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Barriers and Incentives to the Commercialization of Solar Heating and Cooling of Buildings

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Abstract

This paper reviews potential barriers to the widespread use of solar heating and cooling systems in residential and commercial buildings. Although solar systems have been technologically proven and are used to a limited extent today, economic, institutional, and legal barriers may slow future commercialization. Consideration of incentives which might reduce these barriers raises the question of how to evaluate alternative policy question options.

1. INTRODUCTION

A viable, although small, commercial market for solar heating and cooling of buildings (SHACOB) now exists in the U.S. While the technical feasibility of SHACOB systems for residential and commercial buildings is well established, a number of potential social problems could slow commercialization. Several economic, institutional, and legal barriers may confront SHACOB commercialization, limiting the energy contribution from this technology. In order for SHACOB to become a significant energy source, these barriers will need to be overcome. The barriers discussed in this paper are not unique to the introduction of solar heating and cooling systems and are likely to confront the introduction of many new technologies into the building industry. Recognition and resolution of potential barriers at an early date will accelerate SHACOB commercialization.

This paper is based on work performed by Midwest Research Institute while assisting the Federal Energy Administration in the preparation of the Solar Heating and Cooling of Building Commercialization Report.[1] Barriers to SHACOB commercialization and policy options to overcome these barriers are examined. Barriers are categorized as economic, institutional, and legal. It is important to realize, however, that many of these barriers have overlapping aspects and could be placed in more than one barrier category.

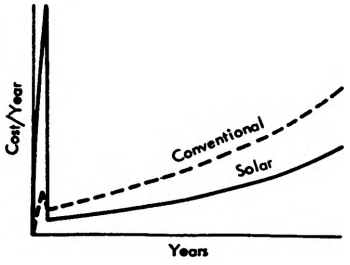
2. ECONOMIC BARRIERS

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

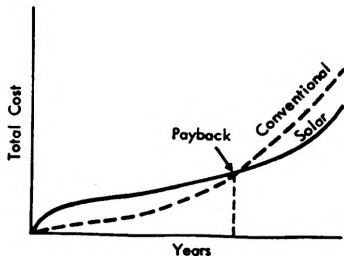
2.1 CONSUMER ECONOMIC DECISION CRITERIA

The consumer's economic decision criteria refer to how potential buyers determine 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 life-cycle cost criterion. The major difference in these approaches involves the number of cost factors considered, which has a major impact on which energy alternative is chosen. Figure 1 shows that on the basis of first costs, solar cannot compete with conventional systems. On the basis of payback, Figure 2 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. Under very short payback requirements, solar will have difficulty competing. 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. Similarly, stringent payback requirements and high discount rates will make it difficult for SHACOB to compete in both the residential and commercial sectors.



Source: Midwest Research Institute
Figure 1 - Cash Flow Patterns



Source: Midwest Research Institute
Figure 2 - Cumulative Expenditures

2.2 OWNERSHIP

As shown in Figure 3, in many building situations the person 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 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 is also the billpayer, as is the case with the custom-built, single family home, installation of a SHACOB system is more likely to be considered, because decision-makers are assured that they will realize the benefits of the SHACOB system through lower utility bills.

2.3 COST BARRIERS

SHACOB systems, while often less expensive than conventional systems on a payback or life-cycle cost basis, are almost always 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, thereby 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.

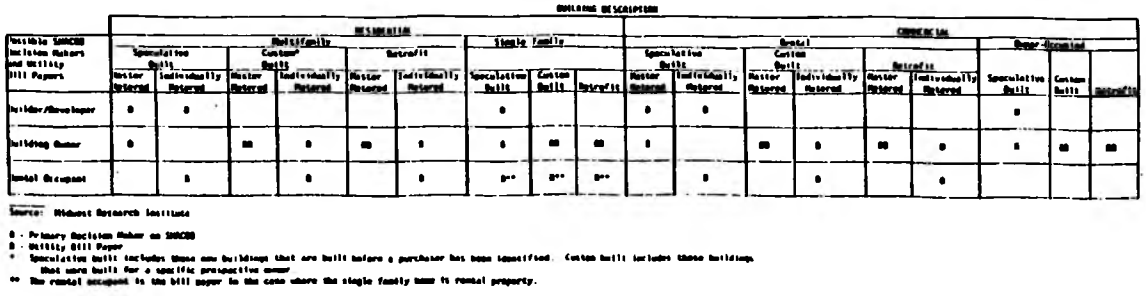


Figure 3 - Matrix of SHACOB Decision Makers and Utility Bill Payers for Alternative Buildings

2.4 FINANCING PROBLEMS

The high initial cost of SHACOB systems creates financing problems for SHACOB owners. Most building owners must borrow the needed funds 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".

2.5 COMPETITION WITH ALTERNATIVE FUELS

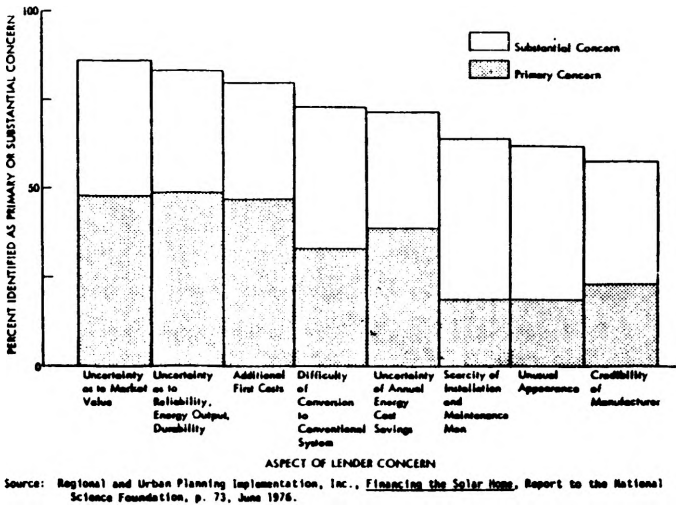
The value of the conventional fuel being displaced by SHACOB is derived from current and future fuel prices. However, the value to the nation of displacing conventional fuels is not necessarily reflected in current market prices. The large number of special tax benefits, direct subsidies, research and 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.

3. 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.

3.1 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. Currently lenders appear to be hesitant to make a large number of loans for SHACOB systems. The results of a recent survey [2] of lenders are shown in Figure 4. According to this survey, a



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

Figure 4 - Percentage of Lenders Identifying Selected Aspects of Solar Heating Systems as Primary or Substantial Concerns in Lending Decisions.

major lender 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, and 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 because the amount of financing a bank is willing to provide a propective new home buyer is currently based, almost exclusively, 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%. As shown in line C of Figure 5, 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.

		Loan Type	First Mortgage: Conventional			First Mortgage: FHA	First Mortgage: VA	Second Mortgage: Conventional	Home Improvement: Title I	Home Improvement: 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.

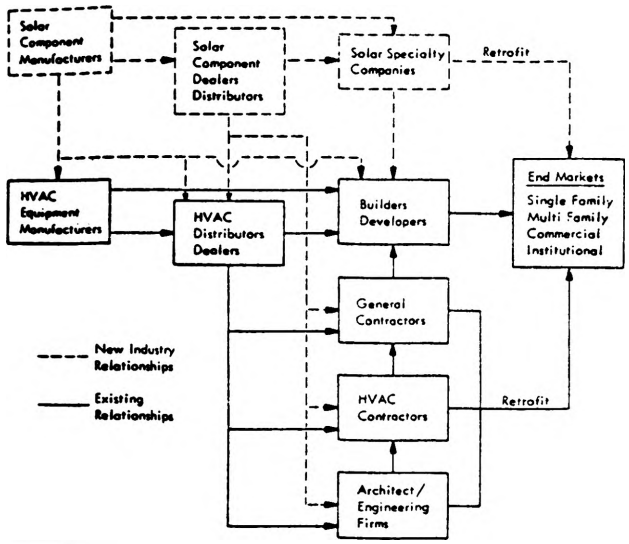
Figure 5 - Comparative Initial and Monthly Financing Costs Residential Solar Energy System, for Selected First Costs, Under Private Lender Financing Alternatives*

3.2 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, 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.[3] 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 for a mature industry to evolve. 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.

3.3 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.[4,5] HUD/FHA Intermediate Minimum Property Standards for solar water and space heating systems have also been completed.[6] These criteria and standards are



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

Figure 6 - Schematic Diagram of Industry Infrastructure.

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.

3.4 SHACOB-ELECTRIC UTILITY INTERFACE

SHACOB systems are usually not 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 to conventional buildings.[7,8] 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 electrical backup which are being installed today.

3.5 SHACOB-GAS UTILITY INTERFACE

The gas utility industry poses a major barrier to SHACOB because 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.[9] This fact has a negative impact on the ability of SHACOB systems to compete with natural gas and is therefore a barrier to commercialization.

3.6 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 uncertainties 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.

4. 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.

4.1 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.[10,11] 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.

4.2 LAND USE AND ZONING ORDINANCES

Land use controls and zoning ordinances may inhibit SHACOB development by regulating building height, bulk, aesthetic appearance, and location.[12] These restrictions may prohibit the use of solar collectors, or force SHACOB purchasers to choose a less than optimal location for the collector array, thereby 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.

5. IMPACT OF INCENTIVES ON SHACOB BARRIERS

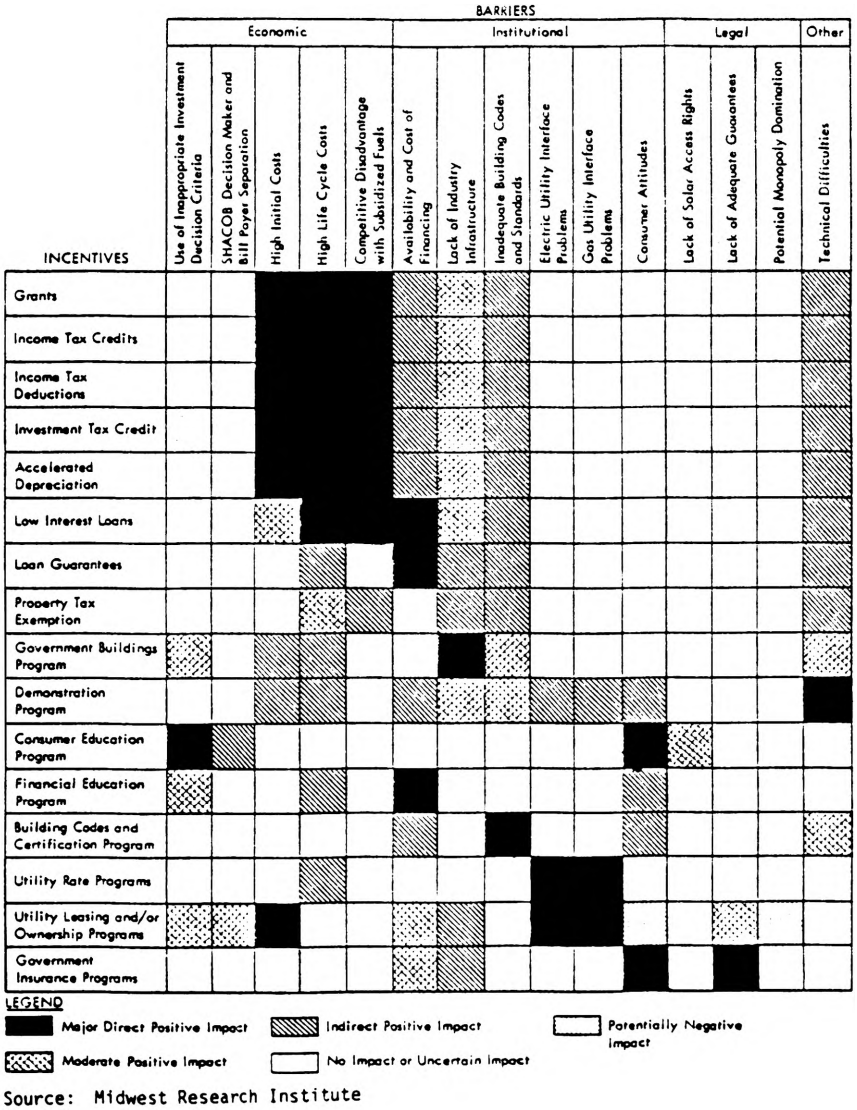
A number of incentives could potentially act to reduce or overcome barriers to SHACOB commercialization Figure 7 presents a matrix of the relationship between SHACOB incentives and barriers. The barriers discussed above are shown on the horizontal axis, and possible incentives are shown on the vertical axis. 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, but their major impact is on financial availability and life-cycle cost rather than on 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.

Important questions concerning the impact of incentives on SHACOB market success need to be answered so that government resources can be invested in SHACOB in an optimal manner. The costs and benefits associated with various incentives options need to be understood. Analysis must consider both private sector and social costs and benefits. Several completed and ongoing studies have examined the impact of selected incentives on SHACOB market

penetration.[13] Only a very small amount of research effort has been devoted to evaluating the social costs and benefits of incentives. One of the functions of the Analysis and Assessment Division of the Solar Energy Research Institute (SERI) is to provide objective, analytical evaluations of the issues which underlie these types of policy decisions influencing the widespread application of solar energy technologies.

6. CONCLUSION

Solar heating and cooling of buildings is likely to become a significant energy contributor in the future. The extent to which potential social barriers to commercialization are recognized and resolved at an early date will have a significant impact on SHACOB market success. SERI will be examining these barriers as well as possible policy actions to overcome them in detail.



Source: Midwest Research Institute

Figure 7 - Comparison of Impacts of Incentives on SHACOB Barriers

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8. BIOGRAPHIES

Dennis R. Costello is currently Acting Branch Chief of the Economics and Market Analysis Branch of the national Solar Energy Research Institute. Mr. Costello specializes in the economic analysis and energy policy alternatives. He has considerable experience in the detailed economic evaluation of solar energy systems, has served as project leader on several solar energy projects, and has authored several publications. Mr. Costello received the M.A. in Economics from Ohio State University and has completed many requirements toward the Ph.D. in Economics. He holds the B.A. in Economics from the State University of New York where he graduated magna cum laude. He is a member of the American Institute of Banking and Omicron Delta Epsilon, the international economics honor fraternity.

David M. Posner is a policy analyst in the Policy Analysis Branch of the national Solar Energy Research Institute. He specializes in the investigation of the impacts of technical, economic, and social forces on the development and utilization of solar energy systems. He has participated in several research projects on both social and technical aspects of solar energy systems. Mr. Posner received a B.A. from Brown University (1976) in an interdisciplinary program entitled "Scientific and Technological Approaches to Social Problems." Upon graduation, he received the William Gaston Premium Scholarship and the Brown Chapter of Sigma Xi award.