Factors Affecting the Diffusion of Two Energy Efficient Innovative Housing Systems

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More than 19 percent of the energy used in our nation is consumed by private dwellings. Further, building systems, both residential and commercial, account for more than one-third of the energy consumed in the country as a whole (American Institute of Architects, 1974). As a result of high energy use in housing, numerous approaches designed to achieve a balance between energy supply and consumption have been attempted. The most noticeable of these efforts include energy education, increasing the costs of energy fuels, and conservation programs designed to alter energy consuming lifestyles. Government and industry programs have been formulated to increase the supply of fuel, provide tax credits for installation of energy efficient equipment and materials, and design innovative building systems that reduce the initial and continuing reliance on fossil fuels as sources of energy. Economic incentives include the Federal Tax credits to home owners for equipment and systems which reduce the space conditioning of a house. Nineteen states also have an income tax credit to encourage the use of energy efficient equipment (Vadnais, 1980).

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According to the American Institute of Architects (1974), energy usage could be reduced by 15 to 25 percent in existing buildings through conservation practices. In newly constructed buildings, energy consumption could be reduced by 35 to 50 percent. A Task Force of the Federal Power Commission (1973) reported that the annual energy consumption of a good quality, single-family residence could be reduced 40 percent without affecting the lifestyle of the occupants; and, that means for effecting these savings are within current technologies.

The two broad categories of energy conserving building systems, earth sheltered and passive solar, appear to have great potential for reducing energy consumption without demanding the substantial increase in initial capital output required of active solar systems. Earth sheltered systems encompass a broad range of underground and earth embanked housing units which are surrounded partially or completely by

soil, thereby utilizing the earth's natural ability to cool in hot weather and to warm in cold weather. Passive solar systems use construction materials and methods, design concepts, landscaping, and site orientation to retain or prevent natural heating of the sun's rays. Despite the tremendous potential of these low-cost energy conserving systems, the utilization of such systems has been limited.

Basic theories on the diffusion or adoption of innovations can shed light on the slow rate of utilization of earth sheltered and passive solar systems. Such theories suggest that technological superiority is not the sole factor in the rate in which innovations are accepted by the general population. Rosenberg (1972) states that the diffusion process is often based on an economic assessment; yet, the rate of change is slow. The early adopter makes decisions based on economic incentives and when inadequate baseline data are available for life cycling costs, the diffusion of the innovation is slowed (Larsen, 1981).

Consistent with this thesis, an attempt was made to identify factors and/or conditions related to the limited use of earth sheltered and passive solar building systems in selected counties in Oklahoma and Arkansas. Data reported are derived from preliminary community studies designed to devise a regional framework for identifying societal constraints to the adoption of innovative housing alternatives.

Theoretical Framework

Katz et al. (1963) suggest that the diffusion of an innovation is the acceptance of an idea or practice by individuals or groups. An adopting unit often functions in communicating the innovations to a given system of values or culture. In this study, two energy efficient housing systems, earth sheltered and passive solar, were the innovations compared. Housing intermediaries (i.e., lenders, builders, appraisers and inspectors) were considered "adopting units" in the diffusion process, as they are required to react to innovations in housing forms as technological developments spread throughout their profession and the lay consumer public.

Rogers (1972) identified general characteristics of innovations which affect adoptability. These include:

Relative advantage:	The degree to which an innovation is superior to the ideas it supersedes;
Compatibility:	Degree to which an innovation is consistent with existing values and past experiences of the adopters;
Complexity:	Degree to which an innovation is relatively difficult to understand and use;
Divisibility:	Degree to which an innovation may be tried on a limited basis;
Communicability:	Degree to which the results of an innovation are easily observed and communicated to others.

Additionally, market factors involved in the production and distribution of housing suggest that innovative housing designs may be considered entrepreneurial innovations. This factor increases the caution exercised by "adopting units" as entrepreneurial innovations involve greater economic, social and political risks (Pedersen, 1978). Competition is also involved in entrepreneural innovations in the sense that first use is often conceived as being an adoption or non-adoption by the community. Housing intermediaries therefore face great risks as adopting units in the diffusion of housing innovations.

The adoption of any innovative idea is generally the result of movement through a multi-staged continuum, beginning with awareness and moving to interest, evaluation, trial, and finally adoption. The movement through the continuum might progress as follows: read an article (awareness), actively seek more information (interest), compare various alternatives (evaluation), apply innovation on a small scale (trial), and use the innovative practice on a continual basis (adoption). The numerous risks faced by housing intermediaries necessarily dictates slowness in the beginning stages of the continuum, with an increase in speed as more adopters spread information about the benefits of the housing innovations. According to Kirton (1976), differences exist in general readiness

to accept innovative change. Therefore, the readiness to adopt and/or the actual adoption of innovations among housing intermediaries may affect the general public's reaction to the innovation.

The major purpose of the present study is to ascertain the attitudes of four housing intermediaries (i.e., lenders, inspectors, appraisers and builders) toward two specific innovative housing systems: earth sheltered and passive solar. Specifically, the study sought to determine the following:

(a) The existence of constraints and policies, real or perceived, to the production and distribution of the innovative housing systems;
(b) Factors related to the acceptance of innovative housing systems by the housing intermediaries;
(c) The position of the housing intermediaries in the multi-staged adoption process.

Methods

Procedures for data collection and analysis fell within a broad qualitative approach to research inquiry. The intent of the study was to isolate broad areas of concern rather than to identify frequency distributions that fall within a quantitative paradigm. Intensive interviews were held with housing intermediaries in eight counties in Arkansas and Oklahoma during the fall of 1980. Counties were selected on the basis of similarity to counties identified for study in the S-141 regional housing project. All non-SMSA counties in each state were placed in the following quartiles: high median family income—high percent of non-farm households, high median family income—low percent of non-farm households, low median family income—high percent of non-farm households, and low median family income—low percent of non-farm households. One county was selected from each quartile in the two participating states. All housing intermediaries that maintained office facilities in the four counties in each state were interviewed. Fifty-two housing intermediaries were interviewed: 10 builders, 16 appraisers, 22 lenders, and 4 inspectors. Table 1 gives the distribution of the number of housing intermediaries in each professional group interviewed by state.

Working drawings of the two innovative systems were shown during each interview and respondents were asked to identify constraints related to the designs they might encounter in their professional role. Key questions were developed for each professional group prior to conducting the interviews. Instantiation and follow-up questions were formulated during the interview process in an effort to probe and clarify the responses. The assessment of factors affecting the diffusion of the two innovative systems was based upon the perceptions verbalized by the respondents.

Results and Discussion

All housing intermediaries interviewed in this study identified constraints to the adoption of the two innovative housing systems. Conversely, few features of the innovative systems that would facilitate adoption and subsequent diffusion were identified. Table 2 lists the various characteristics of the earth sheltered and passive solar systems perceived to constrain and/or facilitate the adoption of the two housing systems. The constraints identified support the authors' contention that innovative housing systems are in fact, entrepreneurial innovations. All respondents identified constraints to the adoption of the two housing systems that pose economic, social and political risks for the adopting unit.

Table 1—Distribution of Number of Respondents in Each Professional Group By State

State	Professional Group				Total
	Lenders	Builders	Appraisers	Inspectors	
Oklahoma	13	7	10	4	34
Arkansas	9	3	6	0[a]	18
Total	22	10	16	4	52

[a]None of the counties selected in Arkansas had building codes.

The economic risk mentioned most frequently by builders, lenders and appraisers was expressed as skepticism regarding the saleability of the housing units. Appraisers felt that additional research was needed prior to appraising earth sheltered and passive solar units and expressed concern over the economic feasibility of conducting the needed investigations. Other economic risks were indicative of perceived

Table 2—Constraints and Facilitators to the Adoption of Earth Sheltered and Passive Solar Housing Systems Perceived by Housing Intermediaries

Intermediary	Constraints		Facilitators	
	Passive Solar	**Earth Sheltered**	**Passive Solar**	**Earth Sheltered**
Lenders	Resale value Novelty of design Too speculative Public acceptance Differing mortgage provisions Increased cost of construction	Resale value Novelty of design Too speculative Public acceptance Differing mortgage provisions Increased cost of construction	Similarity in design to conventional housing Energy efficiency	Energy efficiency
Inspectors	Zoning Community Covenants	Zoning Community Covenants		Storm safety
Appraisers	Lack of knowledge and experience Lack of comparables Lack of cost data Lack of energy-use data Consumer knowledge Sale and resale value	Lack of knowledge and experience Additional inspection of soil and engineering Lack of comparables Lack of cost data Lack of energy-use data Consumer knowledge Sale and resale value	Energy efficiency	Energy efficiency
Builders	Lack of experience Increased cost of construction Accessibility of equipment and materials Additional use of architects and engineers in design process	Lack of experience Increased cost of construction Accessibility of equipment and materials Environmental restrictions Additional use of architects and engineers in design process	Energy efficiency	Energy efficiency

higher construction and financing costs. Housing intermediaries did not identify energy saving potential or life cycle costs of energy efficient units as having any potential for reducing economic risks.

Social risks were perhaps the major deterrents to adoption identified. The intermediaries consistently identified consumer lack of knowledge about the systems and questionable willingness to invest in the systems as major areas of concern. Additionally, many felt that the design of the earth sheltered unit would adversely affect consumer acceptance. Perceived problems with outdated building codes and zoning ordinances were the political risks identified by the respondents.

The major advantage of the two systems identified by the housing intermediaries was the energy efficiency of both the earth sheltered and passive solar systems. However, many respondents were reticent in acknowledging the full potential for energy efficiency of the two units because of a lack of data available on initial building and continuing maintenance costs of the two systems. Further, respondents wanted long-term data on energy usage and savings. Most felt that if this information was readily available, consumer acceptance would be greater. Perceived storm safety was identified as an advantage for the earth sheltered system. Particular importance was attributed to this feature by respondents in Oklahoma.

In terms of characteristics of innovations which affect adoptability, perceptions of the housing intermediaries indicated many characteristics of these innovative housing systems that would adversely affect adoptability. The fact that all intermediaries were skeptical of consumer knowledge and acceptance suggests that these innovative systems are relatively difficult to understand and use (complexity). Expressed concern for design characteristics of the earth sheltered system indicated inconsistency with existing values and past experiences of the adopters (compatibility). The passive solar system appeared to have greater potential for divisibility in that many passive features may be tried on a limited basis. Although all intermediaries expressed interest in energy efficient housing systems, their perceptions of the degree to which these systems are superior to ideas they supersede (relative advantage) are questionable. Several respondents suggested that energy conserving conventionally built housing is the way of the future. Regarding the degree to which the results of an innovation are easily observed and communicated to others (communicability), the housing intermediaries expressed a desire for additional data on many aspects of the two designs. Again, the expressed skepticism for consumer knowledge and acceptance information indicate difficulty in communicating the benefits of these innovative systems. This difficulty in communicability may be, in part, related to the size and cost of the innovation under consideration.

Although all intermediaries expressed an interest in various energy efficient housing systems and believed that housing in the future must be energy conserving, differences in stages in the adoption process were identified for the housing intermediaries. All respondents appeared to be beyond the "awareness" stage and into the "interest" stage. Several intermediaries were at the "evaluation" stage of adoption and a few were adopting on a trial basis. Two appraisers had completed appraisals of either an earth sheltered or passive solar housing unit and two lenders had loaned monies for an earth sheltered unit. One lender indicated a willingness to lend monies for earth sheltered housing but reported that he did not have requests from consumers. These data indicate that only five intermediaries were beyond the evaluation stage in the adoption process. Because these housing intermediaries function as change agents in the diffusion process, their acceptance and willingness to adopt the innovative housing systems impacts consumers' awareness and willingness to adopt.

Housing intermediaries consistently expressed reticence on issues related to novelty of design and consumer acceptance. Resale potential as well as intitial saleability were major issues of concern. However, the limited experience of these intermediaries with either earth sheltered or passive solar systems suggests that this reticence may be based as much on conjecture as on reality. The situation may be primarily perpetuated by the absence of consumer acceptance data on the innovative housing systems. Additionally, the housing intermediaries wanted empirical data on initial and continuing cost and on energy usage and cost savings potential. Once these

data are available and are communicated to the general public, the knowledge of the economic advantages of these systems may aid in the diffusion process.

Conclusion

The data presented in this article indicate that housing intermediaries function as an adopting unit in the diffusion process and consequently impact the rate of diffusion of the innovative systems. The numerous risks to adoption faced by these intermediaries impede their progress through the adoption continuum. Clearly, a major factor in the diffusion of these innovative housing systems must be a reduction in the risks to adoption faced by the intermediaries. Economic incentives in the form of government tax reductions, higher energy prices and interest subsidies may encourage housing intermediaries to become more active in the earth sheltered and passive solar markets. Increased activity in these markets would aid in garnishing energy usage, cost, benefit and consumer acceptance data.

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