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EXPLORING THE CONSUMER DECISION PROCESS IN THE ADOPTION OF SOLAR ENERGY SYSTEMS

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FOR DISCUSSION PURPOSES ONLY

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ABSTRACT

This study examines residential solar energy systems within an adoption and diffusion of innovations framework. The findings indicate considerable differences between adopters and non-adopters on many measures. MNA and MDF techniques are used to develop classification models based on both attribute perceptions of solar energy systems and demographic characteristics.

Solar energy systems continue to gain prominence in North America as consumers seek alternatives to increasingly expensive conventional energy sources. Concern over energy usage and energy costs is expected to further the consumer demand for solar energy systems, accompanied by a rapid expansion in the acceptance of these systems in future years.

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 increased 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 buying 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?

Further, 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 generally unknowledgeable about such systems.

The study provides insights in several areas, including: (1) solar energy itself, (2) comparative analytical techniques, and (3) the adoption process for a major technological innovation. The primary focus is on the final area. As such, this study is positioned within an adoption and diffusion of innovations framework, examining the purchase decision process of a major technological innovation. An important aspect of this research is its consideration of the non-adopter as well as the adopter in this process.

THEORETICAL FOUNDATIONS

The basic concepts of adoption and diffusion of innovations have received considerable research attention over the years (Ryan and Gross 1943; Rogers 1962; Rogers and Shoemaker 1971; Robertson 1971; Ostlund 1974; Midgley 1977; Midgley and Dowling 1978). The individual processes of adoption and diffusion can be integrated as component parts of the larger process of social change. Zaltman and Lin (1971) have developed a summary paradigm of the social process which provides an interesting perspective on this relationship. The basic components of interest here are: (1) the innovation itself, that is, some "new" product, method, or idea; (2) an individual who decides to adopt the innovation, thus exhibiting innovative behavior; and (3) the diffusion of the innovation through a social system, as further individuals make an adoption decision.

The concept of innovativeness can be considered at several levels. Traditionally, it has been defined as "the degree to which an individual is relatively earlier in adopting an innovation than other members of his system" (Rogers and Shoemaker 1971, p. 27). This is in fact an operational and behaviorally observable measure of the hypothetical trait, innate innovativeness.

Rogers (1976) argues that innovative behavior can be explained by two types of variables: (1) the individual's personality, attitudes, etc., and (2) the nature of the social system itself. In line with the former, numerous researchers have attempted to relate innovativeness to various personality traits (Robertson and Myers 1969; Donnelly 1970; Jacoby 1971; Baumgarten 1975; Ostlund 1969, 1974) as well as certain demographic measures (Bell 1963, Robertson 1971).

Additionally, discussion has focused on the identification of summary attributes of innovations and the measurement of individual adopters' perceptions of these various attributes (Rogers and Shoemaker 1971; Ostlund 1974). Those attributes most commonly considered include: (1) relative advantage, or the degree to which the innovation is perceived as being superior to the idea or product it replaces; (2) perceived risk, the expected probability of economic or social loss resulting from innovation; (3) complexity, the extent to which the innovation appears difficult to use and understand; (4) compatibility, the degree to which the innovation is seen as consistent with the innovator's existing values, past experiences, and needs; (5) trialability, the extent to which one can experiment on a limited basis with the innovation; and (6) observability, the degree to which the results of innovating are visible to others.

The Rogers and Shoemaker work indicates that individual perceptions of these attributes affect the rate of adoption of an innovation, or the relative speed with which an innovation diffuses through the members of a social system (typically expressed as the length of time elapsing before some percentage of the system has adopted). Ostlund (1974) extended this research to predict innovativeness (adoption versus non-adoption) by individuals on the basis of the individuals' perceptions of the innovation attributes. In these studies, the directions of the relationships between the attribute perceptions and innovative behavior are generally found to be positive, with the exception of perceived risk and complexity. That is, adopters of a given innovation tend to rate it as being higher in relative advantage, compatibility, trialability, and observability, and lower in perceived risk and complexity, than non-adopters of the innovation.

Findings in Consumer Behavior Diffusion Studies

In categorizing the consumer behavior literature to date, several trends can be identified: a focus on observed innovativeness, a consideration of adopters to the exclusion of non-adopters, an inherent research bias in favor of innovators, and a lack of development of theoretical bases or models (Rogers 1976). We judge these insights to be excellent directions for future research in this area. The fundamental thrust of this research follows these suggestions.

The concept of innovativeness is of central importance in much of the consumer behavior diffusion literature. Indeed, the major concern of many studies has been the identification of correlates of observed innovativeness. Demographic and psychographic factors, social interaction factors, consumption patterns, and various other factors have most commonly been correlated with innovativeness (Robertson 1971). A few general directions of correlations emerge, but considerable ambiguity and contradictory findings are also evident, leading one to the conclusion that innovativeness may well be product or situation-specific.

Diffusion studies have traditionally focused on adopters alone, and have not considered non-adopters (Rogers 1976). What should be of greater concern than simply studying adopters is to understand the process by which consumers evaluate an innovative product. Several models relevant to the adoption decision process have been suggested (Robertson 1971, Palda 1966). These models tend to closely parallel many general models of consumer behavior, postulating three levels of involvement on the part of potential adopters (cognitive, affective, and behavioral), and tracing through a stepwise process ultimately leading to adoption of the innovation.

What is missing from the literature, however, is a specific evaluation of the non-adopter. This person likely goes through the early steps of the process in the same fashion as the adopter, yet because of a differential evaluation of factors arrives at a decision not to adopt. Consideration of both adopters and non-adopters will further the understanding of the total process.

Solar Energy Research

Published research concerning the consumer behavior of solar energy is, at this writing, scant. Only recently has research appeared which considers the diffusion of solar energy technology (Leonard-Barton 1980).

Several preliminary studies dealing with solar energy from a consumer behavior perspective are suggestive of the fertile research ground in this area, and pose numerous interesting further issues. Sparrow (1977) reported the findings of a study of 45 owners-users of solar custom homes located throughout the United States. This study considered various socioeconomic factors involved in the adoption of solar energy technologies. However, the small and geographically-diverse sample presents difficulties. Due to region-specific situational factors, it is expected that major differences would be encountered in consumer attitudes as well as in factors of importance for those adopting solar energy systems in different geographical regions. An in-depth study of one particular area seems an appropriate further research focus.

A survey by Cesta and Decker (1978) identified a number of factors which are likely to affect the demand for solar energy products among consumers over the next ten years. This survey, which was of a highly exploratory nature, employed a two-stage Delphi technique utilizing a sample of individuals with solar product experience, including manufacturers and suppliers as well as consumers. Factors which were identified as potentially stimulating or inhibiting future demand included: product cost, extent of governmental support, product quality, the cost of energy, and the amount of publicity concerning solar systems.

The focus of the research presented here is on individuals throughout the adoption process. Several comments are in order concerning the decision process being examined by this study and how this process relates to the definition and specification of the various population groups of interest. If one considers the individuals in a population, a number of subgroupings can be formed on the basis of an individual's interest and knowledge of solar energy systems. For example, one might define the following groups: (1) those people who are unaware of solar energy systems; (2) those who are aware of the existence of solar energy systems but who have taken no interest in them, and have little or no information or knowledge about such systems; (3) people who have become interested in solar energy systems, and who have taken the pro-active stance of searching out information concerning such systems; and (4) those individuals who have adopted solar energy. Other variations are possible; these represent some of the more important groups from an awareness - attitude formation - behavioral response perspective. The last three of these groups form the basis of this research.

The inclusion of knowledgeable non-adopters as a group worthy of attention, in addition to adopters and knowledgeable 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 on innovativeness established in the adoption research cited previously, 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 incomes (H1.3), are earlier in the family life cycle (H1.4), and have higher occupational status (H1.5).

Previous research has established correlations between adoption behavior and individuals' perceptions regarding certain attributes of innovations (Rogers and Shoemaker 1971; Ostlund 1974). These findings are used to formulate hypothesized directions of beliefs of adopters concerning residential solar energy systems. Specifically,

> H2 Adopters and non-adopters differ on the basis of their perceptions of certain aspects of solar energy 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).

The various factors considered by adopters and knowledgeable non-adopters in evaluating solar energy systems are of considerable importance and relevance. Although one could reason that differences would be apparent between the groups in terms of the importance of various factors in the decision process, the directions of possible differences are not clear a priori. Hence,

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

A basic thrust of the diffusion literature has been to categorize individuals into groups according to their relative time of adoption of the given innovation, and to correlate group membership with differences in such characteristics as demographic and innovation attribute perceptions.

As such, innovators are considered as distinct from the early majority of adopters, and so forth. One issue of interest here is to determine whether the diffusion of solar energy systems has progressed to the point that all true innovators have already adopted, and that individuals who are most recently installing solar energy systems are more appropriately considered to be part of the early majority of adopters. The following hypothesis is advanced to help resolve the issue.

> 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).

One would anticipate that both demographic characteristics and attitudinal perceptions would be of importance in explaining individual adoption behavior of residential solar energy systems. From a consumer behavior viewpoint, one would be reassured by the finding that attitudinal attributes function better in some sense than demographics in predicting innovative behavior, since a model constructed using attributes as opposed to demographics represents a movement toward a more theoretical approach in prediction. The following hypothesis evaluates this issue.

> 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.

METHODOLOGY

The data for analysis were collected through a mail survey of 631 individuals in one geographic region. For the purposes of this survey, the relevant population from which a sample was selected was defined as all residents of the state of Maine. Three subsets of the general population were defined: adopters of solar home heating or hot water heating systems, non-adopters who were aware of and knowledgeable about such systems, and unknowledgeable non-adopters.

Estimates of the number of residential solar installations in Maine vary depending on how one classifies passively heated homes. At the time of the survey, approximately 250 active solar installations existed. Including modern passive designs at least doubled this number. For this survey, lists of known installations were obtained from solar dealers and installers, the Maine Office of Energy Resources, and the Maine Solar Energy Association.

Identifying those individuals who were aware of and knowledgeable about solar systems but who had not yet adopted presented an interesting problem. Considering the various populations of individuals who would be expected to possess such knowledge, the following groups were used to generate the required sample: a group of unsuccessful applicants for solar hot water tax grants, the non-adopting members of the Maine Solar Energy Association, and the registrants from a series of alternative energy workshops held in Maine.

The third subset, the remaining general population of Maine, categorized here as unknowledgeable non-adopters and defined as all those not in the previous two categories, was sampled by means of a random selection of households from the total Maine population.

Considerable attention was given, both in terms of sampling procedures and questionnaire design, to insure that respondents were indeed members of the identified population subsets. This is of particular importance given the non-panel nature of the survey. The questionnaires were designed to be answered by the househould decision maker, either male or female. Concerning adopters, questions were included to screen and eliminate non-decision-makers in the solar adoption process. Similarly, knowledgeable non-adopters were screened to exclude apartment dwellers. The unknowledgeable non-adopters category excludes both unaware individuals and adopters. Individuals in this group however, are likely to differ somewhat from one another in their relative ignorance of solar energy.

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. Respondent's perceptions of seven characteristics of solar energy systems were measured using seven-point Likert-like scales: relative advantage over other currently available energy sources, complexity, compatibility with personal values, observability, perceived financial riskiness, perceived social riskiness, and trialability.

(Insert Table 1 here)

Adopters and knowledgeable non-adopters were asked to rate the importance of a series of factors in their purchase deliberations. These factors included economic factors (initial cost, payback period, perceived rising future energy costs of other energy sources, and the availability of government incentives or programs to offset installation costs), product-specific factors (quality and reliability of the system itself and the installer, service availability, product warranties, installation difficulties, and the relative efficiency of current systems versus possible future solar energy systems), and social factors (concern over energy conservation, behaving in a socially-responsible manner, aesthetic appearances of the system, and status-appeal of having a solar system). Each of these factors was measured using seven-point Likert-like scales.

Adopters were asked to indicate the approximate month and year that their system was installed. From this information, they were classified according to their relative time of adoption to assess any trends on the other measures dependent upon time of adoption.

Various demographic data were also collected, including age, education and income levels, stage in family life cycle, and occupational status. Categorical data were collected concerning age, education, and income. Open-ended responses to questions concerning marital status, family size, and occupation were used to derive family life cycle and occupational status data.

Table 1 also includes detailed information concerning sample sizes and response rates. Two mailings of the survey were sent to each individual; each mailing included a stamped return envelope. The overall usable return response rate was 69% among those in the original adopter mailing, 76% of those in the knowledgeable non-adopter mailing, and 48% of the general population sample. Final usable returns by category were 170, 232, and 229, respectively.

Some potential for bias exists due to the differing percentage response rates obtained by group, and specifically the lower percentage response among the general population group. However, several analyses suggest this bias is not substantial. First, a comparison of the demographic characteristics of the Maine population and those reported by the general population sample respondents reveals very similar profiles. Additionally, there are no apparent trends in the data distinguishing those respondents in the general population group who responded relatively earlier to the survey versus those who responded relatively later. Given these findings, further support is lent to the argument of minimal nonresponse bias.

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 stepwise multiple discriminant function analysis (MDF), were employed to evaluate H5 concerning the importance of attribute perceptions and demographic characteristics in determining adoption.

MNA, an analysis developed by Andrews and Messenger (1973), is designed to perform comparably to the traditional discriminant analysis, while producing results which are more interpretable. Several empirical comparisons of the techniques have shown predictability to be equivalent between the two, while error patterns differ (Gitlow 1979, O'Malley 1972). From the standpoint of understanding relationships within datasets, as opposed to simple category prediction, MNA appears to offer considerable advantages.

Given the exploratory nature of this study, MNA was chosen as the primary analysis technique. As applied to this work, MNA was used to predict category membership (adopters versus non-adopters of solar energy systems) based on the various predictive measures identified. These analyses were replicated with MDF utilizing a holdout sample to provide statistical validation as well as for comparison purposes. Hypothesis H5 was evaluated using a one-tailed t-test for the differences between proportions of individuals correctly classified using attribute perception data versus demographic data.

It should be noted that the term "prediction", as it is used here and throughout this paper, refers to statistical prediction after the fact on the basis of survey data. Thus, the MNA and MDF techniques attempt to identify ("predict") an individual's category membership as an adopter or non-adopter.

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. (see Table 2)

Very few differences are apparent between the adopters and knowledgeable non-adopters. Education, income level, and occupational 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, however. In general, the adopter and knowledgeable non-adopter appear to be demographically very similar, yet very different from the general population.

(Insert Table 2 here)

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. (see Table 2). 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 knowledgeable non-adopters. Adopters perceive somewhat greater relative advantage, less risk, less complexity, greater compatibility, and less observability than do knowledgeable non-adopters. However, with the exception of complexity and observability, these differences are not statistically significant. Thus, as was the case with demographic characteristics, knowledgeable non-adopters and adopters seem fairly similar to each other, and quite different from the general population.

Factor Ratings

Table 3 summarizes the results obtained regarding factors of importance in the solar energy system adoption decision. One finds that the knowledgeable 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 the 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 knowledgeable 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.

(Insert Table 3 here)

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 at a .05 level of probability. That is, individual demographics were found to be statistically the same, irrespective of the year of installation of the system.

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 a .05 level of probability.

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 are presented in Tables 4 through 6 as a means of assessing hypothesis H5, that attribute perceptions are more effective than demographic characteristics in predicting an individual's category membership as an adopter versus an knowledgeable non-adopter or a member of the general population. Table 4 presents summary statistics for each model, as well as statistics relating to the relative effectiveness of each variable in each model. The classification matrices including the percentages of individuals correctly classified by each model are shown in Tables 5 and 6. The MDF classification matrices are based on a holdout sample of .33 of the data; no significant differences were found between the MDF estimation and validation samples.

(Insert Tables 4, 5, and 6)

A comparison of these results indicates some support for the contention that attribute perceptions are more effective predictors than demographics. From Table 4, 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, Tables 5 and 6 indicate mixed results in classification ability. While the attribute perception models are more successful than the demographics models overall in terms of the total percentage of individuals correctly classified (62% versus 56% for the MNA results and 55% versus 47% for the MDF models), a comparison of the category-specific results reveals differences. The improvement in prediction of adopters by using attribute perceptions as compared to demographics is statistically significant: 57% correct versus 37% for the MNA runs, $p < .005$; and 69% correct versus 43% using MDF, $P < .005$. For both knowledgeable non-adopters and the general population group, MNA predictions based on attributes are not statistically different than those based on demographics. They are, however, considerably different from the classification results obtained through MDF. The MDF results show a relative inability to handle knowledgeable non-adopters with either set of predictors, as well as a much greater ability to correctly classify the general population group via demographics than by attribute perceptions ($p < .005$).

These 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.

DISCUSSION

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 excepting trialability, a continuum can be defined with adopters as a group at one end, the general population group at the other, and knowledgeable 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 knowledge of solar energy systems to adoption, the less observable to others one perceives such an innovation. This finding, which is contrary to earlier findings regarding innovation attribute perceptions, suggests that for solar energy systems, as one becomes more familiar with the innovation, it becomes less of a novelty and is thus expected to be perceived as being less observable to others.

More fundamentally, a reconsideration of traditional adoption models, such as that advanced by Robertson (1971), would appear to be necessary when considering solar energy adoption. For example, the issue of trial of solar energy systems is difficult to evaluate in the traditional sense of adoption modeling. Although the results show that most individuals perceive it likely that some sort of trial behavior occurs, such as trying solar energy on a small scale prior to adoption of a more complete and complex system, it must be recognized that even such a small "trial" represents a major financial commitment and personal involvement. This is due to the nature of the product class. Solar systems are not new types of hair spray that are repurchased monthly, nor are they even innovative durables such a automobiles that may be traded after three years or less. Instead, they represent a long term commitment with no real possibility for non-involved, low risk trial. Trial, short of vicarious trial through the experiences of others, does not appear to be an applicable concept for solar energy systems.

Since the opportunity for personal trial is limited or impossible, the stages in the adoption process immediately preceeding adoption are of particular interest. Specifically, the focus centers on the area of product legitimization, which likely involves both word-of-mouth information from various friends and neighbors as well as business and governmental information sources. The step from legitimization to adoption becomes a large one, underscoring the level of commitment needed before adoption will take place.

This level of commitment necessary for solar energy system adoption is evident from the ratings of factors of importance by both adopters and knowledgeable 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 interest. 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. Knowledgeable non-adopters, on the other hand, lacking this experience are more wary and skeptical.

Another potential explanation is that this phenomenon represents a cognitive dissonance reduction process. The adopter is committed to the system. His ratings of the factors, some of which may still be of concern, reflect a dissonance-reduction response that discounts their importance.

A further issue is the direction of causality regarding attribute perceptions and adoptive behavior. That is, are attribute perceptions determinants of adoption or the result of experience with the innovation? While the direction of causality cannot be inferred from these exploratory results, at a minimum a strong association is demonstrated between adoptive behavior and attribute perceptions.

In evaluating the results of the MNA and MDF-generated models, it is apparent that attribute perception data afford somewhat greater classification ability than do demographic data. Further, the MNA models yield somewhat better overall classifications than do the corresponding MDF models. While it is beyond the scope of this article to examine the comparative predictive power of these two methodologies, the discrepancies which appear in a cell-by-cell evaluation of the individual classification matrices suggest that different methodologies may be appropriate dependent upon one's research focus.

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 results. Further, some bias due to sampling techniques and non-response errors is likely due to the methodology employed. However, great care was taken to minimize these biases.

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.

TABLE 1

SURVEY INFORMATION AREAS AND SAMPLE RESPONSE RATES

	Category		
	Adopters	Knowledgeable Non-Adopters	Control Group
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)*	147	396	475
Usable returns (n=631)	102	300	229
Response rate (%)	69	76	48
Usable returns by actual category **	170	232	229

* excluding bad addresses

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

TABLE 2

DEMOGRAPHIC AND ATTRIBUTE PERCEPTION RATINGS

	Category			Significance	
	Adopters	Knowledgeable Non-Adopters	Control Group	Chi* Square	Prob.
DEMOGRAPHIC CHARACTERISTICS					
Age (median)	36-45	36-45	46-55	46.04	.005
Education (median)	college degree	college degree	some post-HS	125.46	.005
Income (median)	$20,410	$19,050	$14,670	41.08	.005
Occupational status (mode)	profl/ semi-prof	profl/ semi-prof	service/ crafts	70.23	.005
Family Life Cycle (mode)	Full Nest I	Full Nest II	Full Nest II	55.36	.005
ATTRIBUTE PERCEPTIONS (means)					
relative advantage	5.46	5.19	4.63	32.56	.005
complexity	1.39	1.97	2.78	106.09	.005
compatibility	6.61	6.58	5.68	88.09	.005
financial risk	3.36	3.88	4.47	47.25	.005
social risk	1.24	1.33	1.84	53.73	.005
observability	5.84	6.43	6.58	49.92	.005
trialability	5.57	5.68	5.46	8.13	NS@.05

* Chi-square tests evaluate differences between adopters, knowledgeable non-adopters, and the general population sample on each characteristic or perception rating.

TABLE 3

MEAN RATINGS OF FACTORS OF IMPORTANCE BY FACTOR GROUP

Factor Group	Adopters	Knowledgeable Non-Adopters	Chi* Square	Prob. Level
PRODUCT				
Quality and reliability of system	6.34	6.60	10.95	NS@.05
Quality and reliability of installer	6.27	6.62	14.85	.01
Service availability	5.87	6.44	20.67	.00
Product warranties	5.71	6.34	26.72	.00
Relative efficiency of Current systems	4.80	5.80	41.39	.00
Installation difficulties	4.42	5.14	17.68	.01
ECONOMIC				
Rising future costs of other energy sources	6.29	6.31	1.27	NS@.05
Initial cost	5.40	5.80	17.03	.01
Payback period	5.02	5.62	25.43	.00
Government incentives	4.49	5.45	32.25	.00
SOCIAL				
Energy conservation	6.06	6.21	6.84	NS@.05
Socially-responsible behavior	4.52	4.54	3.21	NS@.05
Aesthetic appearance of system	3.33	2.90	9.86	NS@.05
First in area with system	1.72	1.40	7.60	NS@.05

* Chi-square tests evaluate differences between adopters and knowledgeable non-adopters in the rating of each factor.

TABLE 4

COMPARISON OF RELATIVE IMPORTANCE OF VARIABLES
IN DEMOGRAPHIC AND ATTRIBUTE PERCEPTION MODELS

	MNA RESULTS		MDF RESULTS	
MODEL	Generalized Eta Squared	Bivariate Theta	Stepwise F-statistic	Ranking of Importance
DEMOGRAPHICS				
Education	.089	.492	35.34	1
Occupation	.073	.488	6.98	2
Family Life Cycle	.043	.432	0.05	5
Age	.024	.426	1.83	3
Income	.012	.391	0.74	4

MNA Generalized R^2 = .1566, Multivariate theta = .5570
MDF F-statistic = 8.78

ATTRIBUTE PERCEPTIONS				
Compatibility	.080	.470	14.14	2
Complexity	.080	.462	27.95	1
Financial Risk	.043	.420	7.22	4
Social Risk	.042	.415	3.81	5
Observability	.034	.409	8.41	3
Relative Advantage	.034	.424	0.62	7
Trialability	.016	.391	0.91	6

MNA Generalized R^2 = .2390, Multivariate theta = .6154
MDF F-statistic = 9.21

TABLE 5

COMPARISON OF CLASSIFICATION MATRICES

DEMOGRAPHIC MODELS, USING ALL PREDICTOR VARIABLES

MNA RESULTS

		AS CLASSIFIED BY MODEL				
		Adopters	Knowledgeable Non-Adopters	Control Group	Total	CORRECTLY CLASSIFIED
A C T U A L	Adopters	52	61	27	140	37%
	Knowledgeable Non-Adopters	33	118	30	181	65%
	Control Group	15	40	89	144	62%
		100	219	146	465	56%

$C_{max.}$ = 39%

MDF RESULTS

		AS CLASSIFIED BY MODEL				
		Adopters	Knowledgeable Non-Adopters	Control Group	Total	CORRECTLY CLASSIFIED
A C T U A L	Adopters	27	13	23	63	43%
	Knowledgeable Non-Adopters	45	18	22	85	21%
	Control Group	9	7	60	76	79%
		81	38	105	224	47%

$C_{max.}$ = 38%

TABLE 6

COMPARISON OF CLASSIFICATION MATRICES

ATTRIBUTE PERCEPTIONS MODELS, USING ALL PREDICTOR VARIABLES

MNA RESULTS

		AS CLASSIFIED BY MODEL				
		Adopters	Knowledgeable Non-Adopters	Control Group	Total	CORRECTLY CLASSIFIED
ACTUAL	Adopters	76	41	17	134	57%
	Knowledgeable Non-Adopters	33	99	35	167	59%
	Control Group	13	36	105	154	68%
		122	176	157	455	62%

$C_{max.} = 37\%$

MDF RESULTS

		AS CLASSIFIED BY MODEL				
		Adopters	Knowledgeable Non-Adopters	Control Group	Total	CORRECTLY CLASSIFIED
ACTUAL	Adopters	42	9	10	61	69%
	Knowledgeable Non-Adopters	35	37	14	86	43%
	Control Group	17	18	46	81	57%
		94	64	70	228	55%

$C_{max.} = 38\%$

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