P. M. WITTE

M.A.

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Patti M. Witte

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Charles D. Johnson

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MICHIGAN CONTRACTORS' PERCEPTIONS OF PASSIVE SOLAR HEATING TECHNOLOGIES IN RESIDENTIAL AND COMMERCIAL CONSTRUCTION

By

Patti M. Witte

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ABSTRACT

MICHIGAN CONTRACTORS' PERCEPTIONS OF PASSIVE SOLAR HEATING TECHNOLOGIES IN RESIDENTIAL AND COMMERCIAL CONSTRUCTION

By

Patti M. Witte

This study examined the perceptions of Michigan contractors towards barriers hindering the incorporation of passive solar heating technologies in residential and commercial construction. Previous literature identified five major categories of barriers: economic, technological, psychological/sociological, informational, and political/legal. The purpose of this study was to (a) determine the extent to which passive solar technologies have been adopted by Michigan contractors, (b) develop a ranking of these barriers, and (c) investigate the relevance of dissemination literature to the adoption of passive solar heating technologies by Michigan contractors. A questionnaire, developed in accordance with these goals, was mailed to a random sample of 500 Michigan contractors. Results indicated that 17% of those responding to the questionnaire considered themselves to be high level adoptors. It was found that economic and informational barriers were the most important obstacles to solar implementation by Michigan contractors. In addition, findings of the present study did not fully confirm previous findings of the dissemination literature.

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CHAPTER I

INTRODUCTION

Solar technology is an alternative energy source that has not yet been fully utilized despite its potential to help avoid further environmental degradation and economic disaster. The residential and commercial sectors of energy consumption are two areas which offer immediate placement of passive space heating solar systems. In order to insure the successful implementation of solar technologies into residential and commercial construction, the support of the contractor is essential. Presently, there are a considerable number of barriers hindering wide-scale acceptance of solar systems by the contractor. Through a systematic identification of these most crucial barriers, a state-wide dissemination strategy can be formulated. The result of such a strategy has the potential of creating thousands of jobs and decreasing pollution and overreliance on imported fuels in the state of Michigan.

This study examined the barriers presently hindering the adoption of passive solar technologies by Michigan contractors. The paper begins with a description of solar technologies and the importance of their successful adoption in the building industry. The various barrier categories (economic, technological, psychological/sociological, informational, and political/legal) are covered in depth, and a general overview of dissemination theory is given. Results and conclusions are presented, followed by the suggestion of a needs assessment to investigate contractors' perceptions of solar energy. Result and discussion sections follow.

The Importance of Solar Technology

According to the Global Report to the President (Council on Environmental Quality, 1980), "If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now." The United States contributes to this world energy problem considerably. Although we account for only 6% of the world's population, Americans consume 30% of the world's per annum total energy production (Leedom, 1980).

Americans have failed to realize that there are limited reserves of conventional energy sources. Production curves published by the Energy Research and Development Administration (ERDA--now Department of Energy [DOE]) show that production of natural gas and petroleum in the United States peaked in the early 1970's. In about 60 years, nearly 80% of the world's crude oil supply will be gone. If we expand production at anticipated rates, the production peak for coal will occur sometime between 2100 and 2200 (Koenig, 1977). In addition, there have been serious negative environmental effects of this consumption rate in the form of acid rain, CO_2 concentrations, and radioactive waste (Council on Environmental Quality, 1980). Most evidence indicates that the development of an alternative energy source is critical.

When compared to our present energy sources, solar energy offers many advantages. It is abundant, renewable, universally available, and not as vulnerable as conventional energy sources to strikes, embargoes, or anti-trust agreements. Negative environmental impacts are relatively minimal, and increased solar technologies have the potential of creating thousands of jobs in Michigan (Council on Environmental Quality, 1978).

Given this information, the benefits of incorporating solar technologies in Michigan could be tremendous. The question becomes, "Are passive solar technologies viable in a state like Michigan?"

The Potential of Solar Energy in Residential and Commercial Construction in Michigan

Geographic location is important to specify when looking at solar dissemination efforts because of the nature of solar space and water heating systems. This topic becomes extremely important in a state like Michigan, known for its cold winters and cloudy skies (Vories & Strong, 1980). The reason for concern is that both active and passive systems utilize direct sunlight to create heat.

The active system, for instance, consists of a darkly colored metal plate which heats up when the sunlight strikes its surface. Reradiation of the sun's infrared energy causes the plate to cool. While some heat is lost to the surrounding air, most heat can be held in by putting sheet glass over the top of the plate (a greenhouse effect).

If fluid is run through tubing attached to the plate, the heat can be drawn away and used for space heating.

Passive solar heating generally involves energy collection through south-facing glazed areas. The sun penetrates the glass, and heat is absorbed by anything in the room of a lower temperature. Ideally, the house would be designed to absorb the heat through a form of thermal mass (concrete, bricks) to insure maximum storage and gradual release of heat when the sun goes down. The energy in this system is distributed naturally, rarely employing pumps or fans.

Despite the fact that Michigan is oftentimes cloudy overhead, passive solar systems can be feasible, practical, and economical if proper calculations are made. In constructing a passive solar space heating system in the state of Michigan, one would have to consider that (a) the system will only be of use during the colder months of the year and (b) the cloudy nature of the state will require investment in the form of back-up energy supply (Kempton, personal communication, 1981). The cost effectiveness of a system is also based on a variety of other factors: the type and cost of fuel being replaced, the lifetime of the new system, the efficiency of the new system, the inflation rate, the payment arrangement on the new system, the energy efficiency of the house, the availability of tax credits or tax write-offs, and the annual cost of maintenance and repairs of the system (Laulainen, 1979; Mrzowski, personal communication, 1981).

It has been documented that solar space heating could decrease Michigan's residential and commercial energy consumption considerably. Specifically, 22% of this state's total energy was consumed by the residential sector in 1978. This is compared to 14% consumption by the commercial sector, 33% consumption by the industrial sector, and 31% consumption by the transportation sector. It has been estimated that 70% of the energy consumed in both the residential and commercial sectors is due to space and water heating (Council on Environmental Quality, 1974). It can be concluded, therefore, that both residential and commercial construction are areas in which passive solar space heating could have considerable impact on energy savings in Michigan. As a result, various members of the building industry have a great amount of power in determining the future of passive solar energy in the state.

The Significance of Michigan Builders in the Dissemination of Solar Energy

Although there have been many groups that have been identified as potential targets of solar dissemination efforts (Belew & Wood, 1980), the growing importance of the contractor/builder is continually stressed in the literature. Vories and Strong (1980), in their analysis of 32 solar studies, concluded that builders and developers are becoming increasingly important figures in the solar industry. Sparrow, Warhov, and Kass (1978) confirmed this conclusion in a survey of 45 solar households, stating that contractors are becoming more prominant in the decision-making process. Most builders, however, are not ready to commit themselves to solar technologies (Vories & Strong, 1980). In a study involving 50 in-depth interviews with builders both with and without solar experiences, the Department of Energy (1978a) found that the building industry is not prepared to deal with the added responsibilities that accompany alterations in their conventional work procedures.

Because of the builders' increasing importance in disseminating solar technology, it is suggested that this sector's viewpoints be obtained in an attempt to organize a strategy to disseminate passive solar heating systems in the state of Michigan. Through the identification of critical issues regarding passive solar heating relevant to the building industry, we can begin to develop a more structured orientation towards christening solar as a more acceptable energy source.

Specific Barriers to the Dissemination of Solar Technologies

Because the builder has been identified as playing a major role in the development of solar technologies within the residential and commercial areas of construction, this paper deals with research primarily relevant to this sector. However, there is a massive network of people and institutions linked to the builder that must be considered: manufacturers, installers, planners, engineers (Belew & Wood, 1980; Belew, Wood, Marle & Reinhardt, 1980, 1981). It would be futile to develop a dissemination program for passive solar technologies while ignoring the other sectors--how they perceive the builder, their relationship to the builder, and the possibilities of implementing solar into their businesses. Through identification of needs and expectations of these various sectors (emphasizing builder relationships), the change agent will be able to strategically prioritize the elements of major concern to the builder/contractor regarding the adoption of passive solar heating technologies. Five major barriers to solar dissemination have been identified in the literature: economic, technological, psychological/ sociological, informational, and political/legal.

Economic Barriers

Economic Barriers to the Building Industry. The most frequently stated barrier to solar adoption on the part of the consumer is the high initial cost of solar systems (Weis, 1978; Unseld, 1979; Vories & Strong, 1980). Although each of these reviews base their conclusions on studies of small or unknown sample sizes and nonrepresentative regional populations, this finding is so consistent that its validity is almost certain.

The implication of this finding is related to the fact that in order to build and sell solar homes, builders must be insured of a demand. If solar homes are not within the competitive range of conventional homes, there is little chance of their success in the housing market (Schoen & Hirshberg, 1975). The necessity of the federal and state governments to initiate financial incentives to either the consumer or industry has been stressed in a plethora of essays (Ezra, 1975; Block & Yarosh, 1979; Fassbender & Cone, 1979). Rebate programs or tax credits appear to be the favored of the financial incentives (Vories & Strong, 1980). The fact that the Michigan solar tax credit system has saved both money and energy is documented in a report by Martin Kushler (1981) of the Michigan Energy Administration.

Another cost-related area which may have some impact but on which there is little research is the tax structure relevant to a solar home. Based on the same principles as the tax structure on conventional housing, the higher the house's market value, the higher its property tax. This may especially serve as a deterrent with active systems where initial housing costs are considerably higher (Little, 1976).

Ironically, economic advantage is also one of the most often-mentioned assets of solar systems (Weis, 1978; Unseld, 1979; Vories & Strong, 1980). Weis explains the inconsistency as a possible misunderstanding most people have on life-cycle costing. Life-cycle costing is a technique in which the cost-benefit of a solar system is figured based on a variety of variables such as the type of fuel being replaced, loan payments and interest arrangements, maintenance costs, etc. Although relatively sophisticated analyses exist (Laulainen, 1979; Ruegg, 1975), they are often time-consuming to figure and situation specific. Those persons who view solar as being uneconomical may be confused as to how life-cycle costing works. Problems could also be a product of a simple lack of data on variables required for life-cycle costing like maintenance and repair costs (Little, 1976).

In another report published by DOE (1978e) participants were instructed to rank the most important barriers to the development of solar energy. This is a very helpful publication in that it looks at each state individually, allowing the reader to focus on a specific geographic location. In this case, Michigan economic barriers were identified, along with those already mentioned, as the following:

1. Energy prices being artificially low and not reflecting true costs.

2. There being no financial incentives for lending institutions to extend mortgages or offer loans to cover the initial costs of solar installations.

3. There are few grant programs available to local organizations for projects which demonstrate solar feasibility in the community.

4. There is presently no convenient way for the average consumer to compare energy costs of alternative structures before building or buying.

5. Solar systems are high-priced because of the lack of mass production.

6. Energy storage facilities are prohibitively expensive in many applications.

7. A lack of funding for independent research and development activities by those not connected with large corporations.

Although this report is entitled "The Citizen's Solar Program," citizens doing the ranking were not identified, nor was the number of citizens revealed. Although "ranking" was stated as the methodology employed, specific instructions for the procedure were not disclosed.

The consumer, of course, is not the only person affected by the cost of solar systmes. A study conducted by Christensen (1978) reports the findings of a one-evening workshop of approximately 30 attendants from all areas in the building industry. The sample was self-selected. The unstructured workshop was intended to simply obtain opinions from and allow interaction among various solar energy industrial and planning groups interested in the commercialization of solar energy. The attendants concluded that a real market demand for solar heating and cooling systems had not yet materialized primarily because of economic factors. The perceived cost barrier of the systems was seen as being directly related to a federal energy bill and financial incentives, tax equality, and tax write-offs for solar systems, insurance rates, and the need for more effective educational and training programs for solar equipment installers and technicians.

The National Academy of Sciences (1976) developed a report for the Energy Research and Development Administration which contained a section on the expressed needs and concerns of the building industry. Data were derived from both a workshop and a mailed survey. Participants in the workshop were invited specialists in the building industry. Workshop participants felt that the design of competitively priced systems was being thwarted by the lack of cost and performance data on existing solar system. Within the same study, 85 of 280 building industry members listed "not economically feasible" as one of their top three reasons for not getting involved with solar technologies. A subgroup of these 280 respondents, 18 of 43 manufacturers stated that they could not support product research because of the lack of working capital, resulting in a lack of more and better-available designed products.

As can be seen, there are a considerable number of economic barriers viewed as important by the various building industry members. These barriers as perceived by the consumer, manufacturers, architects, etc. will have an impact on the ability of contractors to implement solar technologies into their businesses. The above-mentioned barriers are closely related to the economic barriers stated by contractors as being important obstacles to their adoption of the innovation. The following paragraphs outline the financial obstacles to adoption unique to the contractors as cited in the literature.

Economic Barriers to Contractors. The Residential Solar Heating and Cooling Demonstration Program was designed by the Department of Housing and Urban Development (HUD) to encourage flexibility and innovation among builders in residential design and construction decisions (HUD, 1978, 1979, 1980). This project aided in identifying various barriers to the contracting community. The HUD program consisted of five demonstration cycles in which self-selected builders (N = 138) received grants to incorporate variously designed active solar systems into new homes. Data were obtained through interviews conducted with participating and non-participating program builders (N = 260), consumers, and institutions.

Two of the most frequently stated factors that participating builders said would influence them to build solar homes outside of the program were market issues (public interest and consumer demand) and system costs. Comparative builders seemed to stress cost factors (construction costs, economic feasibility, etc.) above all else.

The concern with cost factors is easily explained. As the primary motive behind any business venture is to make a profit, if a profit cannot be seen in the near future, solar technologies will never be widely accepted by the building industry. Related to this is the problem with critical costs. Since the building industry operates on borrowed capital, it is very sensitive to additional costs and their accompanying interest rates. At the present time, the builder/contractor cannot justify the adoption of a risky innovation. This problem is exemplified by the lack of resale value of solar homes (HUD, 1978, 1979). This lack of data does not give the contractor/builder much to work with in terms of selling his/her product to an already hesitant consumer (Rose, 1980).

<u>Summary.</u> High initial costs, lack of demand, lack of financial incentives, artificially low prices of conventional energy sources, insurance rates, the lack of cost and performance data, lack of working capital, and lack of resale value data on solar homes are often-cited economic barriers to solar implementation by various members in the building industry. The degree to which Michigan contractors perceive these barriers as important will influence the strategy for dissemination.

The impact of the consumer and the builder perceiving high system costs should be obvious; that is, if two systems exist that deliver the same service, the decision of which system to buy will be based on a weighting of relative advantages and disadvantages. Cost is usually one of the first considerations in buying or retrofitting a home. Perception of higher cost of passive structures is often erroneous. Perhaps a program designed to educate both contractors and consumers on life-cycle costing would ameliorate this obstacle to adoption.

The fact that conventional energy prices are too low and do not reflect true costs will also have the effect of making solar systems look more expensive. This, along with the lack of financial incentives, could be reconciled through pressure applied at a legislative level. If Michigan builders show a greater concern for the compilation of cost performance data, the task could be taken on by the Michigan Energy Administration or a similar organization.

It is possible that economic factors other than the ones mentioned may be offered by the builders. This stresses the importance of going directly to the target population before initiating any action.

As discussed earlier, economic barriers were only one of five categories of obstacles preventing Michigan contractors from adopting solar technologies. In addition to economic feasibility, the perception of technological viability of an innovation is necessary prior to its widespread acceptance by a population.

Technological Barriers

Technological Barriers to the Building Industry. The technological reliability of solar systems must be substantially confirmed before widespread adoption takes place. Two reasons for this are evident. First, it is very hard to sell a product with questionable performance data when another product is already in successful operation. Second, it would be disastrous to disseminate a technological innovation prior to its readiness for the market (Fairweather & Tornatzky, 1977).

Although there are many reports documenting successful solar implementation, there are just as many reports which reveal problems in the system's operations. For instance, in an evaluation of a solar space heating system in a Page Jackson Elementary School (Howard, 1980), the solar fraction was measured at 23% while the design called for 83%. The reason given for this inefficiency was the extent of physical damage of the solar collectors; mainly the buckling of absorber plates causing the pipes to be pulled loose from them. The fact that there was a monetary savings in energy cost must be added, however, In another performance evaluation (DOE, 1977), excessive heat losses (25%) were found to be occurring as a result of uninsulated pipes and manifolds between the collector and pre-heat tanks. The Argonne National Lab's (DOE, 1979a) reliability study indicated that the major generic problems with solar heating and cooling systems (freezing, leakage, thermal control and collector operation) still affect solar systems, but added that incidence of these problems were less than reported in July, 1978. These problems cannot be isolated from the fact that there is a need for educational programs for both installers and the public to insure proper assembly and maintenance of the systems. This will be discussed in a later section.

In a literature review done by Farhar, Weis, Unseld, and Burns (1979), it was found that half of the respondents involved in two national and one regional survey questioned the technical feasibility of solar to meet electrical needs and to provide space heating. Weis (1978) found that only 39% agreed that "solar energy is predictable enough to depend on for widespread use," 40% were unsure, and 21% disagreed. Neither of the above studies included sample size or selection method in their reviews.

Vories' and Strong's (1980) review indicated that of those persons presently living in a solar home, the majority expressed a high degree of satisfaction with the system. However, as found in Unseld (1979), when asked, most had no idea how well their systems were working or how much money/ energy they might be saving.

In a workshop conducted by the Southern Solar Energy Center, members of the building industry claimed that improved design concepts for buildings and solar equipment was critical to widespread commercialization of solar energy. They also stated that overall performance criteria and ranges based on accepted design assessment and standard inspection techniques were needed. They suggested a pass/fail rating for solar equipment, improved and standardized inspection, and reliable warranties.

In the National Academy of Science's (1976) report, builders identified numerous technical information needs. One complaint dealt with the fact that there is a lack of accurate meteorological information, making it difficult to predict system performance. Workshop participants also mentioned the fact that there is little information on the efficiency and degradation characteristics of specific materials. A related problem was revealed by 148 of 280 engineers, architects, builders, code officials and mobile home manufacturers surveyed who claimed that the lack of data performance and reliability of solar equipment were primary reasons for not having tested solar technologies. Many persons also claimed they had problems getting solar equipment. A problem for designers that seemed to be a prominant complaint was the lack of any generally accepted design procedures. This forces designers to develop new procedures for each structure. As a consequence, both money and time are wasted.

Another problem inherent in the system is the fact that the federal government has concentrated its efforts in high technology research and development (R&D) rather than stressing the simpler, more cost-effective passive systems (DOE, 1978e; Vories & Strong, 1980). Based on concepts of learning and experience from the business management and industrial economics literature it could be argued that costs will decline as firms gain experience with different systems (Kraurec & Flaim, 1979). This fact simply implies that the economic and technological barriers are very closely related.

As with the economic barriers, there were a considerable number of technological barriers viewed as important by the various industry members. The following paragraphs review studies which dealt with adoption obstacles specific to contractors.

Technological Barriers to Contractors. Various technological complications were pointed out by building contractors in a DOE (1978b) study. They commented that specifications on collector performance or storage system efficiencies are often represented in a way that is very difficult for a non-engineer to comprehend. Heat loss calculations, life-cycle cost analysis and extensive insulation were also seen as being intimidating. Respondents also mentioned that there is no present method for evaluating and recommending systems for the less technically proficient person.

Related to this are findings in the National Academy of Science (1976) study which showed that "lack of data on performance and reliability of solar equipment" was mentioned by 34 of 38 builders as a reason for not participating in solar heating and cooling activities. The other most often mentioned response by builders (17 of the 38) specified that information on such things as components, system and component design, etc. were areas that needed attention prior to widespread utilization of solar technologies in the industry.

Summary. Lack of standardized design procedures, lack of meteorological data, lack of information on specific materials used in solar structures, lack of performance data, questionable reliability and difficulty in understanding solar designs are often-cited technological barriers to adoption of solar technologies by various building industry members. As previously mentioned, faith in the technology of an innovation is a prerequisite to its adoption. The degree of confidence Michigan consumers and contractors have in solar systems has yet to be investigated.

Product standardization and warranties are two measures that would have to be pressed through a legislative act. These are two concerns which are repeatedly mentioned by building industry members. It is uncertain whether these concerns are considered primary by Michigan builders. If the contractors show a higher degree of concern in establishing meteorological, performance or materials data, these could be compiled, as with the cost data, by the Michigan Energy Administration or a similar organization.

The literature indicates that technical problems with solar systems are contributing to the slow adoption of solar technologies in residential and commercial construction. Educational programs directed towards builders would help contractors choose systems with proven reliability, in addition to making the solar designs easier for them to understand.

As can be seen, there remain many unanswered questions regarding Michigan contractors and their knowledge and perceptions of solar technology. Psychological/sociological obstacles are another classification of barriers confronting solar adoption by contractors in Michigan.

Psychological/Sociological Barriers

Psychological/Sociological Barriers to the Building Industry. Psychological and sociological barriers are closely linked with economical, technological, informational, and political/legal barriers, yet analysis allows the researcher to look at the problem from a slightly different perspective.

A publication put out by DOE (1978b) analyzed the economic and behavioral processes of solar investment by members of the building industry. Methodology consisted of 27 Decision Analysis Panel meetings with TDS (Technology Delivery Services) segment members of either homogeneous or heterogeneous groups of the TDS. Demographic and attitudinal data were collected immediately before the session, before their views could be influenced by the group discussion. The report was based on the premise that although economic barriers are problematic, they are not the only obstacles to solar commercialization.

Analysis of results revealed that, despite a favorable attitude toward solar, there has been little confirmation through a significant level of buying behavior. Contributers to this fact were identified as (a) the risk involved (will solar work, how can the benefit be measured, is there really an energy crisis), (b) a questionable pay-off, (c) preference for a technological fix, (d) the lack of social support throughout the TDS, and (e) the need to avoid dissonance (the necessity to change actual living patterns to secure their belief in the new technology).

The above barriers were those experienced by consumers and building industry members as cited in the literature. What follows is a brief synopsis of findings relevant to psychological/sociological barriers confronting the contractor.

Psychological/Sociological Barriers to Contractors. Looking specifically at contractors in regards to psychological/sociological barriers, a 1980 HUD report found that the program builders differed significantly from their nonparticipating counterparts in their attitudes and outlook on solar construction. Attitudes, in this case, seemed to be reflected by action in the sense that 43% of the grantee builders were constructing solar units outside of the demonstration program, whereas only 17% of the comparative builders were. At the onset of the program, the majority (72%) of both groups were inexperienced in solar construction. It is not clear exactly what caused the adoption of solar practices by participants following this program. It could be speculated, however, that simple familiarity with the systems and the realization that they could be cost effective were definite contributors to the increased activity.

This study emphasizes the importance of educational and hands-on programs in increasing adoption of passive solar heating technologies.

Summary. The risk involved, questionability of pay-off, preference for a technological fix, necessity to change actual business patterns, and lack of industry support are all psychological/sociological barriers affecting the adoption of solar structures by the building industry. Past studies indicate that these psychological variables can affect a contractor's decision whether or not to implement solar technologies in his/her business. These variables would have to be determined prior to the completion of a dissemination strategy. The contractor should be asked to what extent these psychological/sociological barriers have hindered their adoption of passive solar heating technologies. If a serious problem, educational programs oriented toward the skeptical contractor could be considered. These programs would inform contractor/builders on the types of systems that are proven to work in the Michigan climate, thus eliminating the risk and questionability of pay-off of particular solar structures. Education has the potential of clearing up misperceptions regarding solar technologies as well as giving the contractor a realistic foresight into what changes the implementation of this innovation will entail. As will be seen in the next section, psychological/ sociological barriers are very closely related to informational barriers to solar adoption.

Informational Barriers

In an interview with 280 building industry members (National Academy of Science, 1976), 94 of the respondents listed lack of technical competence as one of their top three reasons for not involving themselves in solar heating and cooling activities. This fact is related to the lack of information all sectors have regarding solar technology, system costs, performance and quality (Christensen, 1978; National Academy of Science, 1976). This lack of technical knowledge can be illustrated by the experience of the New England Electric System Solar Project. In this project, the utilities sponsored the retrofit of 100 solar hot water heating systems. Only 15 worked well, 8 had no serious breakdowns, 57 had at least one major stoppage or breakdown requiring repair, and about 20 were severely interrupted and considered inoperable. Most of the problems were attributed to installation flaws. The installers and manufacturers of the 15 systems that worked well were among the most experienced with solar systems (Burns, Mason, Armington, 1979). Christensen (1978) found that members of the building industry felt an urgent need for massive educational and training programs for all sectors.

Demonstration projects are another technique used to expose both consumers and installers to solar technologies. In the "Commercial Solar Demonstration Performance Evaluation Report" (General Electric, 1979), the authors conclude that their demonstration project had been successful on the basis that the system had no major breakdowns after two and one-half years. Educational programs were conducted to over 5,500 people in 1977, and the demonstration was visited by 37,000 people. The report does not mention if persons were asked their opinions of the demonstration or if actual follow-up was made to verify any actual effects of the program.

Although some members of the building industry agree with demonstration programs (Christenson, 1978), pessimism of demonstration homes by builders themselves is expressed in a statement made by the then vice-president of the National Association of Homebuilders Research Foundation that, "One of anything doesn't mean much to the housing industry" (Schoen & Hirshberg, 1975).

One last informational barrier was found in several articles reflecting the fact that most governmental agencies have handled their information on solar in a very disorganized manner. In order for the public or persons in the industry to get anything at all from these institutions, they will have to pull their resources together. A suggestion has been made for implementation centers (DOE, 1978b) which would make information easily accessible and problem specific.

Although no research was found dealing specifically with contractors' lack of knowledge, it is certain that this is a problem contractors share with other building industry members. This question could be answered by examining specific informational obstacles to solar adoption. If lack of knowledge is seen as a barrier by Michigan contractors, educational programs dealing with technical information on solar systems for the contractors could have considerable impact on increasing the number of solar structures built each year (Gilleland, Hunt, and Niland, 1979). In addition, if inadequate governmental material is prioritized as one of the major barriers to solar implementation, an alternative similar to the New England application centers should be considered for Michigan. It is believed that if the logical steps are taken in response to the barriers presented by the contractor/builders, solar energy will become a popular heating technology in Michigan construction.

Up to this point, economic, technological, psychological/ sociological, and informational barriers to the implementation of solar technologies in residential and commercial construction have been reviewed. The last barrier to be covered is related to legal/political barriers to solar adoption.

Legal/Political Barriers to the Building Industry

For a new technology to be efficiently utilized, changes in existing laws are oftentimes necessary (Spivak, 1979). There are two major players in the barriers related to the legal/political factor: zoning and coding officials and bankers. Once again, a lack of knowledge of solar energy on the part of each of these players will determine the rate of solar acceptance.

Zoning and Coding Officials. Zoning can be a problem in an area because of the necessary orientation of solar buildings on lots in order to maximize exposure to the sun. Required patterns of the new structures might be found to be inconsistent with either the height, bulk, or frontage requirements of local zoning ordinances. Inherent to the zoning problem is the present absence of sun rights in most states (Kraemer, 1978; Jaffe, 1978). Tukel, Catalioto and Marshall (1979) found this to be the case in the federally funded Bergen County Community Action Program, a training program which concentrated on installing energy conservation materials in several hundred low-income homes. Close to 70% of the houses inspected would not accept the solar devices because of general conditions affecting orientation.

Building codes are another major constraint. The purpose of these codes is to regulate public health and safety by specifying how buildings are to be constructed and what materials are to be used. The process as it presently stands is a time-consuming one, and the new materials used in solar systems add to the delay. Unless coding officials are educated on the materials and technology behind solar systems under some uniform procedure, there is little incentive for builders to employ the new technology (Little, 1976). The problem here is twofold. On one hand the lack of provision for new methods and materials is criticized as leaving too much to the discretion of individual officials; on the other, excessively restrictive provisions might also interfere with present or new developments (Riley, Odland, & Barker, 1979).

Municipal planning and zoning bodies may also encourage or discourage the use of solar energy by including or excluding solar considerations in comprehensive planning, local zoning and subdivision regulations. In a 1980 HUD report, interviews were conducted among 105 officials of planning and zoning agencies whose jurisdictions included solar grant houses. It was determined that obtaining zoning and site plan approval had not been a problem for most grantee builders. The lack of problems might be explained by the fact that most areas have not addressed solar zoning issues directly. The authors did not try to explain why obtaining zoning approval was found to be even less difficult for grantee builders than for a comparative sample.

Most of the surveyed officials in this study perceived no existing legislative or administrative impediments to the use of solar systems in their jurisdiction. Interviews conducted with 104 building code officials indicated that demonstration home-builders have encountered few code-approval problems and delays. Seventy-eight percent of the code officials believed that local codes, as presently written, did not pose barriers to solar system installation. Fourteen percent of the participating solar builders, compared to 5% of nonparticipating builders, however, experienced difficulty in obtaining inspection approval. The most often reported problems were of an administrative nature, requiring additional information to be supplied and extra time for approval. Difficulties for comparative builders were related to strict code enforcement, whereas solar builders' main problem was the inspectors' unfamiliarity with the system.

It seems clear that there are a variety of problems associated with zoning and coding for solar systems. There is evidence that both the existence and absence of these laws cause problems for the builder (Rose, 1980); Christensen, 1978). Because of the local nature of this type of legislation, it would be necessary to investigate the needs of a particular area before initiating any action to correct the situation. If barriers of this type are identified as being primary obstacles to solar implementation by contractors, specific negotiations between the contractors and state governmental officials could help alleviate these problems.

A second political/legal barrier is associated with bankers and the role they play in securing loans for those in need of personal or business-related financing.

Bankers. The majority of persons finance their homes through a bank or savings and loan. Most bankers are concerned with (a) the effect of solar systems on the resalability of the home (on which there is little to no research) and (b) the effect of the high first cost of solar systems on the ability of the mortgagee to pay the loan (Little, 1976).

As mentioned earlier, virtually nothing is known concerning the resale value of solar homes. Research in this area might alleviate some of the apprehension experienced by lending organizations. Encouragingly, however, in Little's (1976) study, it was found that almost half of the appraisers (45%) included entire cost of the solar system in their overall appraisal of the value of the demonstration houses. Most appraisers determined the value of the solar system itself at about 50% to 60% of the full cost claimed by the builder or purchaser. Over one third of the lenders believed that solar costs could be recovered in resale.

In regard to the high first cost of the systems, another bank-generated barrier is the fact that energy cost savings are not included in estimating income requirements for a loan. This might force some prospective home-buyers out of the solar system market because the added first cost of a solar-equipped home might result in the lender requiring higher income levels to qualify for a loan (Little, 1976).

In most research studies, however, there is little documentation of finance problems unique to solar home-buyers. In the Residential Solar Demonstration Program (HUD, 1980), for example, 86% of the 276 households seeking financing had no difficulty in obtaining a home mortgage with terms comparable to those granted to conventional home-buyers. In this same study, it was found that lenders are increasingly, though still a minority, including energy costs as a factor in determining monthly mortgage payments.

Through interviews with 105 participating construction lenders and 92 comparative lenders, the HUD report concluded that, overall, construction lenders are optimistic on the long-term prospects for solar energy acceptance. Only a small number of the solar builders had any difficulty in obtaining finances. Nearly all of the participating lenders knew that the builders were involved in federally subsidized programs and admitted that this was a positive factor in the loan decision. Fifty-two percent of the lenders said that they thought the builders would have had more trouble obtaining a loan without the federal grant.

Because both the consumer and the builder oftentimes go through banks for financing, the degree of difficulty in obtaining loans may have considerable effect on the adoption of solar systems. If banks and savings and loans are seen as primary deterrents in solar adoption, some type of program might be set up with banking personnel to determine changes that could be made.

Summary. As can be seen from the literature, various political/legal barriers stand in the way of widespread solar dissemination. Because of the local or geographic characteristic of most of these variables, it is questionable whether the results of the reviewed literature can be generalized to Michigan. Solar access, building codes, product standardization, and obtainment of loans are all possible barriers to solar dissemination within the building industry. It is important to analyze the extent to which these political/legal factors are actually inhibiting the growth of the use of solar technologies in residential and commercial construction in Michigan.

In summary, economic, technological, psychological/ sociological, informational, and political/legal barriers pose obstacles to Michigan contractor/builders to implementing passive solar technologies. By specifying which barriers are seen as the most important obstacles to solar adoption, a methodological strategy can be developed to overcome these barriers. The dissemination process, however, is more complex than it might appear at first glance. Prior to approaching the contractors with the speculation of adopting solar technologies, an understanding of the "dissemination of innovations" process in necessary. An understanding of this process will help pinpoint other important variables which should be considered when devising a strategy to disseminate passive solar heating technologies.

Diffusion and the Innovation-Decision Process: A Model for the Dissemination of Solar Energy

Both individual and organizational dissemination theory has been generated by a large spectrum of diffusion specialists (Brown, 1978; Havelock, 1969). The "communication" perspective, defined by Brown (1978) is an approach which purports that attributes of potential adopters and the structure and operation of communication channels are helpful in determining diffusion outcomes (Posner et al., 1979). Dissemination literature based on this perspective has the potential of aiding in the establishment of the factors requisite to the development of a strategy to disseminate solar technologies to Michigan builders. The following paragraphs describe some of the literature based on this perspective.

Individual Influences on the Adoption of Innovations

Rogers and Shoemaker (1971) define diffusion as a process by which innovations spread to the members of a social system. The theme of the book, Communication of Innovations, is that communication is essential for social change. Diffusion is seen as a special type of communication. According to Rogers and Shoemaker, the crucial elements in the diffusion of new ideas are: the innovation, time, communication of the innovation through certain channels, and members of the social system in which the innovation is being disseminated. A closer look at each of these variables helps to pinpoint specific issues that must be kept in mind when developing a dissemination strategy for a particular innovation (passive solar technology) to a particular population (Michigan contractors).

The Innovation. An innovation has been defined as a new idea, method, or device (Webster, 1969). Rogers and Shoemaker (1971) found five attributes inherent in an innovation to be correlated with the rate of the innovation's adoption.

1. Relative advantage: the degree to which an innovation is seen as being better than the idea it supercedes (Ross, 1952; Wilkening, 1952). For example, it would be interesting to investigate whether Michigan builders perceive passive solar technologies as having any advantages over conventional energy sources. If a particular builder were aware of advantages of the innovation over coal or oil, for instance, it would be speculated that this builder would be more likely to adopt solar technologies.

2. Compatibility: the degree that an innovation is perceived as consistent with the receiver's needs, values, and experiences (Fairweather et al., 1974; Santopolo, 1961; Yeracaris, 1961). One measure of compatibility would be the builder's perceived risk of the innovation. The less the perceived risk of passive solar technologies, the greater the likelihood of adoption.

3. Complexity: the degree that an innovation is perceived as difficult to understand (Kivlin, 1960). This attribute was found to be negatively correlated with adoption.

It could be suggested that builders viewing the technology of solar systems (concepts of heat transfer, unknown building technologies) as being significantly more difficult to understand than the operation of conventional furnaces, etc. would be less likely to adopt the innovation.

4. Trialability: the extent to which an innovation can be experimented with on a trial basis. The more passive solar technologies are seen as being easily tested on a trial basis, the more apt builder/contractors are to adopt it.

5. Observability: the degree to which the innovation's results are visible to others (Erasmus, 1961). If builders can readily observe solar systems working successfully in Michigan, they will be likely to adopt them.

Rogers and Shoemaker (1971) would, therefore, predict that persons viewing an innovation as being relatively advantageous, compatible with their needs and beliefs, trialable, observable and not technologically complicated would be more likely to adopt the innovation than those who do not hold these views. In conjunction with attitudes held toward the innovation, Rogers and Shoemaker felt that the individual's reaction to an innovation was influenced by his/her stage in a time-determined phenomenon they termed "the innovation-decision process."

Time. Rogers and Shoemaker (1971) identified four stages which they termed the "innovation-decision process," a mental process through which an individual passes from first knowledge of an innovation to a decision to adopt or reject it. The four stages of this process were as follows:

1. Knowledge: the individual is exposed to the innovation and its functions (Beal et al., 1957). Example: Has the contractor ever heard of solar technology? How familiar is the contractor with solar systems?

2. Persuasion: the individual forms an attitude toward the innovation. Example: Has the contractor formed any strong opinions in favor of or against solar energy?

3. Decision: the individual makes a choice to adopt or reject. Example: To what extent has the contractor already adopted solar technologies?

4. Confirmation: the individual seeks confirmation for the decision. Example: Has the contractor sought out a source of confirmation for his/her decision?

Understanding these stages would help the change agent detect where the majority of builders stand with regard to the adoption of solar technologies in their businesses. For example, if it were found that many contractors had not yet formed definite opinions regarding the innovation and that knowledge level were low, dissemination might simply be a matter of education.

Hart, Kantrowitz, and Kurtz (1981) developed a similar set of stages specifically for builders and the adoption of solar energy. They paralleled a previous set of stages developed by Rogers (1962). These five stages were as follows:

1. Awareness: being exposed to or becoming aware of solar as an option.

2. Interest: showing active interest in solar as an option.

3. Examination: analyzing solar as an option in detail and comparing it to standard practice.

4. Preference: seeking specific information and studying to the point of selecting a preference.

5. Action: buying or specifying the preferred solar option.

As will be seen in the following section, finding out where Michigan contractor/builders stand in regard to these stages will determine the best strategy to approach them with the speculation of adopting passive solar technologies.

Communication. Rogers and Shoemaker (1971) concluded that the channels through which an innovation is communicated are also important in determining whether or not the individual decides to adopt. Specifically, Rogers found that interpersonal channels were most important when the potential adopters were aware of the innovation but had not yet formed a strong opinion on whether or not to adopt. On the other hand, Rogers pointed out that mass-media channels were most important when the change agent's goal was to make persons aware of the innovation. The most effective method of approaching the Michigan builder/contractor with an innovation such as solar energy could be determined, then, by looking at their stage in the innovation-decision process.

Another influence on the adoption process concluded by Rogers and Shoemaker was the individual's characteristics and the social system in which s/he operated.

The Individual and the Social System. Rogers and Shoemaker (1971) state that both receiver variables and social system variables are important in determining a dissemination strategy. Receiver variables are composed of personality characteristics and perceived need for the innovation. One particular subset of this group are adopter categories which categorize receivers (in this the contractors) based on their level of innovativeness. Innovativeness is the degree to which an individual is relatively quick in adopting new ideas compared with other members. Rogers (1962) discussed five adopter categories: innovators, early adopters, early majority, late majority and laggards. Because of the newness of this innovation, it would not be feasible to distinguish amongst the different levels of adopters in the builder sample. However, it has been speculated that all persons exhibit some level of general innovativeness or receptivity to new technologies. Builders rating higher on a scale of general innovativeness would be more likely to adopt solar technologies. For example, a contractor who generally incorporates innovative building ideas prior to colleagues would be expected to adopt this innovation relatively early, too.

Cosmopoliteness is another receiver variable correlated with adoption. Cosmopolitans are those who are oriented toward the world outside their local community (Hill, 1982). Cosmopoliteness of builders could be measured in terms of their tendency to go beyond the traditional boundaries of the building industry for obtaining builder information. It has been found, for example, that early adoption is related to the use of a large number of information sources, traveling widely beyond the boundaries of their organization, the tendency to belong to other groups and organizations that include other innovators, and reading other non-local publications (Hill, 1982).

Personality characteristics such as venturesomeness, imaginativeness, dominance, sociability, self-sufficiency and educational status have all been found to be related to adoption (Loy, 1969). Related to this is the builder's perceived need for the innovation. It would be likely that those persons who perceive a need for solar technologies in residential construction would adopt solar technologies before a contractor who did not.

It should be remembered that all of the above variables must be evaluated within the social context of the contractor/builder. Rogers continually stressed the importance of cultural values of the potential adopters (Apodaca, 1952; Pederson, 1951). The primary context from which the contractor/builder operates is the building industry. It would be advisable to keep in mind that the building industry is a reputedly conservative business with traditional norms. It took, for example, 28 years for the industry to widely use forced air heating combined with air conditioning, even though a major savings resulted from the combination (Schoen & Hirshberg, 1975). This behavior is not extraordinary, especially in a traditionally conservative business like the building industry (Schoen, 1967).

Another aspect of the social context of the building industry is the individual company. Determination of adoption, as implied earlier, can also depend on a variety of organizational factors inherent in the company run by the builder/contractor. The next section looks at the organizational variables found to have had an influence on the adoption of innovations.

Organizational Influences on Innovation Adoption

It has been noted that individual variables do not always account for the largest amount of variance when considering innovation adoption by organizations (Baldridge & Burnham, 1975). Therefore, a rudimentary review of the literature on organizational variables related to innovation adoption will be presented.

Zaltman, Duncan and Holbek (1973) looked at the adoption of innovations by organizations in a vein comparable to Rogers and Shoemaker (1971). The authors determined five organizational characteristics to be related to innovation adoption:

1. Complexity: the number of occupational specialties in the organization and their professionalism.

2. Formalization: the emphasis placed on following specific rules and procedures in performing one's job within the organization.

3. Centralization: the locus of the authority and decision-making in the organization.

4. Interpersonal relations: the degree of impersonality in interpersonal relationships within the organization.

5. Ability to deal with conflict: how well the organization deals with conflict.

Complexity was mentioned in several studies (Aiken & Hage, 1971; Baldridge & Burnham, 1975; Hage & Dewar, 1973) as being positively related to the adoption of organizational innovations. Complexity is generally defined as the number of occupational specialties and the degree of professional activity.

In a study done by Hage and Aiken (1971), executive directors of 16 health and welfare offices were interviewed. "Innovation," the dependent variable, was based on their response to how many new programs or practices they had started in the previous five years. In addition to the executive directors, 314 staff were interviewed. Findings from this study also indicated a positive relationship between flexibility of work roles and innovation adoption. Formalization or rigidity of work roles was, in this case, operationally defined as to whether the organization had a rules manual, whether the organization had job descriptions, and whether rules were diligently enforced by the organization.

Also supportive of conclusions stated by Zaltman et al. (1973), Hage and Aiken (1971) found that there was a positive relationship between decentralization of decision-making and adoption of new programs or services in the 16 health and welfare organizations. For this variable, staff members were asked how often they participated in organizational decisions regarding the hiring of personnel, the adoption of new organizational policies, the adoption of new programs and services, and the promotion of personnel. This was consistent with a study conducted by Deal, Meyer and Scott (1975), which established a positive relationship between organizational innovation and the proportion of total district administrative staff in special administrative positions.

Another theory based on the type of decision-making in a company was proposed by Hart, Kantrowitz, and Kurtz (1981). This study categorized building companies into three major groups based on volume of business, size and staff, expertise of staff and housing production process. They were as follows:

1. Internal: the largest builders. These companies have a staff which is large enough to handle all the requirements of homebuilding including design, architecture, and engineering.

2. Custom: the builder is either an architect or is using design services. The house is built to the needs and specifications of the purchaser. This process often involves collaboration with the consumer.

3. External: rely on information from manufacturers and suppliers and on pre-design of the home. The designs are available through either plan services or plan companies, previous experience of the builder or directly from the prospective purchaser of the house.

Hart et al. (1981) indicated that there may be an interaction effect between the stage of the decision-innovation process and the type of building company in regard to which adoption barriers would be seen as most important.

In the same study mentioned earlier (Hage & Aiken, 1971), as Zaltman et al. (1973) proposed, interpersonal relations were also found to be positively correlated with adoption of new programs and services. A measure of both formal and informal communications between staff members was based on the number of communications made each week and with whom.

In addition to the major variables established by Zaltman et al. (1973), Hill (1982) listed eight major organizational considerations found in the literature to be made by the adopter before deciding whether to implement the innovation. The potential adopter's prognosis of the organization's reaction to the innovation was based on whether the following conditions were met:

1. The innovation was compatible with the organization's needs and priorities.

2. Others had or would have a favorable evaluation of the innovation.

3. The organization would reward participation in the implementation of the innovation.

4. The organization perceived or would recognize a need for the innovation.

5. The organization had or could get resources needed to adopt the innovation.

6. The organization's environment was amenable to adoption (e.g., organizational, professional or community support).

7. There had been a number of prior changes adopted recently or proposed but not implemented. (If so, adoption was not probable.)

8. There was currently a high rate of organizational change. (If so, adoption was not probable.)

Although the above-mentioned studies differed in their operationalization of the terms "innovation" and "adoption," and several could be criticized for having inadequate sample sizes, they succeeded in establishing a number of organizational variables which may be related to adoption of solar technologies. It could be hypothesized that future organizational studies of innovation adoption would find a positive relationship between innovation adoption and organizational complexity, informalization, decentralization, and number of formal and informal communications between staff members. It could also be hypothesized that builders at various stages of adoption would fall into different categories of building companies and would differentially identify barriers to solar implementation according to these categories.

Summary

In the previous pages, some basic principles of diffusion were described. These principles consist of findings of individual and organizational dissemination research. Several conclusions can be made from this literature:

1. Persons viewing an innovation as being relatively advantageous, compatible with their needs and beliefs, trialable, ovservable, and not technologically complicated will be more likely to adopt the innovation than those who do not hold these views.

2. Each individual can be described according to what stage of the innovation-decision process they are presently in.

3. The method of communication of an innovation to a population should be determined by the stage of the innovation-decision process experienced by the majority of persons. Different approaches can be tailored to various subsets of the population based on varying levels of this process.

4. Various receiver variables (innovativeness, cosmopoliteness, venturesomeness, etc.) and cultural values of the various adopters must be kept in mind when creating a dissemination strategy.

5. The more complex, informalized, decentralized, and interpersonal an organization, the more likely adoption of an innovation will occur.

6. The innovation's compatibility with organizational needs, favorable evaluation of the innovation by the organization, reward of the innovation's implementation in the organization, a perceived organizational need for the innovation, presence of organizational resources necessary to adopt, organizational support of the innovation, and lack of recent or on-going organizational changes will all contribute to making adoption of an innovation more likely.

It would be crucial, at this point, to determine whether these past findings are relevant to the dissemination of passive solar heating technologies to Michigan contractor/builders. With an understanding of the dissemination process within the building industry, the change agent will be able to strategically approach the contractor/ builders with the possibility of adopting the proposed innovation.

In summary, disseminating an innovation technique into the building industry is not an easy task. Because of the number of variables involved, a strategic plan of intervention is in order. It is important to look at the problem from the builder's perspective. This strategy involves answering three primary questions:

1. What are the most important barriers identified by Michigan contractors preventing the incorporation of passive solar heating technologies into their businesses?

2. How closely does the dissemination of passive solar technologies to Michigan contractor/builders follow the dissemination theory literature?

3. Given this information, what would be the best method to approach Michigan contractors with the prospect of adopting this innovation?

A needs assessment is suggested to investigate the needs, opinions, beliefs and knowledge of solar energy of a sufficiently-sized sample of contractors in Michigan to determine the disseminability of solar energy at this time.

Needs Assessment

The needs assessment has a likeness to evaluation in that it enables a comparison to be made between desired outcomes and the present state of affairs. This is accomplished through the collection and analysis of relevant data. In this study the eventual goal is the dissemination of solar energy. The needs assessment was designed to analyze the needs, current perceptions, and knowledge of solar energy of Michigan contractors. It was designed to create feedback to the change agent as to whether solar dissemination is not only feasible or practical in these areas but also to identify any possible barriers that may be blocking further movement in this direction.

Martha Williams (1978) states that "the overall purpose of needs assessment is to analyze the discrepancy between what is and what is desired in a way that illuminates means of reducing the discrepancy. From the viewpoint of disseminating solar energy, the needs assessment will aide in determining a strategy towards its development as a viable alternative. It will direct the change agent towards the objectives that need immediate attention, whether they be at a federal, state, or local level.

This study addressed research issues and questions in two broad categories. The following questions relate to the extent of and barriers to adoption of passive solar heating by Michigan contractors:

1. To what extent have passive solar heating technologies been implemented by Michigan contractors?

2. What do Michigan contractors perceive as the major barriers to their implementing passive solar heating technologies into their businesses?

3. Do solar knowledgeable contractors perceive documented barriers differently than contractors who are not knowledgeable of solar technologies?

4. Are barrier importance ratings related to level of adoption of passive solar technologies?

5. Are barrier importance ratings related to organization type?

The following research questions address the relationship of level of adoption of passive solar heating with variables described in the literature on dissemination theory:

1. Are the contractors' perceptions of the innovation's attributes (relative advantage, compatibility, trialability, and observability) related to adoption?

2. Are individual contractor characteristics (innovativeness, cosmopoliteness, and knowledge of the innovation) related to adoption?

3. Are organizational characteristics (number of employees, number of subcontractors, presence of recent business changes, building industry and company support, complexity, formalization, centralization, and interpersonal relations) related to adoption?

4. Who do Michigan contractors identify as being the person they go to most often to help them with business decisions?

CHAPTER 2

METHOD

Subjects

Five hundred Michigan contractors were randomly selected from a list of 23,000 licensed contractor/builders obtained from the Michigan Department of License and Regulation. This list was considered to be complete, as it is a requirement to be licensed in Michigan to be involved in the contracting profession.

Ninety of the original 500 contractors returned the questionnaire. This is an approximate 20% response rate. Respondents ranged from 24 to 65 years old. The number of contractors at each age was evenly distributed. (See Table 1 for sample statistics.) Ninety-nine percent of the respondents were men. (Twenty-three persons did not answer this question.) The average level of education was 13.7 years. Most respondents stated the fourth year of high school as the last grade completed in school. Participants had been in the contracting business anywhere from 1 to 36 years. Only 3% of the businesses were subsidiaries of larger firms. Number of employees ranged from 0 to 150. Twenty-three percent of the contractor/builders were in business for and by themselves. Number of subcontractors ranged from 0 to 400. These statistics indicated that the majority of contractors (69%) did not subcontract their work. Eighty-three percent of the subjects did the majority (50% to 100%)

Table 1

Demographic Statistics

Variable	Persons responding to question n	%	Range	Mean	SD	Mode
Age	69	77	24-65	43.15	12.08	32
Sex	67	74	female, male	---	---	male
Last grade completed	87	97	8-17	13.70	2.31	12
Years in business	90	100	1-36	14.17	10.32	5
Subsidiary	90	100	yes, no	---	---	no
# employees	79	88	0-150	5.94	17.43	0
# subcon-tractors	83	92	0-400	7.75	44.38	0
# new struc-tures built	77	86	0-700	18.47	81.24	1
# renovated structures	79	88	0-500	31.08	74.74	5

of their work in residential construction, as opposed to 9% who did the majority of their work in commercial construction (see Table 2). There seemed to be an even split between the percentage of persons working primarily in renovation (55%) and new construction (40%) and also between those working primarily in urban (49%) and rural (42%) areas. Ninety-one percent of the contractors answering the questionnaire worked primarily (75% to 100%) within a 100 mile radius of their business. This is opposed to 11% and 7% who did the majority of their work statewide or nationwide, respectively. (Some of the numbers do not add up to 100% because of participant coding error.) The number of new structures built annually ranged from 0 to 700 (see Table 1). The number of structures renovated annually ranged from 1 to 500. Gross annual income ranged from under $250,000 to over $25,000,000. Seventy-one percent of the respondents claimed a gross annual income under $250,000 (see Table 3).

There is no indication that the responding sample differed from the population of contractor/builders in Michigan. Because, however, a chance for a $100 prize was given for return of a complete questionnaire, it could be argued that businesspersons in more need of money may have had a greater tendency to respond. The response rate of 20% was a disappointment expecially because it was believed that the chance for the $100 would increase the response rate beyond that which is generally expected. Measures such as personalizing cover letters to increase the contractors'

Table 2

Areas and Percentage of the Contractor's Business

Area	Persons respon- ding to question	% of work done in area			
		0-25%	25-50%	50-75%	75-100%
Residential					
n	89	9	6	17	57
%	99	10	7	19	64
Commercial					
n	77	59	11	5	2
%	86	77	14	6	3
Renovation					
n	84	22	16	22	24
%	93	26	19	26	29
New construction					
n	84	33	17	15	19
%	93	39	20	18	23
Urban					
n	85	20	23	17	25
%	94	24	27	20	29
Rural					
n	79	29	17	18	15
%	88	37	21	23	19
Local					
n	89	3	0	5	81
%	99	3	0	6	91
State					
n	65	56	1	1	7
%	72	86	2	2	11
National					
n	61	55	0	1	4
%	68	90	0	2	7

Table 3

Gross Annual Income

Income level	n	%
Under $250,000	62	71
$250,000--$1,000,000	16	18
$1,000,000--$5,000,000	6	7
$5,000,000--$25,000,000	3	3
Over $25,000,000	1	1

likelihood of returning the questionnaire were attempted. The greatest factor in limiting the response rate was probably the length of the final questionnaire (15 pages).

Measures

The needs assessment employed in this study was based on a thorough examination of the literature, including both a computer and manual search of the research in the area. It was composed of several sections: a socio-demographic survey, a dissemination theory section (DTS), a passive solar heating perception section (PSHPS), and an outcome measure based on Hart, Kantrowitz, and Kurtz's (1981) stages of adoption.

Socio-Demographic Survey

The first part of the questionnaire was the socio-demographic survey. This section consisted of 28 items aimed at identifying demographic characteristics of the contractors and their businesses participating in the study (see Appendix A). The advantage of this type of data was that it enabled the researcher to do analyses on a number of relevant issues (individual contractor descriptors, business size, complexity, location, income, and type).

Several of the items (age, sex, last grade completed in school) were variables relevant to the individual contractor. Although the dissemination literature did not discuss these variables, it was believed that this information would be important to describe the sample.

Many of the items were included in the instrument because they had been identified in the construction literature as distinguishing amongst businesses. These items included variables such as years in business; subsidiary status; percentage of business which is residential vs. commercial; percentage of business which is renovation vs. new structures; number of structures both renovated and built annually; percentage of business which is local, state-wide, and nation-wide; percentage of business which is rural vs. urban; and gross annual income. This information was used to describe the sample.

Finally, some of the items were included because of their relevancy to the dissemination/adoption literature. Among these variables were number of business employees; number of employed subcontractors; identification of the person most instrumental in aiding with business decisions; number of different employee categories (business complexity); description of the business type (according to Hart et al., 1981); average number of annual out of town business trips taken (cosmopoliteness); number of professional building journals subscribed to (cosmopoliteness); presence of recent business changes; and number of passive solar heating classes, workshops, and regularly read solar journals (originally put in as a measure of knowledge). This information was used in various statistical tests which will be discussed in the following chapter.

Dissemination Theory Section

The dissemination theory section (DTS) consisted of 22 items based on the dissemination of innovations literature (see Appendix A). These items dealt with concepts such as individual contractor, organizational, and innovation characteristics. All of the items were based on a 1 to 5 Likert-type scale in which the contractor was to indicate his/her degree of agreement.

The complete list of descriptors for these variables included some items from the socio-demographic survey. Because these items were also involved in the scaling procedures, the next few paragraphs include items from both sections.

Individual Contractor Characteristics. The following items were used to measure each of the individual contractor characteristics. When the variable is followed by α, items were computed as a scale; α is the scale's standardized alpha, a measure of internal consistency. When the questionnaire item is followed by a "recoded" statement, the direction of the variable score coding was reversed prior to analysis.

Two items from the socio-demographic survey (SDS) were used to measure cosmopoliteness:

1. On the average, over the last five years, how many out of town trips have you taken each year to attend some type of contractors' function (conventions, organization meetings, etc.)? (SDS Item I-13)

2. List the professional builders' journals you subscribe to each year. (These were counted.) (SDS Item I-14)

A simple Pearson correlation was used to investigate whether there existed an empirical association between the two variables assessing cosmopoliteness. These items showed an empirical relationship ($\underline{r}$ = .37, $\underline{p} < .01$), but not one large enough to justify putting them into one scale.

The following item was used to measure individual contractors' level of innovativeness: I do not have the tendency to try out new building or renovation techniques prior to their general acceptance in the building industry (Item II-t). This item was rated from strongly agree (1) to strongly disagree (5).

A series of items were used to assess the contractor's knowledge of the innovation. The following question was asked in regard to a number of issues: If I were to build or renovate a passive solar structure within the next three months, I would need to know more about _________ used in passive solar structures. Contractors rated their agreement from strongly agree (1) to strongly disagree (5) in reference to each of the following topics:

1. Different types of building materials (Item II-g).
2. The price of building materials (Item II-h).
3. The durability of building materials (Item II-i).
4. How to get ahold of building materials (Item II-j).
5. Heat storage methods (Item II-k).
6. Maintenance techniques (Item II-l).

7. The actual construction or renovation techniques (Item II-m).

8. The physics (Item II-n).

Responses to the above eight items were combined to form a scale measuring knowledge of the innovation (α = .90). Although originally believed to be knowledge variables, number of solar classes and workshops taken and number of solar journals subscribed to were eliminated from the knowledge scale. Elimination was based on low inter-item correlations and item-total correlations.

Items assessing all of the above individual contractor characteristics were combined to form a scale. The standardized alpha of this scale was .32. (See Table 4 for a matrix of intercorrelations among these items.)

Organizational Characteristics. A number of items were used to measure the organizational characteristics of the contractor's business. Size was measured as (a) the number of employees (SDS Item 3), and (b) the number of subcontractors (SDS Item 4).

Organizational complexity was measured by counting the number of categories indicated in SDS Item 4 (number of subcontractors) as business employees.

Presence of recent business changes was assessed by the following two items:

1. Have you made any major changes in your organization with regard to building or renovating techniques, styles, or designs in the last three years? (Yes or No) (Item I-15)

Table 4

Matrix of Intercorrelations among Individual Characteristics

Characteristic	2	3	4
1. # business trips	.37	.06	-.02
2. # professional journals	--	-.04	.13
3. Innovativeness		--	.15
4. Knowledge of innovation			--

2. Have you made any major changes in your business (besides those mentioned in question 15) in the last three years? (Yes or No) (Item I-16)

The two items above showed an empirical relationship ($r = .30$, $p < .01$), but not one large enough to justify putting them into one scale. Therefore, they were treated as separate measures of recent business changes.

Other organizational characteristics were measured by items which were rated strongly agree (1) to strongly disagree (5):

1. Company support: I think that most persons working in this company would support the incorporation of passive solar heating systems into the structures we build or renovate (recoded Item II-ac).

2. Building industry support: I think that the Michigan building industry is supportive of the incorporation of passive solar heating systems into Michigan structures (recoded Item II-ad).

3. Formalization: I want my employees to closely follow established rules and procedures in performing their jobs within the company (recoded Item II-u).

4. Centralization: I make most decisions regarding the adoption of new housing techniques on my own (recoded Item II-v).

5. Interpersonal relations: For the most part, in my business, employees across different job positions discuss business matters with each other (for example, architects

talk to engineers, plumbers talk to electricians, etc.) (recoded Item II-ab).

Items assessing all of the above organizational characteristics were combined to form a scale. The standardized alpha for this scale was .65. (See Table 5 for a matrix of intercorrelations among these items.)

Innovation Characteristics. A number of items were used to measure the innovation's attributes. Each item was rated from strongly agree (1) to strongly disagree (5).

The relative advantage of solar technology was assessed by the following item: The benefits or advantages of passive solar heating are obvious to me (Item II-aa).

Compatibility of solar technology with the contractor's beliefs and values was measured by the following five items:

1. There is no need for the U.S. to move away from the use of conventional fuels (Item II-a).

2. The U.S. must begin to regulate energy consumption to avoid a future shortage of energy resources (recoded Item II-b).

3. The building industry can influence energy consumption through its decision on the type and quality of homes to be built (recoded Item II-c).

4. The U.S. needs to put more money and effort into the development of solar technologies (recoded Item II-e).

5. It is risky to incorporate solar technologies at this time (Item II-r).

Table 5

Matrix of Intercorrelations among Organization Characteristics

Characteristic	2	3	4	5	6	7	8	9	10
1. # employees	.33	.82	.10	-.04	.06	.22	.26	.07	.48
2. # subcontractors	--	.61	.11	.21	.06	.09	.15	.02	.11
3. Complexity		--	.11	.03	.07	.09	.27	.06	.38
4. Design changes			--	.20	-.17	.17	-.02	.18	-.09
5. Other business changes				--	-.08	.15	.07	.38	-.06
6. Company support					--	.31	.03	.02	-.02
7. Industry support						--	.04	.28	.39
8. Formalization							--	.22	.20
9. Centralization								--	.11
10. Interpersonal relations									--

These items were combined to form a scale of compatibility. The standardized alpha of the scale was .51.

Complexity of the innovation was measured by two items:

1. The technology of passive solar heating systems is more complex than conventional heating systems (recoded Item II-p).

2. It is not difficult to understand the architectural designs of a passive solar structure than it is to understand the designs of conventional structures (Item II-q).

The above two items measuring complexity showed an empirical relationship ($\underline{r}$ = .31, $\underline{p} < .01$), but not one large enough to justify putting the two items into one scale. Therefore, the two items were treated as separate measures of complexity.

Trialability of the innovation was measured with the following item: Passive solar heating systems are not easily tested on a trial basis (Item II-s).

Observability was assessed as follows: I have seen few working and reliable passive solar systems in the state of Michigan (Item II-az).

Items assessing all of the above innovation characteristics were combined to form a scale. The standardized alpha for this scale was .21. (See Table 6 for a matrix of intercorrelations among these items.)

Summary. The standardized alphas of the individual contractor and innovation characteristic scales were surprisingly low. The items simply did not seem to correlate highly

Table 6

Matrix of Intercorrelations among Innovation Characteristics

Characteristic	2	3	4	5	6
1. Relative advantage	.20	-.31	-.12	.22	.15
2. Compatibility	--	-.01	.08	.19	-.00
3. Complexity		--	.31	-.05	-.08
4. Difficult to understand			--	-.03	.04
5. Trialability				--	.05
6. Observability					--

amongst each other (see Tables 4 and 6). The standardized alpha for the organizational characteristics scale was high (.65), although many of the individual correlations among items were low (see Table 5). For these reasons, variables for each of the different characteristics were not treated as scales. In the following chapter, the relationship between these items and adoption of passive solar technologies will be examined.

Passive Solar Heating Perception Section

In the passive solar heating perception section (PSHPS), contractors were asked to rank 39 barriers on the extent (important barrier [1] to unimportant barrier [5]) to which they perceived the factor as being an obstacle in adopting passive solar heating technologies (see Appendix A). This section included all the relevant barriers found in the preceding literature review: economic, technological, psychological/sociological, informational, and political/ legal. If the contractor had already adopted passive solar technologies, s/he was asked to answer the questions in terms of the extent to which they felt the factor posed a barrier to Michigan builders in general in regards to the adoption of passive solar heating at that time.

A combination of empirical and confirmatory factor analysis was used to group individual items into scales. Resultant scales and their standardized alphas follow: (a) economic barriers (α = .79), (b) technological barriers (α = .78), (c) psychological/sociological barriers (α = .66),

(d) informational barriers (α = .76), and (e) political/ legal barriers (α = .80).

One of the primary questions of this study was to prioritize these barriers on their importance as obstacles for solar implementation by Michigan contractors. This will be covered, along with other relevant analyses, in the next chapter.

Outcome Measure

The outcome measure, or stage of adoption, was based on Hart et al. (1981). The contractor was asked to choose one of the following seven consecutive and incremental stages of adoption of passive solar heating technologies which best described her/him (see Appendix A):

1. I have not been exposed to passive solar heating.

2. I have been exposed to or am becoming aware of passive solar heating as an option.

3. I am showing active interest in passive solar heating as an option (reading and talking to others about it).

4. I am analyzing passive solar heating as an option in detail and am comparing systems to conventional heating systems.

5. I am seeking specific information and studying passive solar heating to the point of selecting a preference among the solar options (looking at different passive heating systems and comparing them).

6. I am using the solar option I prefer.

7. I have used solar and have discontinued using it.

This is the measure which was used to investigate the extent to which solar technologies have been implemented by Michigan contractors along with the relationship between individual, organization, and innovation characteristics and stage of adoption. This is covered in the following chapter.

Pilot Study

The final edition of the questionnaire discussed above was the result of a pilot study conducted several weeks prior to the final mailing. The pilot study was conducted in order to (a) identify any major questions that contractors felt were not included in the questionnaire, (b) detect wording or format problems (usage of terms that might be considered too vague or academic), and (c) estimate a test-retest reliability quotient.

The pilot sample consisted of 10 contractors (out of 25 originally asked) selected through their association with friends of the researcher. The pilot sample was selected in this non-random fashion because it was expected that they would tend to be more cooperative in critiquing the instrument and filling out a second questionnaire for the reliability check. Both solar-experienced and -nonexperienced contractors were chosen for this preliminary investigation.

Two questionnaires were sent to each participant. S/he was asked to fill out one of the questionnaires the day on which the surveys arrived and to wait two weeks before filling out the second one. It was made clear that they were not to consult the first questionnaire when filling out its counterpart. The contractors were asked to identify any problems they had with specific questions by writing comments in the margin. Although personal interviews with all ten participants were not possible, the researcher met with more than half of the contractors to document problems and suggestions they had regarding the survey.

Pearson correlations were run between those questionnaires filled out upon arrival and those filled out two weeks later. Because substantial correlations ($r > .60$, $p < .05$) were found for the majority (62%) of the items, the questionnaire was determined reliable across time. Following revision of the original questions based on the suggestions of the pilot sample, the survey was ready to be administered to the larger sample.

Procedure

The Questionnaire Packet

The questionnaire packet contained a consent form (see Appendix B), a cover letter (see Appendix C), the questionnaire (see Appendix A), and a self-addressed business reply envelope in which they could return the survey at no cost to them. The consent form was a simple written statement that the contractors were asked to sign and return to confirm that they were voluntarily filling out the questionnaire and to assure them that answers to the survey would remain confidential. The cover letter (personalized through the use of a word processor) explained that the information was being compiled by the researcher in conjunction with Michigan State University. The letter included a statement asserting that anyone who returned a completed questionnaire by the specified deadline date would be eligible for a chance to win $100. All letters were personally signed by the researcher. An identification number was written at the top of each questionnaire to insure anonymity.

The questionnaire packet was mailed to the sample through the university mail system. Originally, the packet was intended to be sent bulk-rate but, because the researcher was working within a very restricted time schedule, the packet had to be sent first class.

The Prod Letter

Five weeks following the original mailing, 86 completed questionnaires had been returned. A prod letter (see Appendix D) was sent to all contractors who had not yet replied. This second mail-out (of approximately 400 letters) resulted in the return of only four additional questionnaires.

This chapter involved a description of the contractors who responded to the questionnaire as well as an overall look at the composition of the survey. Prior to reading the next chapter, it is advisable to review the actual instrument sent to the contractors (Appendix A). The next chapter answers the research questions addressed at the end of chapter 1.

CHAPTER 3

RESULTS

Extent of and Barriers to Adoption of Passive Solar Heating

This chapter has been organized according to the research questions described at the end of chapter 1.

Extent of Adoption of Passive Solar Heating by Michigan Contractors

Before looking at the major barriers perceived by Michigan contractor/builders, the extent of solar adoption by participants will be reviewed. This question was a derivation of Hart et al.'s (1981) stages of solar adoption. In this measure, contractors were asked to describe themselves in terms of the degree to which they had adopted solar technologies. The percentage of persons describing themselves at each level follows the description in parentheses.

1. I have not been exposed to passive solar technologies (22%).

2. I have been exposed to or am becoming aware of passive solar heating as an option (22%).

3. I am showing an active interest in passive solar heating as an option (reading and talking to others about it) (29%).

4. I am analyzing passive solar heating as an option in detail and am comparing systems to conventional heating systems (10%).

5. I am seeking specific information and studying passive solar heating to the point of selecting a preference among the solar options (looking at different passive heating systems and comparing them) (10%).

6. I am using the solar option I prefer (7%).

7. I have used solar and have discontinued using it (0%).

As can be seen, only 7% of the responding contractors had actually adopted solar technologies at the time of the study. This statistic further reinforces the need for a strategy to actively disseminate passive solar technologies to Michigan contractor/builders.

Identification of Important Barriers

To answer the question regarding which barriers are seen as instrumental in preventing Michigan contractors from implementing passive solar technologies into their businesses, barriers from the passive solar heating perception section (PSHPS) were prioritized by the percentage of number 1 responses assigned to each obstacle. As previously mentioned, items were rated on a scale from very important (1) to not an important (5) barrier. Because of skewed and non-normal distributions, each barrier was dichotomized such that a number 1 rating meant that the barrier was rated as important (originally received a rating of 1 or 2) and a number 2 rating meant that the barrier was not rated as important (originally received a rating of 3, 4, or 5). In addition, obstacles were put into the five barrier category scales based on both empirical and rational evidence (see Table 7

Table 7

Prioritization of Barriers by Percentage of Responses in #1 (Important Barrier) Category

Barrier	% of responses in #1 category	Overall ranking
Economic (α = .79)		
The lack of consumer demand	81.0	1.0
The risk of not recovering the cost of the passive solar system when the structure is sold	80.5	2.0
The high cost of passive solar heating systems	78.0	5.0
The lack of available working capital necessary to adopt passive solar technologies	77.0	8.0
The financial risk involved due to any number of reasons	77.0	8.0
High interest rates on loans for passive solar buildings	72.0	12.5
The lack of an easy way to compare energy costs of different passive solar structures	70.5	15.5
My belief that anticipated revenues from building or renovating passive solar structures will not cover the relevant costs (direct, indirect, and capital)	70.0	17.5
The lack of financial incentives directed at contractors to construct or renovate structures utilizing passive solar technologies	70.0	17.5
The cost of establishing distribution channels of passive solar products	57.5	28.0

Table 7 (cont.)

Barrier	% of responses in #1 category	Overall ranking
Technological (α = .78)		
The lack of cost and performance data for passive systems	79.5	3.0
Michigan's cold and cloudy climate	73.0	11.0
The lack of generally accepted passive solar design procedures	71.0	14.0
The lack of design data for passive solar systems	65.5	21.0
Lack of specific information on products I would use in passive solar heating (glass, storage structures, etc.)	62.5	22.0
The unreliability of passive solar heating products	59.0	26.5
The lack of accurate weather data	37.0	36.0
Psychological/sociological (α = .66)		
Starting relationships with unfamiliar solar businesses involves a risk of that company going out of business and leaving you without a warranty, etc.	78.0	5.0
The lack of support for passive solar technologies in most sectors of the building industry	74.0	10.0
Passive solar technologies are not easily tested on a trial basis	72.0	12.5

Table 7 (cont.)

Barrier	% of responses in #1 category	Overall ranking
Psychological/sociological (cont.)		
The difficulty of establishing distribution channels of passive solar heating systems	62.0	23.5
Solar houses being ugly	45.0	33.0
My belief that people will not be buying structures with solar heating systems in the future	41.0	34.0
Having to make changes in my normal business procedures in order to begin utilizing passive solar design	35.0	37.0
The threat of vandalism to newly constructed or renovated solar structures	34.5	38.0
The lack of support for passive solar technologies from your employees of your business	26.0	39.0
Informational (α = .76)		
An individual owner not knowing enough about passive solar systems	78.0	5.0
Your not seeing enough properly working systems in Michigan	77.0	8.0
Not knowing where to go for reliable information on passive solar heating systems	66.0	20.0
The lack of passive solar-related information and skills of the majority of my employees	57.0	29.0

Table 7 (cont.)

Barrier	% of responses in #1 category	Overall ranking
Informational (cont.)		
The lack of my understanding of the benefits or advantages of passive solar heating systems	48.0	30.0
Inadequate governmental reading materials on passive solar technologies	47.0	31.5
The degree of difficulty in understanding the technology of passive solar systems	40.0	35.0
Political/legal (α = .80)		
The difficulty in obtaining loans for passive solar buildings	70.5	15.5
Zoning and coding officials holding up the building process because of their unfamiliarity with passive solar technologies	67.0	19.0
The lack of passive solar product standardization	62.0	23.5
The inflexibility of structure designs required by zone laws	60.0	25.0
The lack of passive solar warranties	59.0	26.5
The lack of zoning laws protecting solar access	47.0	31.5

for standardized alphas). When appropriate, these scale scores were used in analyses rather than the individual barriers.

The percentages of number 1 ratings can be observed in Table 7. As can be seen in the table, the majority of the ranked barriers can be found under the economic and psychological/sociological subheadings. The top ten ranked barriers were as follows:

1. The lack of consumer demand (economic).

2. The risk of not recovering the cost of the passive solar system when the structure is sold (economic).

3. The lack of cost and performance data for passive systems (technological).

4. The high cost of passive solar heating systems (economic).

5. Starting relationships with unfamiliar solar businesses involves a risk of that company going out of business and leaving you without a warranty, etc. (psychological/sociological).

6. An individual owner not knowing enough about passive solar systems (informational).

7. The lack of available working capital necessary to adopt passive solar technologies (economic).

8. The financial risk involved due to any number of reasons (economic).

9. Your not seeing enough properly working systems in Michigan (informational).

10. The lack of support for passive solar technologies in most sectors of the building industry (psychological/ sociological).

As indicated, lack of consumer demand came out as being the number one barrier. As mentioned before, the primary goal of a businessperson is to make a profit. S/he cannot be ensured of this profit until there is a demand for her/his product. With all the other major indicated concerns about adopting the innovation (risk of not recovering costs, lack of cost and performance data, etc.), it would not be expected that businesspersons would adopt an innovation for which they perceived no demand. It simply would not be worth it. Therefore, time and effort must be put into the consumer sector in regard to increasing the demand for passive solar technologies in Michigan. As stated in the literature review, there are many contributing factors to the slow adoption of solar technologies by consumers. The strategy for increasing Michigan consumer adopters will have to be developed as a separate project.

Differences in Barrier Perception between Knowledgeable and Non-knowledgeable Contractors

The third question in this section investigated differences in the rating of the barrier scales by contractors knowledgeable and not knowledgeable about passive solar heating technologies. This question was based on the assumption that contractors with knowledge of the innovation would more accurately assess the barrier potential of the stated obstacles than non-knowledgeable contractors. In order to determine whether there was a discrepancy between the two contractor groups, correlations between the knowledge scale and the economic, technological, psychological/sociological, and political/legal scales were examined. (The informational scale was eliminated because of its obvious relationship with knowledge.) The correlations were significant for each of the barrier types (see Table 8).

Table 8

Pearson Correlations between Knowledge and Barrier Scales

Barrier	Knowledge
Economic	$-.25^{**}$
Technological	$-.27^{**}$
Psychological/sociological	$-.28^{**}$
Political/legal	$-.17^{*}$

$^{*}p < .05$. $^{**}p < .01$.

This analysis showed that non-knowledgeable contractors tended to rate the scales as more important barriers to solar implementation than contractors with more knowledge. This showed that the contractor's knowledge is related to his/her perception of the importance of each of the barrier types involved in solar implementation. Because a relationship has been documented between knowledge and level of adoption

(r = .24, p < .01), it could be speculated that inaccurate perceptions might prevent the contractor from adopting for non-existent, misconceived reasons. As a result, it would be in the change agent's best interest to provide the contractor with a clearer picture of passive solar technologies.

Barrier Importance and Level of Adoption

In order to assess whether there was a relationship between the importance of barrier types and level of adoption, correlations were run between each of the barrier groups and the outcome measure (see Table 9). The correlations in the table indicate that a definite relationship exists between each barrier type and level of adoption.

Table 9

Pearson Correlations between Level of Adoption and Barrier Scales

Barrier	Level of adoption
Economic	$-.34^{**}$
Technological	$-.39^{**}$
Psychological/sociological	$-.40^{**}$
Informational	$-.44^{**}$
Political/legal	$-.18^{*}$

$^{*}p < .05$. $^{**}p < .01$.

To further investigate this finding, a multivariate analysis of variance (MANOVA) was utilized to compare three levels of adoption on ratings of the barrier scales (see Table 10). The three levels were compiled by condensing the original number of adoption stages.

Low level of adoption was composed of the following two stages:

1. I have not been exposed to passive solar heating.

2. I have been exposed to or am becoming aware of passive solar heating as an option.

Medium level of adoption included the following two stages:

1. I am showing an active interest in passive solar heating as an option.

2. I am analyzing passive solar heating as an option in detail and am comparing systems to conventional heating systems.

High level of adoption was defined by the following two stages:

1. I am seeking specific information and studying passive solar heating to the point of selecting a preference among the solar options.

2. I am using the solar option I prefer.

The overall MANOVA indicated a significant difference between the groups [$F(2,10) = 2.93$, $p < .01$] by the Wilks' Lambda criterion. A discriminant function analysis was performed for a more detailed examination of the discrepancy

Table 10

Discriminant Function Analysis Comparing Barrier Ratings of Contractors with Low, Medium and High Levels of Adoption of Passive Solar Technologies

Barrier	MS between groups	Univariate F[a]	Standardized discriminant function coefficient
Economic	.40	6.98*	-.41
Technological	.58	6.98*	-.22
Psychological/ sociological	.39	7.58*	-.23
Informational	.77	9.78*	-.56
Political/legal	.20	1.83	.34

[a] df for univariate F tests = 2,85.

*$p < .01$.

between the three groups. These findings, along with the univariate F tests, can be found in Table 10.

All but the political/legal scale were found to significantly differentiate among the three levels of adoption. By examining the means in Table 11, it can be concluded that the higher level adopters rate economic, technological, psychological/sociological and informational barriers as significantly less important than the lower level adopters.

Table 11

Observed Means for Barrier Scales for Contractors with Low, Medium, and High Levels of Adoption of Passive Solar Technologies

	Level of adoption		
Barrier	Low	Medium	High
Economic	1.82	1.68	1.57
Technological	1.76	1.59	1.44
Psychological/ sociological	1.59	1.52	1.32
Informational	1.68	1.61	1.29
Political/legal	1.65	1.63	1.45

The discriminant function analysis suggests that the ranking of barriers on power to discriminate on adoption level is as follows: informational, economic, political/legal, psychological/sociological, and technological. Because this analysis does not infer a causal relationship, one must be cautious in interpreting this finding as meaning high barrier ratings lead to low adoption level or vice versa. However, since the contractors were rating the degree to which they perceived a barrier hindering implementation of solar technologies, it suggests that the perception of heavier weighted barriers leads to low adoption.

Barrier Importance Related to Organization Type

As stated in the literature review, Hart et al. (1981) hypothesized an interaction effect between the stage of the decision-innovation process (level of adoption) and the type of building company in regards to which barriers would be seen as most important. The following is a review of the different organization types and the percentage of the sampled contractors describing themselves in each way:

1. Internal: large enough to handle all the requirements of structure building, including design, architectural and engineering services (13%).

2. Custom: employ someone or design structures or renovations by self. Structures are built to the needs and specifications of the purchaser (56%).

3. External: use pre-designs available through plan services, plan companies, previous experience or from the prospective purchaser. Rely on information from manufacturers and suppliers on the pre-design of the structure (31%).

A MANOVA was run to investigate the possibility of an interaction. The MANOVA for comparing the barrier scale ratings of contractors of different types of businesses was not found to be significant [$F(2,10) = 1.46$, $p > .05$] by the Wilks' Lambda criterion. Also, the MANOVA for comparing the barrier ratings of contractors with interacting organization types and adoption levels was not found to be significant [$F(4,20) = 0.74$, $p > .05$].

Therefore, it does not seem that the three organization types rated the barriers differently nor that their ratings were reliant on a combination of their type and level of adoption.

Dissemination Theory

Individual Contractor Characteristics Related to Level of Adoption

Research indicated that a positive correlation would be expected between the following individual characteristics and level of adoption: cosmopoliteness (number of annual out of town business trips and number of professional building journals subscribed to), innovativeness, and contractor's knowledge of the innovation. A correlation matrix indicated a significant positive relationship for number of annual out of town business trips taken ($r = .24$, $p < .01$); innovativeness ($r = .37$, $p < .01$); and, as mentioned earlier, contractor's knowledge of the innovation ($r = .24$, $p < .01$) and stage of adoption (see Table 12).

These findings indicated the following:

1. The more annual out of town business trips taken by Michigan contractors (cosmopoliteness), the greater the level of adoption.

2. The more a Michigan contractor rates him/herself as generally innovative, the greater the level of adoption.

3. The greater the contractor's knowledge of passive solar heating, the greater the level of adoption.

Table 12

Pearson Correlations between Individual Characteristics and Adoption Level

Individual characteristics	Adoption level
Cosmopoliteness	
Number of out of town business trips	.24*
Number of professional builders' journal subscriptions	.17
Innovativeness	.37*
Knowledge of the innovation	.24*

*$p < .01$.

This, of course, is a correlational analysis and cannot be interpreted, in any case, as either of the variables causing the other.

Organization Characteristics Related to Adoption

Past findings predicted a positive relationship between adoption level and each of the following variables: organization size, organization complexity, company support of the innovation, building industry support of the innovation, and interpersonal relations. A negative relationship was predicted between adoption level and presence of recent business changes, formalization, and centralization.

The correlation matrix indicated a significant positive relationship between level of adoption and each of the following: number of subcontractors (organization size)

(r = .21, $p < .05$); presence of recent design business changes (r = −.27, $p < .01$); presence of other recent business changes (r = −.20, $p < .05$); and company support (r = .35, $p < .01$ (see Table 13). These findings indicated the following:

1. The greater the number of subcontractors, the higher the level of adoption.

2. With presence of recent design business changes, the greater the level of adoption.

3. With presence of other recent business changes, the greater the level of adoption.

4. The greater the amount of company support, the greater the level of adoption.

The findings related to recent business changes were opposite of what was predicted. Implications of these findings will be discussed in the next chapter.

Innovation Characteristics Related to Adoption

A positive correlation was predicted between adoption level and relative advantage, compatibility, trialability, and observability. A negative correlation was predicted between level of adoption and complexity of the innovation. A series of Pearson correlations indicated a significant positive relationship between level of adoption and relative advantage (r = .23, $p < .01$) and observability (r = .19, $p < .05$) (see Table 14). These findings indicated the following:

1. The more the Michigan contractor is aware of the

Table 13

Pearson Correlations between Organization Characteristics and Adoption Level

Organization characteristics	Adoption level
Number of employees	-.16
Number of subcontractors	.21*
Recent business changes	
Design changes	.27**
Other changes	.20*
Organization complexity	-.13
Formalization	-.17
Centralization	-.08
Interpersonal relations	-.08

*$p < .05$. **$p < .01$.

Table 14

Pearson Correlations between Innovation Attributes and Adoption Level

Innovation attributes	Adoption level
Relative advantage	.23**
Compatibility	.12
Complexity	
Solar more complex than conventional systems	-.15
Solar more difficult to understand than conventional systems	-.12
Trialability	.11
Observability	.19*

*$p < .05$. **$p < .01$.

benefits and advantages of passive solar heating, the greater the level of adoption.

2. The more working passive solar heating systems the contractor has seen in Michigan, the greater the level of adoption.

Since this was a correlational analysis, cause and effect cannot be assumed.

Relevant Advisor

The following question was asked to identify the persons Michigan contractors most often go to for help with business decisions: Which of the persons listed above are most instrumental in helping you make decisions on implementing or incorporating new housing techniques, styles, or designs?

It was found that the majority (59%) of the contractors chose architects and local designers (28%) or themselves (31%) as being most instrumental in helping them make decisions regarding new housing techniques (see Table 15).

This finding indicates that going directly to the contractor is an appropriate strategy for disseminating passive solar heating technologies to Michigan contractors. It also indicates that it is advisable for the change agent to consult with architects and local designers to enhance the receptivity of Michigan contractors to passive solar technologies.

With this review of the data, the next chapter discusses the implications of these findings and how they relate to future policy and research.

Table 15

Categorization of Relevant Advisors

Advisor	# of contractors choosing	% of contractors choosing
Self	21	31.0
Architects or local designers	19	28.0
Salespeople	5	7.5
Relatives	5	7.5
Business partner	3	4.5
Magazines	3	4.5
None of the above	2	3.0
Consumers	1	1.5
Construction workers	1	1.5
Plumbers	1	1.5
Subcontractors	1	1.5
Carpenters	1	1.5
Supervisors	1	1.5
Estimators	1	1.5
All of the above	1	1.5

CHAPTER 4

DISCUSSION

The purpose of this study was to (a) determine the extent to which passive solar technologies have been adopted by Michigan contractors, (b) develop a ranking of the importance of various barriers to the adoption of solar technology, and (c) investigate the relevance of dissemination literature to the adoption of passive solar heating technologies by Michigan contractors. Data were acquired through a mailed questionnaire to a random sample of Michigan contractors.

This chapter will review major findings of the study and discuss methodological issues relevant to its analysis. This will be followed by theoretical implications and a discussion of the study's implications for future policy and research.

Major Findings

It was found that only 7% of the participants have adopted passive solar technologies in their Michigan contracting/building businesses. An additional 10% stated that they were studying passive solar technologies to the point of selecting a preference among the solar options. These two statements led to the conclusion that 17% of the respondents to the questionnaire considered themselves to be high level adopters of the innovation. This means that the majority of contractors in the study (83%) considered themselves to be either low or medium level adopters of passive solar technologies. This fact emphasized the importance of having the contractors identify important barriers to the adoption of solar systems.

Overall, consumer demand and other economic barriers had the greatest percentage of "important barrier" ratings, followed by technological, political/legal, informational, and psychological/sociological barriers, respectively.

A correlational analysis showed that contractors not knowledgeable of passive solar technologies tended to rate the economic, technological, psychological/sociological, and political/legal scales as more important barriers to solar implementation than contractors with solar knowledge. A positive relationship between knowledge of solar technologies and level of adoption of the innovation ($r = .24$, $p < .01$) was also determined.

Another correlational test indicated significant relationships between economic ($r = -.34$, $p < .01$), technological ($r = -.39$, $p < .01$), psychological/sociological ($r = -.40$, $p < .01$), informational ($r = -.44$, $p < .01$), and political/legal ($r = -.18$, $p < .05$) barrier groups and level of adoption. A MANOVA determined that barrier ratings on all but the political/legal scale were found to significantly differentiate among low, medium, and high levels of adoption. A discriminant function analysis suggested that the ranking of barriers on power to discriminate on level of adoption was as follows: informational, economic, political/legal, psychological/sociological, and technological.

This study showed that the three organization types, as described by Hart et al. (1981) did not rate the barriers differently as expected. Nor was it found that the contractors' ratings of the barrier types were a function of organization type and level of adoption, as proposed.

Individual contractor characteristics found to be significantly correlated with level of adoption were number of out of town business trips taken, innovativeness, and knowledge of the innovation. Organization characteristics found to be significantly positively correlated with adoption level were were number of subcontractors employed, presence of recent business changes, and company support for the innovation. Innovation characteristics found to be significantly positively related with level of adoption were relative advantage and observability.

Architects and local designers were often consulted by the contractors for advice on decisions regarding new housing techniques.

Methodological Issues

The most important methodological issue for this study was the generalizability of the results. As mentioned previously, the response rate was estimated at 20% (90 of the originally randomly selected 500 contractors returned a completed questionnaire). It was also mentioned that, because a chance in a drawing for a $100 prize would be granted to those returning a completed questionnaire, there was a possibility respondents might consist of those contractors in greater need of money. More importantly, however, the statistical tests employed in analyzing the results could have had more power if they had been applied to a larger sample size. Therefore, it is advisable to read the results as preliminary findings rather than definitive conclusions.

Important Barriers

Only 17% of the Michigan contractors considered themselves to be high level passive solar adopters. Contributing to this fact is the abundance of barriers hindering adoption of the innovation. Economic barriers were identified as being the most important obstacles to Michigan contractors' adopting passive solar technologies in their businesses. However, when knowledge of passive solar technologies was taken into account, all groups of barriers were rated as more important by contractors without knowledge of passive solar technologies. In addition, the more solar knowledge a contractor had, the higher his/her level of adoption. In fact, of all barrier groups, informational barriers were found to have the greatest power in discriminating among low, medium, and high level adopters. Therefore, although Michigan contractors identified economic barriers as being the greatest obstacles to implementation of passive solar technologies in their businesses, further statistics indicated that level of solar information had an even stronger relationship with level of adoption.

It could be inferred here that solar education programs would increase adoption of passive solar systems. However, because of the correlational nature of this study, decisions for new programs should not be based on these findings alone. This point should, however, be considered for future research and will be discussed under that section.

Implications for Theory

Several of the questions in chapter 1 were directly related to dissemination of innovations theory. These questions investigated the relationship between individual contractor, organizational, and innovation characteristics. Findings of this study did not fully document what had been found in past research.

With regard to individual contractor characteristics, three of the four investigated relationships with adoption level were found to be significant. Number of professional building journals subscribed to (a measure of cosmopoliteness) was not significantly correlated with the outcome measure ($r = .17$, $p < .05$). Given the conservative nature of the building industry, professional journals might not be a good measure of cosmopoliteness for this population. It could be speculated that a fair number of professional building journals actively encourage the construction of traditional structures. Therefore, even the most conservative builder/contractors would subscribe to professional journals. For the most part, however, this study re-established the positive relationships between number of out of town business trips taken (consmopoliteness), innovativeness, and contractor's knowledge of the innovation and level of adoption.

Findings on organization characteristics supported only two of the proposed relationships and did not support another. All of the following were not found to be significantly correlated with the outcome measure: number of employees ($r = -.16$, $p < .05$), organization complexity ($r = -.13$, $p < .05$), building industry support ($r = .05$, $p < .05$), formalization ($r = -.17$, $p < .05$), centralization ($r = -.08$, $p < .05$), and interpersonal relations ($r = -.08$, $p < .05$). Only number of subcontractors and company support followed predicted relationships.

The presence of recent design changes and presence of recent other business changes were found to be positively correlated with stage of adoption. This was opposite of what was predicted. Recent changes were previously found to be negatively correlated to adoption (Hill, 1982). This finding might be explained in two ways. First, the item was phrased so that "recent" was described as "within the last three years." There is a possibility that this was an inappropriate time period to define "recent" in the context of the building industry. Second, "recent design changes" were positively correlated with innovativeness ($r = .36$, $p < .01$). This finding suggests that "recent design changes" were being made by innovative builders. Since innovativeness and level of adoption were positively correlated ($r = .37$, $p < .01$), it would be expected that "recent design changes" would also be positively correlated to the outcome measure. This is definitely a finding to keep in mind with future research.

Regarding innovation attributes, only two of the characteristics were found to be positively correlated with adoption level. Relative advantage and observability were the only innovation attributes associated with adoption. Therefore, if a contractor is familiar with the innovation's benefits or has been exposed to a number of working and reliable systems, chances are adoption level will be higher. Compatibility ($r = .12$, $p > .05$), solar technologies' being more complex (complexity) ($r = -.15$, $p > .05$), solar designs being difficult to understand (complexity) ($r = -.12$, $p > .05$), and trialability ($r = .11$, $p > .05$) were not found to be significantly correlated to adoption level as previously reported. It is possible that these variables were not represented by valid items in the questionnaire. This, however, is not thought to be the case since all of the items were correlated with level of adoption in the hypothesized direction. Given the exact probabilities for each correlation, there was a nonsignificant trend for each of the variables. If there were a greater number of subjects in the study, the correlations would probably have been significant.

In summary, if one were interested in finding higher level adopters of passive solar technologies, one would look for contractors that took quite a few annual out of town business trips, were generally innovative, were knowledgeable about the innovation, had subcontractors, envisioned that they were supported by their companies, had experienced recent business changes, understood the benefits of passive solar technologies or had seen a number of working systems in the state.

Implications for Future Policy and Research

Ideally, this study would have been able to lay down the law for solar policy directed towards Michigan contractors. Because of the small sample size, however, findings must be considered exploratory as opposed to conclusive. These findings can be used, though, to determine what steps need to be taken to increase the implementation of solar technologies by Michigan contractors.

Because economic and informational barriers were most often identified as influencing adoption of passive solar technologies, future research concerning Michigan contractors should emphasize these two areas. Two specific research projects would be appropriate.

Most importantly, it would be interesting to set up a series of educational programs directed towards contractors based on their present level of solar knowledge. Program ideas could be obtained through a survey sent out to the contractors. This program would be set up in an area, of course, which demonstrated enough interest in the service to warrant its establishment. A randomly selected control group would be chosen for comparison. Level of adoption would be measured both before and one year after the solar classes/workshops. This study would be able to determine whether an increase in solar knowledge actually affects the degree of solar adoption.

Another study implied by these findings would be one investigating various economic policies for Michigan contractors. This study could establish a number of economic incentives to increase solar adoption in the state. This could be done through a needs assessment administered to a large sample of Michigan contractors. It would be advisable to consult architects as well.

In addition, as stated in this report, contractors identified "lack of consumer demand" as their number one barrier. This finding implies a need for consumer programs and incentives. A needs assessment directed towards Michigan consumers of new and renovated housing could be administered. Findings could be used to develop programs and incentives to increase adoption of solar structures and systems by Michigan residents.

In conclusion, the above-mentioned research suggestions have been based on a preliminary investigation into the perceptions of Michigan contractors of passive solar heating technologies.

APPENDICES

APPENDIX A

QUESTIONNAIRE

APPENDIX A

QUESTIONNAIRE

ID: ________________ AGE: ________ SEX: F M

LAST GRADE COMPLETED IN SCHOOL (Circle one)

1-8 9 10 11 12 12 14 15 16 MA/MS Phd

1. How many years have you been in business? _________

2. Is your business a subsidiary of a larger firm?

   YES NO

3. How many employees do you have working for you? ________

4. Please give the number of persons working in each position at your company.

POSITION	NUMBER	POSITION	NUMBER
Secretaries	______	Salespeople	______
Architects	______	Advertising	______
Construction Workers	______	Subcontractors	______
Plumbers	______	Others (explain)	
Electricians	______	________________	______
Accountants	______	________________	______

5. Which of the persons listed above are most instrumental in helping you make decisions on implementing or incorporating new housing techniques, styles, or designs? (CIRCLE ONE)

   If not one of the above, who? ___________________________

I. For the following questions, please circle the correct response for each category.

6. What percentage of your business would you say is:

a) residential

1. 0-25% 2. 25%-50% 3. 50%-75% 4. 75%-100%

b) commercial/institutional:

1. 0-25% 2. 25%-50% 3. 50%-75% 4. 75%-100%

c) other (explain, please) ____________________________

1. 0-25% 2. 25%-50% 3. 50%-75% 3. 75%-100%

7. What percentage of your business would you say is:

a) renovation (includes retrofit)

1. 0-25% 2. 25%-50% 3. 50%-75% 3. 75%-100%

b) building new structures

1. 0-25% 2. 25%-50% 3. 50%-75% 4. 75%-100%

8. On the average, over the last 5 years:

a) how many structures have you renovated annually?

____

b) how many structures have you built annually?

____

9. What percentage of your business is located:

a) locally (within a 100-mile radius from your business)

1. 0-25% 2. 25%-50% 3. 50%-75% 4. 75%-100%

b) throughout the state of Michigan (excluding the local area)

1. 0-25% 2. 25%-50% 3. 50%-75% 4. 75%-100%

c) throughout the United States (excluding Michigan)

1. 0-25% 2. 25%-50% 3. 50%-75% 4. 75%-100%

10. What percentage of your business is located:

    a) in rural areas

        1. 0-25%   2. 25%-50%   3. 50%-75%   4. 75%-100%

    b) in urban areas

        1. 0-25%   2. 25%-50%   3. 50%-75%   4. 75%-100%

11. What is your business' approximate gross income range?

    1. under $250,000

    2. $250,000-$1,000,000

    3. $1,000,000-$5,000,000

    4. $5,000,000-$25,000,000

    5. over $5,000,000

12. Which of the following best describes your business?

    a) large enough to handle all the requirements of structure building including design, architectural and engineering services.

    b) employ someone or design structures or renovations by self. Structures are built to the needs and specifications of the purchaser.

    c) use pre-designs available through plan services, plan companies, previous experience or from the prospective purchaser. Rely on information from manufacturers and suppliers on the pre-design of the structure.

13. On the average, over the last five years, how many out-of-town trips have you taken each year to attend some type of contractors' function (conventions, organizations, etc.)?

    1. 0   2. 1-2   3. 3-4   4. 5 or more

14. List the professional builders' journals you subscribe to each year.

    ______________________   ________________________

    ______________________   ________________________

15. Have you made any major changes in your organization with regard to building or renovating techniques, styles, or designs in the last three years?

    YES NO

    If yes, what? ______________________________

    ____

16. Have you made any other major changes in your business (besides those mentioned in question 15) in the last three years?

    YES NO

    If yes, what? ______________________________

    ____

II. For the next set of questions, please circle the number which most closely reflects how much you agree or disagree with the statement. The key below tells you what each number stands for. Please answer each question.

All references to solar energy refer to <u>passive solar space heating</u> <u>NOT</u> passive solar water heating or active solar systems. Passive solar space heating refers to solar systems utilizing southern oriented glazing possibly accompanied by some type of heat absorption capacity: interior walls, trombe wall, bricks, etc. Minimal use of fans for air circulation is permissible. (Attached greenhouses are also an example of passive solar heating.)

1	2	3	4	5
strongly agree	agree	neither agree nor disagree	disagree	strongly disagree

a) There is <u>no</u> need for the U.S. to move away from the use of conventional fuels.

   st agree 1 2 3 4 5 st disagree

b) The U.S. must begin to regulate energy consumption to avoid a future shortage of energy resources.

   st agree 1 2 3 4 5 st disagree

c) The building industry can influence energy consumption through its decision on the type and quality of homes to be built.

   st agree 1 2 3 4 5 st disagree

d) The U.S. needs to put more money and effort into the development of nuclear energy.

st agree 1 2 3 4 5 st disagree

e) The U.S. needs to put more money and effort into the development of solar technologies.

st agree 1 2 3 4 5 st disagree

f) I (speaking of yourself) am likely to build or renovate a structure which utilizes some type of passive solar heating system within the next five years.

st agree 1 2 3 4 5 st disagree

g) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about different types of building materials used in passive solar structures.

st agree 1 2 3 4 5 st disagree

h) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about the price of building materials used in passive solar structures.

st agree 1 2 3 4 5 st disagree

i) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about the durability of building materials used in passive solar structures.

st agree 1 2 3 4 5 st disagree

j) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about how to get ahold of building materials used in passive solar structures.

st agree 1 2 3 4 5 st disagree

k) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about heat storage methods.

st agree 1 2 3 4 5 st disagree

l) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about maintenance of passive solar structures.

st agree 1 2 3 4 5 st disagree

m) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about the actual construction or renovation of passive solar structures.

st agree 1 2 3 4 5 st disagree

n) If I were to build or renovate a passive solar structure within the next three months, I would need to know more about the physics of passive solar structures.

st agree 1 2 3 4 5 st disagree

p) The technology of passive solar heating systems is more complex than conventional heating systems.

st agree 1 2 3 4 5 st disagree

q) It is not any more difficult to understand the architectural designs of a passive solar structure than it is to understand the designs of a conventional structure.

st agree 1 2 3 4 5 st disagree

r) It is risky to incorporate solar technologies at this time.

st agree 1 2 3 4 5 st disagree

s) Passive solar heating systems are not easily tested on a trial basis.

st agree 1 2 3 4 5 st disagree

t) I do not have the tendency to try out new building or renovation techniques prior to their general acceptance in the building industry.

st agree 1 2 3 4 5 st disagree

u) I want my employees to closely follow established rules and procedures in performing their jobs within the company.

st agree 1 2 3 4 5 st disagree

v) I make most decisions regarding the adoption of new housing techniques on my own.

st agree 1 2 3 4 5 st disagree

w) More people will be buying homes with passive solar heating within the next five years.

st agree 1 2 3 4 5 st disagree

x) It is expensive to establish distribution channels for passive solar system parts.

st agree 1 2 3 4 5 st disagree

y) It is difficult to establish distribution channels for passive solar system parts.

st agree 1 2 3 4 5 st disagree

z) The anticipated revenues from building or renovating passive solar structures will <u>not</u> cover the relevant costs (direct, indirect and capital).

st agree 1 2 3 4 5 st disagree

aa) The benefits or advantages of passive solar heating are not obvious to me.

st agree 1 2 3 4 5 st disagree

ab) For the most part, in my business, employees across different job positions discuss business matters with each other (for example, architects talk to engineers, plumbers talk to electricians, etc.).

st agree 1 2 3 4 5 st disagree

ac) I think that most persons working in this company would support the incorporation of passive solar heating systems into the structures we build or renovate.

st agree 1 2 3 4 5 st disagree

ad) I think that the Michigan building industry is supportive of the incorporation of passive solar heating systems into Michigan structures.

st agree 1 2 3 4 5 st disagree

ae) I do not have the financial resources necessary to build or renovate passive solar heating structures.

st agree 1 2 3 4 5 st disagree

af) If contracted to do a solar job in my business, the employees who design the structures are familiar enough with solar technologies that they would not have to seek help from sources other than persons normally referred to for design problems

st agree 1 2 3 4 5 st disagree

ag) If contracted to do a solar job in my business, the employees who renovate or construct the structures are familiar enough with solar technologies that they would not have to seek help from sources other than persons normally referred to for construction problems.

st agree 1 2 3 4 5 st disagree

ah) If contracted to do a solar job, the majority of my employees would need to be educated on passive solar heating systems.

st agree 1 2 3 4 5 st disagree

ai) There are presently too few incentives directed at Michigan contractors to construct or renovate structures utilizing passive solar technologies.

st agree 1 2 3 4 5 st disagree

aj) There is no easy way to compare energy costs of different passive solar structures in the state of Michigan.

st agree 1 2 3 4 5 st disagree

ak) There exists little cost and performance data for the operation of passive solar systems in Michigan.

st agree 1 2 3 4 5 st disagree

al) There exists little design data for passive solar structures in the state of Michigan.

st agree 1 2 3 4 5 st disagree

am) Passive solar structures are very costly to build or renovate.

st agree 1 2 3 4 5 st disagree

an) There is a great possibility that the cost of the passive solar system will not be covered when the structure is sold.

st agree 1 2 3 4 5 st disagree

ao) Passive solar heating products are unreliable.

st agree 1 2 3 4 5 st disagree

ap) There exists little accurate weather data for Michigan.

st agree 1 2 3 4 5 st disagree

aq) A contractor would have to make changes in their normal business procedures in order to incorporate passive solar design into their business.

st agree 1 2 3 4 5 st disagree

ar) Michigan's climate is not suitable for passive solar energy systems.

st agree 1 2 3 4 5 st disagree

as) Governmental reading materials on passive solar technologies are often inadequate.

st agree 1 2 3 4 5 st disagree

at) There is not a lack of zoning laws protecting passive solar access in Michigan.

st agree 1 2 3 4 5 st disagree

au) The structural designs required by Michigan zoning laws are very flexible for passive solar design.

st agree 1 2 3 4 5 st disagree

av) Michigan zoning and coding officials will hold up the building and renovation of passive solar structures due to their unfamiliarity with solar technologies.

st agree 1 2 3 4 5 st disagree

aw) It would be difficult for me to obtain loans to build or renovate passive solar structures.

st agree 1 2 3 4 5 st disagree

ax) The interest rates on loans for passive solar buildings are very high in Michigan.

st agree 1 2 3 4 5 st disagree

ay) There is a lack of generally accepted solar design procedures in Michigan.

st agree 1 2 3 4 5 st disagree

az) I have seen few working and reliable passive solar systems in the state of Michigan.

st agree 1 2 3 4 5 st disagree

ba) There are not a lack of standardized solar products.

st agree 1 2 3 4 5 st disagree

bb) There are few passive solar products which offer warranties.

st agree 1 2 3 4 5 st disagree

bc) There is a large financial risk in a contracting company incorporating passive solar design in Michigan.

st agree 1 2 3 4 5 st disagree

bd) There is a lack of consumer demand for structures with passive solar heating systems.

st agree 1 2 3 4 5 st disagree

be) Michigan passive solar structures are ugly.

st agree 1 2 3 4 5 st disagree

bf) There is a threat of vandalism occurring at the sites of newly constructed or renovated solar structures in Michigan.

st agree 1 2 3 4 5 st disagree

bg) I do not know where to go for reliable information on passive solar heating designs.

st agree 1 2 3 4 5 st disagree

bh) In order to use solar designs, I will have to deal with solar companies which may very well go out of business.

st agree 1 2 3 4 5 st disagree

III. The literature claims that all of the items listed below have been found to be barriers to U.S. contractors to implementing passive solar heating systems into their businesses.

For the following questions, circle the number which best indicates the degree to which you see it as a barrier to your implementing passive solar heating in your business. IF YOU ARE PRESENTLY BUILDING OR RENOVATING SOLAR STRUCTURES, PLEASE ANSWER EACH ITEM IN TERMS OF THE DEGREE TO WHICH YOU THINK IT ACTUALLY POSES A BARRIER TO MICHIGAN CONTRACTORS IN IMPLEMENTING PASSIVE SOLAR HEATING.

Please check one:

_____ I am answering for myself

_____ I am answering for other builders

1	2	3	4	5
a very important barrier	an important barrier	neither important nor unimportant barrier	a somewhat unimportant barrier	an unimportant barrier

a) The lack of financial incentives directed at contractors to construct or renovate structures utilizing passive solar technologies is

very impt barrier 1 2 3 4 5 unimpt barrier

b) The lack of consumer demand is

very impt barrier 1 2 3 4 5 unimpt barrier

c) The lack of an easy way to compare energy costs of different passive solar structures is

very impt barrier 1 2 3 4 5 unimpt barrier

d) The lack of passive solar-related information and passive solar skills of the majority of my employees is

very impt barrier 1 2 3 4 5 unimpt barrier

e) The lack of cost and performance data for passive systems is

very impt barrier	1	2	3	4	5	unimpt barrier

f) The lack of design data for passive solar systems

very impt barrier	1	2	3	4	5	unimpt barrier

g) The high cost of passive solar heating systems is

very impt barrier	1	2	3	4	5	unimpt barrier

h) The lack of available working capital necessary to adopt passive solar technologies is

very impt barrier	1	2	3	4	5	unimpt barrier

i) The risk of not recovering the cost of the passive solar system when the structure is sold is

very impt barrier	1	2	3	4	5	unimpt barrier

j) The unreliability of passive solar heating products is

very impt barrier	1	2	3	4	5	unimpt barrier

k) The lack of accurate weather data is

very impt barrier	1	2	3	4	5	unimpt barrier

l) The lack of my understanding of the benefits or advantages of passive solar heating systems is

very impt barrier	1	2	3	4	5	unimpt barrier

m) The cost of establishing distribution channels of passive solar products is

very impt barrier	1	2	3	4	5	unimpt barrier

n) The difficulty of establishing distribution channels of passive solar heating systems is

very impt barrier	1	2	3	4	5	unimpt barrier

o) The lack of support for passive solar technologies in most sectors of the building industry is

very impt barrier	1	2	3	4	5	unimpt barrier

p) Having to make changes in my normal business procedures in order to begin utilizing passive solar design is

very impt barrier	1	2	3	4	5	unimpt barrier

q) Michigan's cold and cloudy climate is

very impt barrier	1	2	3	4	5	unimpt barrier

r) Inadequate governmental reading materials on passive solar technologies is

very impt barrier	1	2	3	4	5	unimpt barrier

s) The lack of zoning laws protecting solar access is

very impt barrier	1	2	3	4	5	unimpt barrier

t) The inflexibility of structure designs required by zoning laws is

very impt barrier	1	2	3	4	5	unimpt barrier

u) Zoning and coding officials holding up the building process because of their unfamiliarity with passive solar technologies is

very impt barrier	1	2	3	4	5	unimpt barrier

v) The difficulty in my obtaining loans for passive solar structures is

very impt barrier	1	2	3	4	5	unimpt barrier

w) High interest rates on loans for passive solar buildings is

very impt barrier	1	2	3	4	5	unimpt barrier

x) My belief that people will not be buying structures with passive solar heating systems in the future is

very impt barrier	1	2	3	4	5	unimpt barrier

y) Lack of specific information on products I would use in passive solar heating (glass, storage structures, etc.) is

very impt barrier	1	2	3	4	5	unimpt barrier

z) The lack of generally accepted passive solar design procedures is

very impt barrier	1	2	3	4	5	unimpt barrier

aa) Your not seeing enough properly working systems in Michigan is

very impt barrier	1	2	3	4	5	unimpt barrier

ab) The degree of difficulty in understanding the technology of passive solar systems is

very impt barrier	1	2	3	4	5	unimpt barrier

ac) The lack of passive solar product standardization is

very impt barrier	1	2	3	4	5	unimpt barrier

ad) The lack of passive solar warranties is

very impt barrier	1	2	3	4	5	unimpt barrier

ae) The financial risk involved due to any number of reasons is

very impt barrier	1	2	3	4	5	unimpt barrier

af) Solar houses being ugly is

very impt barrier	1	2	3	4	5	unimpt barrier

ag) The threat of vandalism to newly-constructed or renovated solar structures is

very impt barrier	1	2	3	4	5	unimpt barrier

ah) Not knowing where to go for reliable information on passive solar heating systems is

very impt barrier	1	2	3	4	5	unimpt barrier

ai) Starting relationships with unfamiliar solar businesses involves a risk of that company going out of business and leaving you without a warranty, etc. is

very impt barrier	1	2	3	4	5	unimpt barrier

aj) Passive solar technologies are not easily tested on a trial basis is

very impt barrier	1	2	3	4	5	unimpt barrier

ak) An individual owner not knowing enough about passive solar systems is

very impt barrier	1	2	3	4	5	unimpt barrier

al) The lack of support for passive solar technologies from your employees of your business is

very impt barrier	1	2	3	4	5	unimpt barrier

am) My belief that anticipated revenues from building or renovating passive solar structures will not cover the relevant costs (direct, indirect, and capital) is

very impt barrier	1	2	3	4	5	unimpt barrier

an) Which of the following statements best describes you? (check one)

_____ I have not been exposed to passive solar heating

_____ I have been exposed to or am becoming aware of passive solar heating as an option

_____ I am showing active interest in passive solar heating as an option (reading and talking to others about it)

_____ I am analyzing passive solar heating as an option in detail and am comparing systems to conventional heating systems

_____ I am seeking specific information and studying passive solar heating to the point of selecting a preference among the solar options (looking at different passive heating systems and comparing them)

_____ I am using the solar option I prefer

_____ I have used solar and have discontinued using it

ao) How many classes have you taken that have gone over the concepts of passive solar heating? ______

ap) How many workshops have you taken that have gone over the concepts of passive solar heating? ______

aq) List the journals you read which regularly include articles on passive solar systems.

______________________ ______________________

______________________ ______________________

APPENDIX B

CONSENT FORM

APPENDIX B

CONSENT FORM

In order to clear the project with Michigan State University, we are required to have each person sign the consent form below.

I am willingly filling out this questionnaire for the project being run by the Center for Innovation Research at Michigan State University on solar energy. I realize that I may discontinue filling out the form at any time and that I have a choice whether or not to return it. I understand that my responses to the questionnaire will not be directly associated with me or my business but that the name of my company will be mentioned in the write-up of the final report. I also know that if I want to find out the results of the study, they will be available to me upon request.

Signature: ____________________________

Date: ____________________________

APPENDIX C

COVER LETTER

APPENDIX C

COVER LETTER

MICHIGAN STATE UNIVERSITY

Center for Innovation Research East Lansing, MI 48824
401 Olds Hall

Feb 23, 1983

Dear ___________________:

The research staff at the Center for Innovation Research of Michigan State University is presently working on a project to determine where Michigan contractors stand in regard to solar technologies in residential and commercial construction. In this effort we have compiled a list of questions that we think are relevant and important to the building industry. Because of your familiarity with the industry, we are seeking your viewpoints on solar construction in Michigan.

The questionnaire will take approximately 30-40 minutes to fill out. By doing so, you will be helping us to determine if and what statewide policy changes need to be made to make it easier and more profitable for contractors to incorporate solar technologies into their businesses. This is an area which we feel will become increasingly important to all members of the building industry. Your participation in this study ensures that we will get an accurate picture of the contractor's perspective.

We are offering all persons filling out and returning the entire survey a chance to win $100.00 in a drawing to occur March 19. To be eligible for this drawing, your questionnaire must be received by us no later than March 18, 1983. The name of the winner of the drawing will be available upon request by March 20. If your name is drawn, a check will be sent to you through the mail.

We appreciate your taking the time out of your busy schedule to complete our questionnaire. We believe that this is a highly significant study which has important implications for the building profession.

Thank you,

P.M. Witte
Project Director

P.S. Please carefully read the next page, sign it and return it with the questionnaire.

Enclosures

PMW/opt

APPENDIX D

PROD LETTER

APPENDIX D

PROD LETTER

April 1, 1983

Hello,

I am writing this short note as a reminder asking you to fill out the questionnaire that was sent a few weeks ago from the Center for Innovation Research. I would like to stress the importance of this research to you, as a businessperson in Michigan and also to those of us interested in seeing solar energy become more accepted by the Michigan building industry.

Because I sent the surveys to a limited number of people, it is very important that I am able to analyze the responses of as many contractors as possible. The data from this research project will be presented at the American Solar Energy Society Conference in Minneapolis this June. As there will be a large number of professionals (architects, policy analysts, social scientists, etc.) attending this presentation, I want to be sure that the data accurately represents the opinions of Michigan contractors towards passive solar technologies. The data will be used, in essence, as a basis for policy changes that will make it easier for contractors to incorporate passive solar technologies into their businesses.

I certainly appreciate your taking the time to fill out the survey at your earliest convenience.

Thank you,

Patti Witte
Project Director

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