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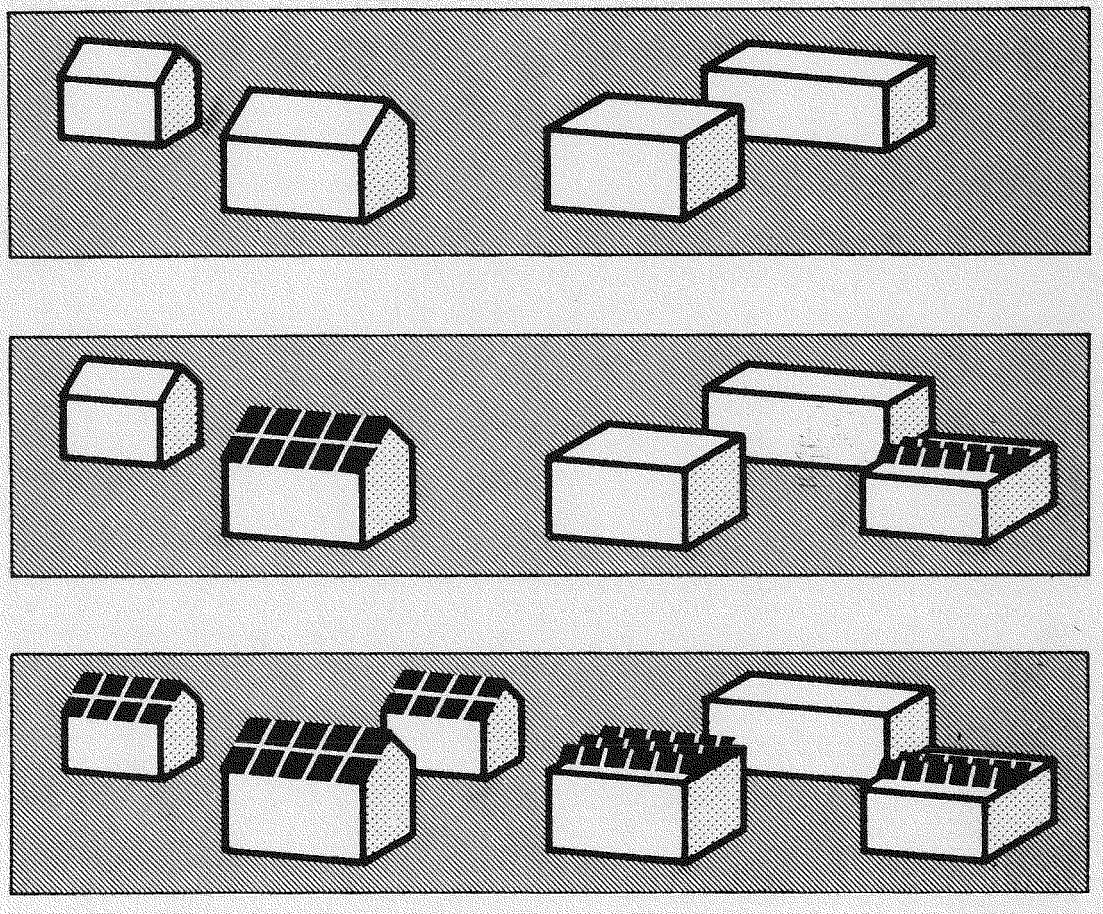
Solar Heating and Cooling of Buildings (SHACOB) Commercialization Report

Part A - Options and Strategies

Volume I — Executive Summary

July 1977



Prepared For
U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Conservation
and Solar Applications
Task Force on Solar Energy
Commercialization (FEA)

Under Contract No. CR-05-70065-00

May 1978

FEDERAL ENERGY ADMINISTRATION ACTIVITIES

The Federal Energy Administration (FEA) is involved with the development and use of solar energy encompassing a broad range of interests including: the direction of the nation's solar-related endeavors as part of our national energy strategy; the policy, planning and overall coordination of solar energy commercialization; and certain regulatory and resource management functions which affect the use of solar energy.

FEA's legislative authority for solar-related activities is based on a number of laws including PL 93-275, PL 93-438, and PL 94-385. Of significance, the Energy Conservation and Production Act (PL 94-385) authorizes 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." As part of PL 94-385, the Congress listed several solar energy commercialization activities which it expects FEA to carry out, a few of which include:

- 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;
- Develop state solar energy commercialization plans and programs and coordinate with state energy conservation programs; and
- Develop such major commercialization projects as, but not limited to, the "Southwest Project," the "Solar Energy Government Buildings Project," among others.

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Prepared By
The Midwest Research Institute

417 1000

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U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Conservation
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Task Force on Solar Energy
Commercialization (FEA)
Washington, D.C. 20545

Under Contract No. CR-05-70065-00

May 1978

NOTE: This report was prepared for the Task Force on Solar Energy Commercialization, Federal Energy Administration (FEA) prior to the activation of the U.S. Department of Energy (DOE) by the Energy Reorganization Act. FEA'S functions have now been transferred to DOE.

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 for the Federal Energy Administration's Task Force on Solar Energy Commercialization. Norman W. Lutkefedder is the Director of the Task Force. Other Task Force members who contributed to this report are: Samuel J. Taylor, LaVerne P. Johnson, Robert Grubenmann, 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.

CONCLUSIONS

• The Principal Conclusions of this Report are...

• A viable, although small, commercial market for solar heating and cooling of buildings (SHACOB) currently exists in the U.S. However, without implementation of the SHACOB incentives contained in the President's proposed National Energy Plan (NEP) and possibly additional incentives, it is uncertain whether the technology will reach its full potential as a major national energy source.

• The utilization of solar heating and cooling in buildings yields national benefits above those incorporated in private sector decision processes. These benefits include; the conservation of highly valued fossil fuels, the long-term availability of the resource, the lack of environmental degradation in energy production, and the reduced dependence on imported energy supplies. Government decisions concerning investments in SHACOB should be viewed in this broader societal perspective.

• Several federal government programs, such as the demonstration program and the development of standards and codes are already aiding the commercialization of SHACOB. Several state governments have also implemented incentives.

• Economic barriers to the accelerated commercialization of SHACOB are currently the most critical. Any comprehensive SHACOB incentive strategy should contain incentives which will directly reduce economic barriers.

• There are also significant institutional and legal barriers to the accelerated commercialization of SHACOB. Economic incentives to SHACOB have only a minimal impact on many of these institutional and legal barriers. Therefore, any comprehensive SHACOB incentive strategy should not be limited to only economic incentives.

• The NEP contains three incentives to reduce economic barriers and two incentives addressing institutional barriers. The NEP, therefore, represents a foundation for the development of a SHACOB market and industry infrastructure.

CONCLUSIONS

- Many federal incentives for SHACOB are best implemented in cooperation with state and local governments.

- Potential barriers associated with the interface between SHACOB systems and gas and electric utilities could be a major retardant to accelerated commercialization. Most currently proposed incentives have very little impact on the SHACOB-utility interface. A comprehensive SHACOB incentive strategy should include programs which directly address the SHACOB-utility interface. Because SHACOB-utility interface incentives have a high potential to negatively affect accelerated commercialization, these incentives should be carefully planned in advance of program implementation. Small-scale utility incentive experiments should probably be conducted in advance of a widespread incentive program.

- Solar market penetration models are helpful in evaluating and comparing the impacts of SHACOB incentives. However, because of the uncertainties and limitations of such modeling efforts, policy decisions should not be based solely on their results.

- SHACOB incentives differ in their impact on various income and interest groups. However, incentives that effectively accelerate SHACOB commercialization but provide disproportionate benefits to specific income or interest groups should not be eliminated from consideration solely on the basis of their equity implications.

OBJECTIVES AND SCOPE

• Report Objectives...

The two primary objectives of this report are to (1) analyze the potential barriers to the commercialization of solar heating and cooling of buildings in the residential and commercial sectors, and (2) investigate government incentives that could accelerate the commercialization process. Most of the barriers to SHACOB commercialization are social rather than technical in nature. These barriers include economic, legal and institutional problems. A wide variety of government incentives could be implemented which will reduce or eliminate these barriers. The incentives are examined individually and then compared to determine their impact on SHACOB barriers, their impact on various income and interest groups, and possible mechanisms for administering them. Finally, the incentives are combined into alternative strategies for accelerating the commercialization of SHACOB.

• Scope...

The term "solar energy" encompasses a wide variety of energy technologies. These generally include solar water heating, 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 considers only the direct conversion of sunlight to energy for producing domestic hot water and space heating and cooling in residential and commercial buildings.

This report emphasizes solar hot water and space heating more than solar cooling because of two factors; (1) solar hot water and heating equipment is closer to widespread commercialization and (2) most of the existing research in the area has focused on solar hot water and heating.

Figure 1 illustrates the scope of this report in terms of possible solar applications to building end uses. As indicated in the figure, applications not addressed here will be the topic of future FEA reports.

SOLAR ENERGY TECHNOLOGY

Building End-Use	DIRECT THERMAL		TOTAL-ENERGY		PHOTOVOLTAICS		WIND
	Non-Concentrating	Special and Concentrating	Thermal	Photovoltaic-Thermal	Non-Concentrating	Concentrating	
Hot Water	■	■					
Heating	■	■					
Cooling	■	■					
Electricity							

■ Addressed in this Report ☐ Addressed in Later Reports

Figure 1 - Solar Energy Applications for Buildings Addressed in This Report

BACKGROUND

• National Perspective...

Energy problems in the United States are continuing to grow more severe. U.S. energy demand in 1975 was equivalent to about 34 million barrels of oil per day (mmb/d). Demand is projected to grow to 47 mmb/d by 1985 and 55 mmb/d by 1990. The integral role that energy plays in the U.S. economy makes energy of vital interest to policymakers and the nation. SHACOB represents a partial solution to our current energy problem.

Government investments in SHACOB can be viewed from two perspectives. Investment decisions can be made on the basis of economic factors, as viewed by the private sector, or on the basis of broader societal costs and benefits. Factors entering the broader decision perspective include; environmental costs and benefits, balance of trade implications, impacts on conservation of domestic resources and the societal value of conventional fuel savings. Because solar energy is an inexhaustible, environmentally benign, domestically available and abundant resource, this broader perspective more accurately reflects the interests of the nation.

The benefits of conserving fossil fuels depend on the amount of fuel saved and its value to society. As a substitute for conventional fuels, each Btu of energy produced from solar energy usually displaces up to 3 Btus of fossil fuels because of losses that occur in the generation, transmission and conversion of those fuels to usable heat in buildings. Because the demand for limited supplies of fossil fuels is expected to grow in the future, the value to society of using alternative energy sources such as solar energy will increase.

Alternative projections of future fuel prices (the most widely used private sector measure of energy's value) differ widely. However, because the prices of electricity, fuel oil, and natural gas are generally expected to increase in the future, the economic value of SHACOB in displacing conventional energy sources will also increase. An additional benefit of SHACOB from a private sector as well as societal point of view is the certainty of its long-term availability.

• Regional Perspective...

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 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. Because of regional variations in these factors, SHACOB systems may ultimately be used more extensively in some regions of the country than in other regions.

• Participation in SHACOB Commercialization...

The federal government, state and local governments, the solar industry, and utilities have been participants in the development of the SHACOB market to date and will continue to play important roles in future commercialization.

THE FEDERAL GOVERNMENT: The federal government has been active in the accelerated 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 Congressional action most relevant to this report. The act authorizes the Federal Energy Administration (FEA) to develop plans and strategies to promote the accelerated commercialization of solar energy and provide coordination of federal solar energy commercialization activities. The 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 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;

- Develop state solar energy commercialization plans and programs;

- Develop such major commercialization projects as, but not limited to, the "Southwest Project," and "Solar Energy Government Buildings Project."

This report represents an initial step in accomplishing these objectives.

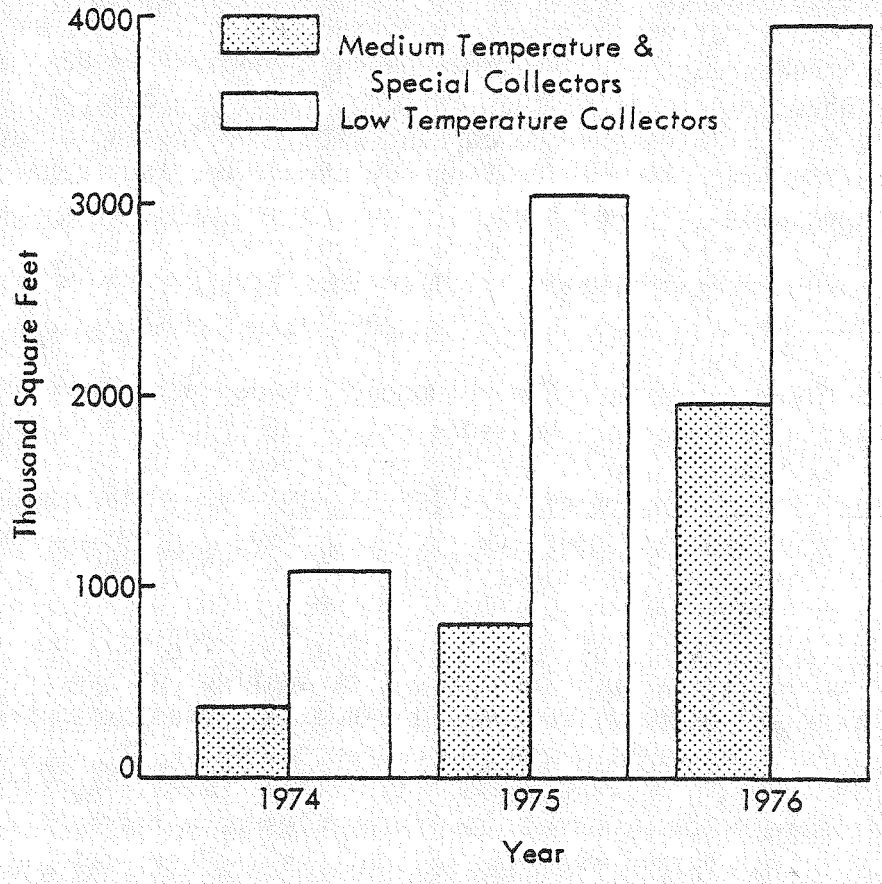
A multi-agency federal approach to accelerated solar energy commercialization is necessary because no single federal agency encompasses all the expertise and working relationships with the private sector that are essential for accelerating solar energy commercialization. Under the present multi-agency structure, the key federal energy agencies are FEA, the Energy Research and Development Administration (ERDA), and the energy-related parts of the Department of Interior. Concurrent with coordination of solar energy commercialization within the federal energy structure, the "non-energy agencies," especially the Department of Housing and Urban Development, 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.

Solar energy research, development and demonstration programs are coordinated by ERDA under the legislative authorization of the following acts: the Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409), the Energy Reorganization Act of 1974 (PL 93-438), the Solar Energy Research, Development and Demonstration Act of 1974 (PL 93-473), and the Non-Nuclear Energy Research and Development Act of 1974 (PL 93-577).

STATE AND LOCAL GOVERNMENTS: Many state and local governments have been active in implementing policies affecting SHACOB. Programs introduced in the past few years include tax incentives, building code modifications, easements, zoning ordinances, 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.

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 or finance offices. Some states also have a public information program. The federal government has been working cooperatively with the states through demonstration programs, the energy extension service and other programs to accelerate SHACOB commercialization.

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. Collector manufacturing is a primary indicator of the industry state of development. Figure 2 summarizes known collector manufacturing activities during the past 3 years.



Source: FEA Collector Survey, April 1977. The Survey is included in Volume III, Appendix A.

Figure 2 - Solar Collector Annual Production Rate

BACKGROUND

The cumulative production of all types of collectors from January 1974 to June 1976 was approximately 11 million sq ft. Medium temperature (140°-250°F) and special collectors, the collectors most commonly used in SHACOB systems, accounted for approximately 26% of this production while low temperature (60°-90°F) collectors accounted for 74%. Low temperature collectors are used almost exclusively to heat swimming pools. The total production of all collectors from 1974 to 1976 represents a fuel savings of approximately 1,300 barrels of oil equivalent per day.

There were 177 companies manufacturing medium temperature collectors in the second half of 1976. The fragmentation of the current collector industry, in conjunction with its small volume output, reflects the early stage of industry development.

UTILITIES: Utility involvement in SHACOB usually takes the form of providing backup energy. Backup energy is required because it is rarely 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 have become aware of their roles in SHACOB commercialization and are experimenting with SHACOB systems.

A wide variety of SHACOB projects have been sponsored by electric utilities. Some projects are undertaken only for informational purposes. Another type of project commonly sponsored by electric utilities is the provision of instrumentation for monitoring the performance of solar buildings. Other electric utilities have provided financing for SHACOB demonstration projects or sponsored SHACOB research projects in universities. A final type of project sponsored by several utilities addresses the specific problem of the SHACOB-electric utility interface.

Gas utilities have also begun to explore 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 undertaken by gas utilities and the federal government is the solar assisted gas energy (SAGE) experiment. The objective of the SAGE experiment is to explore the potential for commercializing gas-supplemented solar water heating systems in multi-family dwellings in Southern California.

• Barriers to SHACOB...

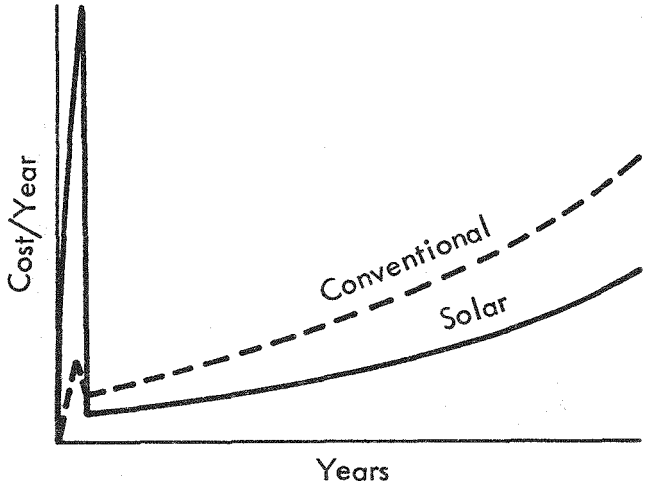
While the potential benefits of the widespread use of solar energy in buildings are significant, there are a number of barriers that could slow SHACOB commercialization. These barriers are categorized as economic, institutional, legal, technological and environmental. It is important to realize, however, that many of these barriers have overlapping aspects to them and could be placed in several of the barrier categories.

• Economic Barriers...

Economic barriers to SHACOB commercialization are currently believed to be the most critical. There are five basic economic barriers:

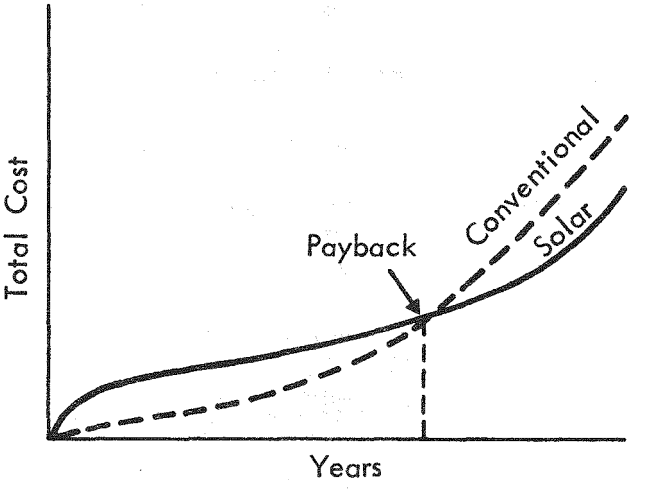
CONSUMER ECONOMIC DECISION CRITERIA: The consumer's economic decision criteria refers to how a potential buyer determines whether the SHACOB investment is worth the cost. Residential, commercial, and institutional building owners and developers currently use a wide variety of decision criteria. These include choosing systems based on their first costs, a payback calculation, or a life-cycle cost criterion. The major difference among these approaches is the number of cost factors considered, which has a major impact on which energy alternative is chosen. Figure 3 shows that on the basis of first costs, solar cannot compete with conventional systems. On the basis of payback, Figure 4 shows that at some point in time the cumulative savings from solar will equal the additional first costs. The key factor is how long a payback consumers will accept. A life-cycle cost analysis, which includes a discount factor that makes future benefits less valuable than current outlays, may discourage the solar investment. If first costs continue to be the predominant decision criterion in the residential sector and parts of the commercial sector, SHACOB will face a major barrier.

BARRIERS TO SHACOB



Source: Midwest Research Institute

Figure 3 - Cash Flow Patterns



Source: Midwest Research Institute

Figure 4 - Cumulative Expenditures

OWNERSHIP: As shown in Figure 5, in many building situations, the person who is responsible for choosing mechanical systems is not the same person ultimately responsible for paying the utility bills. Because the decision maker is unable to directly receive the benefits from a SHACOB system, which are realized through reduced utility bills, he may not be motivated to install a solar system. This is the case in all buildings that are constructed and sold on a speculative basis, where no specific owner has been identified. Many rental buildings present a similar situation. Until developers and owners of rental property can be assured that they can pass on the higher costs of solar systems through higher sale prices and rents, the decision maker and bill payer separation could be a serious barrier to SHACOB in a large number of buildings. When the SHACOB decision maker and bill payer are the same individual, as is the case with the custom built, single family home, installation of a SHACOB system is more likely to be considered. This is because decision makers are assured that they will realize the benefits of the SHACOB system through lower utility bills.

Possible SHACOB Decision Makers and Utility Bill Payers	RESIDENTIAL								
	Multifamily						Single Family		
	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		
Building Owner	B		DB	D	DB	D	B	DB	DB
Rental Occupant		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. Custum 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 5 - Matrix of SHACOB Decision Makers and Utility Bill Payers for Residential Buildings

COST BARRIERS: SHACOB systems, while oftentimes less expensive than conventional systems on a payback or life-cycle cost basis, are more expensive on the basis of first costs. Solar water heating is the SHACOB technology that is currently closest to economic feasibility in most areas and has reached that point in some areas. At an installed cost of $25/sq ft of collector, the initial cost of a solar water heating system for a single family home would typically be approximately $1,250 (50 sq ft is a typical collector area for a single family home). Solar heating and combined heating and cooling systems currently have substantially higher initial costs. A consumer may need to finance the purchase of a solar system with a loan, adding financing costs to the cost of the solar system. Even with future increases in fuel prices, some SHACOB systems may not be competitive with conventional systems on a life-cycle cost basis. Competitiveness on the basis of life-cycle cost will depend on the discount factor and system lifetime that consumers are willing to use.

FINANCING PROBLEMS: The high initial cost of SHACOB systems creates financing problems for SHACOB owners. The only way for most building owners to obtain the needed funds is by borrowing from a financial institution. Securing a loan adds interest costs to the

cost of owning a SHACOB system. There may also be some problems in obtaining loans for SHACOB from financial institutions. The problems of obtaining loans are described in detail below under "Financial Institutions."

COMPETITION WITH ALTERNATIVE FUELS: 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. The large number of special tax benefits, direct subsidies, research and development subsidies, and regulations concerning pricing and operation of conventional fuel supplies insures that current prices do not reflect either the costs of production or the fuel's value to the consumer. Any part of the total cost of conventional fuels that is shared by all sectors of the society, such as pollution costs, is also not reflected in the prices of conventional fuels. All of these factors reduce the ability of SHACOB to compete with conventional systems.

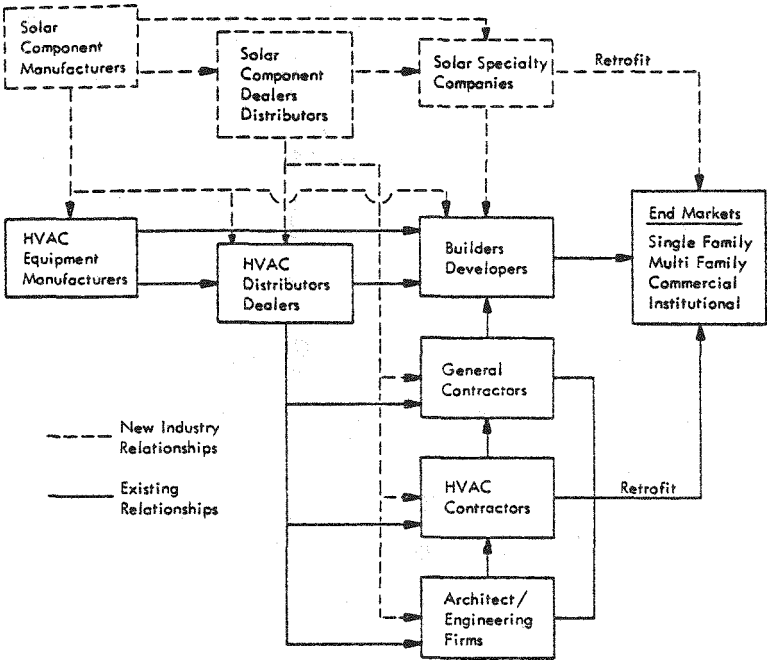
• Institutional Barriers...

A number of potentially serious institutional barriers to SHACOB commercialization have surfaced in recent solar research and early SHACOB installations. There are six basic institutional barriers.

FINANCIAL INSTITUTIONS: Traditional financial institutions, which currently play a major role in providing both construction and long-term financing for the building industry, will need to play a similar role in the development of the SHACOB industry. Lenders appear to be currently hesitant to make a large number of loans for SHACOB systems. Their primary concern is that the actual value of a solar system on the resale market may be less than its cost. Uncertainty of system performance, lack of sales data on the market response to solar homes, the small amount of experience of the solar industry are other lender concerns. In addition to these concerns, the high first costs of a SHACOB system could disqualify many homebuyers for mortgages on the quality of house they wish to purchase. The terms under which a SHACOB system is financed will have a major impact on the economic attractiveness of the system. First mortgages offer the most lenient terms. The high monthly carrying costs of a system financed through a second mortgage or a home improvement loan may present a significant barrier. Most retrofit systems will be financed through a home improvement loan.

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, and installation of a SHACOB system represent individual steps in the delivery of the final product. Historical analyses of the introduction of past innovations in the building industry show that fragmentation and horizontal stratification within the industry act to resist change. Figure 6 is a schematic diagram of the relationships that could exist for completing a SHACOB system in a mature SHACOB industry. The figure shows the existing participants in the delivery of heating, ventilating and air conditioning equipment (HVAC) 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. The threat of delay associated with inexperience, and inflated costs resulting from uncertainty on the part of industry participants, act to reduce the attractiveness of SHACOB to prospective purchasers. In addition to the participants directly involved in the manufacture, distribution and installation of a SHACOB system, lending institutions, code authorities, insurance companies and other organizations play important roles in the completion of a SHACOB system. These organizations must also gain experience with SHACOB systems.



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

Figure 6 - Schematic Diagram of Industry Infrastructure

BUILDING CODES AND STANDARDS: The federal government has already initiated an effort to remove the barrier presented by the lack of codes and standards covering SHACOB systems. Interim Performance Criteria for both residential and commercial SHACOB systems have now been completed. HUD/FHA Intermediate Minimum Property Standards for solar water and space heating systems have also been completed. These criteria and standards are expected to be adopted by relevant industry groups as consensus standards. 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 standards to be implemented at the local level. The severe fragmentation of building codes necessitates that any SHACOB standard be applied by a large number of administering organizations.

SHACOB-ELECTRIC UTILITY INTERFACE: SHACOB systems are rarely economically designed to supply 100% of a given load. It is essential, therefore, that a backup supply of energy be available to the SHACOB user. If a SHACOB system depends on an electrical backup system, uncertainty in the supply and cost of backup electricity could be a significant barrier to SHACOB. Existing rate structures may not adequately reflect the cost of service to a solar building as well as conventional buildings. Utilities, therefore, may adopt more cost reflective rates in the near future. Under different rate structures, the practicality of various SHACOB system concepts and specific designs may be radically different. The uncertainty as to how this problem will be resolved casts significant doubt on the cost effectiveness of SHACOB systems with electricity backup which are being installed today.

SHACOB-GAS UTILITY INTERFACE: The major barrier to SHACOB posed by the gas utility industry is that the current federal and state pricing policies of gas utilities require that the retail price of gas be based on the average wholesale cost of gas to the utility company. 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. Under the average pricing policy, the consumer, a 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 is therefore a barrier to commercialization.

CONSUMER ATTITUDES: While cost may be expected to be the dominant consumer concern in using solar systems, other considerations may have a significant impact on the solar purchase decision. Other than cost, public understanding of the energy crisis in general, the lack of consumer information on SHACOB 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. A large number of negative consumer experiences with SHACOB systems could have a detrimental impact on the future success of SHACOB.

• Legal Barriers...

Legal problems could also be barriers to SHACOB commercialization. The two most significant legal barriers are solar access and land use and zoning ordinances.

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. 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. In most states, no binding legal precedents for sun rights have been established. 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 for a specified length of time.

LAND USE AND ZONING ORDINANCES: 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.

• Other Barriers...

Two other barriers that affect SHACOB commercialization are technological barriers and environmental impacts.

TECHNOLOGICAL BARRIERS: For the most part, SHACOB has demonstrated its technical feasibility. Some improvements, however, are needed in many areas, particularly in the areas of solar cooling, energy storage, system life and overall system performance. Currently, solar cooling systems require temperatures that can only be supplied by expensive concentrating and special collectors. Energy losses and the economics of thermal storage systems could be improved. Improved materials and manufacturing methods could increase system durability and expected useful life. The performance of all SHACOB systems can be improved. Technical improvements should enhance the commercial prospects for SHACOB.

ENVIRONMENTAL IMPACTS: The only significant direct negative environmental impacts that are expected to result from SHACOB commercialization are the by-products of processing raw materials, manufacturing components, and construction activities for SHACOB. Because solar energy does not directly involve combustion or nuclear reactions, the two primary sources of environmental concern associated with energy production are eliminated.

• Modeling Penetration...

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 design, (4) economic comparisons, (5) market penetration curve development, and (6) national impacts estimation. Figure 7 presents these elements and their relationships.

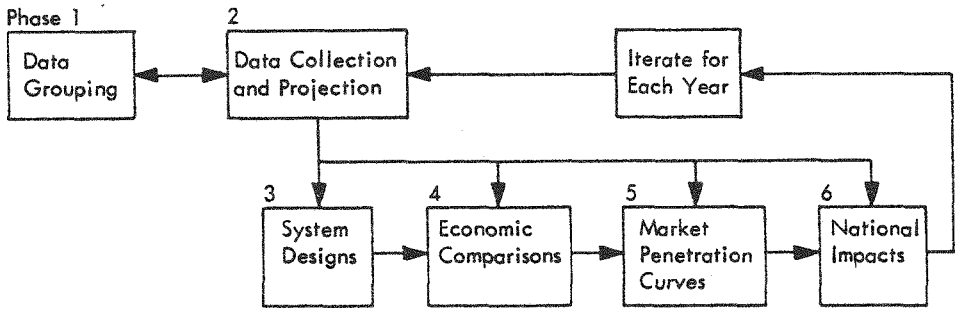


Figure 7 - Basic Elements of All Solar Energy Market Penetration Models

MODELING PENETRATION

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. has developed an extensive model of SHACOB market penetration for 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. ERDA, with support from the MITRE Corporation, has undertaken a similar modeling effort to project the market penetration of SHACOB.

SHACOB market penetration estimates from 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 U.S. energy demand.

• Solar Incentives...

It appears that the near-term market penetration of SHACOB will be uncertain and probably small if currently established government programs are the only SHACOB incentives provided. The potential benefits of SHACOB suggest that additional SHACOB incentives could be justified.

• Federal Economic Incentives...

Federal economic incentives include those actions by the federal government that would have a direct impact on the cost of SHACOB systems. Economic incentives can be directed at SHACOB individual users, business users, SHACOB producers, builders, developers and utilities. User incentives are emphasized in this report because most incentive policies to date have been formulated with the thought that stimulating the demand for SHACOB systems may be sufficient incentive to stimulate the production of SHACOB components. However, most user incentives could be designed to be directed at producers. One specific producer incentive, a program to use solar energy in government buildings, is examined.

GRANTS: A grant could be made by the federal government to an individual or business SHACOB user to reduce the cost of the SHACOB system. The grant would equal the total value of the system or some fraction of the total cost. The grant could be paid in advance of purchase. A grant program is already being pursued by the federal government on a limited basis. These grants, however, have been primarily directed at demonstrating SHACOB systems. Recently, the federal demonstration efforts have been expanded to make grants up to $400/unit for the residential use of solar water heating systems. A commercial grant program providing grants for the installation of solar hot water systems in hotels and motels has also been initiated.

INCOME TAX CREDITS: An income tax credit offsets the income tax liability of homeowners purchasing solar energy systems. An income tax credit for residential solar equipment is a key solar incentive in the President's proposed National Energy Plan. The amount of the tax credit is equal to a specific percentage of the SHACOB system cost, up to a maximum amount. The credit could be limited to the SHACOB purchaser's tax liability in the year of purchase, or be designed to allow for payment in excess of the liability, or spread the credit over several years. The SHACOB purchaser must first purchase the system entirely with his own funds and then later be partially reimbursed by the credit.

INCOME TAX DEDUCTIONS: Under an income tax deduction 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 apply to the business user. The actual value of the deduction is directly related to the users income tax rate, with users with higher tax rates receiving larger amounts.

INVESTMENT TAX CREDITS: The investment tax credit is an incentive that lowers the first costs of SHACOB for business users. An investment tax credit for SHACOB is included in the President's proposed National Energy Plan. The incentive allows SHACOB purchasers to claim an additional percentage credit above the credit for which they would otherwise be eligible.

ACCELERATED DEPRECIATION: Another incentive designed to encourage the use of solar equipment by business users is the accelerated depreciation allowance. Proposed legislation, modeled after the federal law permitting the 60-month amortization for costs of pollution control facilities, would allow a taxpayer to amortize over a 5-year period solar equipment used in nonresidential buildings.

LOW INTEREST LOANS: A low interest loan incentive is designed to lower life-cycle costs. There are a number of different types of low interest loan programs that could be used to accelerate SHACOB commercialization. The federal government could directly provide low interest loans for SHACOB systems offering the same interest rate as the U.S. 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 interest rate. The loan program could be directed at either individual or business users, or both groups. A low interest loan program could also be designed to assist SHACOB producers, particularly small businesses.

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 option, intended to limit the government insurance to cover only the additional risks of the SHACOB system, would be for the government to pay for system repair, replacement, or conversion to a conventional system in the event that under foreclosure, the system lowered the resale value of the property.

PROPERTY TAX EXEMPTION: This federal incentive is intended to exempt solar hardware from state and local property taxes. The incentive could be designed to have state and local governments waive property taxes on solar systems and then be reimbursed for the lost revenue by the federal government. Alternatively, the federal government could allow all property taxes paid on solar systems as a tax credit on federal income tax returns. The property tax exemption could be applied to all user groups. The complexity of administering this incentive may reduce its effectiveness.

SOLAR ENERGY GOVERNMENT BUILDINGS PROGRAM: This incentive is directed at SHACOB producers. The program is defined as a planned program of accelerated procurement and installation of SHACOB systems in federal buildings throughout the U.S., using technically proven equipment. A program to use SHACOB in government buildings is included in the President's proposed National Energy Plan. The purpose of the program is to help stimulate the growth and improved efficiency of the SHACOB industry infrastructure, and thereby reduce system costs and increase the public and private availability of SHACOB systems.

• Federal Noneconomic Incentives...

There are a number of federally initiated programs, which, although having no direct impact on SHACOB system costs, could accelerate SHACOB commercialization. These programs are directed at institutional, legal, as well as some economic barriers to SHACOB commercialization.

DEMONSTRATION PROGRAMS: The federal government is currently sponsoring a substantial program to demonstrate residential and commercial SHACOB systems. The program is designed to identify any technical or other constraints to SHACOB use, and to develop approaches to remove these constraints. A key aspect of the program is the collection of data on the technical and economic performance of SHACOB systems and the acceptance of SHACOB by industry and consumers. Three cycles of awards for residential buildings and two cycles for commercial buildings have already been completed under the program.

CONSUMER EDUCATION PROGRAM: While the federal government has already initiated a consumer education program on a small scale, a more aggressive program could be a significant incentive for SHACOB. The function of the program is to provide the general public, builders, developers and various special interest groups with information on SHACOB systems. The 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 federally financed joint federal and state consumer education program is proposed in the President's National Energy Plan.

FINANCIAL EDUCATION PROGRAM: A financial education program could have several functions. 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. Another function would be to inform the primary mortgage lenders of the terms on which SHACOB mortgages would be saleable on the secondary mortgage market. The program could 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.

BUILDING CODE AND CERTIFICATION PROGRAMS: The federal government has already initiated complementary programs that will lead to definitive performance criteria, minimum property standards, and, in conjunction with industry groups, voluntary consensus standards for SHACOB systems. 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, as proposed in the President's National Energy Plan, could work with the states to develop certification programs that would document compliance of SHACOB components with the appropriate standards. A program to accelerate the adoption of solar standards by local code authorities could also be developed.

UTILITY RATE PROGRAMS: The major policy option for removing the barrier to SHACOB commercialization posed by utility rate policies is to develop rate structures that would encourage rather than penalize SHACOB use. There are several rate options that could be implemented. Their impacts on both the SHACOB users and the utilities are not yet well understood. Electric utilities could adopt time-of-day rates, perhaps in conjunction with an interruptible service agreement, to insure that the SHACOB user does not aggravate the utility's peak load. In return, the SHACOB user could be offered a lower utility rate. The President's proposed National Energy Plan would require electric utilities to adopt more cost responsive rates such as time-of-day rates. Gas utility policies could be changed to require long-run marginal cost pricing, removing the average pricing barrier. Utility rate changes will need to be made with caution as they will have substantial impacts on consumers.

UTILITY LEASING OR OWNERSHIP PROGRAMS: A policy option that has been suggested to reduce the problems posed by the SHACOB utility interface is to permit the utility to own 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. Regulatory policies will need to be modified to allow utility involvement in the SHACOB industry.

GOVERNMENT INSURANCE PROGRAMS: A government insurance program could be used to remove the barrier presented by the lack of adequate system guarantees that are currently offered by the SHACOB industry. The program 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 the SHACOB system. Defective components or inoperative systems would be repaired or replaced at the expense of the federal government. The insurance program would, of course, be conducted in the context of an adequate standards and certification program, as was discussed previously. This would reduce any deliberate efforts to exploit an insurance program. The exact structure of this type of program needs to be further evaluated. It is possible that the program could encourage poorly constructed systems.

• State and Local Incentives...

Many of the federal incentives examined require state and local government participation. Other federal incentives could be more effective with state and local participation. State and local governments could also act directly to provide incentives for SHACOB. Some state and local governments have already demonstrated their commitment to SHACOB development by implementing incentives. To date, state and local 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.

• Incentive Comparisons...

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. The comparisons presented below are based on: (1) the impact of federal incentives on SHACOB barriers, (2) the equity implications of federal incentives and (3) the administrative mechanisms that could be used to implement federal incentives.

IMPACT OF FEDERAL INCENTIVES ON SHACOB BARRIERS: Figure 8 presents a matrix of the relationship between SHACOB incentives and barriers. 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 cost rather than initial costs. The government buildings program is different in that its major impacts could be on the SHACOB industry infrastructure and the use of inappropriate decision criteria.

The other incentives impact a wider variety of barriers but influence economic barriers only minimally. In fact, there is very little similarity in how these other incentives influence barriers. Most are designed to eliminate one or two specific barriers and have only minimal effect on other problems. Examples of this situation include; the consumer education program, financial education programs, building code and certification programs, utility rate and leasing programs, and government insurance programs. The potential for negative impacts on SHACOB commercialization is highest with utility leasing and rate structure programs. However, poor design or administration of almost any incentive could negatively impact SHACOB commercialization.

Based on the impacts of SHACOB barriers, a comprehensive SHACOB incentive strategy would include economic incentives and a selected group of other incentives aimed specifically at institutional, legal and technical barriers.

INCENTIVE COMPARISONS

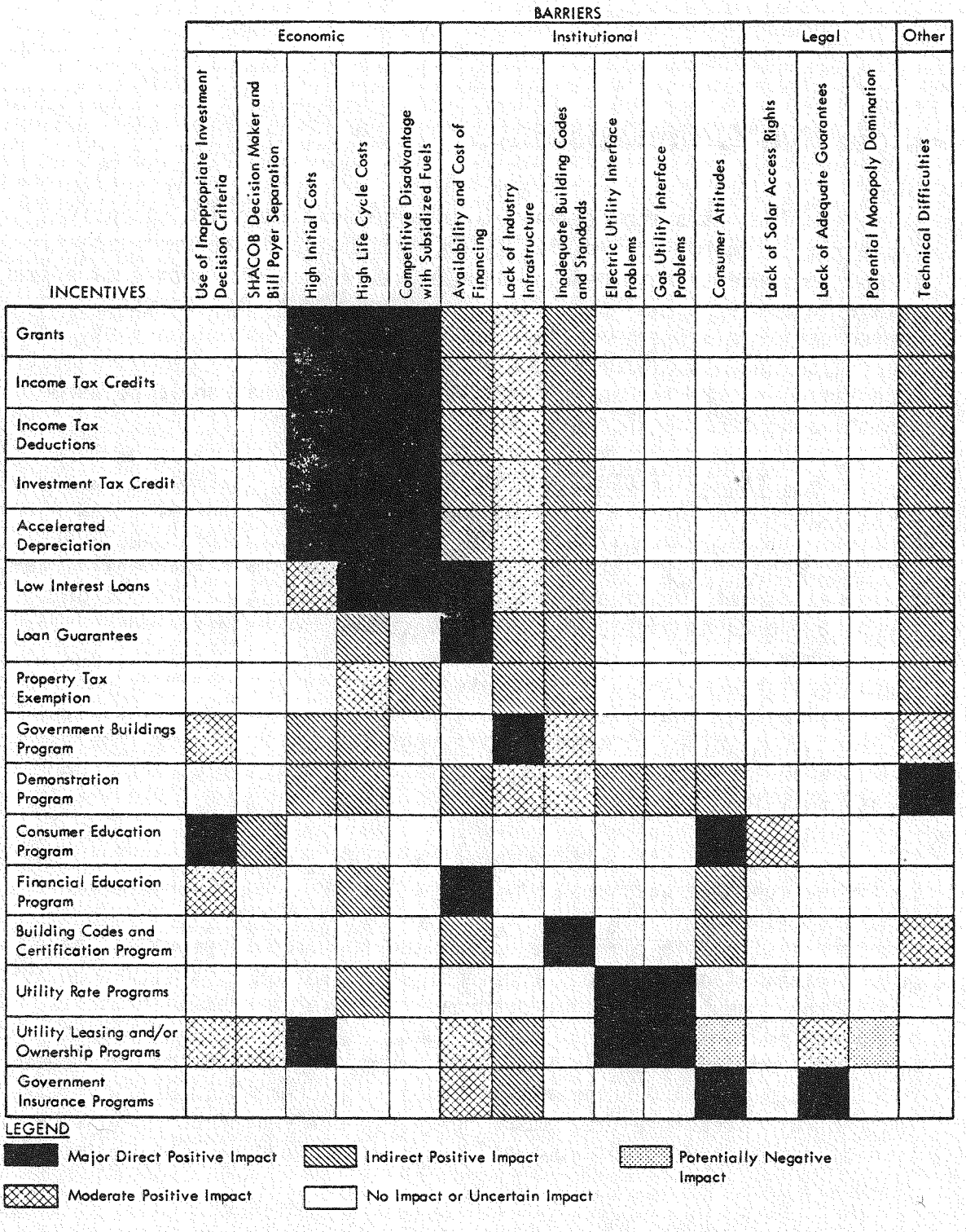


Figure 8 - Comparison of Impacts of Incentives on SHACOB Barriers

INCENTIVE COMPARISONS

COMPARISON OF EQUITY IMPACTS OF FEDERAL INCENTIVES: Incentives also differ in their impact on the various income and interest groups. Figure 9 summarizes the equity impacts of the incentives. Figure 9 indicates that several of the federal economic incentives affect the three user groups (i.e., low income, middle and upper income, and business users) differently. Tax deductions and, to a lesser extent, tax credits provide disproportionate benefits to middle and upper income groups. The grant program appears to be the most flexible economic incentive. Figure 9 also indicates that the SHACOB industry benefits from almost all incentives. Utilities only receive direct benefits from a very small number of the incentives. Most incentive programs discussed to date are directed at user groups.

It may be more important to combine incentives to assure rapid market penetration by impacting the most serious SHACOB barriers rather than allow equity to be an overriding consideration. Incentives which might be very effective in accelerating SHACOB commercialization may produce some inequities. It is possible to offset these inequities through other federal programs. However, an incentive program's equity implications should be understood before the program is implemented.

INCENTIVE COMPARISONS

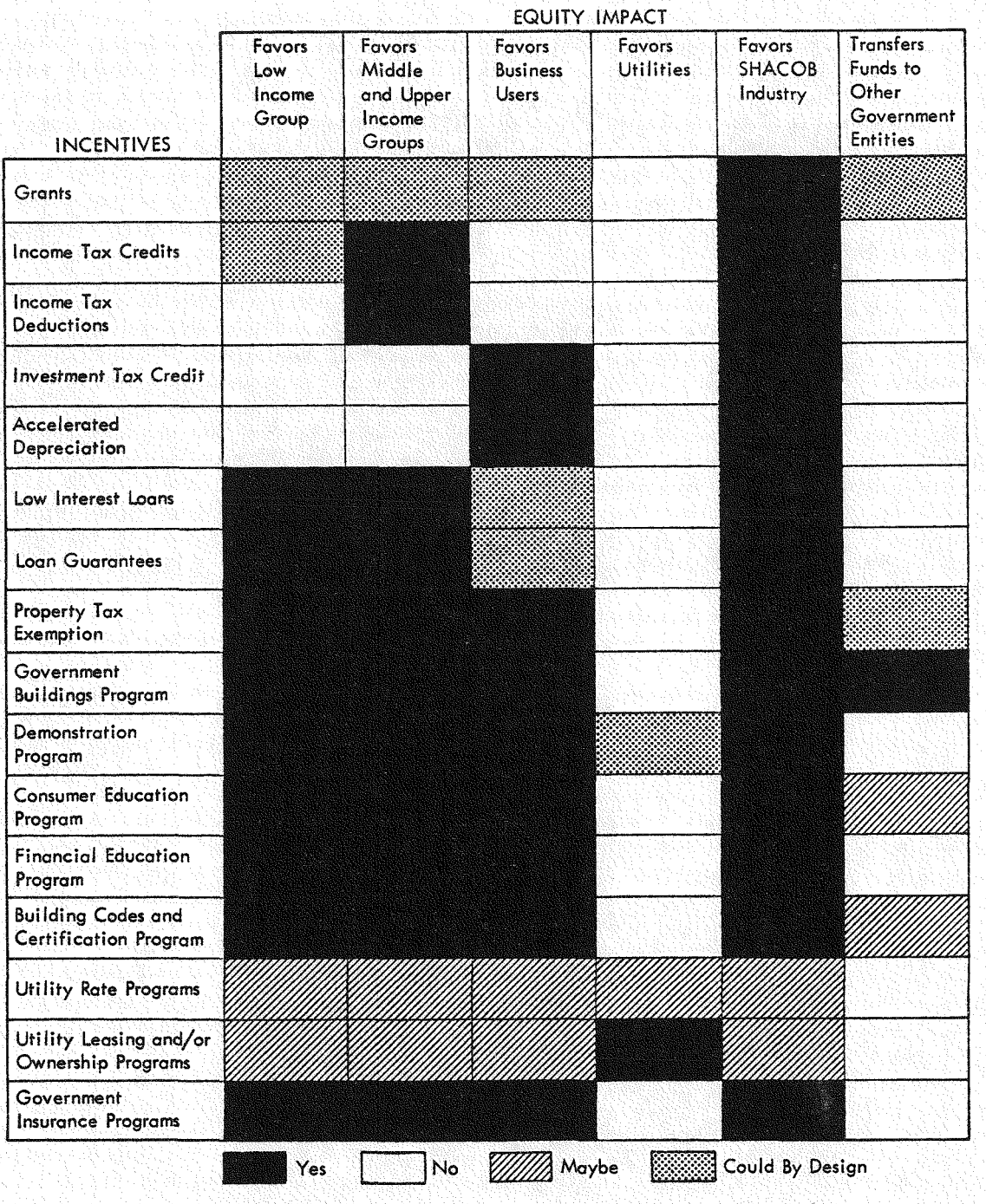


Figure 9 - Summary of Equity Impacts of SHACOB Incentives

INCENTIVE COMPARISONS

COMPARISONS OF ADMINISTRATIVE MECHANISMS OF FEDERAL INCENTIVES: Figure 10 summarizes the administrative mechanisms available for each of the incentives. As expected, the federal government will play a role in administering any federal SHACOB incentive. 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 also be very helpful in implementing grant incentives, consumer education programs, and government insurance programs.

All of the incentives could be administered through existing government entities, although new entities could be created to administer a few. Very few estimates of the administrative costs of solar incentives are currently available. In addition, it is not clear that the creation of a new government entity would require more funds than expansion of existing organizations. Therefore, the administrative mechanism of incentives should not have an integral role in the choice of an optimal combination of incentives.

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

Figure 10 - Summary of Administrative Mechanisms for Federal SHACOB Incentives

• 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. Three incentive combinations representing three levels of government investment in SHACOB are examined.

• National Energy Plan...

The President'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 solar components of the NEP are:

- residential tax credit providing a credit equal to 40% of the first $1,000 and 25% of the next $6,400, for a maximum credit of $2,000 to homeowners, phased out gradually over 7 years;
- business investment tax credit providing an additional 10% credit, above the normally applicable credit, for solar equipment installed in industrial and commercial buildings;
- solar energy government buildings program authorizing FEA, in conjunction with other federal agencies, to install SHACOB systems in federal buildings, budgeted at $100 million through 1980;
- consumer education and promotion program supported by the federal government and operated in cooperation with state governments;
- standards development and certification program supported by the federal government and operated in cooperation with state governments; and

- encourage state governments to pass legislation exempting SHACOB equipment from property taxes, to pass legislation protecting solar access, and to develop guidelines to prevent utilities from implementing policies that discriminate against SHACOB users.

Adoption of all the solar incentives contained in the NEP is expected to have a substantial positive impact on SHACOB commercialization. First cost and life-cycle cost barriers for both business users and homeowners will be significantly reduced by the tax provisions contained in the program. These cost reductions 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 lead to the elimination of 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 large 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 research, development, and demonstration programs, should greatly reduce any technical difficulties with SHACOB systems.

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 reduce availability. Proposals to encourage utility rate reform, such as requiring utilities to implement time-of-day rates, also have implications for SHACOB. The exact impact of the NEP utility rate reform proposals on SHACOB is not yet well understood.

• Expanded National Energy Plan...

A number of programs in the proposed NEP could be expanded to form SHACOB incentives. These expanded NEP incentives, in conjunction with incentives already enacted into law but not yet implemented, comprise another comprehensive strategy for SHACOB commercialization. The incentives that could be included in an expanded NEP program, in addition to those incentives included in the NEP, are:

- consumer education program and standards and certification program pursued more aggressively than in NEP;
- expand NEP program requiring utilities to offer homeowners financing for residential energy conservation measures to include financing for SHACOB;
- make SHACOB eligible for grants which the NEP offers to public and non-profit schools and hospitals for conservation equipment;
- expand Federal Energy Management Program to assure that the cost effectiveness criteria allow installation of SHACOB;
- implement loan guarantees for loans made for SHACOB systems as authorized under Title IV of the Energy Conservation and Production Act (PL 94-385).

An expanded NEP that included the programs described above in addition to the basic NEP solar incentives is expected to have a significantly larger positive impact on SHACOB commercialization than the NEP alone. There will, of course, be increased costs associated with this program.

• New Initiatives...

It is possible that SHACOB incentives in addition to those contained in the NEP and expanded NEP programs may be desirable. These new initiatives could be implemented if it were decided that the benefits of SHACOB warranted further accelerated commercialization. New initiatives include:

- increased funding of the proposed NEP government buildings program from $100 million to $200 million or $500 million;
- an accelerated depreciation incentive for business users;
- a low interest loan program;
- a financial education program;
- a government insurance program; and
- require new buildings with natural gas hookups to install or at least investigate the feasibility of SHACOB systems.

This program would have several positive impacts on SHACOB commercialization barriers in addition to the impacts of the expanded NEP, leading to greater market penetration as well as greater cost to the government.