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THE MARKET FOR SOLAR COOLING: PERCEPTIONS, RESPONSE AND STRATEGY IMPLICATIONS

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Solar cooling provides an energy alternative for the fastest growing component of U.S. energy use. This paper evaluates market reaction to the solar cooling concept. It isolates and shows the importance of noneconomic issues, such as system modernness, reliability and power-rationing protection, on market receptivity. The paper also shows that the industrial cooling decision process typically includes a number of individuals, from engineers to top managers to outside consultants who have different attitudes toward system characteristics and who perceive relative system advantages differently. The implication of these differences for a solar cooling marketing program are described. The analysis is positioned in the context of an industrial marketing decision support system which pinpoints areas of improvement in industrial product design and provides a meaningful basis for the development of industrial communications strategies.

1. Introduction

Currently, over 25% of the energy used in the U.S. is consumed by heating and cooling of buildings and by providing hot water (Westinghouse Phase 0 report [10]). At a conversion efficiency of 10%, 11,000 square miles of solar collectors (or 0.3% of U.S. land area) could have satisfied the 1970 water and space heating and cooling needs of the U.S. (Williams [11]).

Space cooling is the fastest growing area of U.S. energy use, projected to account for over 5% of U.S. energy demand by 1980 [10]. A substantial portion of this demand is for use in industrial buildings. Thus, a considerable amount of fossil fuel could be saved by wide scale adoption of solar powered cooling systems.

Recognizing the potential for this saving, the U.S. Energy Research and Development Administration, together with the U.S. Economic Development Administration is sponsoring a multi-year study to (a) demonstrate the technical feasibility of solar powered cooling in a commercial/industrial setting and (b) to evaluate the potential market for such a system.

This paper reviews some of the analysis and the initial results of that study. Specifically, it has been found that

(1) Adoption of cooling systems is not solely an economic decision; issues such as reliability, protection against power failures, modernness, complexity are also important issues.

(2) The adoption process for cooling systems in industrial organizations contains a number of phases from need evaluation to final selection.

(3) The adoption process typically involves several individuals with different backgrounds and job responsibilities. These individuals have different attitudes toward system-characteristics and perceive relative system advantages in different ways.

The careful measurement of this process of adoption and of the differences in perception across decision participants leads to specific suggestions for a marketing program for solar cooling. The implications and role of the analysis presented here for the development of an industrial marketing decision system are reviewed in the concluding section of the paper.

2. Technical background – cooling systems

There are two major classes of cooling systems in wide use today – compression systems and absorption systems, comprising about 90–95% of the market and 5–10% of the market respectively. Solar cooling makes use of an absorption system.

Compression cooling, the most familiar system used in cars, room air conditioners, most refrigerators, etc., uses a single refrigerant in conjunction with an evaporator, a compressor and a condenser. In the evaporator, the refrigerant, under pressure, passes through an expansion valve and vaporizes. As it evaporates, the refrigerant absorbs heat from the vehicle (water or air) that it is cooling. The refrigerant vapor is then compressed and sent to the condensor where it rejects heat to the environment. Finally, the refrigerant returns to the evaporator to start the cycle again. The initial cost of compression cooling systems is the lowest available and it is also the most efficient convertor of thermal or electric energy into cooling.

An absorption chiller uses a refrigerant (e.g., water) and an absorbent (e.g., lithium bromide) in conjunction with an evaporator, absorber, generator and condenser. In the evaporator, the refrigerant, in a vacuum, is vaporized by a sprayer. As it evaporates, the refrigerant absorbs heat from the water that is used to cool the building. The refrigerant vapor is then absorbed by the solution in the absorber. The resulting solution is heated in the generator to drive off the refrigerant. At the condenser, the refrigerant vapor condenses and rejects heat to the environment. The refrigerant then returns to the evaporator to start the cycle again.

Initial costs for absorption systems tend to be significantly higher than for compression systems. They are particularly inefficient at sizes under 100 tons, making residential applications (around 5 tons) inappropriate. These systems are generally used by firms (such as pharmaceutical companies) which use steam for other industrial processes and wish to make additional use of that steam.

The solar cooling system investigated in this study uses an absorption cycle in which the necessary heat to drive off the refrigerant is captured by solar collectors.

3. The industrial cooling adoption process: background and measurement

The objective of the market analysis is to obtain an understanding of the technical, economic and organizational issues associated with the adoption of cooling systems in general and solar cooling in particular. Specifically, we wish to determine (a) what kinds of decision variables are important in the adoption process for solar cooling and (b) who takes part in, or influences that decision process.

To this end a series of in-depth personal and group interviews were conducted with personnel from industry and heating, ventilating and air conditioning (HVAC) consulting firms. As these interviews progressed, a questionnaire was gradually developed, refined and pilot-tested. Two versions of the questionnaire were finally developed – one for internal, company people and a second for outside consultants.

Both these questionnaires are structured with sections numbered as follows:

(1) *Company information*: the size, growth rate, location, and other information about the firm are requested.

(2) *Investment information*: the criteria and importance of characteristics such as economic life, ease of maintenance, warranty, payback period, etc. on the adoption decision are evaluated.

(3) *Attitudes toward alternative systems*: the respondents are exposed to three one-page product-concept statements – one for a compression system, one for an

1. The system provides reliable air conditioning.
2. Adoption of the system protects against power failures.
3. The system is made up of field-proven components.
4. The system conveys the image of a modern, innovative company.
5. The system cost is acceptably low.
6. The system protects against fuel rationing.
7. The system allows us to do our part in reducing pollution.
8. System components produced by several manufacturers can be substituted for one another.
9. The system uses too many concepts that have not been fully tested.
10. The system leads to considerable energy savings.
11. The system is too complex.
12. The system provides low cost a/c.
13. The system offers a state-of-the-art solution to a/c needs.
14. The system increases the noise level in the plant.

Note: Items 9 and 11 above were constructed "negatively" (i.e., agree implies one doesn't like the system) in order to screen out respondents who were not paying attention. In otjer words, an agree on both items 3 and 9 leads to review of the response.

Fig. 1. Attributes used for industrial cooling system evaluation.

You have just rated three alternative industrial air conditioning systems. Now we would like to know your overall preferences for these systems, listed below. Write a "1" next to the one which would be your first choice, a "2" next to your second choice and a "3" next to your third choice.

Conventional Absorption a/c system	0.04 *
Conventional Compression a/c system	0.55 *
Solar Absorption a/c system	0.41 *

* Fraction of firms rating as first choice, $N = 132$.

Fig. 2. Rank-order preference question.

absorption system, and one for a solar absorption system. The respondent is then asked to rate each of these concepts on a set of perceptual scales representing relevant attributes along which decision participants assess products in this class. (See fig. 1.) Seven point agree-disagree scales were used for this purpose.

(4) *Perference questions*: respondents are then asked to state their preference for the various systems. These represent preferences conditional to financial acceptability to the adopting organizations. Fig. 2 displays the rank-order preference question along with the fraction of the population that stated the alternative as first preference.

(5) *Decision process information*: as the purchase of an industrial cooling system typically involves several participants, a question here requests information about which categories of individuals are involved in the phases of the decision process – both within-company personnel and people external to the firm.

(6) *Personal information*: personal information about the respondent is requested in the last section of the questionnaire.

The questionnaire was administered as follows: A sample of firms was selected by size, S.I.C. code and geographic area and a senior management member was identified. He was sent a personal letter asking for names of two or three members of his organization most likely to be involved in the adoption decision process for industrial cooling equipment. A detailed questionnaire was then sent to the individuals mentioned. This two-step sampling procedure increased the likelihood of reaching key people in the adoption decision for the class of product. The return rates were 27% and 46% respectively.

Analysis of the survey results confirmed initial hypotheses. The adoption process for industrial cooling equipment seemed to have the following general phases:

Evaluation of cooling needs, specification of system requirements.
Preliminary budget approval.
Search for alternatives, preparation of a bid list.
Equipment and manufacturer evaluation.
Equipment and manufacturer selection.

The process was also found to involve the following categories of individuals:

Company personnel:
Production and maintenance engineers.
Plant/factory managers.
Financial controllers or accountants.
Procurement or purchasing agents.
Top management.

External personnel:
HVAC/engineering firm.
Architect, building contractor.
A/C equipment manufacturer.

From the data collected it appears that plant engineers, together with HVAC consultants are mainly responsible for the evaluation of needs, and the establishment of system specifications. These requirements are usually discussed with production people and with plant management. The financial function then gives preliminary budget approval and search for a system begins. In this phase, the company engineer or HVAC consultant chooses a system or systems that fit the firm's requirements. These choices are often affected by conversations with the air conditioning manufacturer, or a representing engineering firm. Final evaluation involves production and maintenance personnel as well as plant management. Top management gives the final approval.

The multi-person nature of this decision process raises some important questions which are at the heart of the analysis that follows. Evidence suggests that participants in industrial purchasing decisions utilize a number of more personal or non-rational criteria in selecting products and services (Sheth [9]). It is therefore important to investigate the differences in perception and evaluation criteria among different buying influences. The key questions that will be investigated in the remainder of this paper are (1) how can these differences in perceptions and decision criteria be determined? and (2) how can these differences be used to develop better industrial marketing programs?

4. Decision participant analysis

4.1. Product perceptions

In the analysis which follows, likely purchase decision participants are grouped on the basis of job responsibility. This decision is consistent with Sheth's [8] contention that product perception and evaluation criteria tend to differ among decision participants as a result of differences in educational background, experience, sources of information, and reference groups. The existence of company policies that reward individuals for their specialized skills and viewpoints also tend to reinforce these psychological differences.

As some variation must be expected across companies in the responsibility corresponding to different job titles, a request was made in the questionnaire that the respondent describes his main job responsibility. Five groups of respondents were then created and are used in this analysis. These groups differ slightly from those distinguished in the previous section but correspond more directly to the respondents' stated responsibility. We distinguish Production Engineers (PE), Corporate Engineers (CE), Plant Managers (PM), Top Managers (TM), and HVAC consultants (HC).

The perceptual analysis performed here assumes a multidimensional perceptual space common to all categories of decision participants involved in the adoption of an industrial cooling system. The perceptual space is spanned by the fourteen attribute scales on which ratings were obtained for each industrial cooling alternative. An individual's perception of a product is then a vector of coordinates in this space and is provided by his ratings of the product on the corresponding attribute scales. We can define a group's average perception of a product similarly.

Our problem in the perceptual analysis is to answer the two following questions: For each of the five categories of decision participants, are the three industrial cooling alternatives perceived differently? This step of the analysis is called product *discrimination* analysis.

Alternately, for each industrial cooling alternative, do the five categories of decision participants exhibit substantial perceptual differences? This step of the analysis is called *differential perception* analysis.

Table 1 shows average perceptions of the three systems for each group of decision participants. From this table it appears that the three products are, indeed perceived differently by *each* group of decision participants. For example, PE's rate

Table 1

Item	Group means for absorption cooling system					Group means for compression cooling system					Group means for solar cooling system				
	PE	CE	PM	TM	HC	PE	CE	PM	TM	HC	PE	CE	PM	TM	HC
1. The system provides reliable air conditioning	5.38	5.25	4.80	5.18	5.46	5.60	5.96	5.91	5.74	5.95	3.88	3.76	3.91	3.95	3.86
2. Adoption of the system protects against power failures	1.88	2.17	2.57	1.86	2.47	1.54	1.39	1.82	1.43	1.53	3.85	2.80	4.56	4.22	3.17
3. The system is made up of field-proven components	5.08	5.17	5.14	5.08	5.56	6.11	6.25	5.86	6.05	6.09	3.08	2.80	3.34	2.87	3.24
4. The system conveys the image of a modern, innovative company	4.02	3.57	4.04	3.18	3.03	4.08	4.10	4.30	3.82	3.29	6.05	5.65	5.82	5.42	5.69
5. The system cost is acceptably low	3.17	3.53	3.23	2.78	3.21	5.20	5.28	5.08	5.30	5.51	2.88	2.19	2.47	2.37	1.88
6. The system protects against fuel rationing	1.91	2.03	2.66	1.97	2.19	3.25	4.00	3.26	2.94	3.25	5.60	5.42	5.78	5.65	5.49
7. The system allows us to do our part in reducing pollution	2.67	1.85	3.47	2.43	2.54	3.68	3.25	3.91	3.33	3.67	5.85	5.84	6.04	5.92	5.83
8. System components produced by several manufacturers can be substituted for one another	3.97	3.64	3.71	3.94	3.84	4.94	4.82	4.82	4.51	5.12	3.40	3.80	3.60	3.07	4.16
9. The system uses too many concepts that have not been fully tested	2.64	2.03	2.95	3.02	2.34	1.80	1.35	2.34	1.79	1.79	4.45	4.88	4.73	4.75	4.07
10. The system leads to considerable energy savings	2.20	2.92	3.19	2.48	2.55	2.94	2.92	2.65	2.74	3.17	6.14	5.03	5.69	5.95	6.10
11. The system is too complex	3.52	3.21	3.61	3.67	2.96	3.02	2.39	3.04	2.71	2.12	3.60	4.11	3.60	3.62	3.57
12. The system provides low cost a/c	2.76	3.17	3.33	2.97	3.15	3.48	3.50	3.26	3.92	4.53	4.91	4.61	4.95	4.80	4.21
13. The system offers a state-of-the-art solution to a/c needs	3.20	3.64	3.57	3.45	3.85	3.77	4.42	4.34	4.12	4.63	5.02	4.61	5.52	4.75	4.56
14. The system increases the noise level in the plant	2.00	1.60	2.57	2.13	2.04	5.11	4.71	4.95	4.82	4.82	1.65	1.80	1.82	1.95	2.07

the solar system as 5.60 on item 6, the absorption system as 1.91, and the compression system as 3.25 on that same item.

The second question which arises here is whether the groups appear to have different perceptions of the *same* product? Consider the solar cooling system. Here we see that HC rate the solar system as 4.56 on item 13, whereas PM rate the system as 5.52 on that item. Similar perceptual differences appear along the other scales and are even more substantial in the case of the two traditional cooling systems, compression and absorption.

A more formal assessment of product discrimination and differential perceptions across categories of participants requires the use of multivariate statistical methods. In this study, the analysis is performed as follows. Within each group of decision participants, product discrimination is tested via one-way multivariate analysis of variance. Our aim is (a) to test whether the concept statements do indeed convey an accurate representation of each product alternative and (b) to assess the discriminating power of the perceptual scales. Then, for each product alternative, differential perceptions across groups of influencers are tested via multivariate profile analysis (Morrison [7]). If the groups differ in their perception of an alternative, univariate analyses of variance are performed to isolate those items that are the major sources of these differences.

Implementation of this methodology revealed that each group of decision participants perceived the three available alternatives as substantially different (Choffray and Lilien [3]). This result was not unexpected, as the three products indeed presented important differences. Significant perceptual differences were also registered between groups of decision participants for each product concept.

Analysis of the perceptual differences via one-way univariate analysis of variance, suggests for example that plant managers view solar cooling as a more substantial means of protection against power failures than do HVAC consultants. They also consider it more cost effective than HVAC consultants. Finally, plant managers view the solar system as a complex system whose components have not been fully tested, but which provides a state-of-the-art solution to industrial cooling needs. HVAC consultants' perception of the solar system differ considerably in this respect.

The results of the perceptual analysis therefore confirm the existence of substantial perceptual differences among the different groups of influencers. Moreover, it appears that the selection of the scales was appropriate, as they all contributed to the differences noted among groups of decision participants.

4.2. *Product evaluation analysis*

When forming judgments about product alternatives, it is not likely that individuals consider all product attributes independently and simultaneously. Rather, individuals organize these attributes into a smaller set of higher-order evaluation criteria (Howard and Sheth [5]).

Accordingly, we define the *evaluation space* common to a group of decision participants as an m-dimensional subspace of the perceptual space that reflects the way individuals in that group structure basic product attributes. The coordinate axes in that evaluation space approximately span the original perceptual space. We refer to those axes as the evaluation criteria common to a group of decision participants. An individual's evaluation of a product may then be seen as a vector of coordinates in this reduced space.

In industrial purchasing situations, the question which we must first investigate is whether the groups of individuals involved in the decision process differ in the way they structure basic product attributes; that is, do these groups differ in the number and/or composition of their evaluation criteria?

Consider tables 2 and 3, which display the inter-perceptual item correlation matrices for PM and HC respectively. A comparison of the individual entries suggests that differences exist between these two correlation matrices. For example, items (2,1) are −0.21 and −0.58 and (3,2) are −0.23 and −0.48 respectively. This suggests that these two groups of decision participants structure industrial cooling system attributes in a different way.

Fig. 3 outlines the steps which are used to formally analyze differences in the evaluation space of several categories of decision participants. Variance-covariance matrices between all perceptual items and across all product alternatives are calculated for each of these groups (PE, TM, HC, etc.). If these matrices are unequal, they are factor-analyzed separately, and the parallel analysis method (Humphreys

Table 2
Inter-perceptual item correlation matrix for plant managers (PM)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1														
2	−0.58													
3	−0.75	−0.48												
4	−0.09	0.09	−0.25											
5	0.40	−0.13	0.36	−0.21										
6	−0.26	0.50	−0.41	0.37	−0.01									
7	−0.31	0.41	−0.51	0.43	−0.03	0.76								
8	0.37	−0.24	0.58	0.11	0.18	−0.12	−0.20							
9	−0.68	0.47	−0.75	0.14	−0.27	0.44	0.49	−0.53						
10	−0.21	0.43	−0.41	0.53	−0.29	0.57	0.70	−0.07	0.53					
11	−0.31	0.17	−0.28	−0.08	−0.13	−0.08	−0.05	−0.18	0.47	−0.09				
12	−0.05	0.39	−0.18	0.38	−0.11	0.48	0.47	0.13	0.10	0.65	−0.26			
13	−0.08	0.32	−0.21	0.43	−0.07	0.57	0.56	0.01	0.09	0.49	−0.14	0.14		
14	0.49	−0.38	0.43	−0.16	0.45	−0.19	−0.26	0.37	−0.52	−0.46	0.00	−0.03	−0.04	

Table 3
Inter-perceptual item correlation matrix for H.V.A.C. consultants (HC)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1														
2	−0.21													
3	−0.76	−0.23												
4	−0.22	0.36	−0.34											
5	0.51	−0.24	0.62	−0.22										
6	−0.28	0.38	−0.41	0.49	−0.21									
7	−0.24	0.31	−0.40	0.68	−0.29	0.61								
8	0.23	−0.09	0.23	0.14	0.35	0.02	0.10							
9	−0.44	0.22	−0.58	0.32	−0.44	0.32	0.32	−0.14						
10	−0.31	0.28	−0.43	0.66	−0.29	0.55	0.66	0.06	0.34					
11	−0.32	0.22	−0.36	0.18	−0.39	0.20	0.19	−0.16	0.39	0.20				
12	0.12	0.05	0.11	0.19	0.28	0.24	0.22	0.28	−0.08	0.34	−0.08			
13	0.21	−0.01	0.14	0.33	0.19	0.23	0.30	0.25	−0.02	0.21	0.01	0.36		
14	0.27	−0.19	0.30	−0.22	0.47	−0.09	−0.13	0.16	−0.17	−0.14	−0.18	0.21	0.05	

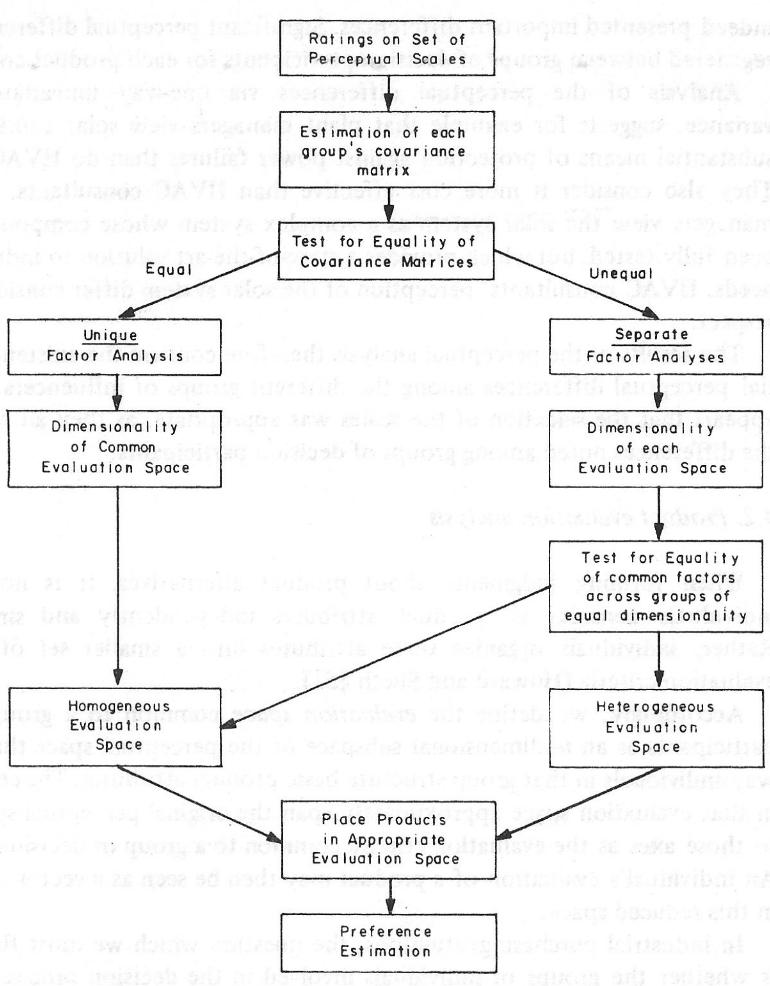

Fig. 3. Outline of evaluation space methodology.

and Ilgen [6]) is used to determine the dimensionality of the evaluation space for each group of participants. Groups with an identical number of evaluation criteria are tested for equality of these criteria using a test presented in Choffray and Lilien [3]. If the evaluation criteria are similar, the common perceptual space is obtained by factor analysing the pooled covariance matrix for the corresponding groups. The final step of the analysis is preference estimation, linking individual preferences to product coordinates in the appropriate evaluation space.

Results of this analysis indicate that two groups of decision participants have an evaluation space of dimensionality two (CE and PM), and the other three groups (PE, TM, HC) have a three-dimensional evaluation space. This suggests that Produc-

Table 4
Comparison of factor solutions for CE, PM

	Factor A	Factor B
Corporate Engineer (CE)	Field tested First cost Reliability Noise level	Reduced pollution Energy savings/Protection Modernness
Plant Manager (PM)	Energy savings/Protection Low operation cost Reduced pollution Modernness	Reliability/Field tested Modularity Noise level

tion Engineers, Top Manageres, and HVAC consultants, who have relatively more responsibility in the decision process (see Cheston and Doucet [1]), appear to use more decision criteria.

Accordingly, common factor analyses were run for CE and PM, and a varimax rotation was performed on each. Most similar factors were identified and their equivalence tested one at a time (see Choffray and Lilien [3] for the procedure and the statistical results). Factor A is significantly different for the two groups (and factor B is nearly so); therefore, we reject the hypothesis of equality of evaluation criteria for these two groups. Similarly, PE, TM and HC's have an evaluation space of dimensionality three. The equivalence of similar factors was also tested and rejected.

Therefore, our analysis indicates substantial differences across groups of decision participants in their respective evaluation criteria. These differences underline the need for relating product evaluations to preferences for each of these groups separately.

Interpretation of these evaluation criteria leads to interesting qualitative distinctions between decision participant groups. For the two factor solutions we summarize and interpret the results in table 4.

The issue of industrial cooling systems' initial costs does not appear as clearly for Plant Managers. Modernness, energy savings, and protection againgst fuel rationing and power failure, on the other hand, account for a substantial portion of the variance in Plant Managers' perceptions. Corporate Engineers see the system's reliability and first costs as primary issues.

Similarly, table 5 presents an interpretation of the factor solutions for the other three groups, TM, PE and HC. The composition of the first factor indicates minor differences between these groups in terms of their first evaluation criteria. (TM include protection against power failures, and HC do not place the same emphasis on low operating cost.) Major differences, however, arise in the second and third factors. Production Engineers (PE), emphasize system complexity and modularity

Table 5
Comparison of factor structures for PE, TM and HC

	Factor A	Factor B	Factor C
Production Engineer (PE)	Energy savings/ Protection Low operating cost Modernness Reduced pollution	Modularity Noise level	Complexity Field tested/ Reliability
Top Manager (TM)	Energy savings/ Protection Low operating cost Modernness Protection against power failure Reduced pollution	Reliability/ Field tested Initial cost Complexity	Noise level
HVAC Consultant (HC)	Modernness Reduced pollution Energy savings/ Protection	Field tested/ Reliability	Noise level Initial cost

more than other groups. First cost comes out clearly as an essential element in top managers' (TM) evaluation of industrial cooling equipment.

In sum, our analysis of the evaluation space for each group of participants suggests that they not only differ in the *number* of evaluation criteria but, that substantial variation appears in the *composition* of those criteria. Different marketing strategies, including product positioning and sales presentations, can be targeted at these different groups to take advantage of these differences.

5. Marketing strategy implications

The relevance of these differences for marketing strategy formulation can be formally assessed by linking individuals' preferences for the three alternative industrial cooling systems to their evaluation of these alternatives. For this purpose, a linear regression model was fitted with rank order preference used as the response variable (as in fig. 2) and individual product evaluations (estimated individual factor scores) used as independent variables. (Hauser and Urban [4] suggest that least squares regression closely approximates monotonic regression for integer rank order preference variables.)

The results of this analysis are presented in table 6. Separate evaluation spaces were used for each group of participants. These results suggest important differences in the way product evaluations are related to individual preferences within each group. First, consider Corporate Engineers and Plant Managers. (Table 4 interprets the factors.) Corporate Engineers find reliability and first cost

Table 6
Rank-preference regression coefficients

Group	Constant	Regression coefficients 1st factor	Regression coefficients 2nd factor	Regression coefficients 3rd factor	No. of observations
CE	2.02	−0.46	−0.10	[a]	115
PM	2.00	−0.25	−0.19	[a]	84
PE	1.99	−0.39	0.27	(0.09) [a]	66
TM	1.99	−0.37	−0.18	−0.13	123
HC	1.99	(−0.02) [a]	−0.31	−0.45	273

[a] Not significantly different from 0 at the 0.10 level.

important, while Plant Managers find modernness, fuel savings and low operating costs to be most significant.

The comparison of the other three groups is most interesting. Production Engineers find modernness, low operating cost and protection against fuel rationing most important. But they seem to favor less field proven, less noisy and less easily substitutable equipment. Production Engineers are perhaps the only individuals in the decision process who will work with this equipment directly, and seem to favor that equipment which makes their job more challenging. Top Managers also find modernness, protection and low operating cost most important, but weight reliability and initial cost heavily as well, in the expected direction. Finally, HVAC consultants do not seem concerned about modern image, low operating cost, and fuel rationing protection. Their concerns are immediate – they weight initial cost and noise level most heavily and, secondarily reliability and the presence of field proven components.

Hence, each of these groups not only evaluates the various alternatives differently, but the nature of the link between products evaluations and individual preferences appears different as well. It is important to note that preference regressions were also run assuming a common evaluation space and heterogeneous preference parameters and suggested neither the positive association with less substitutable, less proven equipment noted above for Production Engineers (PE), nor the absence of association with modernness, low operating cost and fuel rationing protection for HVAC consultants (HC). The derivation of the evaluation space for each category of decision participant is, then, an important step in the development of accurate and behaviorally relevant models of industrial product evaluation. We summarize the differences between these groups in table 7.

The table suggests that, for example, when communicating with Top Managers and Plant Managers, low operating and initial costs should be stressed, along with modernness of company image and protection against fuel rationing. When promoting the new product to an HVAC consultant, however, first costs, reliability and low noise level should be emphasized.

Table 7
Importance of issues to different groups of decision participants

	Issues of key importance	Issues of less importance
Production Engineer (PE)	Modernness Protection against fuel rationing Less substitutability Less field proven	First cost
Corporate Engineer (CE)	Reliability First cost	Moderness of image Energy savings
Plant Manager (PM)	Protection against fuel rationing Modernness Low operating cost	First cost
Top Manager (TM)	Protection against fuel rationing Modernness Low operating cost	Noise level in plant Case of component replacement
HVAC Consultant (HC)	Noise level in plant First cost Reliability	Modernness Low operating cost

Following this analysis, a sales presentation or advertisement for solar cooling to top management via a business-oriented publication might stress: "Be a leader in your field and insure yourself against the hardships of rationing – use solar cooling," etc., whereas sales material directed at HVAC professionals would stress: "Solar cooling – the quiet, reliable cooling system best suited to your clients' needs. Offers substantial long-term savings," etc.

The analysis therefore provides salesmen and advertising managers with key data that can be used in sharply targeting a communications program stressing those product features of most importance to the group being addressed.

The analysis also has important impact on product design. For example, reliability is an important issue across groups and might justify R&D expenditures for establishing reliability standards for the equipment. The preference models provide a tool to determine just what an improvement in the image of product reliability will do to receptivity for each group of influencer. Most importantly, the analysis provides a framework to quantitatively assess trade-offs in the design and positioning of industrial products which provides essential information into R&D activities. For example, it is clear that improving system efficiency, implying higher first costs and lower operating costs would have a considerably different impact on HVAC consultants' and Plant Managers' preferences for industrial cooling alternatives respectively.

6. Assessment and conclusion

The analysis presented here can be used in two ways:

– Identification of areas of potential weaknesses in design and positioning of an industrial product by assessing its position relative to that of competitors in the evaluation space specific to each category of buying influencers.

– Development of communication programs and product presentations that account for the needs and evaluation criteria of different groups of buying influencers.

The assessment of the full potential of this analysis, however, suggests that we view the results within the framework of the development of better tools to assess industrial market response to marketing strategy.

Fig. 4 outlines a framework which can be used to structure this analysis. Here

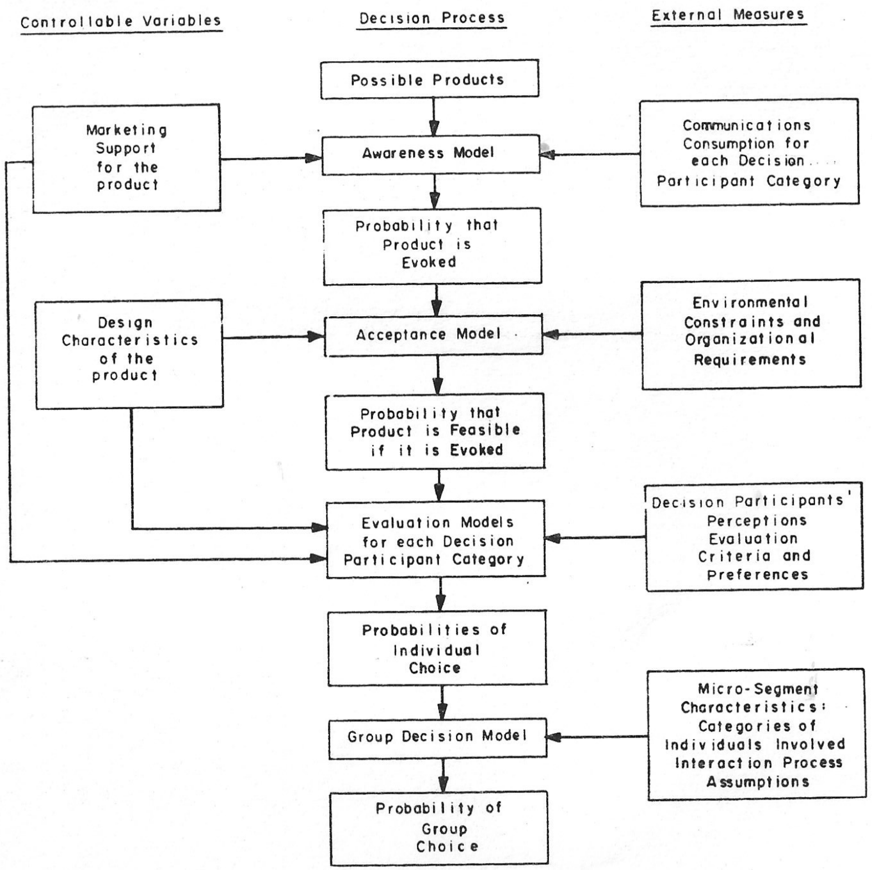

Fig. 4. General structure of the industrial market response model.

the industrial adoption process is formalized as a four-element model. The first element, the *Awareness* model, links the marketing support for the industrial product – measured in terms of spending rates for such activities as personal selling, technical service, and advertising – to the probability that an individual will evoke it as a potential solution to the organizational purchasing problem.

The second element of the response model is the *Acceptance* sub-model which relates the design characteristics of the product to the probability that it will fall in the feasible set of any organization. This sub-model accounts for the process by which organizations in the potential market screen out "impossibles" by setting product selection standards (e.g., limits on price, reliability, payback period, number of successful installations, etc.).

The third element, called *Evaluation Models*, relates individual perceptions of product characteristics to preferences for each category of decision participant involved in the adoption process. These models are essential when managers want to perform a sensitivity analysis on industrial market response to changes in product design or positioning. The analysis performed in this paper supplied the measurements needed to calibrate these models.

The last element of the model is the *Group Decision* model that maps individual choice probabilities into an estimate of the group probability of choice. Choffray and Lilien [2] propose four classes of descriptive models of the multiperson choice process that can be used at this stage. They distinguish a weighted Probability Model, a Proportionality Model, a Unanimity Model, and an Acceptability Model. These models encompass a wide range of possible patterns of interaction between decision participants categories and offer representation of this process for most industrial buying decisions.

A key aspect of the structure in fig. 4 is the explicit consideration of controllable variables as they affect each component of the industrial adoption process. A more complete description of this framework is contained in Choffray and Lilien [2].

The analyses outlined here are therefore part of a more general structure designed to assess industrial market response. That structure provides guidance for considerable improvement in industrial market analysis. Solar cooling systems represent a unique opportunity for addressing our nation's energy problems and, hence, are an area of intense study and application of the methodology.

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