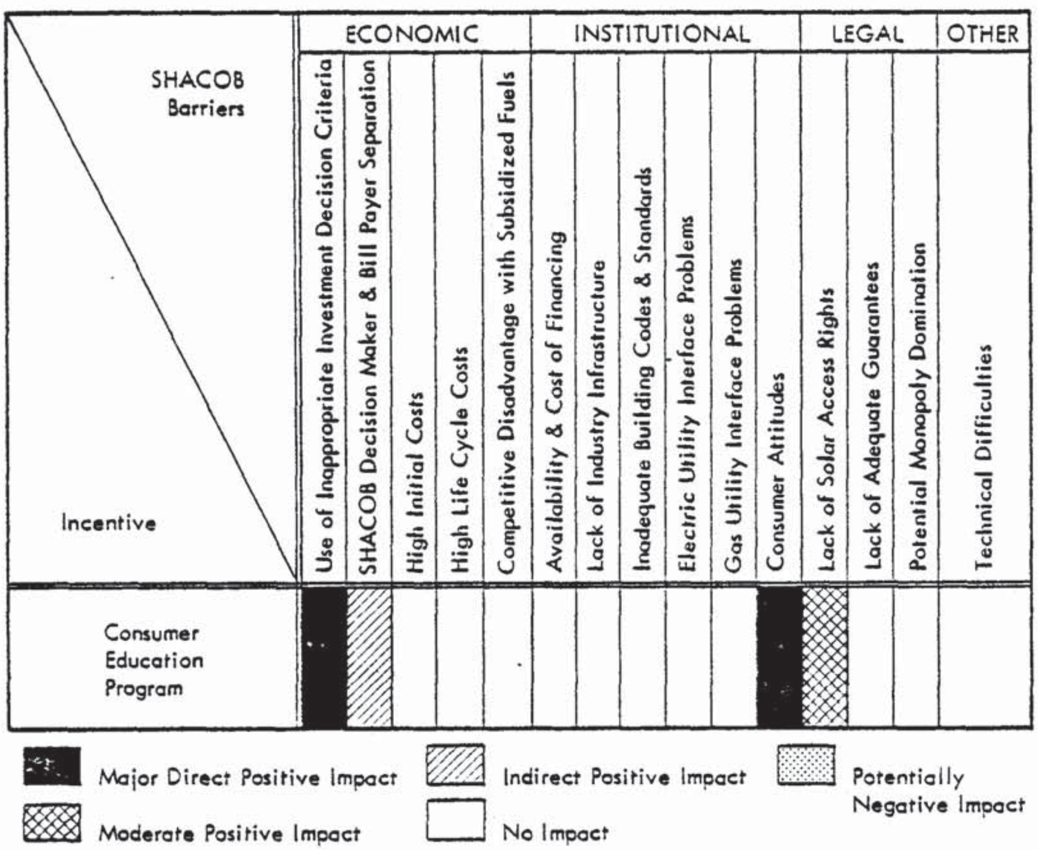

Figure 49 - Impact of Consumer Education Program on SHACOB Barriers

A consumer education program would have an indirect positive impact on the barrier caused by the separation between the SHACOB decision maker and the utility bill payer. As discussed in Chapter 2, this situation exists in all speculatively constructed buildings and many rental buildings. Improved consumer awareness of the benefits of SHACOB may motivate builders, developers, and building owners, who make the SHACOB decision, to select SHACOB even in situations in which they are not the utility bill payer (and thus the recipients of the benefits of the SHACOB system) and pass on the costs to purchasers or renters.

The sun rights barrier could also be significantly reduced by a consumer education program. Because in a large number of cases, sun rights is a perceived barrier posing no real problem, a consumer education program that clarified the issue could remove consumer concerns about potential sun rights problems.

Figure 50 shows that a consumer education program benefits all prospective individual and business users of SHACOB. The program would provide information to any group interested in SHACOB. The SHACOB industry would receive considerable benefits from the program, as it would promote the use of SHACOB. Utilities would receive no direct benefits from the program. If the program were operated in cooperation with the states, funds would be transferred from the federal government to state governments.

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Consumer Education Program	Yes	Yes	Yes	No	Yes	Maybe

Figure 50 - Equity Impact of Consumer Education Program

The administrative mechanism for a consumer education program is presented in Figure 51. The program could be administered by several existing federal agencies, and could be operated in cooperation with state agencies. It may be desirable to coordinate a consumer education program with other federal agencies which have already established lines of communication with potential SHACOB consumers, particularly builders. HUD currently is managing a program in this manner. Involvement of private industry associations, as for example, the National Association of Home Builders, may also be attractive.

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Consumer Education Program	Federal State	Yes FEA, ERDA, HUD, and State Agencies	No

Figure 51 - Administrative Mechanism for Consumer Education Program

A SHACOB consumer education program might be one part of an information program covering the entire energy situation. As pointed out in the section on consumer attitudes in Chapter 2, the extent to which people are willing to sacrifice for energy conservation appears to be related to their understanding of the general energy picture.

The major costs of a consumer education program will be administrative costs. The total cost to the government is likely to be minimal compared to direct economic incentives. However, the program will have no impact on SHACOB system costs.

3. Financial education: As discussed in Chapter 2, the terms and the extent of availability of private finance for SHACOB may have a significant effect on SHACOB market success. Two incentives aimed at increasing the amount of financing available for SHACOB and at improving the terms on which this financing is available (i.e., federal loan guarantees and loans subsidized by the federal government) were discussed above. A program to educate the financial community could be used in conjunction with these other incentives, or separately, to improve the SHACOB financial environment.

A financial education program could have several functions.1/ It could be used to publicize to both lenders and consumers the eligibility of SHACOB for any special loan guarantees or subsidized loan programs which are implemented. One function would be to inform the primary mortgage lenders of the terms on which SHACOB mortgages would be saleable on the secondary mortgage market. Another function would be to assist lenders in assessing the acceptability and performance of SHACOB systems for which individuals and developers seek construction loans or permanent financing. An educational program could also be used to try to induce lenders to include energy costs in the determination of the prospective borrower's eligibility for financing (PITI + E).

Figure 52 indicates that the primary impact of these educational programs would be to increase the willingness of financial institutions to make private financing available for SHACOB. Publicizing the availability of special SHACOB financing programs would make more lenders aware of these programs and would probably result in using them more extensively. Publicity aimed specifically at the terms of eligibility for SHACOB loans for resale on the secondary mortgage market would remove the barrier of primary lender resistance to make SHACOB loans because of uncertain resale value. Providing lenders with useable information on the acceptability of specific systems would relieve the lender of the burden of having to make this judgement himself. Some type of certification program would also reduce lender uncertainty of the quality of SHACOB systems. Inclusion of energy costs in the determination of borrower eligibility would make a wider income range of borrowers eligible for loans for solar buildings.

None of these educational programs would have a direct impact on the initial cost of a SHACOB system to the individual owner. However, the program could have a favorable impact on interest rates and thereby indirectly reduce life-cycle costs. Figure 52 also indicates that the program could be structured to reduce the use of inappropriate investment decision criteria by consumers. The program could also indirectly foster positive consumer attitudes.

1/ Regional and Urban Planning Implementation, Inc., op. cit., pp. 220-225.

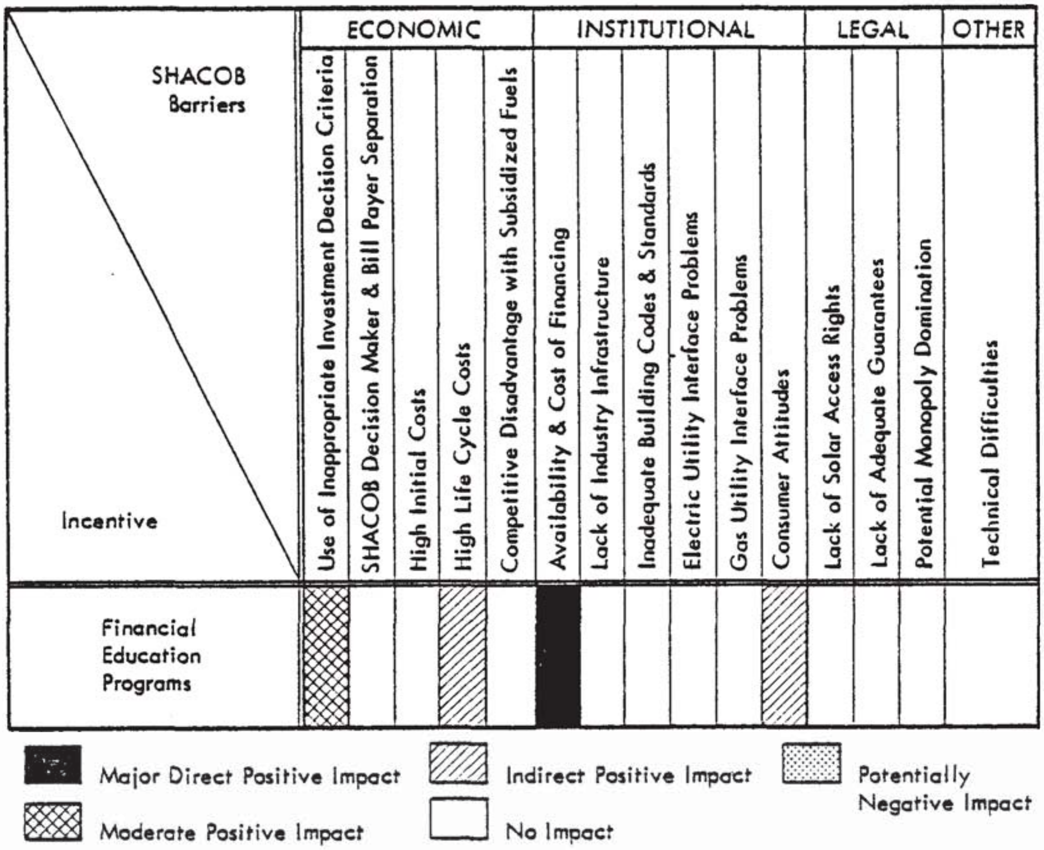

Figure 52 - Impact of Financial Education Programs on SHACOB Barriers

Figure 53 shows that no one income group is likely to receive greatly disproportionate benefits from a financial education program. Because lower income groups usually have greater difficulty obtaining financing than the higher income groups, a financial education program may have a larger positive effect on the ability of lower income groups to purchase SHACOB systems.

The financial education program would probably be administered by the federal government as shown in Figure 54. It could be administered through a number of existing agencies, including the energy related agencies and those usually involved with the financial community.

The cost to the government of a financial education program would be relatively low because no direct cost subsidies are involved. Administrative costs will depend on the complexity of the program attempted. If the program focuses primarily on financial institutions, it probably can be accomplished without excessive cost.

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Financial Education Programs	Yes	Yes	Yes	No	Yes	No

Figure 53 - Equity Impact of Financial Education Programs

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Financial Education Programs	Federal	Maybe FEA, ERDA, FHA, VA, SBA, Etc.	No

Figure 54 - Administrative Mechanism of Financial Education Programs

4. Building code and certification program: In accordance with P.L. 93-409, the federal government has already begun to take action to remove the barrier to SHACOB commercialization posed by the lack of building codes and standards that apply to SHACOB. Interim Performance Criteria (IPC) for both residential and commercial buildings have already been completed.1/ The IPC are intended primarily for use in conjunction with the federal demonstration program. These intermediate performance criteria will be followed by definitive performance criteria.

At the same time that performance criteria are being developed, Intermediate Minimum Property Standards (IMPS) have been developed for solar water and space heating systems.2/ These standards are now included in the HUD/FHA Minimum Property Standards. These standards are primarily intended for use in evaluating solar systems for FHA mortgage insurance purposes. They are, however, expected to have a wider impact because, traditionally, HUD/FHA Minimum Property Standards have been adopted by a large part of the construction industry, for private mortgage insurance review, and as the basis of many building codes. The solar IMPS are also expected to be used to determine SHACOB system eligibility in proposed tax incentives and government buildings programs. NBS is now in the process of using the IMPS to develop language for solar sections of model building codes.*

While definitive performance criteria are still being formulated, the interim standards are expected to lead to a set of voluntary consensus standards supported by industry groups such as ANSI, ASTM, ASHRAE, ASME, ARI and SEIA. The federal government has also completed a set of intermediate test procedures for evaluating solar collectors and storage systems.3/ These procedures are now being used by several laboratories and have been adopted by ASHRAE as consensus standards.

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* Model building codes are drafted by model code associations such as the International Conference of Building Officials (ICBO), Southern Building Code Congress (SBCC), and Building Code Administrators International (BOCA). These model code associations draft codes which are then adopted by an increasing number of local code authorities.

1/ Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings and Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities, op. cit.

2/ Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems, op. cit.

3/ Hill, Streed, Kelly, Geist, and Kusuda, Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices, National Bureau of Standards Technical Note 899, U.S. Department of Commerce, February 1976.

While the federal government is well along the way to developing codes and standards applicable to SHACOB, these efforts could be supplemented by programs aimed at implementation. The federal government could work with the states to develop certification programs that would document compliance of SHACOB components with the appropriate standards. Certification programs administered at the state level have been examined by the Florida Solar Energy Center under support from FEA and the State of Florida.1/ A federally funded joint federal and state program of standards development and certification is proposed in the President's National Energy Plan.

The expected impact of the federal building codes and certification program is shown in Figure 55. Obviously, the major impact of the program is to remove the building code barrier. The program is expected to have positive impacts on consumer attitudes and the availability of financing for SHACOB. Reduced possibility of delay in the building process and greater confidence in system performance and quality by both lenders and consumers are likely to result from comprehensive standards program. While these results may lead to slightly lower costs of SHACOB systems, their primary impact will be to improve the willingness of consumers to purchase SHACOB systems and the willingness of lenders to approve loans for SHACOB systems. A well administered building code and certification program is also expected to reduce the number of technical difficulties with SHACOB systems, because components and systems would be required to comply with specified standards.

The impact of a code and certification program on various income and interest groups is shown in Figure 56. The program would benefit both individual and business users by reducing consumer uncertainty and increasing the availability of financing. The SHACOB industry itself would also receive benefits because SHACOB systems would be more widely accepted as a result. If the program were structured so that state government agencies would certify compliance with standards under federal support, the program would transfer funds from the federal government to state governments.

The administrative mechanism for the program is described in Figure 57. Because codes are administered at the state and local government level, a program of government cooperation is needed. The cooperation of model code associations and relevant industry groups is desirable. Federal agencies directly involved in the formulation of standards, such as ERDA, FEA, HUD and NBS, are also logical participants in the program. As the federal effort evolves to encourage certification and implementation, various state and local government agencies could also participate.

1/ Solar Energy Commercialization at the State Level: The Florida Solar Energy Water Heater Program, Florida Solar Energy Center, prepared for the Federal Energy Administration and the State of Florida, FSEC-76-3, March 1977.

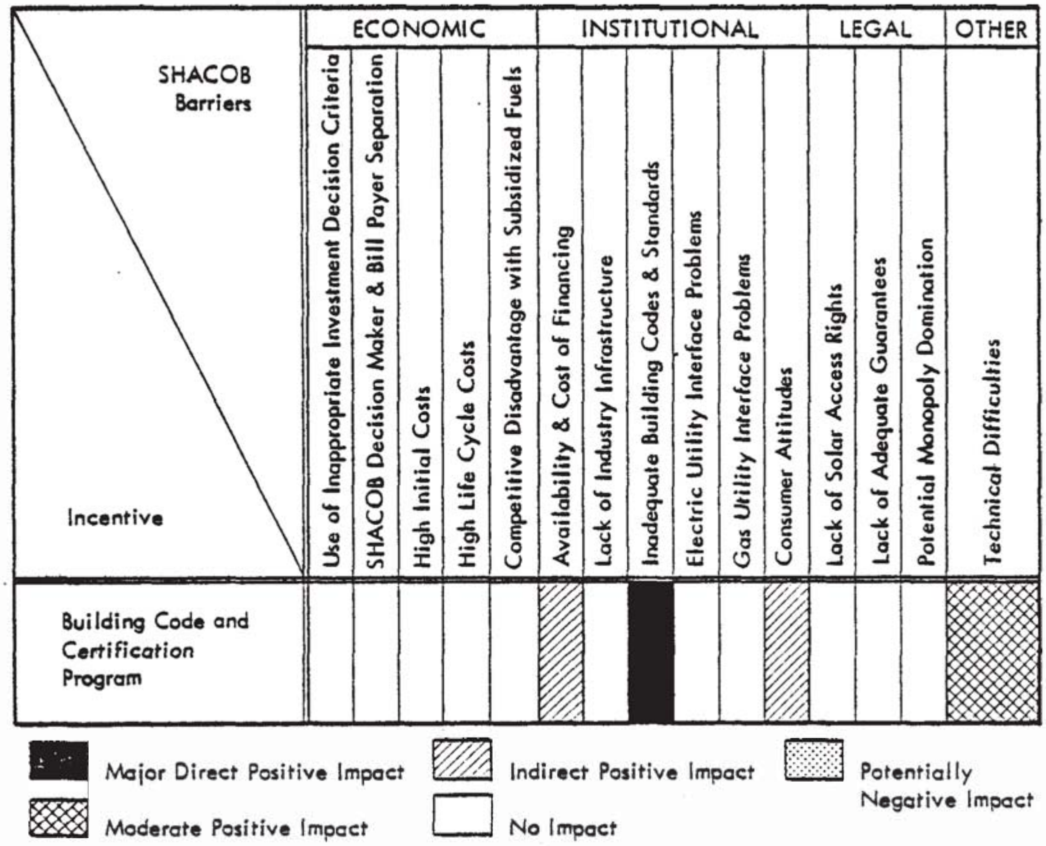

Figure 55 - Impact of Building Code and Certification Program on SHACOB Barriers

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governme Entities
Building Code and Certification Program	Yes	Yes	Yes	No	Yes	Maybe

Figure 56 - Equity Impact of Building Code and Certification Program

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Building Code and Certification Program	Federal State Local	Yes Existing National and Local Code Authorities	Maybe

Figure 57 - Administrative Mechanism for Building Code and Certification Program

The major costs to the government of a standards program are the cost of developing the standards and the cost of administering any programs to encourage their adoption or to certify SHACOB system and component compliance with the standards.

5. Utility programs: The barriers to SHACOB commercialization presented by the electric and gas utilities were described in Chapter 2. A number of different policy options that would address the SHACOB-utility interface have been suggested. Many of these policies can be applied equally to electric and gas utilities. The policies investigated include utility rate programs and utility ownership and leasing programs.

a. Utility rate programs: The major policy option for removing the barrier to SHACOB commercialization posed by the electric utility interface is to develop electric utility rate structures which would encourage rather than penalize SHACOB use. As discussed in Chapter 2, one possibility would be to implement a time-of-day rate structure which allows SHACOB users to utilize electrical backup service during peak or off-peak hours of demand. This arrangement would increase the probability that the SHACOB user was not adding to the utility's peak demand. In return, the utility could then charge the SHACOB user a reduced, off-peak rate. The proposed NEP requires that electric utilities develop plans to implement more cost responsive rates such as time of day rates. Regional variations in load patterns, and the current lack of detailed information on the dynamics of the SHACOB-electric utility interface make it difficult to propose a single national policy to resolve the electric utility rate structure problem at the present time.

Another approach to electric utility rate programs is to offer SHACOB customers an interruptible service rate, similar to industrial customers. Interruptible service allows the utility to discontinue service to the SHACOB customer during periods of peak demand. This approach would insure that SHACOB does not aggrevate peaking problems. If the SHACOB user does not allow his storage to completely discharge in the normal course of operation, the impacts on his comfort should be minimal. The benefits are a much lower utility rate.

A number of utility rate programs could also be applied to gas utilities. As described in Chapter 2, the major barrier posed by the SHACOB-gas utility interface is the current pricing policies of the gas utility. Regulatory policy requires the price charged to the consumer be based on the average wholesale cost of gas to the utility. This policy results in averaging the cost of new gas and old gas. The average price charged to the consumer, therefore, does not reflect the marginal cost of service.

One policy to overcome the average pricing barrier is to implement long-run marginal cost pricing, so that the individual consumer makes a decision based more directly on actual energy economics between new natural gas and SHACOB. The windfall profits to the utility, resulting from this marginal cost pricing policy, would then be taxed.

Another gas utility option is to place restrictions on all new gas hook-ups. These restrictions would require the customer to implement conservation and SHACOB measures in the building before gas is made available. The restrictions could require proof that these options were at least investigated. The restrictions could be made more severe, requiring conservation and solar equipment be installed before gas service is provided. Such restrictions, by reducing the amount of gas required by individual buildings, could spread short supplies of natural gas over a larger number of customers, allowing the removal of moratoria on new natural gas hookups that now are imposed in several areas. Conservation restrictions have recently been implemented by a few state Public Utility Commissions (PUCs). The federal government could encourage state PUCs to institute some type of solar restrictions.

Figure 58 presents the impacts of these utility rate programs on SHACOB barriers. The rate programs are treated as a group rather than each rate option being specified in detail. As expected, the largest impact of these programs is on the gas and electric utility interface barriers. It is possible that programs could have an indirect positive impact on high life-cycle costs. The positive role of utilities in SHACOB, resulting from the program, may improve consumer attitudes. The impact on consumer attitudes is, however, highly uncertain. Most of the rate programs would also reduce the cost of backup energy to the SHACOB user and, therefore, reduce life-cycle costs. Marginal cost pricing policies might decrease but would probably increase the cost of SHACOB backup. However, marginal cost pricing would increase the economic feasibility of SHACOB by having a larger impact on the cost of conventional HVAC systems.

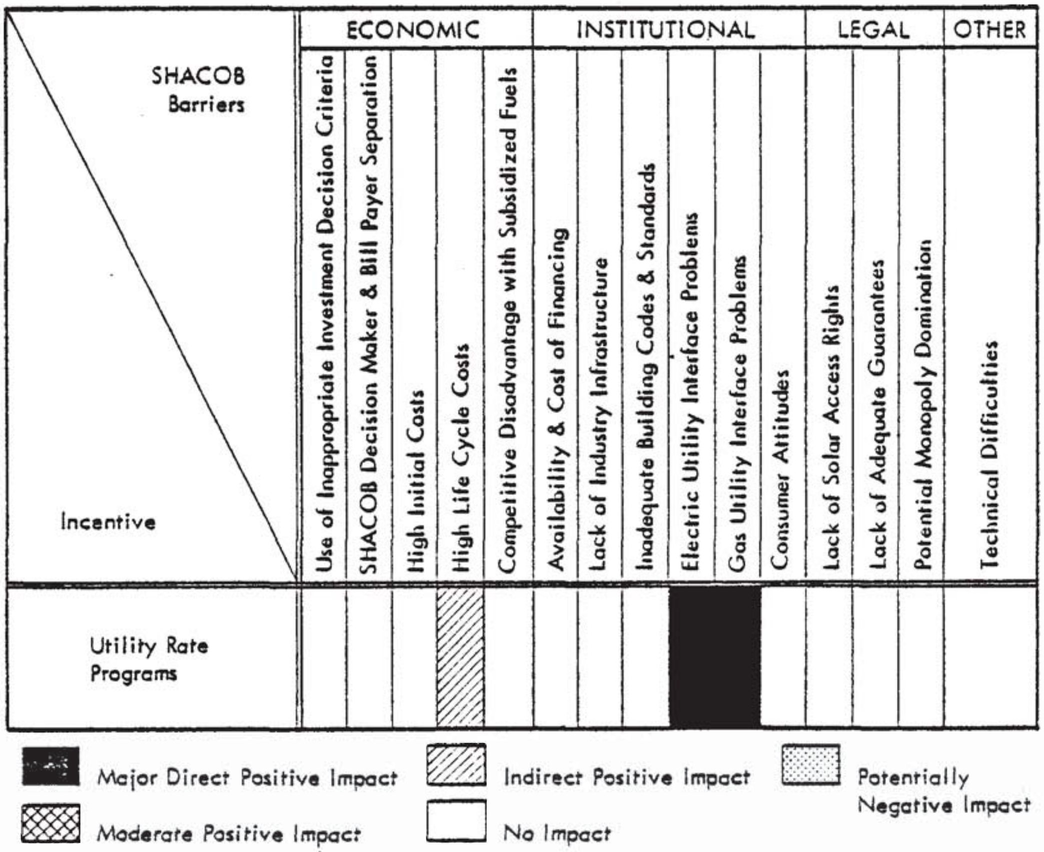

Figure 58 - Impact of Utility Rate Programs on SHACOB Barriers

The equity impacts of utility rate programs heavily depend on the details of the programs. Figure 59 indicates that low, middle and upper income groups or businesses could be favored by the program. The programs would have to be structured to minimize negative impacts on utilities and, probably, favor utilities. The magnitude of the programs and their emphasis will determine whether the SHACOB industry is favorably impacted.

The administrative mechanisms required to institute utility rate programs are already in place. Figure 60 shows that the program could be initiated from the federal or state level. The Federal Power Commission (FPC) could be the federal administrative mechanism. State public utility commissions (PUC) and individual utilities will have to play integral roles in the program.

Incentive \ Equity Impact	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governme[n]t Entities
Utility Rate Programs	Maybe	Maybe	Maybe	Yes	Maybe	No

Figure 59 - The Equity Impacts of Utility Rate Programs

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Utility Rate Programs	Federal State	Yes FPC, State PUC	No

Figure 60 - The Administrative Mechanisms of Utility Rate Programs

The implementation of programs to resolve the complex SHACOB utility problems will require cooperation between both state and federal regulatory agencies. The exact form of the most attractive policy options is not yet known, and there are likely to be different policies which will be appropriate for different situations. Without a clearer picture of the policies that could be implemented, it is difficult to estimate the cost of these policies to the federal government, their administrative costs, or their exact equity implications.

Therefore, in the short run, probably the most realistic policy option is for the federal government to encourage utility participation in experiments with alternative rate structures. These experiments would further the understanding of this complex problem.

b. Utility leasing and/or ownership programs: Another policy option that has been suggested to reduce the problems posed by the SHACOB utility interface is to permit the utility to own and/or lease SHACOB systems. This proposal would use the utilities large existing markets, access to capital at low interest rates, and long-term investment viewpoint to advance the market penetration of SHACOB systems. In fact, if the utility is permitted to invest in a SHACOB system at the point of consumption, and is further permitted to use the SHACOB system in a manner that reduces peak demand (by time of day rates, telemetric control, etc.), it is possible that the investment in SHACOB systems may be more attractive to the utility than expansion of conventional generating capacity. This attraction occurs because the utility makes investment decisions on the marginal cost of service (either gas or electricity), whereas, under current regulatory policies, the consumer is charged the average price. The marginal price is considerably higher than the average price, making SHACOB more cost competitive in the eyes of the utility than the consumer if SHACOB could be used to replace new centralized generation capacity.[1/]

In most states, current regulatory policies do not permit gas utilities to invest in SHACOB. One current proposal suggests that regulatory policies be altered to allow gas utilities to treat investments in conservation and SHACOB systems as an alternative supply option.[2/]

The suggestion of utility involvement in the SHACOB market raises serious questions concerning public utility regulatory policy and restrictions on competition. Unless such a utility ownership or leasing program is set up to provide SHACOB systems to the consumer on attractive terms, there is no guarantee that the program would resolve the interface

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1/ Noll, Roger G., "Public Utilities and Solar Energy Development," Graduate School of Business, Stanford University, pp. 9-13.

2/ ICF, Inc., "Preliminary Analysis of Conservation Investments as a Gas Utility Supply Option," Prepared for the Federal Energy Administration, January 1977.

problem. There is also no fundamental reason why the regulatory process could not be used in conjunction with open competition to achieve goals similar to that of the utility ownership/leasing idea.

Figure 61 presents additional detail concerning the impacts of utility leasing/ownership programs on SHACOB barriers. In spite of the potential problems, the most positive impacts of the programs will probably be on high initial costs and utility interface barriers. The programs could also have a significant positive impact on the use of inappropriate investment decision criteria and the separation between SHACOB owner and utility bill payer. Financing would be handled by the utility and, therefore, removed as a barrier to the customer. Most of the leasing/ownership options discussed include service guarantees. Therefore, the lack of guarantees barrier will be significantly reduced. The program will also have an indirect positive effect on the industry infrastructure.

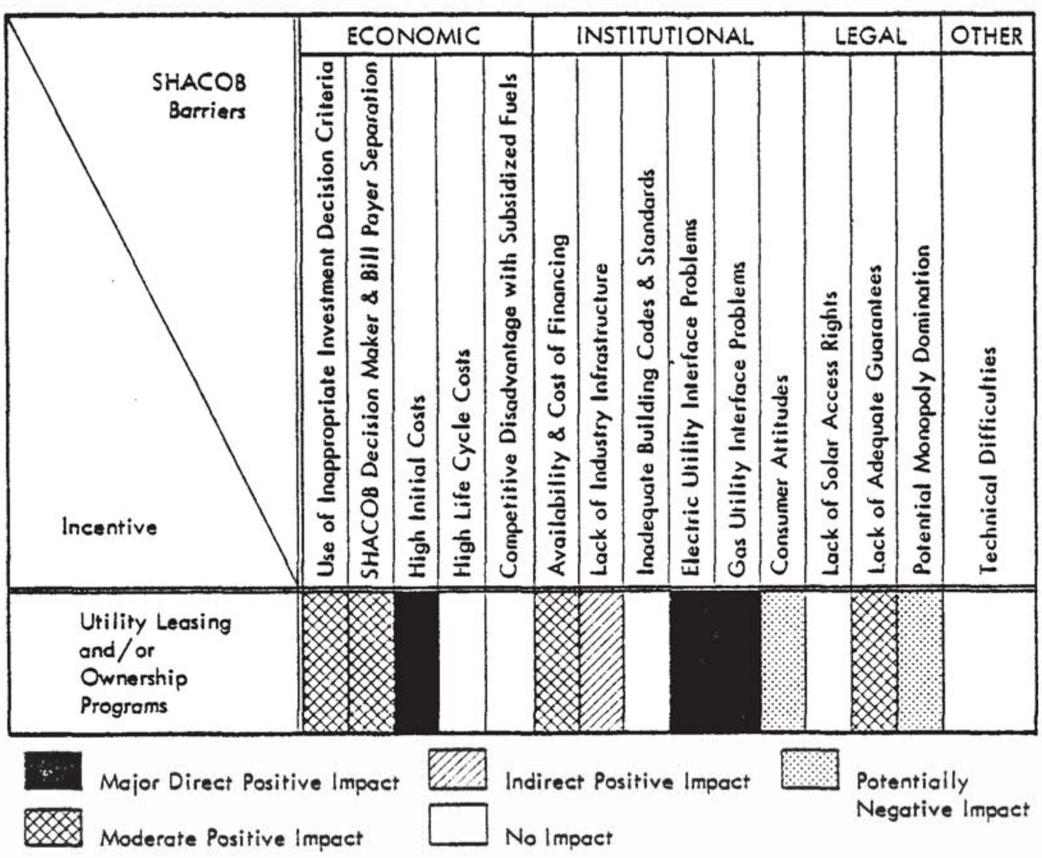

Figure 61 - Impact of Utility Leasing and/or Ownership Programs on SHACOB Barriers

There are some potentially negative impacts of utility leasing/ownership programs. The figure indicates that the programs could have a negative effect on consumer attitudes towards SHACOB and increase the possibility of monopoly domination of the industry. Another possible impact is that customers could be charged higher prices than they would if the systems were owned by the customers. In this case, life-cycle costs would be increased. All three of these negative impacts could result from a poorly planned or regulated utility leasing/ownership program. Therefore, attention to details is especially important in these programs.

Similar to the utility rate programs, the details of the ownership program will largely determine their equity impacts. Figure 62 reflects this problem. It is clear that the utilities will have to be favored to solicit their cooperation.

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Utility Leasing and/or Ownership Programs	Maybe	Maybe	Maybe	Yes	Maybe	No

Figure 62 - Equity Impacts of Utility Ownership/Leasing Programs

The administrative mechanisms available for the ownership programs are parallel to those available for utility rate structure programs as shown in Figure 63. The program can be initiated at the federal or state level. However, state public utility commission and utility involvement is required.

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Utility Leasing and/or Ownership Programs	Federal State	Yes FPC, State PUC	No

Figure 63 - Administrative Mechanisms of Utility Leasing and/or Ownership Programs

Again, federal encouragement of utility participation in experiments with SHACOB ownership and leasing programs is probably the most realistic short-term policy option. The knowledge gained from these projects will lead to a better understanding of the costs and benefits of various policy options. These experiments should also help policy makers avoid potential negative impacts of utility participation in SHACOB.

6. Government insurance program: Under this incentive concept, the federal government would insure a SHACOB purchaser that an installed system operated properly for a specified length of time. In effect, the government guarantees the quality of SHACOB system. Defective components or inoperative systems would be repaired or replaced at the expense of the federal government. The insurance programs would, of course, be conducted in the context of an adequate standards and certification program, as was discussed in Section 4. This would reduce any deliberate efforts to exploit an insurance program.

The impact of a government insurance program on SHACOB barriers is shown in Figure 64. The major impact of the program is to reduce consumer uncertainty resulting from the lack of adequate guarantees that are now provided. In most cases at the present time, only limited guarantees are provided on a component by component basis and for a short period of time (less than 5 years). There are some guarantees covering entire solar water systems, but again those are predominately for only a few years. Offering a comprehensive guarantee covering the entire system for an extended period of time would have a major positive impact on consumer attitudes toward SHACOB. A government insurance program would also have a substantial positive impact on the availability of financing for SHACOB. The program would reduce lender concerns about the quality, durability, and operability of SHACOB systems.

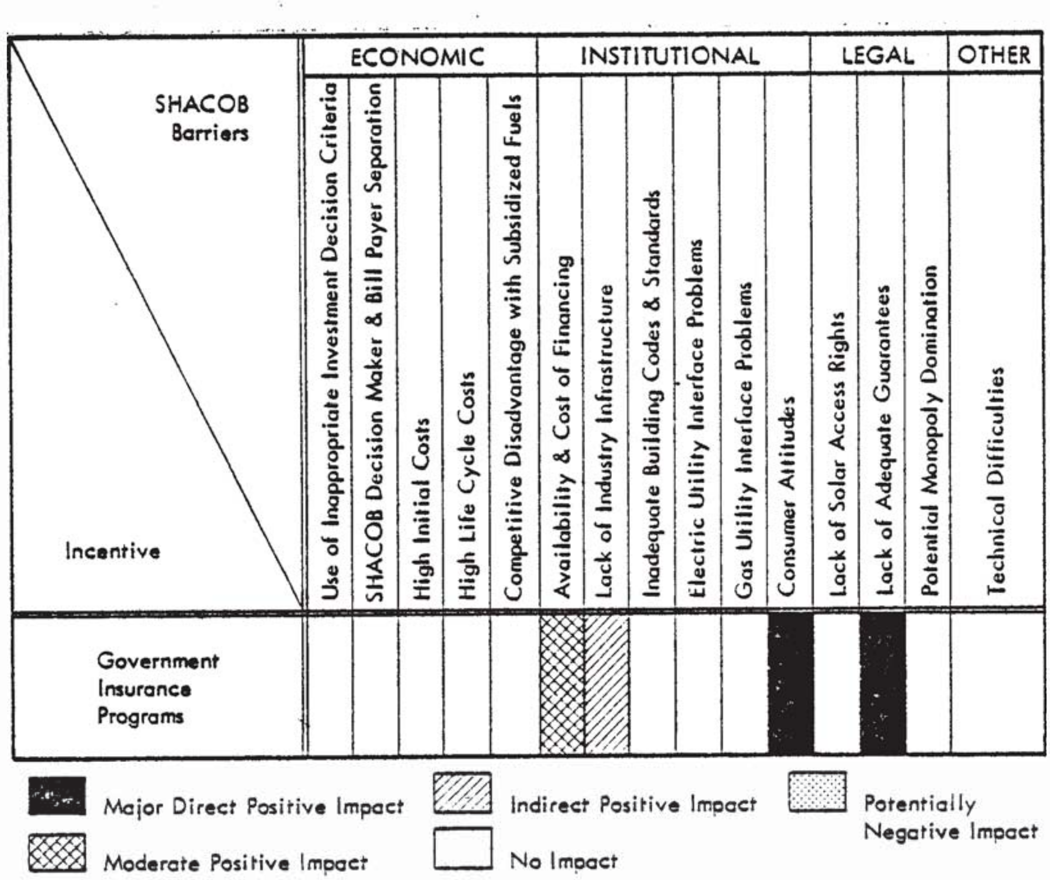

Figure 64 - Impact of Government Insurance Program on SHACOB Barriers

The SHACOB industry infrastructure would be indirectly improved by a federally initiated insurance program. Presently, lack of experience in the industry makes it difficult for companies to offer comprehensive guarantees. With the backing of the federal government, the industry would be able to offer guarantees that are attractive to consumers at a much earlier date than without any government involvement.

The impact of a government insurance program on various interest groups is shown in Figure 65. All user groups would benefit from the program. The SHACOB industry would receive benefits. No direct benefits would be provided to the utilities and no federal government funds would be transferred to other levels of government.

Equity Impact / Incentive	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Governme Entities
Government Insurance Programs	Yes	Yes	Yes	No	Yes	No

Figure 65 - Equity Impact of Government Insurance Programs

Figure 66 shows that the administrative mechanism for a government insurance program is not yet well defined. A program administered by state government and funded by the federal government is a possible mechanism. Perhaps the program could be administered by one of the existing federal energy agencies and some existing state agencies. More research on this incentive will be needed to determine the feasibility of administering it through existing agencies. It would probably be desirable, no matter what government administrative mechanism is used, to design the program to work closely with private industry. Service companies that are already part of the SHACOB industry infrastructure could be contracted to perform any work done under the program. In the event that a SHACOB system needed to be serviced, the system owner could hire a service contractor to repair the system. The bill for the work would then be passed on to the federal government.

There are many uncertainties about the costs and benefits of a government insurance program. Some mechanism will need to be developed to discourage any fradulent use of the program and well defined guidelines will need to be written to regulate it. One critical problem with a government insurance program that must be resolved is that the program may encourage the installation of poor quality SHACOB systems.

Administrative Mechanism / Incentive	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Government Insurance Programs	Federal State	Maybe	Maybe

Figure 66 - Administrative Mechanism for Government Insurance Program

D. State, Local and Joint Government Programs

1. State and local programs: The design of a national SHACOB incentive program must incorporate complementary federal, state and local programs. Each federal solar incentive program must interface with existing practices within state or local jurisdictions. By structuring state and local programs to address the ambiguities or disincentives which are a part of existing governmental laws, regulations, and tax levies, the economic feasibility of installing solar equipment can be enhanced.

State and local governments can act directly to provide incentives for SHACOB.* Some states have already demonstrated their commitment to SHACOB development by implementing incentives. To date, state efforts promoting the adoption of SHACOB include: tax incentives, support of energy research, development and demonstration requiring life-cycle costing for state construction and procurement decisions, installing solar equipment on state buildings, incorporating solar easements into zoning regulations, and public education.1/

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* Appendix B surveys existing state legislative initiatives to encourage the adoption of SHACOB systems.

1/ See, (1) Analysis of State Solar Energy Policy Options, National Conference of State Legislatures Energy Policy Project, prepared under FEA Contract No. CO-12-60496-00, (2) Turning Toward the Sun, National Conference of State Legislatures Energy Task Force, prepared under National Science Foundation grant (IRS-74-1552), and (3) Solar Energy Commercialization at the State Level: The Florida Solar Energy Water Heater Program, Report to FEA, op. cit.

The discussion of federal incentives above shows how state and local governments can be involved in administering incentives. Most of these incentives can be initiated at the state level without federal action. The following discussion highlights some of the state and local incentive actions that are currently underway.

a. Tax incentives: State tax incentives have been designed to reduce the tax burden associated with the high initial cost of solar energy systems. Initial state legislative efforts have focused on the problem of incremental property taxation which penalizes the owner of a solar installation by taxing the property's increased assessed value. Present state legislation has exempted all or part of the solar equipment from property taxes.

The imposition of state and local sales taxes on solar equipment substantially increases the first costs incurred by those who install solar equipment. Most solar applications for heating or cooling require a full capacity backup system using conventional energy supplies. The resulting duplication of taxes on both systems reduces the economic attractiveness of SHACOB. State and local actions to overcome this problem could be implemented at relatively low costs.

b. Energy research, development and demonstration (RD&D): Many states have already established solar energy research, development and demonstration programs.[1/] These have designated state energy priorities and funded RD&D activities concerning unique state solar climatological, economic, and institutional conditions affecting the development of solar technologies. Often state funds serve as seed-money, capable of attracting federal RD&D funds to particular projects defined and initiated by the state.

c. Life-cycle costing: Historically, state construction and procurement decisions have excluded solar equipment applications by usually favoring the lowest first-cost bid. To overcome this limitation, several states have enacted legislation requiring life-cycle costing methods to evaluate new investments. Life-cycle costing procedures can more readily reflect how additional investments in design, materials and mechanical systems (required for solar installations) can substantially reduce long-term operation and maintenance costs.

1/ See, for example, Florida Solar Energy Center Activities Report for the period July 1975 through December 1976, Florida Solar Energy Center, March 1977.

d. Solar installations on state buildings: Related to state incentive programs concerning life-cycle costing, some states have appropriated funds for solar heating and cooling demonstrations on state-owned buildings. This provides the state's citizens an opportunity to see solar equipment in use while also illustrating state level support of solar installations.

e. Solar access: A potential problem accompanying the widespread adoption of solar equipment will be the legal need to have unobstructed access to direct sunlight. Owners of solar systems need access to incident solar radiation. Several states have enacted laws either permitting local governments to enact zoning ordinances, or property owners to negotiate solar easements for the protection of SHACOB owner access to sunshine.

f. Public education: Many states have initiated public education, information, and promotion programs for solar energy similar to the federal programs discussed earlier. Much of this effort has focused on the provision of information concerning the potential of solar energy, the various conversion technologies, and the promotion of private solar activities occurring throughout the state.

g. Utility programs: Utility rate and ownership/leasing programs as they relate to the federal government were discussed above. Because state public utility commissions have major responsibility for several aspects of utility regulation, state PUCs could implement utility programs that encourage SHACOB use without federal action. Some state PUCs are already independently evaluating adoption of time-of-day rates. Several states have already implemented utility leasing and financing programs for energy conservation measures that could be expanded to apply to SHACOB.

2. Combined federal/state incentives: The multitude of federal and state policy options discussed above could easily be combined to offer the prospective investor a greater incentive than either could alone. The figures in this chapter indicating the administrative mechanisms of each incentive (Sections B and C) showed where combined federal/state actions would be most effective. With cooperation between federal and state agencies, combined federal and state incentive programs could offer a wide range of policies in support of solar energy utilization. Some incentives, such as property tax exemptions the development of SHACOB standards, and the initiation of utility programs, will require state and federal cooperation.

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COMPARISONS AND COMBINATIONS OF FEDERAL INCENTIVES

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COMPARISONS AND COMBINATIONS OF FEDERAL INCENTIVES

SUMMARY

Combining incentives into a comprehensive policy is more appropriate (in terms of certainty of results and lower aggregate cost to the government) than using a single incentive. The choice of appropriate combinations is best made by comparing individual incentives.

Those incentives which have the greatest impact on economic barriers, especially high initial and life-cycle costs, generally have a minimal direct impact on institutional and legal barriers. Grants, income tax credits and deductions, investment tax credits and accelerated depreciation fall into this category. Low-interest loans and loan guarantees show a similar trend, except their major impact is on financing availability and life-cycle costs rather than initial costs. The government buildings program is different than other economic incentives in that its major impacts are on the SHACOB industry infrastructure and the use of inappropriate decision criteria, both of which are institutional barriers. The other incentives impact a wider variety of barriers but influence economic barriers only minimally. Therefore, a comprehensive SHACOB strategy would include economic incentives and a selected group of other incentives aimed specifically at institutional, legal, and technical barriers.

The incentives also differ in their impact on the various income and interest groups. However, it may be more important to combine incentives to assure rapid market penetration rather than allow equity to be an overriding consideration. Very little research is available on the administrative costs of various incentives. All of the incentives could be administered through existing government entities.

Alternative combinations of incentives, representing increased government investment in SHACOB, that could be effective are: (1) the SHACOB incentives of President Carter's National Energy Plan (NEP), (2) a program that expands the NEP incentives, representing more federal investment, and (3) an even larger federal program involving new initiatives.

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CHAPTER 5

COMPARISONS AND COMBINATIONS OF FEDERAL INCENTIVES

A. Introduction

The analyses in Chapter 4 pointed out that each SHACOB incentive has distinct advantages and disadvantages. In addition, none of the incentives investigated dealt directly with more than a few barriers to SHACOB commercialization. It may be possible, in an extreme case, for a single incentive to make the economic attractiveness of SHACOB so appealing that investors would solve the other barriers without additional government assistance. However, the dollar magnitude of such an incentive would have to be extremely large to create such a dramatic change in market attitudes. Probably a more appropriate alternative (in terms of certainty of results and lower aggregate cost to the government) is a comprehensive approach to SHACOB, which utilizes numerous incentives simultaneously.

The first objective of this chapter is to compare the incentives investigated individually in Chapter 4. These comparisons will determine the similarities and differences of the incentives regarding how they affect SHACOB barriers, their impact on equity and their possible administrative mechanisms. The second objective of the chapter is to examine possible incentive combinations that could accelerate SHACOB commercialization more effectively than incentives used individually. Incentives should be combined to insure that the maximum number of SHACOB barriers are overcome at the lowest cost to the government (including both direct and administrative costs) with minimal negative impacts on the national distribution of income. The comparisons presented in the chapter will be the basis for choosing candidate incentive combinations.

Barriers and incentives to solar energy development have been the subject of numerous studies in the last several years. The material presented in the previous chapters of this report is based on information and conclusions drawn from those studies. However, very little research exists on how individual incentives can be best combined to form a comprehensive SHACOB commercialization plan. A limited number of studies contain comparisons of individual incentives. However, these comparisons are usually based on the relative effect of incentives on a single market variable--generally the cost of the SHACOB system to the owner.1/ Even fewer studies attempt to

1/ See, for example, "The Impact of Tax Incentives and Auxiliary Fuel Prices on the Utilization Rate of Solar Energy Space Conditioning," H. Craig Petersen, Utah State University, Logan, Utah, for the National Science Foundation, January 1976, and "Evaluating Incentives for Solar Heating," Rosalie Ruegg, op. cit.

project the impact of individual incentives on the total market penetration of SHACOB.[1/] Estimates of this broader impact were projected by A. D. Little, Inc., in a recent FEA study[2/] and by Mitre/METREK Corporation in a recent FEA study on government buildings.[3/] As mentioned in Chapter 3, both Mitre/METREK Corporation and A. D. Little, Inc., are refining their SHACOB market penetration models. Results of the A. D. Little, Inc., model are presented in PART B of this report. The Mitre/METREK model development is being conducted for ERDA.[4/]

This chapter is organized into three major sections. Following the introduction, Section B presents incentive comparisons. The comparative impacts of federal incentives on SHACOB barriers are addressed first. Comparisons of the equity impacts of federal incentives are examined next. The section closes with a comparison of the incentives' administrative mechanisms. Section C presents alternative combinations of federal incentives.

Incentives can be combined in a large number of ways. The combinations discussed in this chapter are organized into three groups. Each combination contains all the incentives of the previous combination plus additional incentives. The first major combination contains the solar incentives included in President Carter's National Energy Plan (NEP). The next combination (termed "expanded National Energy Plan") includes loan guarantees and a variety of educational programs, in addition to the National Energy Plan incentives. The final combination contains an expanded government buildings program, and new incentives such as accelerated depreciation allowances for SHACOB.

B. Comparisons of Individual Incentives

The incentives introduced in Chapter 4 are compared below on the basis of: (1) their impact on SHACOB barriers, (2) their equity implications, and (3) their administrative mechanisms. Quantitative comparisons of incentive costs and incremental benefits are contained in PART B of this report.

1/ See, for example, Proposed Solar Incentive Program, Solar Energy Industries Association (SEIA), unpublished, March 3, 1977.

2/ "An Analysis of the Market Development of Dispersed Usage Solar Energy Systems, 1976-1990," Draft Report, March 1976.

3/ "Solar Energy Government Buildings Program Policy and Implementation Plan," op. cit., January 1977.

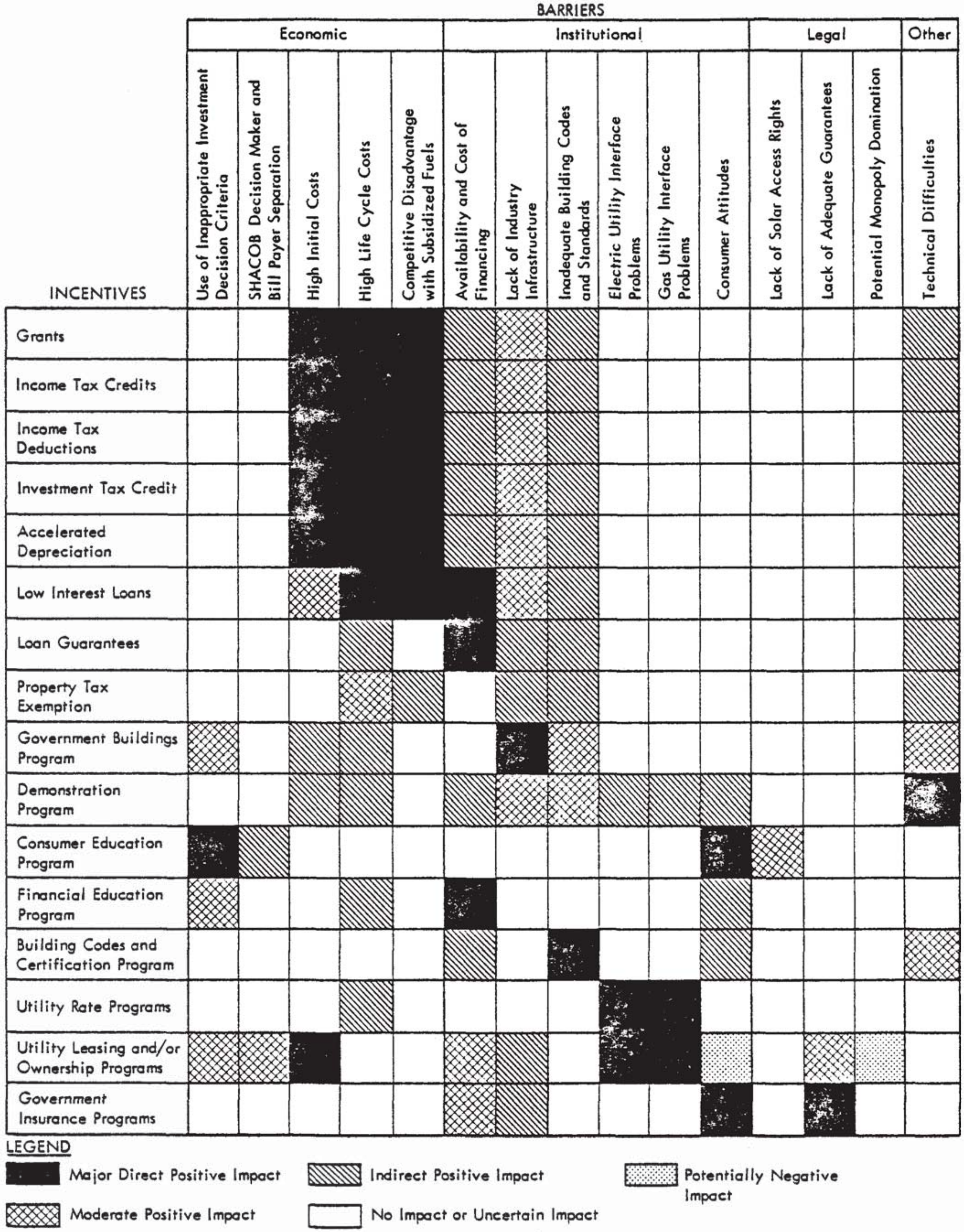
4/ Mitre Corporation, METREK Divisions, "Analysis and Planning Support for the Division of Solar Energy," Energy Research and Development Administration.

1. Comparative impact of federal incentives on SHACOB barriers: Figure 67 presents a matrix of the relationship between SHACOB incentives and barriers. Each column of Figure 67 presents a major SHACOB barrier discussed in Chapter 2. The barriers are again divided into economic, institutional, legal and other categories. The rows of the matrix define each of the major incentive categories discussed in Chapter 4. The magnitude of the effect that the incentives have on each barrier is displayed graphically in the cells of the matrix, as was done in Chapter 4.

Those incentives which have the greatest impact on economic barriers, especially high initial and life-cycle costs, generally have a minimal direct impact on institutional and legal barriers. Grants, income tax credits and deductions, investment tax credits, and accelerated depreciation all have major impacts on first costs and life-cycle costs. The property tax exemption, while probably less powerful than other economic incentives, has a direct impact on life-cycle costs. The only institutional barrier that these economic incentives have a significant impact on is the lack of SHACOB industry infrastructure. This impact is expected because lowering the cost barriers will stimulate demand. If the solar industry is confronted with increased demand, the needed infrastructure will develop quickly to meet this demand. Incentives which have a major impact on system costs are also expected to indirectly help reduce technical difficulties with SHACOB systems. The increased industry experience resulting from these incentives should lead to improvements in system quality. These incentives could have indirect positive impacts on the availability of financing for SHACOB, and on the building code barriers.

Figure 67 shows that low interest loans and loan guarantees have impacts similar to the incentives discussed above. These programs, however, have their major impacts on the cost and availability of financing for SHACOB. A government buildings program is an economic incentive that produces somewhat different results than a tax incentive or grant. This program would have a major positive impact on the development of the SHACOB industry infrastructure. It would also encourage the use of the life-cycle cost decision criteria in the government sector.

Despite the fact that economic barriers are currently believed to be the most severe barriers to SHACOB commercialization, legislation of economic incentives alone would probably not result in immediate, widespread SHACOB market success. Figure 67 shows that many institutional and legal, as well as a few economic barriers, will not be overcome by economic incentives. In formulating a comprehensive strategy for accelerating SHACOB commercialization, noneconomic incentive programs need to be considered. These noneconomic programs address many potentially serious barriers to the widespread use of SHACOB which, even in the event that SHACOB systems are desirable on an economic basis, could slow commercialization.



Source: Midwest Research Institute

Figure 67 - Comparison of Impacts of Incentives on SHACOB Barriers

A consumer education program, for example, could have a major impact on the decision criteria barrier. No direct economic incentive can make SHACOB competitive with conventional systems on a first cost basis, without exhorbitant costs to the government. It could, therefore, be desirable to implement a consumer education program, in conjunction with economic incentives, to encourage prospective SHACOB purchasers to evaluate systems on a life-cycle cost or payback basis.

The federal building code program that has already been initiated is another example of a program that is directed at a barrier that would remain in spite of economic incentives. This program is well on its way to reducing the barrier caused by the lack of building codes that include SHACOB systems. An expanded federal effort to implement the standards that are currently being developed by the federal government, perhaps by means of a SHACOB system and component certification program administered in cooperation with state governments (as proposed in the NEP), may be a necessary component of a successful commercialization program.

A federally-initiated effort to address the SHACOB-utility interface problem will also be needed before SHACOB is likely to achieve widespread commercialization. The complexities of this problem are at the present time not well understood. The implications of the problem are, however, great. Without an acceptable resolution of the interface problem that does not adversely affect the attractiveness of SHACOB systems, the long range potential of SHACOB is in doubt. Both utility rate programs and ownership or leasing programs should be considered. An ownership or leasing program, as shown in Figure 67, appears to be the only incentive which could have a significant impact on the SHACOB decision maker and bill payer separation barrier. Because a large number of buildings today are speculatively built, this barrier may limit SHACOB market potential.

The ongoing federal demonstration program is expected to have a major positive impact on removing technical problems of SHACOB systems. Figure 67 shows that no other federal incentive is as important to the technical difficulty barrier. Other incentives, through the increased industry experience they stimulate, will also help reduce technical problems. But these incentives alone, without a demonstration program that has been structured to resolve technical problems with all types of SHACOB systems, run the risk of discouraging consumers because of excessive problems with systems.

Consumer uncertainty about SHACOB system operability, durability, and performance could continue to be a barrier. In order for consumers to be willing to accept the life-cycle cost concept, they must be assured that the SHACOB system will perform properly over a reasonably long period of time. The early state of the industry makes it difficult for most companies to provide this assurance. If a government insurance program was included as part of an accelerated commercialization strategy, this barrier could be removed. However, the insurance program concept needs to be evaluated more carefully as it may encourage the installation of poor quality systems.

This comparison of federal incentives indicates that a comprehensive SHACOB commercialization plan should combine incentives to impact the largest possible number of barriers. Attention to one or a small group of barriers, without consideration of other barriers, may lead to a program with disappointing results. Specific combinations of federal incentives are presented in Section C.

2. Comparisons of equity impacts of federal incentives: The examination of incentives in Chapter 4 indicated that individual incentives have different impacts on various income and interest groups. Equity may be an important consideration in formulating a comprehensive strategy for SHACOB commercialization. One of the goals of a SHACOB incentives program could be that disproportionate benefits are not given to one particular user group, or that utilities are not given an unfair competitive advantage. It is, of course, possible to attempt to offset any inequitities in a SHACOB incentives program through broader welfare oriented federal programs.

Equity should probably not be the primary concern in putting an incentives program together. It may be more important to combine incentives to assure rapid market penetration by impacting the most serious SHACOB barriers rather than having equity implications be an overriding consideration. However, an incentives program's equity implications should be understood before the program is implemented.

Figure 68 summarizes the equity impacts of the individual incentives examined in Chapter 4. The impacts of the incentives on various income and interest groups are indicated by a graphic code, defined at the bottom of the figure.

It is clear from Figure 68 that the SHACOB industry benefits from almost all incentives. Clearly, all incentives designed to accelerate SHACOB commercialization would also benefit the industry.

Utilities are only expected to receive direct benefits from a very small number of the incentives examined in this report. This should not be interpreted to mean that utilities are necessarily adversely affected by any of the SHACOB incentives. Rather, it is an indication that most incentive programs proposed to date are directed at user groups. Figure 68 shows that there are some programs that could be implemented that could benefit the utilities directly.

The first three columns in Figure 68 represent user groups. The figure shows that several of the federal economic incentives affect user groups differently. A grant program, for example, appears to be the most flexible economic incentive. The grant program could be designed to favor any of the the user groups. The income tax credit would probably provide disproportionate benefits to the upper and middle income groups. However, the credit could be structured to minimize this problem by allowing a federal cash payment in excess of the individual's tax liability. The tax deduction,

INCENTIVES	EQUITY IMPACT					
	Favors Low Income Group	Favors Middle and Upper Income Groups	Favors Business Users	Favors Utilities	Favors SHACOB Industry	Transfers Funds to Other Government Entities
Grants	Could By Design	Could By Design	Could By Design	No	Yes	No
Income Tax Credits	Could By Design	Yes	No	No	Yes	No
Income Tax Deductions	No	Yes	No	No	Yes	No
Investment Tax Credit	No	No	Yes	No	Yes	No
Accelerated Depreciation	No	No	Yes	No	Yes	No
Low Interest Loans	Yes	Yes	Could By Design	No	Yes	No
Loan Guarantees	Yes	Yes	Could By Design	No	Yes	No
Property Tax Exemption	Yes	Yes	Yes	No	Yes	Could By Design
Government Buildings Program	Yes	Yes	Yes	No	Yes	Yes
Demonstration Program	Yes	Yes	Yes	Could By Design	Yes	No
Consumer Education Program	Yes	Yes	Yes	No	Yes	Maybe
Financial Education Program	Yes	Yes	Yes	No	Yes	No
Building Codes and Certification Program	Yes	Yes	Yes	No	Yes	Maybe
Utility Rate Programs	Maybe	Maybe	Maybe	Yes	Maybe	No
Utility Leasing and/or Ownership Programs	Maybe	Maybe	Maybe	Yes	Maybe	No
Government Insurance Programs	Yes	Yes	Yes	No	Yes	No

Yes No Maybe Could By Design

Source: Midwest Research Institute

Figure 68 - Summary of Equity Impacts of SHACOB Incentives

also an incentive for individual users, would probably provide even fewer benefits to low income users. The investment tax credit and the accelerated depreciation incentive both are directed only at business users. The loan program incentives could be designed to favor any or all of the user groups. The property tax exemption could also probably favor all user groups.

The noneconomic incentive programs would provide indirect benefits to all SHACOB user groups, with no one group receiving benefits distinguishably larger than another group. The benefits of these noneconomic programs are in a sense "collective," being shared by all who use solar systems. However, for the most part, these incentives are indirect in the sense that no direct economic benefits are provided to any user group. Rather, these incentives result in making higher quality systems available to all user groups.

3. Comparisons of administrative mechanisms of federal incentives: The examination of individual incentives presented in Chapter 4 included discussions of possible administrative mechanisms that could be used for their implementation. Figure 69 summarizes the administrative mechanisms available for each of the incentives. As mentioned previously, the focus of this report is on federal actions to accelerate SHACOB commercialization. Therefore, the focus of the administrative mechanism is at the federal level. Participation of state and local government is only indicated when their participation is necessary or extremely useful to implement the program.

The first column in Figure 69 lists the 16 incentives discussed in Chapter 4. Column 2 indicates which level of government would administer the program. The federal government plays a role in administering all of the programs because of the federal focus of the report. State and local governments will have a role in administering property tax incentives, building code and certification programs, utility rate programs, and utility leasing/ownership programs. State and local involvement would be very helpful in implementing grant incentives, consumer education programs, and government insurance programs. All the incentives focusing on federal income taxes would not require state cooperation, although in some cases state cooperation would be desirable.

The last two columns of Figure 69 indicate whether an existing agency can be used for implementation, or a new organization is needed. In most cases, administration of the incentives can be accomplished through existing government organizations. New organizations could possibly be set up to implement loan guarantee incentives, low-interest loans, building code and certification programs, or government insurance programs. However, these incentives could also probably be administered by existing agencies.

The federal agencies taking part in incentive administration depend on the nature of the program. As expected, the Internal Revenue Service (IRS) will have to take the leading role in administering income tax credits and deductions, investment tax credits, and accelerated depreciation allowances.

Incentive \ Administrative Mechanism	Administered by What Level of Government	Could be Administered by Existing Agency	Would Require New Organization
Grants	Federal, State	FEA, ERDA, HUD, States	No
Income Tax Credit	Federal	IRS	No
Income Tax Deduction	Federal	IRS	No
Investment Tax Credit	Federal	IRS	No
Accelerated Depreciation	Federal	IRS	No
Low-Interest Loans	Federal	Maybe (HUD, SBA, GNMA, FNMA)	Maybe
Loan Guarantees	Federal	Maybe, (FEA, FHA, VA, SBA)	Maybe
Property Tax Exemption	Federal, State and Local	Federal, State and Local Depts. of Revenue	No
Government Buildings Program	Federal	FEA	No
Demonstration Program	Federal	ERDA, HUD, DOD	No
Consumer Education Program	Federal, State	FEA, ERDA, HUD and State Agencies	No
Financial Education Program	Federal	FEA, ERDA, VA, SBA, Etc.	No
Building Codes and Certification Program	Federal, State and Local	Existing National and Local Code Authorities	Maybe
Utility Rate Programs	Federal, State	FPC, State PUC's	No
Utility Leasing and/or Ownership Programs	Federal, State	FPC, State PUC's	No
Government Insurance Programs	Federal, State	Maybe	Maybe

Source: Midwest Research Institute

Figure 69 - Summary of Administrative Mechanisms for Federal SHACOB Incentives

The energy related agencies such as the Federal Energy Administration (FEA) and the Energy Research and Development Administration (ERDA) will play important roles in other incentives. Grants, demonstration programs, the government buildings program and consumer and financial education programs could be administered by these groups. The Federal Power Commission (FPC) and the state public utility commissions (PUC's) will play important roles in any utility oriented incentives. Housing and financial agencies will be important to the grant programs, low-interest loans, loan guarantees and consumer and financial education programs. The housing and financial organizations include the Department of Housing and Urban Development (HUD), the Small Business Administration (SBA), the Farmers Home Administration (FHA), Veterans Administration (VA), the Government National Mortgage Association (GNMA), and the Federal National Mortgage Association (FNMA).

There is very little information available on the probable costs of administering each of the incentives listed in Figure 69. Therefore, comparisons of incentives based on administrative costs have not been presented. In fact, those incentives requiring new organizations should not be considered more expensive to administer a priori. Administering incentives through existing agencies often requires major additions to the staff and capabilities. A recent report appearing in The Congressional Record indicates that administering a solar income tax credit incentive, for example, would cost the Internal Revenue Service and the taxpayers a significant amount.1/ The higher costs are attributed to: (1) the need for more time spent on audits due to the added complexity of the tax forms, (2) added time and cost to the taxpayers due to increased complexity, and (3) the cost to the taxpayer of additional record keeping. However, the magnitude of these costs are not estimated in the report.

Most of the incentives could use existing federal and state government organizations for implementation. However, even those incentives requiring new government entities should not be excluded from consideration based solely on this drawback. Therefore, administrative mechanisms of incentives should not have an integral role in the choice of an optimal combination of incentives.

C. Incentive Combinations

Combining incentives into a comprehensive strategy of accelerated SHACOB commercialization is based on the premise that incentive combinations can be more effective and cost less than a government investment of the same magnitude in a single incentive. The comparisons of incentives in Section B

1/ Congressional Record-Senate, U.S. Government Printing Office, April 7, 1977, pp. S5819-S5822.

of this chapter support this premise. Also the A. D. Little, Inc., draft report to FEA states that synergistic effects would be experienced by implementing several incentives concurrently.1/

The first question to be addressed in the combination of incentives is what should the combinations be based on? Combinations discussed in this chapter are ordered by the number of incentives included and, therefore, the magnitude of government investment required. Figure 70 presents a conceptual framework for choosing incentive combinations that could make the energy produced by solar technologies reach a specified target of energy savings.

The rows of the matrix in Figure 70 represent alternative targets of energy saved by all solar technologies. The Congressional target of "on the order of 1 million barrels per day of oil equivalency in energy savings by 1985" (P.L. 94-385) is the first target in the matrix. Other targets could be higher or lower than the current Congressional target. Each column of the matrix represents a different strategy for achieving the desired goal. The strategies are distinguished by their emphasis on SHACOB. For example, the first strategy in the first row places relatively little emphasis on the contribution of SHACOB to attaining the 1 million barrels of oil per day savings goal. The next two strategies in the first row place increasing dependence on the contribution of SHACOB.

The insert in Figure 70 illustrates alternative combinations of incentives that will allow SHACOB to reach its potential. Combination A in the figure represents the SHACOB incentives contained in the President's proposed National Energy Plan (NEP). Combination B is an expansion of the NEP. Combination C is the largest combination, including all those included in A and B plus some new initiatives. Each of these combinations is explained in more detail below.

1. Incentive combinations of the National Energy Plan: President Carter's proposed National Energy Plan (NEP), in conjunction with already established SHACOB programs, contains the basic elements of a comprehensive commercialization strategy for SHACOB. The NEP explicity proposes three major new incentives for SHACOB. These are: (1) residential solar tax credit, (2) business investment tax credit, and (3) federal solar energy government buildings program. The NEP also explicity proposes two noneconomic SHACOB incentives: (1) a federally supported joint federal/state consumer education and promotion program, and (2) a federally supported federal/state program of standards development and certification. In addition to these incentives, the NEP proposes to encourage state governments to pass legislation exempting SHACOB equipment from property taxes, to pass legislation that protects solar access, and to develop guidelines to prevent utilities from implementing policies that discriminate against SHACOB users.

1/ A. D. Little, Inc., "An Analysis of the Market Development of Dispersed Usage of Solar Energy Systems," op. cit.

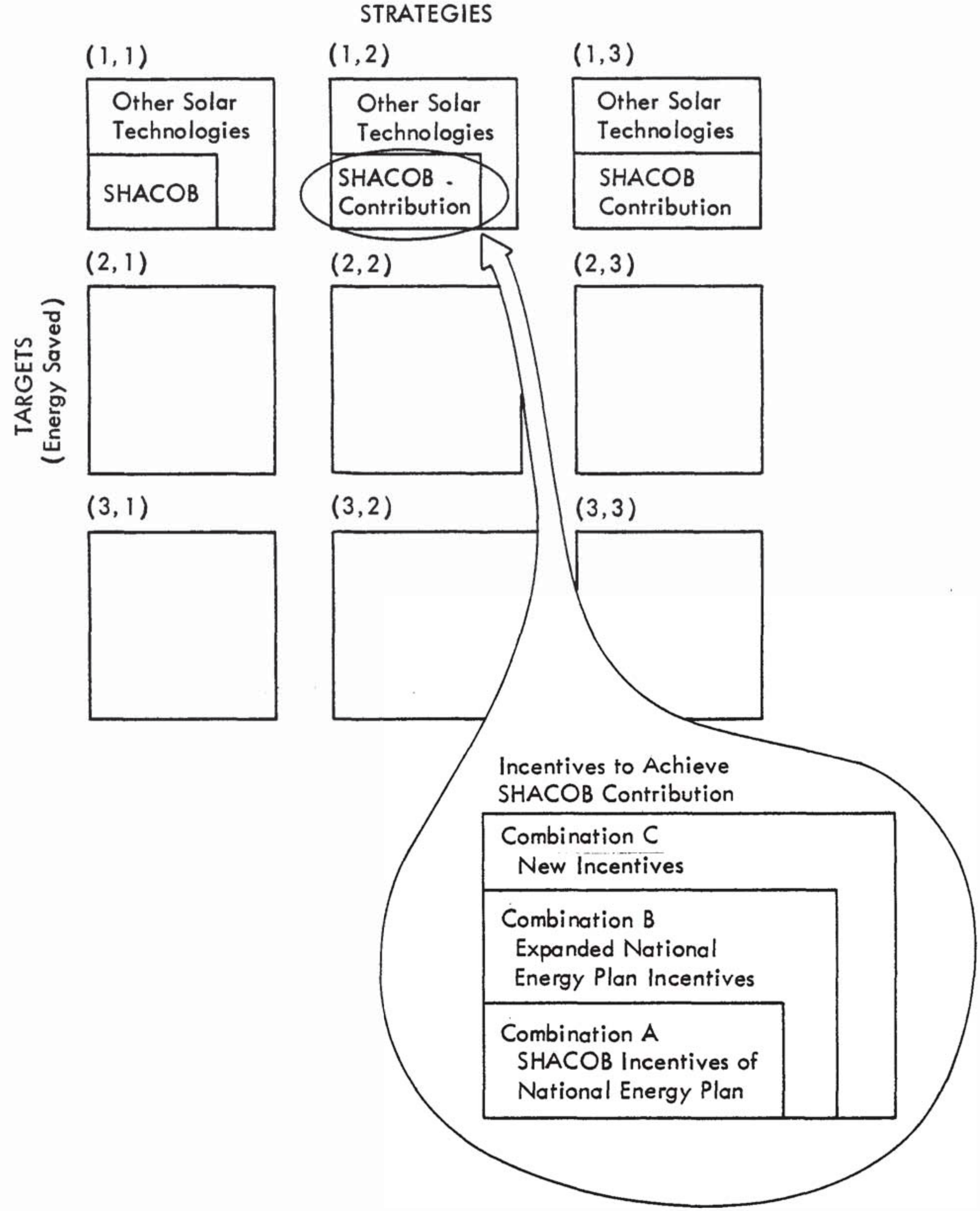


Figure 70 - Conceptual Framework for Choosing Incentive Combinations for SHACOB

The residential tax credit incentive specified that a credit, equalling 40% of the first $1,000 and 25% of the next $6,400, up to a maximum credit of $2,000, will be provided to the homeowner for purchasing solar equipment. The credit is limited to the tax liability of the homeowner in the year that the system is purchased. Only owner-occupied single family or owner-occupied multifamily residential buildings are eligible for the credit. The credit decreases gradually over time, equaling 25% of the first $1,000 and 15% of the next $6,400 (maximum $1,210) in 1984, the last year the credit is effective.

The business investment tax credit provides an additional 10% credit, above the normally applicable credit, for solar equipment installed in industrial and commercial facilities. SHACOB systems installed in commercial buildings would be eligible for the credit. The credit is effective through January 1, 1983.

The President's proposed NEP would authorize FEA, in cooperation with other federal agencies, to install SHACOB systems in federal buildings in those parts of the country where SHACOB appears to have near-term potential. The program is proposed to be budgeted at up to $100,000,000 through 1980.

No detailed definitions of the scope of the NEP noneconomic incentives have yet been developed. The consumer education program and the standards and certification program are both to be operated in conjunction with the states.

The other solar components of the NEP are also not yet fully defined. These programs, intended to encourage states to provide property tax exemptions, pass solar access legislation, and consider the effects of utility policies on SHACOB, are expected to be voluntary under the NEP. These programs are likely to get moderate funding under NEP to support their implementation.

Adoption of all the solar incentives contained in the NEP is expected to have a substantial impact on SHACOB commercialization. Referring back to Figure 67, it can be seen that the first cost and life-cycle cost barriers for both business users and homeowners would be significantly reduced by the tax provisions contained in the proposed NEP. These cost reductions would have a major impact on SHACOB's competitive position with conventional fuels. The government buildings program should have a major positive impact on the development of the industry infrastructure. The federal/state standards and certification program should minimize the building code problem, and improve consumer and lender attitudes toward SHACOB. The consumer education program should have a major positive impact on consumer attitudes. The education program could also lead to the use of payback or life-cycle cost decision criteria by a larger number of potential consumers. The solar access barrier, and the barrier posed by the utility bill payer and SHACOB decision maker separation could also be indirectly reduced by the consumer education program. All of these programs, particularly in conjunction with the already established federal demonstration program, should greatly reduce technical difficulties with SHACOB systems. Clearly, the proposed NEP impacts a large number of important SHACOB commercialization barriers and should accelerate market penetration.

The components of the NEP that relate to fossil fuels and other energy sources are also expected to have a substantial impact on SHACOB commercialization. Policies that would raise domestic oil prices to be equal to the world price, and policies that increase the price of natural gas all should have a positive impact on SHACOB as they improve SHACOB's competitive position with fossil fuels. The positive impacts, however, may not be divided equally between the residential and commercial sectors. Gas policies, for example, as proposed in the NEP, are designed to maintain the flow of relatively inexpensive gas to the residential sector while the commercial sector would face higher prices and reduced availability. Proposals to encourage utility rate reform, such as requiring electric utilities to evaluate the feasibility of implementing time-of-day rates, also have implications for SHACOB. The exact impacts of the NEP utility rate reform proposals on SHACOB are not yet well understood. In summary, the NEP overall strategy of reducing the consumption of scarce fossil fuels and gradual transition to renewable energy sources such as solar, should provide a foundation for the development of a growing SHACOB industry.

2. Incentive combinations of an expanded National Energy Plan: In addition to the incentives and programs included in the President's proposed National Energy Plan that apply specifically to SHACOB, there are a number of other programs in the NEP that could be expanded to apply to SHACOB. There is also one SHACOB incentive program which has already been enacted into law but has not yet been implemented. This program could be activated. These programs could be added to the specific solar incentives in the NEP to create a more aggressive strategy for SHACOB commercialization. Programs that could be added to the NEP are discussed in this section.

The first component of an expanded NEP is that the NEP noneconomic programs would be pursued more aggressively. States would also be more aggressively encouraged to exempt solar equipment from property taxes, pass solar access legislation, and develop guidelines to prevent utility policies from discrimination against SHACOB users.

A second component of an expanded NEP is to apply a program, now contained in the NEP for energy conservation, to SHACOB systems. The program, as now structured, requires state public utility commissions to direct utilities to offer their customers a residential energy conservation service.

The program, in effect, provides utility financing for residential energy conservation investments, with the customers paying for the service through utility bills. The program could be expanded to provide this same service for SHACOB systems.

A third component of an expanded NEP also parallels an NEP program for energy conservation. The program would make loans for SHACOB systems, made by private lending institutions, eligible for resale on the secondary mortgage market through the Federal Home Loan Mortgage Corporation and the Federal National Mortgage Association.

The fourth component of an expanded NEP would be to allow SHACOB systems to be included as an eligible energy "conservation measure" in the NEP proposed energy conservation program for schools and hospitals. As proposed in the NEP, the program, an ammendment to the Energy Conservation and Production Act (PL 94-385), would be funded at $3 billion per year for 3 years. Grants require matching state funds.

The fifth component of an expanded NEP would be to make SHACOB systems an eligible "conservation measure" in the NEP proposed Federal Energy Management Program (FEMP). The program calls for all federal agencies to implement conservation efforts that would reduce energy consumption in their existing buildings in 1985 by 20% from their 1975 levels of consumption. New federal buildings would have energy consumption levels in 1985 that are 45% below 1975 consumption. FEMP would fund only those energy conservation efforts that are cost-effective. If FEMP were structured to use life-cycle costs as the cost-effective decision criterion, and SHACOB systems were eligible, then solar systems might be installed in a number of federal buildings to meet FEMP goals.

Finally, the sixth component of an expanded NEP is to implement loan guarantees for loans made for conservation and renewable resource systems as authorized under Title IV of the Energy Conservation and Production Act (PL 94-385). The act, as written, permits loan guarantees for solar systems, but this provision has not yet been utilized.

An expanded NEP that included the six programs described above, in addition to the basic NEP solar incentives, is expected to have a significantly larger positive effect on SHACOB commercialization than the NEP alone. The expanded NEP will have a number of positive impacts on SHACOB commercialization barriers, in addition to the impacts of the NEP described in Section 1.

The availability of financing barrier should be significantly reduced by the eligibility of SHACOB loans for resale on the secondary mortgage market and by the loan guarantee program. The cost barriers will be reduced for a user group not included in the NEP--nonprofit and public schools and hospitals. Utility financing of SHACOB systems for residential customers could reduce SHACOB first costs and help reduce the utility interface barrier. A more aggressive standards and certification program could remove the code barrier sooner than a modest program and thereby have a larger and earlier positive impact on consumer attitudes. A more aggressive consumer education program should have greater positive impacts on consumer attitudes than a modest program, and should accelerate the use of payback and life-cycle cost decision criteria. States would be more aggressively encouraged to exempt SHACOB from property taxes, to pass solar access legislation, and to address the utility interface problem than under the NEP. The inclusion of SHACOB systems in the Federal Energy Management Program would, in effect, be an expansion of the solar energy government buildings program, further accelerating the development of the SHACOB industry infrastructure. All of these programs combined are expected to result in greater market penetration of SHACOB than under the NEP incentives program.

3. Incentive combinations representing new solar initiatives: It is possible that SHACOB incentives in addition to those contained in the NEP and expanded NEP programs may be desirable. This section describes an incentives program that adds six new initiatives to the incentives contained in the expanded NEP program. These new initiatives could be implemented if it were decided that the benefits of SHACOB warranted further acceleration of its commercialization. The new initiatives are only briefly described here, as most of them are described in detail in Chapter 4.

The first new initiative is to increase the funding level of the proposed NEP solar energy government buildings program from $100 million to $250 million or $500 million. This incentive would greatly expand the government market for SHACOB. A large part of the additional expenditures would be recouped by the government through reduced energy costs.

The second new initiative is to implement a 5-year accelerated depreciation incentive for business users. This incentive allows a business to amortize, over a 60-month period, the cost of the SHACOB system.

A low-interest loan program is the third new initiative. The program would subsidize the interest rate on loans made for SHACOB installations by homeowners. Various program options need to be evaluated before a specific program is defined.

The fourth new initiative is an education program directed at financial institutions. The program would provide these institutions with information about SHACOB certification, available loan incentives, and other information relevant to the lender decision process.

A government insurance program is the fifth new initiative. The program would insure SHACOB users against defective systems for a specified length of time. The exact details of an effective, low cost insurance program needs to be further investigated.

The final new initiative would be to require new buildings with natural gas hookups to install or, at least, investigate the feasibility of using SHACOB systems to reduce natural gas consumption.

This combination of incentives will have the largest impact on SHACOB commercialization of the three programs discussed in this chapter. The program would have several positive impacts on SHACOB barriers, in addition to those impacts of the expanded NEP. The expanded government buildings program would further accelerate the development of the industry infrastructure. Accelerated depreciation would reduce the first and life-cycle costs of SHACOB systems to business users beyond the reduction resulting from the investment tax credit. A low interest loan program would have a major positive impact on the cost of financing and life-cycle cost barriers. Combined with a financial education program, the availability of financing would be increased. A government insurance program would reduce consumer and lender uncertainty by providing adequate guarantees for SHACOB systems. The new natural gas hookup with a requirement for the installation of some type of SHACOB system would overcome the inability of SHACOB to compete with gas under existing rate policies, and would reduce the number of areas where moritoria restricting new gas hookups are necessary. An incentive program with new initiatives will further accelerate SHACOB market penetration.

GLOSSARY

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ANSI - American National Standards Institute.

ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers.

ASME - American Society of Mechanical Engineers.

ASTM - American Society for Testing and Materials.

Absorber Surface - The surface of a solar collector which accepts the solar radiation for conversion to thermal or electrical energy, or both.

Absorption Chiller - A commercially available device which chills water when supplied with heated water or steam. The heated water may be obtained from a high temperature solar collector. The chilled water can be used to cool a building during the cooling season.

Accelerated Commercialization - A joint government-private sector process--might be defined as government actions that are taken to increase the rate, level, and breadth of both acceptance and utilization of a new type of product, system, technique, manufacturing process or service. The general objective of such government actions should be to achieve the maximum market penetration rate of the new type of system, at a given level of government expense, while minimizing any possible negative sociopolitical impacts of the system. Such government actions, in general, can take the form of:

- Stimulating market demand;
- Stimulating the early development of a viable, self-sustaining (i.e., not requiring government subsidies) industry/market infrastructure; and
- Mitigating, where possible, any technical, economic, legal, institutional or environmental constraints.

It should be strongly emphasized that government actions in the form of accelerated commercialization policy and planning efforts must proceed concurrently, and not just sequentially, with government and private sector research, development, test and evaluation efforts. Concurrent action is necessary because, in many instances, market development requires a longer lead-time than does an R,D,T&E effort. For example, preparing the manufacturing industry, the marketplace, and the associated institutions for large-scale integration of wind energy generators into federal hydro-electrical systems, let alone private utility systems, may take up to 5 years. However, the technology may be available in 2 to 3 years. In such cases, effective federal accelerated commercialization planning (i.e., in line with market development lead-times) should be initiated early enough to permit rapid implementation as soon as technical feasibility has been demonstrated (see Commercialization).

Active Solar System - A system in which a liquid or air is circulated through solar collectors angled toward the sun. Solar energy heats up the fluid, which then is usually moved by pumps or fans through pipes or ducts to a storage unit--which might be a water tank, or a bin full of warm rocks. The heat is then delivered from the storage unit when needed (see Passive System).

Administrative Costs - The costs incurred by the government in implementing an individual incentive or policy. The costs include the staff time and materials needed to insure that the incentive reaches the people for which it was designed.

Average Cost Pricing - The pricing policy currently used by most gas utilities. Under average cost pricing, the price of old gas and higher cost new gas are averaged together based on the percentage that each contributes to a given utility's gas supply (see Marginal Cost Pricing).

BTU - British Thermal Units, a standard energy measurement.

Back-up - The fossil-fired or electric HVAC systems which provide energy when the solar energy system is not capable of meeting all of the energy demand.

Barrel of Oil - 42 gallons of oil. One barrel of oil is equivalent to 5.8 million Btus.

Baseline Scenario - A set of assumptions about future costs for solar system components and fossil fuels. The costs are considered as the "most probable" description of the future.

Capital Costs - The costs of the equipment and facilities which must be installed before a system is operable. These include piping, solar collectors, storage, etc. These are one-time rather than recurring costs.

Commercialization - May be defined as a process whereby a new type of product, system, technique, manufacturing process or service moves from a merely technology availability status to a status of marketplace acceptance, consumption, and profitability by the private (non-government) sector. The commercialization process is considered to be successful when the venture has proven to be economically viable and private capital represents the primary source of financing.

The process for the successful commercialization of a new system is long and complex. It begins at the conceptual stage with an idea or identified need for a new system, product, or service, or, through financial pressures or opportunities, the development of a new approach to a particular problem. From here it may proceed as follows:

- The "need or idea" must be further defined, the potential market assessed and engineering development, production, and marketing costs projected.

- If initial product costs and marketability appear viable, preliminary funding must be secured for initial efforts, and sources of extended financial support solicited.

- The regulatory environment must be examined and patent privileges defined.

- Market strategy and engineering/product development efforts are undertaken.

- The practicality of the new system must be demonstrated and its possible environmental impacts determined.

- Management actions are undertaken, e.g., site acquisition, tooling and industrial engineering, labor force training, etc.

- New venture groups, organizations, or operations may need to be formed to conduct a specific commercialization effort.

(see Accelerated Commercialization.)

Conventional Fossil System - This is a system which consumes fossil fuel to produce hot water and space conditioning using conventional methods. Fossil fuels is used to fire individual heating and cooling systems at the point of use.

Conversion Efficiency - The percent of one type of energy which is converted to another type of energy by a particular device. In the case of a solar collector, it is the percent of solar radiation converted to thermal or electrical energy. In the case of electric power generation, conversion efficiencies of 33% are typical.

Custom Built - Refers to a building that is constructed for a specific prospective owner.

DOD - Department of Defense.

DOE - Department of Energy; proposed new federal department to combine parts of or entire federal agencies into a single, cabinet level department.

DOI - Department of Interior.

Declining Block Rate - This is currently the most common electric utility rate structure. Under this structure, the customer is charged a different rate for each quantity or block of electricity he consumes in a given billing period. For the first block, the customer is charged a certain fixed amount that covers a portion of the utilities fixed costs in serving the customer (i.e., generating, transmission, and distribution costs), a portion of the utilities demand costs (i.e., the cost of having the generating capacity, transmission and distribution systems that will meet the customers peak demand), and the actual fuel costs of generating the electricity used by the customer in the first block. The next blocks in the declining block rate structure include the balance of the utilities demand costs, and the fuel costs of the electricity consumed in these blocks. The last block includes charges only for the cost of fuel to supply the electricity consumed in this block.

Degree Day - The temperature difference between the daily mean temperature and 65°F.

Depreciation - The reduction in value of an asset as it is used. Depreciation is a tax deductible expense and thus affects the effective cost of an energy system.

Diffuse Solar Radiation - This is the solar radiation which does not come directly from the sun but is reflected or refracted by the atmosphere, air-borne particles, or the earth's surface. A portion of the diffuse solar radiation may be utilized by non-focusing collectors and the Winston collector (see Direct Solar Radiation, Total Solar Radiation).

Direct Solar Radiation - That radiation which comes directly from the sun without being reflected or refracted. This radiation is the only radiation which can be utilized by a focusing collector (see Diffuse Solar Radiation, Total Solar Radiation).

Discount Rate - The rate at which one discounts the future. It is a means of estimating the value of time when calculating costs and making investment decisions.

ERDA - Energy Research and Development Administration.

Economic Feasibility - In this report, economic feasibility refers to whether a proposed energy production technology is less costly than a conventional energy production technology. There are several criteria used to determine economic feasibility (see First Costs, Payback, and Life-Cycle Cost).

Equity - Relates to the distribution of national income over the population. Usually, equity impacts relate to how an incentive effects the well being of low income vs. upper income groups across the U.S.

FEA - Federal Energy Administration.

FHA - Federal Housing Administration.

FHLMC - Federal Home Loan Mortgage Corporation.

FNMA - Federal National Mortgage Association.

FPC - Federal Power Commission.

First Costs - Refers to the capital costs of purchasing a system. First cost comparison is an economic decision criterion often used to choose between alternative heating, cooling, and hot water systems.

Flat Plate Collector - A solar collector which consists of a darkened absorber plate, insulated on the back and sides, with one or more flat transparent covers for admitting solar radiation. A flat plate collector converts solar radiation to thermal energy.

Fossil Fuels - A generic term used to denote energy generated from oil, gas, and coal.

Fuels from Biomass - A solar conversion process where the photosynthesis reaction in plants is used to produce fuels such as plant fiber, methane, and alcohol.

Fuel Costs - The expenditures required to purchase fuel to supply the energy not supplied by the solar portion of the system. These are recurring costs over the life of the system.

GNMA - Government National Mortgage Association.

HUD - Department of Housing and Urban Development.

HVAC - Heating, ventilation and air conditioning.

IRS - Internal Revenue Service.

Industry Infrastructure - All types of organizations with some involvement in the manufacture, delivery, installation, and financing of a solar system are considered to be members of the industry infrastructure.

Insolation - The amount of solar energy falling on a specified surface over a specified length of time. Insolation is usually measured in watts per square meter, langleys per minute, or Btu per square foot per hour.

Langley - A measure of solar radiation equal to one calorie per square centimeter.

Life-Cycle Costs - The cost of owning and operating an energy system over its useful life. Life-cycle cost calculations often include the effects of taxes, the time value of money, and operating and maintenance costs.

Load - The amount of energy to be provided by a given system. A building usually has three different loads that could be supplied by a solar system: water heating load, space heating load, and space cooling load.

Load Factor - The ratio of the customer's average load to his peak load during the day, month or year.

Loan/Value Ratio - The ratio of the amount of a mortgage to the actual market value of the property.

mmb/d - Million barrels of oil per day. One million barrels of oil per day is equivalent to 2.1×10^{11} Btus per year.

Marginal Cost Pricing - Refers to a pricing policy that could be adopted by gas or electric utilities. In the case of the gas utility, the cost of gas would reflect the cost of obtaining new gas supplies (see Average Cost Pricing). In the case of the electric utility, the price of electricity would reflect the differences between the cost of peak and off-peak power (see Time of Day Rate).

Market Penetration - The share of a given market that a system is expected to capture. The market penetration of SHACOB in this report refers to the number (or percent) of new and existing residential and commercial buildings that will use solar energy systems at specific future dates.

Master Metered - Refers to a rental building with multiple occupants but with only one utility meter for the entire building. The building owner usually pays the utility bills in a master metered building, and then adds utility costs into the rent.

NOAA - National Oceanic and Atmospheric Administration.

NEP - National Energy Policy proposed by President Carter on April 20, 1977.

NBS - National Bureau of Standards.

NSF - National Science Foundation.

Noninflated Dollars - These are dollars which have a constant buying power. In other words, they are not affected by inflation.

Ocean Thermal Energy Conversion - A classification of solar energy which utilizes the temperature difference between the warmer surface water which is heated by the sun and the colder sub-surface water in the ocean. This temperature difference is used to drive a low-efficiency heat engine which drives an electrical generator to produce electricity.

Off-Peak - Refers to periods of the day when the demand for electricity is below the average demand (see Peak Demand).

PIES - Project Independence Evaluation System, a FEA computer model of the U.S. energy situation that projects energy supply demand and prices into the future.

PUC - Public Utility Commission.

PITI Ratio - The ratio of Principal and Interest payments plus Taxes and Insurance costs on a mortgage to the prospective borrower's gross income. The PITI ratio is used as a guideline by lending institutions in determining a borrower's eligibility for a home loan. Lending guidelines are usually that the PITI ratio should not exceed 25%.

PITI + E - This ratio includes energy cost in the lenders decision on a home mortgage. PITI + E would take the reduced energy costs of a solar home into consideration in evaluating a mortgage. This would increase the likelihood that a solar home would qualify for a loan.

Passive Solar System - A system which uses creative building design and materials choice instead of separate mechanical devices (see Active Solar System) to use solar energy to heat or cool a building.

Payback - An economic decision criterion that divides the additional cost of a SHACOB system over a conventional system by the annual expected dollar savings resulting from the system.

Peak Demand - Electric utilities experience periods of the day during which demand is considerably higher than the average demand for the utility. Peak electricity is more costly than off-peak for two major reasons: (1) generating equipment used to meet peak loads is sometimes less efficient than base load equipment and usually uses more expensive fuel, and (2) peak generating capacity is used during only a small amount of time.

Photovoltaic Conversion - The conversion of sunlight directly to electricity using solid state semiconductor devices known as solar cells. A solar cell has no moving parts.

Present Value - The economic value which an investor places upon one or more cash flows in the present and/or future. Any future cash flows are discounted by a factor of $1/(1 + r)^n$ to account for the time value of money. (r = interest or discount rate, n = years into the future.)

Quad - One quadrillion British thermal units. A quad is equivalent to approximately 172 million barrels of oil.

Retrofit - Installation of a solar energy system on an existing building.

SHACOB - Solar Heating and Cooling of Buildings.

SEIA - Solar Energy Industries Association.

Solar Access - The legal rights of an owner to have an unobstructed view of the sun from his property. Presently, the courts are ruling that an owner may construct a structure that interferes with the sun rights of another owner. This precedent could be an impediment to the development of solar technology.

Solar Thermal Power Generation - The conversion of solar radiation to thermal energy (heat), and then to electricity. Solar electric systems convert the sun's radiation to electricity using a heat engine to drive a generator.

Solar Total Energy System - A solar thermal power generation system which uses the waste thermal energy to satisfy a thermal load such as building space heating. A photovoltaic conversion system from which heat is extracted from the cells also classifies as a solar total energy system.

Space Conditioning - The control of the temperature and humidity withing the interior of a building. This normally consists of heating the interior in the winter and cooling the interior in the summer.

Speculative Built - Refers to a building that is constructed before a specific owner has been identified (see Custom Built).

Time-of-Day Rate - A rate policy that could be implemented by electric utilities. Lower rates are charged for electricity consumed during the utility's off-peak period of demand and higher rates during peak demand. The time-of-day rate concept is an attempt at implementing marginal cost pricing, because electricity is more costly to produce at peak periods than off-peak periods.

Total National Value (TNV) - The national benefits derived from substituting solar heating for fossil-fuel consumption. They include:

- Reduced dependence on foreign oil with consequent effects on policy independence and balance of trade,

- Safety and environmental effects, compared to those of alternative energy sources:

  - Ecological disruptions as by mining and waste disposal, compared with solar arrays,

  - Threats to future generations from accumulated radioactive wastes,

- Conservation of domestic hydrocarbon reserves for more beneficial uses than consumption as fuel,

- Net advantages over alternative energy sources in their effects on employment, business and productivity.

Total Solar Radiation - The sum of the direct and diffuse solar radiation falling upon a given surface. Solar radiation is normally measured in watts per square meters, Btu's per hour per square foot or in langleys.

Wind Energy - The surface winds on the earth are driven by the sun heating the earth and atmosphere. The collection of a portion of this energy using wind turbines is usually considered to be a form of solar energy utilization.