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Solar energy has been categorized as "the contemporary holy grail... promis(ing) energy salvation but (eluding) capture." (Pertschuk 1978, p. 3). In the past, it has been inefficient and more costly than other energy sources; from an economic viewpoint solar energy was competitive only in certain limited applications. Recent technological changes combined with the increase costs of conventional energy sources are expected to result in solar energy systems contributing a vastly increased percentage of United States energy needs by the year 2000.

Given the current activity and interest in solar energy and the future growth anticipated in this industry, an unusual opportunity exists for the study of the consumer buyer behavior process surrounding solar energy products. Very little is presently known concerning the buying process used by individuals and firms adopting solar energy systems.

Several major research questions are very relevant. First, categorizing those individuals who have already adopted solar energy systems as innovators, how have these people evaluated solar products? Do innovators share common characteristics, in terms of demographics or their perceptions of various attributes of solar energy systems? How do these people differ from those who have considered but not adopted such systems, and from those who have not yet considered solar products? In their evaluation of solar energy systems, what are the relevant factors considered by adopters and non-adopters? Do adopters and non-adopters consider the same or different factors? Are similar factors differentially evaluated by the two groups?

This study focuses on these research questions, presenting empirical results obtained from a sample of: (1) consumers of residential solar heating and hot water heating systems, (2) potential consumers who are aware of and knowledgeable about residential solar systems but who have not installed such a system, and (3) potential consumers who are not knowledgeable about such systems.

The focus of the research presented here is on individuals throughout the adoption process. The inclusion of aware non-adopters as a group worthy of attention, in addition to adopters and unaware non-adopters, represents a departure from traditional research directions. In an effort to assess the importance of product and situation specific variables on existing theory, this research explores the appropriateness of concepts identified in the larger body of adoption-diffusion research to

a product category which entails high technology, represents a large financial commitment, and most importantly has overriding lifestyle implications.

HYPOTHESES

In keeping with the focus of innovativeness established in the adoption research, the following hypotheses are proposed to examine demographic characteristics of adopters and non-adopters.

H1 Adopters and non-adopters of residential solar energy systems differ on the basis of selected demographic measures. As compared to non-adopters, adopters are younger (H1.1), more highly educated (H1.2), have higher income (H1.3), are earlier in the family life cycle (H1.4), and have higher occupational status (H1.5).

H2 Adopters and non-adopters differ on the basis of their perceptions of certain systems. As compared to non-adopters, adopters rate such systems as greater in relative advantage over other energy sources (H2.1), lower in financial risk (H2.2), and social risk (H2.3), lower in complexity (H2.4), more compatible with their personal values (H2.5), more highly observable by others (H2.6), and more possible to try on a limited basis (H2.7).

H3 No differences exist between adopters and aware non-adopters in the product-related, economic, or social factors of importance considered in the residential solar energy system adoption decision.

H4 No differences exist among adopters of residential solar energy systems dependent upon time of adoption in either demographic characteristics (H4.1) or attribute perceptions (H4.2).

H5 Attribute perceptions of residential solar energy systems are more effective than demographic characteristics in predicting an individual's category membership as an adopter, or non-adopter.

METHODS

The data for analysis were collected through a mail survey of 631 individuals in three subsets of the general population of Maine: adopters of solar home heating or hot water heating systems, non-adopters who were aware of and knowledgeable about such systems, and unaware non-adopters. Three questionnaires, each sharing certain common sections, were developed for use

with the three population groups. Table 1 summarizes the information areas addressed by the survey.

Various bivariate and multivariate techniques were utilized in analyzing the data. Bivariate crosstabs were used to evaluate the findings related to personal characteristics, attribute perceptions, factor ratings, and differences dependent upon time of adoption. For each of these cases, chi-square testing was used to evaluate the relevant hypotheses, H1 through H4. Multivariate techniques, specifically multivariate nominal scale analysis (MNA) and dummy variable multiple discriminant function analysis (MDF), were employed to evaluate H5 concerning the importance of attribute perceptions and demographic characteristics in determining adoption. Given the explanatory nature of this study, MNA was chosen as the primary analysis technique.

RESULTS

Demographic Findings

Comparing the adopters with the general population, all of the H1 demographic hypotheses, H1.1 through H1.5, are supported. The adopter is younger, more highly educated, higher in income, earlier in the family life cycle, and higher in occupational status than the general population.

Very few differences are apparent between the adopters and aware non-adopters. Education, income level, and occupation status appear remarkably similar. In age, adopters appear more concentrated around age 35, that is, with less divergence from the categories 26-45. Perhaps reflective of this, there are relatively less single people among adopters, and a larger percentage in the early married stages. These trends are not strong. In general, the adopter and aware non-adopter appear to be very similar, yet very different from the general population.

Attribute Perceptions

Comparing the perceptions of adopters with the perceptions of the general population sample, adopters find solar energy systems to offer greater advantages over other energy sources. Additionally, they evaluate solar systems to be less financially risky, less socially risky, less complex, more compatible with their personal values, and less observable by others. These results support hypotheses H2.1 through H2.5 concerning innovation perceptions. The original hypotheses regarding observability, H2.6, and trialability, H2.7 are rejected.

The same direction of results is found when comparing adopters with aware non-adopters. Adopters perceive somewhat greater relative advantage, less risk, less complexity, greater compatibility, and less observability than do aware non-adopters. However, with the exception of complexity and observability, these differences are not statistically significant.

TABLE 1

SURVEY INFORMATION AREAS AND SAMPLE RESPONSE RATES

	Adopters[a]	Aware Non-Adopters[b]	Control Group[c]
INFORMATION AREAS			
Perceived characteristics of solar energy systems (relative advantage, complexity, compatibility, perceived risk, observability, trialability)	x	x	x
Economic, social, and product-related factors considered in evaluation	x	x	
Date of adoption	x		
Demographic characteristics (age, education, income, occupational status, family life cycle)	x	x	x
SAMPLE RESPONSE RATES			
Total mailing (n=1018)[d]	147	396	475
Usable returns (n=631)	102	300	229
Response rate (%)	69	76	48
Usable returns by actual category[e]	170	232	229

[a] Sampled from lists of known installations obtained from solar dealers, installers, and the Maine Office of Energy Resources.

[b] Sampled from lists of unsuccessful applicants for solar hot water tax grants, membership of Maine Solar Energy Association, and registrants from several alternative energy workshops.

[c] Sampled from random selection of households from the total Maine population.

[d] Excluding bad addresses.

[e] The instrument sent to aware non-adopters was designed to screen for and collect full information from actual adopters. Sixty-eight such individuals were identified.

Factor Ratings

The results obtained regarding factors of importance in the solar energy system adoption decision show that the aware non-adopter generally rates each factor to be of greater importance than does the adopter. This trend holds for each factor with the exception of the two of least importance, aesthetics and status-appeal considerations. For eight of fourteen factors, these differences are statistically significant at a .01 probability level or less. From the ordering of the factors, it is apparent that product-related and economic factors are of the highest concern to both adopters and aware non-adopters. Social factors are uniformly evaluated by both groups to be of far less consequence in the adoption decision process.

On the basis of these results, hypothesis H3, which predicted no differences between experimental groups on factor evaluation, is rejected for both product-related and economic factors.

Differences Dependent Upon Time of Adoption

Information from adopters regarding demographic characteristics and their perceptions of the innovation were analyzed against the year of installation of the solar energy system. Considering demographic characteristics only, no significant differences were found ($\alpha=.05$). Similarly, a consideration of adopters' perceptions of solar energy systems dependent upon their time of adoption showed that few differences exist. Recent adopters were found to evaluate solar energy systems as significantly more compatible with their value systems ($p<.005$) and involving less social risk ($p=.02$) than earlier adopters. Ratings of the other perceptions showed no differences dependent upon time of adoption at the .05 level.

These results generally support hypothesis H4 of no differences among adopters on these characteristics and attitudes dependent upon time of adoption, and confirm that adopters so far are quite similar to one another. Taken together with predictions of large numbers of future installations, these results add support to the contention that those who have adopted solar energy systems to date can be classified as true innovators.

Prediction of Adoption Behavior

The results of a series of predictive models using MNA and MDF indicate some support for the contention that attribute perceptions are more effective predictors than demographics. The MNA generalized R^2 and multivariate theta are both higher for the attribute perception model than for the demographic model; similarly the MDF model F-statistics show the same trend.

However, while the attribute perception models are more successful than the demographics models overall in terms of the total percentage of individuals correctly classified (62 percent versus 56 percent for the MNA results and 55 percent versus 47 percent for the MDF models), a comparison of the category-specific results reveals differences. The results support hypothesis H5 concerning the prediction of category membership as an adopter. For the remaining population categories, no general support of hypothesis H5 is found.

SUMMARY AND CONCLUSIONS

Several interesting observations emerge from a consideration of the attribute perception and demographic findings for each sample group. In comparing summary statistics on these measures, for each one except trialability, a continuum can be defined with adopters as a group at one end, the general population group at the other, and aware non-adopters between and generally closer to the adopters.

The findings regarding observability and trialability are particularly interesting. The further one progresses from being a member of the general population through awareness of solar energy systems to adoption, the less observable to others one perceives such an innovation. Although the results for trial show that most individuals perceive it likely that some sort of trial behavior occurs, it must be recognized that even such a small scale "trial" represents a major financial commitment and personal involvement. This is due to the nature of the product class--a long term commitment with no real possibility for non-involved, low risk trial. Trial, short of vicarious trial through the experiences of others, is not an applicable concept for solar energy systems.

This forces reconsideration of traditional adoption models, such as that advanced by Robertson (1971), when dealing with a product representing such a major commitment. Specifically, it is likely that for this type of product, legitimization of the product by the potential buyer would be followed directly by adoption, with no intervening "trial" stage.

The level of commitment involved in the solar energy system adoption decision is also evident from the ratings of factors of importance by both adopters and aware non-adopters. Economic and functional considerations are clearly of major concern.

The generally higher evaluations of product and economic factors by aware non-adopters is also of interst. Several possible explanations for this trend exist. Individuals, having adopted, may find that their solar systems work to their highest expectations. As they become more satisfied and have more experience with solar systems, each of these factors becomes of less concern. Aware non-adopters, on the other hand, lacking this experience, are more wary and skeptical.

Limitations and Future Directions

In designing a study to provide an in-depth analysis of individuals in one geographic region, there are limitations to the generalizability of results. Further, some bias due to sampling techniques and non-response errors is likely due to the methodology employed.

Insights regarding both adopters and non-adopters of solar energy systems are provided by the current research. It would be beneficial to further study these groups beyond the descriptions presented here, in order to better understand the purchase process involved. The most appropriate extension of the current study is a longitudinal design which tracks the future diffusion of solar energy technology in Maine. Solar energy systems represent an ideal class of products with which to conduct such a study, given their current relative newness and expected continued growth in acceptance. The present study forms a baseline against which changes in adopter and non-adopter profiles and decision making can be measured.

RELATED RESEARCH

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