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AN ATTITUDINAL STUDY OF THE HOME MARKET FOR SOLAR DEVICES.(U)
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TECHNICAL REPORT TR 77-5-25

An Attitudinal Survey of the Home Market for Solar Devices

Vincent N. Campbell
Rex V. Brown
Thomas R. Rhees
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AN ATTITUDINAL SURVEY OF THE HOME MARKET FOR SOLAR DEVICES

by

Vincent N. Campbell, Rex V. Brown,
Thomas R. Rhees and Dominic J. Repici

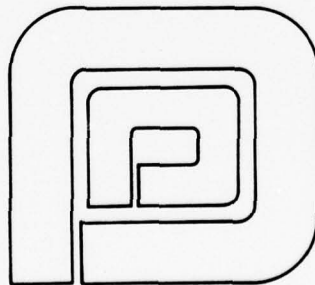
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Almost half (44%) of potential homeowners surveyed would prefer to have their living spaces and hot water heated with solar energy if the total cost averaged \$20 per month more than conventional heating and initial costs were no barrier. Although interest runs high, for various economic and technical reasons only about 1 in 75 American families may have both their home and water heated with solar energy by 1985.

Any development that makes solar energy cost-competitive with fossil fuels for home heating will increase the level of market penetration. Another key to how quickly Americans will have solar homes is how fast builders and developers use solar energy in new homes and can assure good performance.

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SUMMARY

The objective of this study was to estimate residential market penetration of solar space and water heating devices, under varying cost assumptions, based primarily on an attitudinal survey of consumers combined with probabilistic estimates of constraining factors.

Specifically, a residential telephone survey assessed the potential home solar market assuming alternative initial and continuing costs to the consumer and plausible equipment availability. The degree to which this potential would be realized was tentatively assessed from informed opinion and a review of other studies.

The scope of the study was limited in order to provide results in time for possible incorporation with decision-making covering legislative proposals. It is intended to complement the more extensive studies based on alternative approaches commissioned by the Government over a period of time.

Market Penetration Estimates

The method of estimating actual market penetration was behavioral; that is, the model consists of sequential decision stages of the buyer, with the influence of supporting institutions considered at each stage. The first stage is having a favorable attitude toward buying; the second is being in the market; the third is seeking to buy; and the fourth is succeeding in purchase. Market penetration in a given year was estimated by successively reducing the base of all homeowners by the estimated percentage of potential buyers who pass each decision stage. The residential survey results were used for the percentage of homeowners favoring solar

purchase in 1977, and this percentage was estimated for 1985. Subjective assessments were made for the percentage reduction at successive decision stages.

First, these subjective assessments were combined with the percentage of homeowners who favor solar if solar energy costs and conventional costs were equal over the long run. However, since the 1977 tax credit and future fuel savings appear insufficient to offset initial costs and make solar and conventional heating equal, market penetration was also estimated for solar home and water heating averaging \$20 more per month than conventional, and \$5 more per month for water heating alone. Market penetration estimates were also made for savings of \$20 and \$5 per month.

Cumulative market penetration estimates for the most reasonable assumption, that solar heating costs \$20 per month more over the long run (\$5 more for water heating only), are:

- o 1.3% of all homes have a solar space and water heating system by 1985; and
- o 8.5% of homes have a retrofitted solar water heater by 1985.

If solar and conventional heating costs are equal:

- o 2.0% of all homes¹ (new plus retrofit) have a solar space and water heating system by 1985; and
- o 14% of all homes¹ have a retrofitted solar water heater by 1985.

¹To account for the uncertainty in our estimates, we calculated the intervals within which we believe there is a 90% probability the true value falls. The cumulative intervals are 0.5-11% and 10-19%, respectively, for the equal-cost condition.

If solar heating saves \$20 per month (\$5 less for water heating only):

- o 2.2% of all homes have a solar space and water heating system by 1985; and
- o 18% of homes have a retrofitted solar water heater by 1985.

Two other investigators have also collected systematic data on consumer receptivity to solar energy as a basis for estimating market penetration. The population sampled and sample sizes were similar to those of the present study. Their results were generally consistent with those of the present study.

Institutional Inquiry

In order to assess market penetration, it was essential to understand the likely behavior of the institutional segments of the solar market infrastructure. This understanding was achieved by a review of the available literature, augmented by several interviews where some uncertainty remained as to the likely behavior of certain institutions. We concluded that there remains a high degree of uncertainty regarding how rapidly developers and builders will install solar space and water heating systems in speculative-built homes and that their decisions will have a perceptible effect on solar market growth. Interestingly, we encountered no proposals for direct incentives to builders and developers. These observations suggest a possible need to direct further attention to this segment of the solar market infrastructure.

Survey Results

The telephone survey yielded completed interviews from 379 homes in New York City, Nobles County in southwestern Minnesota, Santa Clara County in California, and Metropolitan Washington, DC. These geographical areas represent contrasting economic and social contexts, and recent reports estimate solar space or water heating is practicable in each area and available by 1985 or sooner. They were intended to be representative of the U.S. except for the areas technically least promising for solar energy.

The survey questioned residents about buying a home with solar space and water heating. About two-thirds (68%) of homeowners and renters who were potential homebuyers said they would choose solar over conventional heating if costs were equal over 20 years,² that is, if the added cost of the solar-equipped home (downpayment, monthly payments, etc.) was exactly offset over the 20 years by savings obtained by using solar energy. If costs averaged \$20 per month more over 20 years, less than half (44%) would choose solar, a decrease of 24% from those who would choose solar if costs were equal. If an average of \$20 per month would be saved over 20 years, four-fifths (79%) would choose solar, or 11% more would choose solar than under the condition where average costs were equal. This part of the survey gave two significant findings. First, of homeowners and renters who are potential homebuyers, a substantial proportion expressed willingness to shift to solar heating. Second, economic incentives reducing total solar costs toward equality compared

²Economic studies arrive at various "payback" intervals, depending upon their assumptions and the incentive(s) under consideration. We found no "payback" interval suitable for this type of survey and behavior modeling. Accordingly, we selected 20 years as a time period that the survey subject would not find bothersome in responding to home-buying questions, and 10 years on water heating questions.

to conventional energy costs over 20 years may influence a substantial proportion of homebuyers to seek solar homes; however, incentives which go beyond equality (e.g., relative savings) are likely to yield smaller marginal gains beyond that of equal cost in homebuyer willingness to buy solar homes.

A different approach was taken with one question in the survey to establish the mean "indifference" cost. Potential homebuyers said they would be willing to pay an average of \$12 per month more for the next 20 years to have a solar home rather than a conventional home.

In order to keep survey size within scope, only one question referred to retrofitting homes with solar space and water heating. Owners of homes were asked if they would seriously consider retrofit if the added cost were exactly offset by savings over 20 years, a condition which may be less realistic for existing homes than for new homes because of the large initial cost and short term of home improvement loans. Half (48%) of homeowners would be willing to retrofit under this condition.

The survey questioned homeowners about retrofitting solar water heating. If the added cost of installing and using a retrofit water heater is exactly offset by savings over a period of ten years, one-third (35%) of homeowners said they would replace their water heater this year. An additional one-fourth (24%) said they would replace with a solar water heater if the old one broke down, thus, three-fifths (59%) would be willing to buy a solar water heater if they needed a new one and the cost over ten years was equal. The survey also collected data for a cost of \$5 per month more for solar water heating and for a saving of \$5 per month, over the ten-year period. Lowering water heating costs increases the percent favorable to the idea of buying solar water heaters.

An analysis was made of the reasons given by potential homebuyers for and against buying a home with solar space and water heating. The most frequent response for buying was to conserve energy and other fuels. Economic reasons were next most frequent both for and against. Lower utility bills and cost savings led the reasons for. Total cost, in which initial cost and running costs were most frequently mentioned, led the reasons against. When asked which of the reasons they gave against solar were critical, respondents mentioned the newness of solar and its need to be proven, the need for information and advice, and anticipation of performance and maintenance problems, in addition to cost criticality.

All respondents were asked if they were for or against Federal financial help for installing solar units. Federal assistance was favored by 78% while 10% said they were against it.

The four geographical areas surveyed differed in willingness to buy solar devices but the pattern was not consistent.

Residents with natural gas as their home fuel showed greater willingness to switch to solar energy than did residents using oil, by 71% to 62% for potential buyers of solar homes and by 54% to 33% for retrofitting space and water heating.

Three-fourths of the residents to be sampled were sent a three-page letter describing solar heating in the home, with pictures and diagrams, and listing advantages and disadvantages. Other residents to be sampled were given a three-sentence description of a solar home heating system at the beginning of their interview. All residents were interviewed in the same manner. The group of respondents who had received the letter and the respondents receiving the three-sentence description did not differ at all in willingness to

buy a solar home or buy only a solar water heater. The respondents receiving the brief description were slightly more willing to retrofit their homes with a solar space and water heating system. The longer message did not affect attitudes. The survey showed that most Americans are probably already favorably disposed and in most need of practical help, particularly economic, performance, and experience information. A public education and advertising strategy emphasizing advantages and downplaying disadvantages might backfire because such expectations might not be achieved.

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AN ATTITUDINAL STUDY OF THE HOME MARKET
FOR SOLAR DEVICES

1.0 INTRODUCTION

The general purpose of this study was to assist the Federal Government in the choice of initiatives to encourage home owners to utilize solar energy. The specific objective was to provide consolidated estimates of the penetration of solar heating devices into residential markets, with varying financial incentives.

A review of previous studies reveals thorough analyses of the physical technology of solar energy and the economics of the solar market. Information from current studies brings the physical and economic picture up to date continually in a rapidly-changing context. Congress and the administration have recently explored in depth alternative economic programs for market expansion of solar energy use. Economic feasibility of solar heating, in particular, has been examined because a variety of practical devices and systems are now in use. Conclusions about economic feasibility vary widely (e.g., in cost of systems, and in relative feasibility for different regions of the country), in part because economic feasibility depends greatly on two factors which are very uncertain: future cost reductions of solar devices, and future costs of alternative fuels.

The other major uncertainty on which successful market penetration of solar devices hinges is the disposition of homeowners to opt for solar heating. Purely economic forecasts do not account for beliefs and attitudes of consumers, which may turn market predictions awry. The major focus of

this study was to survey homeowner attitudes and dispositions toward solar heating, given different cost levels and assuming initial costs could be amortized over the life of the equipment so no downpayment would be required.

The resident survey was supplemented by a review of findings of previous studies on the supporting institutions whose cooperation is essential to the rapid expansion of solar heating. That review has been supplemented by personal interviews with key individuals in what appear to be the most critical institutions: utility companies, builders/developers, and lenders.

The final task of the study was to analyze and synthesize new and existing information on homeowners and supporting institutions. The synthesis is not a comprehensive review of research, but rather an attempt to provide approximate estimates of probable market penetration, given the current beliefs and attitudes of prospective buyers of solar heating devices. The results of this synthesis are presented in the final section of the report.

2.0 HOME RESIDENT STUDY

2.1 Approach

The study of residents was designed to answer the following questions:

1. What are homeowners' attitudes toward the future purchase of solar heating devices? Specifically, how willing are they to buy:
 - a. new homes with solar heating of space and water?
 - b. solar heating retrofitted to their present homes?
 - c. solar water heaters retrofitted to their present homes?

(For economy's sake, water heating alone in new homes was not examined. It represents far less potential energy savings in the next ten years than any of the above three actions.)

2. How much does willingness to buy new solar homes and new water heaters vary with the relative economic advantage of solar and conventional systems? Because public disposition to buy solar is greatly affected by the need for a large initial payment (acceptable payback periods have been assessed to be five to ten years), we have studied public attitudes toward solar purchases with no initial payment. This avoids the sticky problem of asking people to tell us their discount value

of time, which others have found very difficult. A tax credit is being given this year to help offset the downpayment, thus reducing one of the major obstacles to solar purchases. If there is insufficient Government financial aid, our assumption of no downpayment is not realistic.

3. What are the primary reasons people volunteer for accepting or rejecting the idea of buying solar heating devices? Which reasons for rejection are most critical?
4. How do the answers to the above questions vary according to the location and background of the respondents?
5. Does basic information on solar heating affect willingness to buy and related attitudes?

Structured telephone interviews were used to collect data bearing on these questions. Several days before the interviewing began, three-fourths of the residents sampled were mailed a letter explaining the purpose of the study and asking them in advance for their cooperation in the telephone interview. The three-page letter described solar heating in the home, including pictures and diagrams, and listed the advantages and disadvantages of solar heating for the prospective buyer. Although the study was conducted by Decisions and Designs, Incorporated (DDI), the letter was sent directly from the Federal Energy Administration, and is shown in Appendix A.

The one-quarter of the sample who did not receive the letter were interviewed in the same manner as the letter group, except that the respondent was given a short three-sentence description of a solar unit for home heating.

2.2 Sample

Approximately 400 home residents were interviewed by telephone, yielding completed interviews from 379. In order to obtain this final sample size, we began initially with a list of 750 names drawn randomly from telephone books in four specific areas of the country. Every fourth name drawn was arbitrarily assigned to the control group and received no letter. In a great majority of the cases failure to complete an interview resulted from failing to make contact with a responsible adult. The number simply unwilling to cooperate was very small, and we therefore inferred that the bias in our results due to nonresponse was probably not large.

The sample was drawn from four geographic areas representing contrasting economic and social contexts. All four areas were drawn from the approximately 90% of the nation for which solar water or space heating has been estimated to be economically feasible by 1985 or sooner. The areas sampled were:

1. New York City, where both fuel costs and solar load are high, with varied economic and social conditions in an urban setting. The sample was drawn from Queens and Staten Island, where a majority of residents are homeowners.
2. Nobles County in southwest Minnesota, a rural farming area not near any metropolitan area, with high fuel costs and high solar load.
3. Santa Clara County, California, with moderate climate, good solar insolation, and rapid growth so that many new homes may opt for solar heating in initial construction. The sample was divided

evenly between San Jose, a city in the middle economic range, and Palo Alto, a more affluent suburb. The Palo Alto area in particular is an area of both high environmental concern and considerable activity in solar energy development.

4. Washington, D.C. area, where economical feasibility and climate are moderate. The sample was divided between downtown D.C., a central city area, and northern Virginia suburbs.

The number of completed interviews obtained from each area were as follows: Washington 84; New York 73; Minnesota 105; California 117.

2.3 Survey Instrument

Interviewers local to each area were trained for approximately two hours, including practice, to use the structured interview form shown in Appendix B (Training and Recording Guidelines are attached at the end of the interview.) The final form of the interview was based on tryout and revision.

The interview contained both structured alternative questions, and open-ended questions, the latter mostly concerning reasons for accepting or rejecting the idea of buying solar devices. Answers to open-ended questions were categorized and all interview data coded, key punched, and verified. Computer analysis included intercorrelations among key attribute and background variables and cross-tabulations, two variables at a time. The sample was not large enough for more detailed breakdown.

2.4 National Results

The key finding was that quite substantial proportions of homeowners expressed a willingness to buy solar devices. Of course, willingness expressed to an interviewer is a far cry from the actual behavior of purchasing the device, as will be discussed in the section on synthesis of market penetration estimates. Nevertheless, a receptive population of homeowners and other users is a prerequisite for rapid commercialization. Supporting institutions such as builders and manufacturers will do their part only if they perceive an increasing number of homeowners to be interested in solar heating.

2.4.1 New solar homes - Renters were not asked about willingness to buy solar homes unless they said they were planning to buy a home within the next two years. These constituted about 10% of the potential homebuyers in the sample, the rest being homeowners. About two-thirds of potential homeowners said they would choose a solar home over a conventional home if the life cycle costs were equal over a twenty-year period (Question No. 7). Slightly less than half (44%) said they would buy a solar home if the life-cycle cost averaged \$20 a month more for the solar home for the next twenty years. Economic incentives which reduce the currently greater life-cycle cost of solar homes toward equality with conventional homes may influence a significant proportion of home buyers to choose solar heating if it is available.

However, Government economic incentives which go beyond equality in twenty-year life cycle costs are likely to yield smaller gains in willingness to buy solar. The survey found that increasing the economic advantage of the solar home from equality to \$20 per month in savings for the solar home would convert an additional 11% of homebuyers to the idea of buying a solar home.

These findings are summarized in Figure 2-1, which shows the percent of potential homebuyers who express a willingness to buy a solar home, as a function of the relative life cycle costs per month of solar and conventional homes. The three small circles on the solid line curve represent the survey results. The curve itself is a projection of these estimates for other relative cost levels. The current actual relative costs of solar homes probably varies from equality to over \$80 per month more for solar homes. We have projected our estimates to \$40 per month more as a very rough approximation of average additional cost per month for solar homes currently being sold.

Average Relative Cost of Solar per Month

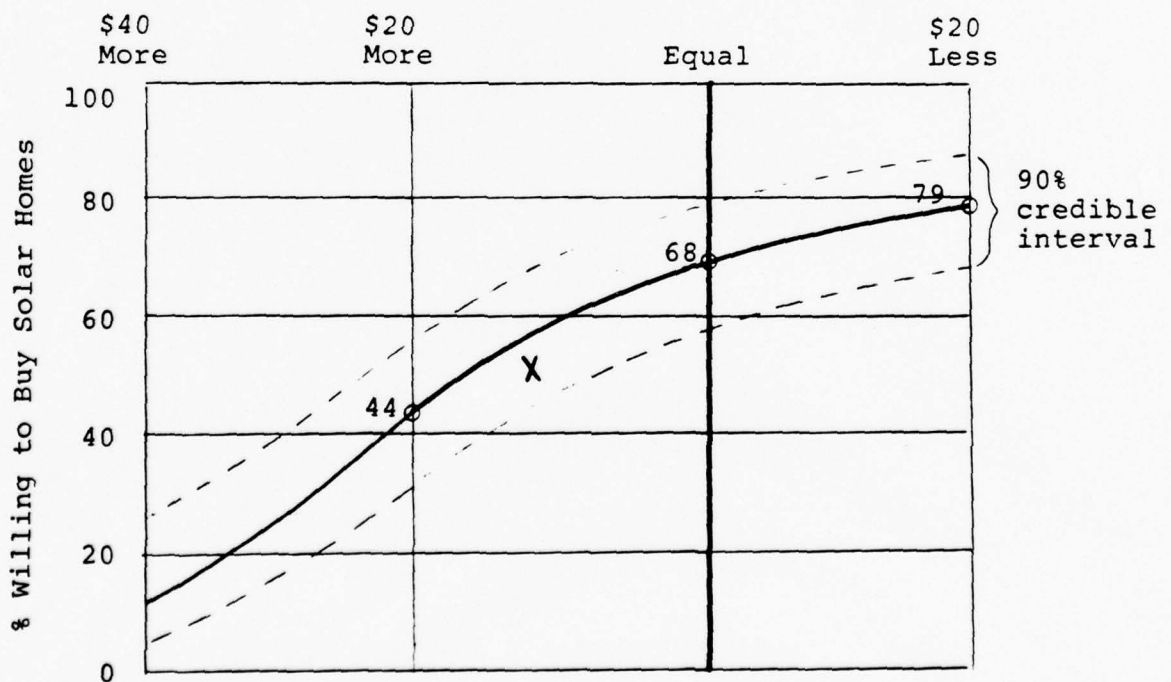


Figure 2-1. Percent of Potential Homebuyers Willing to Buy a Solar-Heated Home, for Different Relative 20-Year Life-Cycle Costs of Solar and Conventional Homes (The X is at the mean indifference cost, \$12 more)

The dashed line curves on the graph express uncertainty regarding our estimates. Specifically, we feel that it is highly probable (90% chance of being right) that actual percent of homeowners favorable to the idea of buying solar homes falls in between the dashed lines. The range or interval between the dotted lines we call the "90% credible interval."

The survey results do not necessarily provide the best estimate of public attitudes toward buying solar. Nevertheless, we have accepted the survey results as our best estimates (the solid line) and have not adjusted these upwards or downwards to allow for any net overall bias, on the assumption that error in one direction is as likely as another. Underestimates in disposition to buy may have occurred because respondents did not fully appreciate that no initial outlay of cash would be required. (See wording of Questions 7, 18, and 24 in Appendix B.) On the other hand, this possible bias downward may be offset by comparable overestimates of willingness to buy, since respondents willing to be interviewed tend to want to be agreeable and to give answers that they think are expected, especially if they are unsure of their feelings. These two kinds of error would tend to offset each other.

Question No. 13 represents a different approach to estimating willingness to buy at different relative costs. In this question, the respondent was asked what difference in cost between solar and conventional homes would make the two about equally good buys. Two-thirds of the potential buyers were able to understand and answer the question satisfactorily. The mean "indifference price" given by those answering was about \$12 more per month for the solar home; that is, on the average potential homebuyers say they would be willing to pay \$12 per month more for the next twenty years to have a solar home rather than a

conventional home. If this indifference price is entered in Figure 2-1 on the 50th percentile (see the point labeled X), it suggests that our estimates of willingness to buy based on the earlier form of question may be slightly high.

For those respondents who said they would buy the solar home if the life cycle costs were equal, the mean indifference price was about \$22 per month more for the solar home. For those who said they would buy the conventional home, the mean indifference price was about \$16 per month less for the solar home.

2.4.2 Retrofit home heating - Retrofitting existing homes to provide total home heating is generally considered less feasible for rapid commercialization than solar heating of new homes or than retrofitting solar water heaters. For this reason we did not investigate willingness to retrofit home heating under a variety of costs. We did ask home owners if they would seriously consider installing solar heating in their present homes if installation costs were spread over the 20 years and life cycle costs were zero; that is, the monthly cost of paying for installation and maintenance was exactly balanced by monthly savings in lower heating bills. (No downpayment was mentioned or assumed. See Question 18 in Appendix B.) About half of the homeowners (48%) said they would be willing to retrofit home heating under these conditions. However, the likelihood of zero life-cycle costs for retrofitting home heating is rather small, owing to high installation costs and the short time period of home improvement loans. Even if fossil fuel costs rise rapidly, a significant penetration of the retrofit home heating market may be doubtful unless the large initial cost can be amortized over a period of 20 years or more. This suggests exploring practical ways to subsume installation costs into existing home mortgages.

2.4.3 Retrofit water heaters - Homeowners were even less inclined to replace their water heaters (unless they broke down), given zero ten-year life-cycle costs, than they were to retrofit home heating given zero twenty-year life-cycle costs. About 35% said they would replace their present water heater this year with a solar water heater under these conditions. An additional 24% said they would be willing to do so if the old water heater broke down. Thus, around 60% might be willing to buy a solar water heater if they felt the need for a new water heater.

Figures 2-2 and 2-3 show the results for different ten-year life-cycle costs of retrofitting a solar water heater, where lower utility bills are included and thereby reduce life-cycle costs. Figure 2-2 projects estimates for those willing to buy in the next year regardless of the condition of their present water heater.

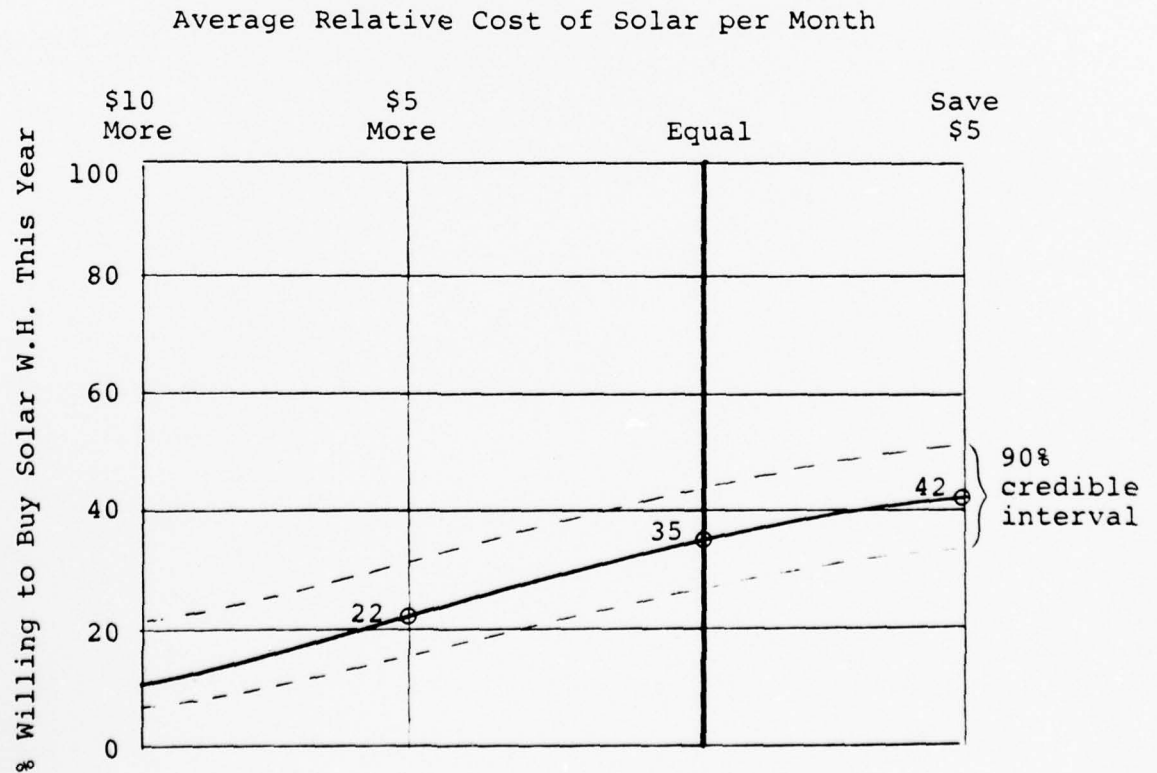


Figure 2-2. Percent of Homeowners Willing to Buy Solar Water Heaters this Year, for Different 10-Year Life-Cycle Costs

Figure 2-3 projects estimates given that the homeowner feels the need to replace this water heater, either for energy or operational reasons. As with new solar homes, lowering costs increases the percent favorable to the idea of buying.

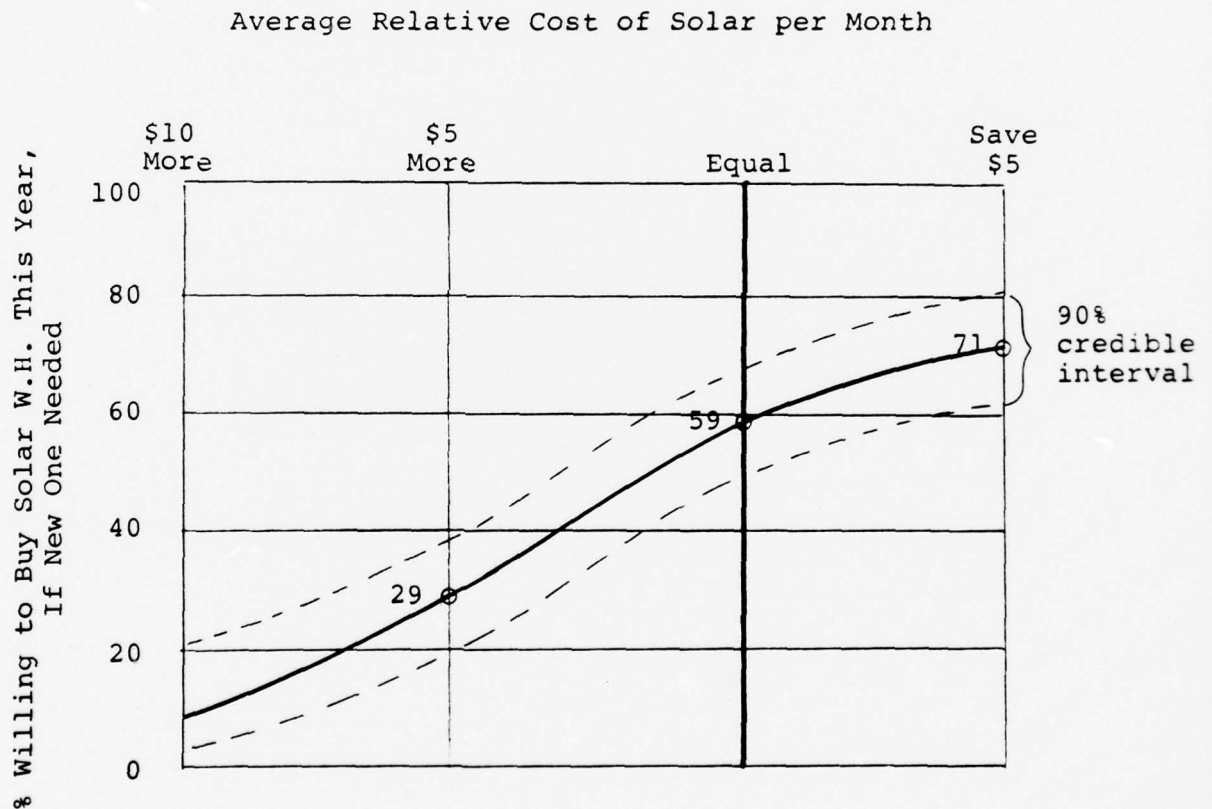


Figure 2-3. Percent of Homeowners Willing to Buy Solar Water Heaters this Year, if a new Water Heater were Needed, for Different 10-Year Life-Cycle Costs

2.4.4 Reasons for accepting or rejecting the idea of solar - Among the 2/3 of potential homebuyers who expressed a preference for solar homes, given equal life-cycle costs, two types of reasons were mentioned by a majority of respondents: to conserve energy and other fuels, and cost savings through lower utility bills. The fact that solar would provide a clean environment was cited by 15%. No other favorable reason was given by as many as 10%. Other reasons mentioned by at least 5% were: interest in a new idea; depending less on utility companies; and the belief that solar units might require less maintenance than others. Reasons for and against buying new solar homes, and their frequency of mention, are shown in Table 2-1.

Those who chose a conventional over a solar home most often mentioned costs as a reason against solar. This suggests they did not understand the question, or at least ignored the condition we specified that life-cycle cost would be equal for 20 years. It is likely that at least a few respondents misinterpreted this to mean monthly cost after an initial payment. Our intent was to assume no initial payment and the spreading of initial costs over the 20 years evenly. In any case, the results show that costs, whether they are initial or long-run, are the most salient issue in the minds of people considering the possibility of solar-heated homes.

Other reasons mentioned by at least 1/4 of the respondents rejecting solar were: concern over performance problems or maintenance, service warranties, etc.; not knowing enough about solar, or wanting more advice before deciding; and the belief that solar heating is too new or different or odd looking and must be proven worthwhile before they would accept it. About 10% of the rejectors were simply satisfied with what they have now and saw no need to switch to solar. Another 10% judged they were too old to be in the market for a new home, solar or not.

<u>Number of Responses</u>	<u>Reasons for Solar</u>
100	Conserve energy and other fuels
92	Cost savings, lower utility bills
13	Innovative, likes new idea
12	Other
11	Depend less on utility companies
9	Low maintenance, trouble-free
8	It is coming anyway
3	Higher resale value of home

<u>Number of Responses</u>	<u>Reasons against Solar</u>
63	Costs, total
(12)	(Initial costs)
(7)	(Long-run costs)
37	Other
28	Don't know enough, need advice before buying
27	Performance problems, maintenance, warranties
20	Too new or different, must be proven
11	Like house I have now
9	I'm too old to buy new home
6	Unsafe
6	Climate, weather
3	Back-up heat source needed

TABLE 2-1: FREQUENCY OF REASONS GIVEN
FOR AND AGAINST BUYING A SOLAR HOME

Almost all those who thought solar was too new and must be proven also said this reason was critical, and they would not change their mind unless it were proven to be worthwhile. About 1/2 of those that said they needed to know more listed this reason as critical, and about 1/3 mentioning performance problems indicated that to be a critical requirement for changing their minds. Similarly, about 1/4 of those mentioning costs described this requirement as critical.

The reasons given for rejecting the idea of new solar homes shown in Table 2-1 were also given with similar relative frequency as reasons against retrofitting space heating or solar water heaters to their present homes. In addition, the other objections mentioned by five or more respondents are shown in Table 2-2.

In addition to the reasons volunteered by the respondents for their choices, all homeowners were asked two explicit questions concerning doubts about solar heating. In Question #14, homeowners were asked if they felt solar heating was presently too new and experimental for them to risk buying it. Fifty-three percent thought it was and 38% thought it was not. (A much smaller percent volunteered this reason, as shown in Table 2-1.) Over half of those who thought it presently too risky had indicated in Question 7 that they would buy a solar home if life-cycle costs were equal. This may indicate that residents do not yet believe that life-cycle costs are equal, or it simply may be that, as often happens, stating the question in a different way yields different results. On the positive side, about half of those who said they would buy solar homes if life-cycle costs were equal think it is not too risky right now.

<u>Home Heating</u>	<u>Water Heating</u>	<u>Reason</u>
18	4	Age or poor condition of home
13	3	Physical layout of home; space shortage
8	2	May leave or sell home soon
0	12	Utility costs not worth bothering about

TABLE 2-2: NUMBER OF RESPONDENTS
GIVING MAIN REASONS AGAINST RETROFITTING
(EXCLUDING REASONS SHOWN IN TABLE 2-1)

The other direct question (#21) asked if they felt that installing solar heating in their present homes would demand too much of their own time and effort. About 57% of the homeowners answering this question said that it would not be too much time and effort.

2.4.5 Renters - Renters were asked if on the whole they favored solar heating of homes, and 85% said yes.

2.4.6 Attitudes toward Federal incentives - All respondents including renters and homeowners were asked near the end of the interview if they were for or against Federal financial help for installing solar units (#27). About 78% said they favored such Federal programs while 10% said they were against them.

2.5 Results by Location and Background

The four areas sampled differed somewhat in willingness to buy solar devices but the pattern was not consistent. About 80% of the California sample said they were willing to

buy a new solar home, while in the other three locations percentages all fell between 60% and 64%. Willingness to buy new solar homes was higher in suburban communities than in urban, small town and rural communities by about the same margin. Californians also showed a greater willingness to install heating systems in their present homes than homeowners in other locations, but the difference was less pronounced than in the case of new homes, as shown in Table 2-3.

In willingness to buy solar water heaters for their present homes, New Yorkers showed the most favorable response, 50%, with California at 41%, the D.C. area 30%, and Minnesota 23%.

<u>Total Home Heating</u>			
<u>Location</u>	<u>New Home</u>	<u>Retrofit Home</u>	<u>Retrofit Water Heater</u>
DC	62	53	30
NY	60	45	50
MN	64	38	23
CA	80	59	41

TABLE 2-3: PERCENT WILLING TO BUY SOLAR HEATING, BY GEOGRAPHIC LOCATION

The most striking difference among locations came in response to the question as to whether installing solar heating would demand too much of their own time and effort. About 91% of Californians said that it would not be too much trouble, compared to 57% for all four areas combined.

There was a regular relation between willingness to buy new solar homes and how soon the respondent expected to be in the market for a new home, as shown in Table 2-4. Those expecting to buy in the next two years favored solar more than those who never expected to buy another home (84% versus 62%).

Residents with natural gas as their home fuel showed more willingness to switch to solar than did residents using oil, electric, or other fuels, as shown in Table 2-5. This may reflect the general awareness that natural gas will soon be in short supply and prices may rise more rapidly than for other fuels. The type of structure that the respondent lived in (single-family versus multiple-unit building) showed no relation either to willingness to buy solar homes or to retrofit heating in the old home.

Age of respondent was slightly related to willingness to buy solar devices in that the younger were generally more interested than the older groups. Higher-income respondents tended to be somewhat more interested in retrofitting home heating and water heaters, but there was no relationship between income and interest in buying a new solar home.

2.6 Effect of Information

Those who received and read a letter given basic information on solar heating generally reported more favorable attitudes toward buying solar devices than those who were

<u>Minimum Number of Years Before Buy New Home</u>	<u>Number of Cases</u>	<u>Percent Willing</u>
0-2	50	84%
3-5	39	77%
6-25	31	68%
Never	127	62%

TABLE 2-4: PERCENT WILLING TO BUY SOLAR HOME
BY HOW SOON THEY EXPECT TO BUY A NEW HOME

<u>Type Fuel</u>	Total Heating			Water Heater	
	<u>No. Cases</u>	<u>New Home</u>	<u>Retro- fit</u>	<u>No. Cases</u>	<u>Percent Willing</u>
Gas	180	71%	54%	186	37%
Oil	63	62%	33%	---	---
Electric	10	*	*	53	23%
Other	5	*	*	4	*

*Too few to estimate

TABLE 2-5: PERCENT WILLING TO BUY SOLAR HEATING
BY TYPE OF FUEL USED CURRENTLY

sent the letter but had not read it at the time of the interview. This is an expected result. Some of those who did not read it probably were not interested in solar heating. If the entire letter group is combined, including those who read and those who did not read the letter, results for the letter and control groups do not differ at all in willingness to buy a new solar home or a solar water heater. In the case of retrofitting home heating, the control group is slightly more willing to retrofit than the letter group. Perhaps the information in the letter reminded people of more retrofitting problems than advantages.

The finding that a balanced message listing both advantages and problems does not markedly change attitudes is somewhat reassuring that the public is not grossly misguided either for or against solar. Or else, their misconceptions for and against solar cancel each other out in the aggregate. There appears to be little reason for an educational campaign designed to produce favorable attitudes in that most Americans are probably already favorably disposed. Furthermore, a campaign emphasizing the advantages and downplaying disadvantages might backfire with good reason when angry consumers discovered the disadvantages at their own expense. A more sensible function for information would be to provide practical help to those interested in buying or installing solar energy devices, especially in the areas of costs, financing, and performance warranties.

3.0 INSTITUTIONAL SUPPORT

The second focus of the study concerned the beliefs and attitudes of key persons in the supporting institutions whose cooperation is essential to rapid expansion of solar heating. In our behavioral approach to estimating probable market penetration, attention is directed mainly to the key actors in the market. Home buyers and owners may be pre-disposed toward solar heating, but realization of this sizeable market potential is conditional upon availability of the institutional support. What then are the barriers perceived and what is the probable response of the institutional elements of the solar market infrastructure?

A preliminary review of the existing information identified the institutions related to the home solar market. The institutions of interest included:

- Developers and Home Builders
- Lending Institutions
- Utility Companies
- State and Local Governments
- Solar Designers, Manufacturers, and Distributors
- Architects
- Installers and Repairmen
- Insurance Companies

The preliminary review also indicated that builders/developers, lenders, and utilities were those enabling institutions for which additional up-to-date information was most needed to assess behavioral attitudes. Owing to resource limitations, the method of inquiry was to acquire and review additional recent documents and to conduct a small number of telephone interviews and personal visits in the Washington, D.C. metropolitan area.

The information developed in the inquiry was used in the behavioral model described in Section 4.0, for estimating the fraction of those seeking to buy solar-equipped homes who will succeed. Also, our analysis of the information resulted in four observations we believe worth noting. First, the developer and home builder can have a major influence on the growth of the solar home market because they will make the decision on the type of heating used in new homes which are built for the speculative home market. This represents a substantial number of homes. Second, there is an indication that the developer/builder sees the major barrier to accelerated installation of solar heating in new homes as his inability to obtain warranties and guarantees on equipment and workmanship. Third, we observed that the developer and home builder do not appear to be offered direct incentives in any of the programs discussed in the literature reviewed in this inquiry. Fourth, we believe that there is greater uncertainty about when and how the developers and builders will act than how lenders and utilities and the other supporting institutions will act.

The developer/builder, lending institution, and utility company inquiries will be discussed in greater detail in the remaining paragraphs of this section.

3.1 Developers and Builders

In recent years, developers and builders have played a key role in the introduction of new equipment or materials in the home. Our three supplementary interviews and our review of the information in recent studies and reports made this point clearly.

As one executive of a major Washington, DC area developer/builder put it: "Look at the experience with central air-conditioning. Once we offered it as a standard in our

houses, almost overnight a luxury became what all buyers expected. Today, only the lowest cost developments in this area might not have it. Central air-conditioning was an option, like fireplaces and extra baths, a few years ago-- now it is expected, and the \$1,000 we include in the price of the house gives nobody any sweat."

From another part of the solar market infrastructure-- lenders: ". . . as in other housing innovations, they (lenders) identified the builder as the key figure in determining the rate of market acceptance. As one lender observed, electric utility companies had made it 'in the builders interest' to build electric-heated homes, and builders had constructed such homes and 'sold' lenders and buyers on them. Similarly, natural gas suppliers in his area had made it 'in the builder's interest' to build gas-heated homes, and builders constructed such homes and 'sold' lenders and buyers on them."¹

Will developers and builders play a similar role with respect to solar heating of homes? It appears likely. The larger developers and builders are looking and experimenting and the innovative builders are beginning to act. A specialist in the Technical Services Department of the National Association of Home Builders commented, "Sure it's coming. A builder in Virginia Beach is now using solar heating and hot water as a standard item in his homes. He manufactures the equipment himself. Another builder, in Columbia, Missouri, offers it as an option. And of course there are big solar efforts in Florida and Colorado."

¹Regional and Urban Planning Implementation, Incorporated, Home Mortgage Lending and Solar Energy, prepared for HUD and ERDA (Cambridge, Massachusetts, February 1977).

But all is not sweetness and light. From a Washington, D.C. developer: "Things are changing. We're feeling pressure from consumer, government, and conservationist about energy. We want to respond in a responsible way. Today, local insulation is heavier than we used in New England a few years ago. On our own, we're putting in heat pumps, which conserve on heating but not cooling costs. We're not being coerced, we think its good, we want to lead, and it sells. But solar hasn't had enough exposure. It isn't a simple system. There are a lot of disparate pieces. Nearly every week salesmen call who say they've got great stuff, but they hesitate when I ask about guarantee. It's available all right, and installation is possible, but there are still a lot of technical problems. When we can put in solar without jeopardizing our reputation, can back up a warranty, and service it, then builders will go for it."

The developer and builder has several other concerns. The size of the residential home market is pyramidal with cost, and builders are established in a certain cost band of the market. The addition of solar space and water heating adds a significant amount to the cost of the house, thus a builder can apparently find himself priced out of his normal market. However, the economic incentives being considered for the buyer may reduce this problem, or the builder could build a smaller house to stay in his price range, or the investment cost of solar equipment may be reduced. In any event, the early resolution of these uncertainties about costs can be expected to make developers and builders decisions easier.

There is concern about the developer/builder and customer interface. What can the prospective buyer be told about utility costs, the appearance of the home, covenants, operating and maintenance problems? Answers to these kinds of questions

are being thought out, and there is confidence this area will work itself out as progress is made in other areas.

There is also the question of industry standards. Again, these are being worked out in a timely manner. Intermediate performance-type standards have been developed and published in the Federal Register. The Sheet Metal Industry has published an installation standard. The area of standards is being worked on by HUD and the American National Standards Institute, and it does not appear to be a significant barrier for the future. Builders recognize the need to ensure safety and health, but they also indicate their need for flexibility and freedom from excessive red tape.

We encountered no proposals for direct developer or builder incentives in our review. Also, in response to a direct question, one very "involved" developer responded that he was not aware of any.

In summary, our inquiry shows that equipment reliability and all aspects of cost are the most important uncertainties from the developer and builder point of view. They appear relatively confident that other concerns are being addressed and will not cause delay. Their outlook is cautious but optimistic.

3.2 Lending Institutions

The activities of lending institutions must be considered in any behavioral model of the solar home market. Obviously, an inability to obtain financing for new homes or home improvement with solar heating would hinder market growth. Our inquiry shows lending institutions pose no a priori deterrent to the borrower insofar as solar heating is

concerned. It is a moot question whether lenders will require more stringent thresholds on loan-to-total cost ratio, term of loan, or interest rate, although it is likely that there will be differences in standards and criteria for financing.

Recent studies^{2,3} show that the activities of lending institutions in the solar energy market for single-family residences is developing along the lines experienced in the past with other innovations. Risks are being evaluated in much the usual manner and financing is being obtained for solar homes today.

When an individual homeowner is to be financed, the lender has absolute assurance that the cost of solar is worth the going price to at least one consumer. When a developer requests a loan, the lender has assurance the developer has professionally evaluated both the technical performance and marketability of the solar system. These are normal aspects of the business and the studies indicate that lending institutions will view solar applications with this kind of outlook.

Of course, experience and the incentives which come into being will have an effect on financing. As would be expected at this early stage, surveys have shown that successful borrowers have obtained loans where the loan, as a percentage of the total cost of the house, was lower than average. Also, homes tended to be in the more expensive range, borrowers were in the upper income bracket, and the

²Ibid.

³Federal Energy Administration, Lender Impacts Upon Energy Conservation in Buildings, FEA/D-77/126 (Washington, D.C., February, 1977).

borrower often had an established relationship with the lender. Successful experience with solar home heating will tend to eliminate these kinds of differentials, increasing the ease with which financing can be obtained even without incentives.

As the solar market gathers impetus, lending institutions are very unlikely to pose any abnormal barrier to market growth. As in the past, credit worthiness and marketable equity will be the criteria determining success or failure of the loan applicant.

3.3 Utility Companies

The utility companies are looked to for assured availability of energy at reasonable cost. In the coming solar market, electric utilities must provide the power to run parts of every solar heating system (motors and controls, for example), and they may be called upon to provide backup heating energy when the primary solar energy source is insufficient. The gas utilities may also be a source of backup energy. Our review showed that the utilities are currently well-informed and have the analytical tools with which to approach their problems as solar heating system design and use progresses to the point where the extent of their role is more clearly defined.

Although there is considerable conjecture as to the impact of mass solar commercialization on utility attitudes, there is insufficient operational experience upon which to base precise conclusions. As one electric utility executive explained to us: "Solar energy over the near-term, when physically dispersed over an operating region, simply makes an ignorable impact upon operations. It is a non-issue and likely to remain such for some time." As another executive put it, the question is "how to service a 'heavy appliance

user' in our system" and time to handle growth of this market is available. The focus, then, is on the economic impact of solar energy on the utilities. This has received considerable attention, mostly consumer-oriented, but our review of the capital requirements of utilities merits a brief discussion here.

The primary technical concern shaping utility behavior toward residential use of solar energy is its impact upon peak-to-baseload differential. If the energy required to supplement solar units is substantial and occurs during peak diurnal or seasonal periods, the differential worsens and additional generating and distribution facilities could be required. Requirements for capital then become a near-term issue, owing to the long facility construction lead times. However, there are counterbalancing possibilities, such as an overall reduction in total demand due to a shift to solar, or charging heat storage tanks during off-peak nighttime hours. Uncertainties do exist, but utilities appear capable of responding to anything but explosive demand, which appears to be unlikely for reasons unrelated to utility attitudes or behavior.

Interestingly, another capital-intensive utility alternative evoked unsolicited and consistent comment from both utility and lender in our small sampling. The idea of having the utilities own and lease to the consumer, or to finance residential solar units, was viewed very negatively. It would impose an immense, unrealistic capital requirement on the utility and involve them in a new business. Lender comment was emphatically against the latter.

In summary, we believe it is unlikely that activities of electric or gas utilities will pose any barrier to meeting goals for expansion of the home solar heating market.

3.4 Conclusions

As was observed in the discussion of developers and builders, reliability of the equipment is a prerequisite for acceptance and it must be proved. Assuming successful experience with home heating, we have encountered no perceptions, concerns, or actions in the supporting institutions which might prevent timely development of the solar home market along the lines experienced in the past with other housing innovations.

We did conclude, for purposes of our estimate of buyer success in acquiring solar homes, that there remains a high level of uncertainty as to how rapidly developers and builders will install solar space and water heating systems in speculative built homes. Their actions will undoubtedly have an effect upon the rate of growth of the solar market.

Interestingly, we encountered no proposals for direct incentives for developers and builders to install solar space and water heating.

4.0 SYNTHESIS

4.1 Behavioral Approach

In contrast to the economic models being developed elsewhere, our method of estimating market penetration is primarily behavioral. That is, attitudes and decisions of key actors in the market are considered in relation to their timing and their joint effect on sales of solar homes and solar devices. The framework is stated in sequential decision stages of the buyer, with influence of supporting institutions weighed at each stage. The four major stages prerequisite to an individual purchase are surmised to be:

- o Favor solar heating. Having a favorable attitude toward the idea of buying solar rather than conventional heating is the first stage, or rather, condition, and must be present throughout the other three stages. This is the variable which we estimated from the results of the home-residential study. We would have combined our estimates with those of other attitude studies at this point, but the only systematic data available were collected two years earlier, as discussed in the last section of the synthesis.

- o In the buyer market. The potential customer must consider himself currently in the market and looking for a new home (or a new heating system, or a new water heater) before he will seriously pursue a purchase. Our estimate of percent of residents in the home-buying market are based on number of new homes sold in relation to total homes and a guess that each year about twice as

many residents are in the market as the number who actually purchase new homes. For retrofit heating and water heaters, the estimate is based on the life expectancy of the existing equipment or interest generated by the energy crisis itself.

- o Seek to buy solar. Of those in the market and favorably disposed toward solar (in the abstract), only a portion will actually seek to buy a solar home or device. This is partly because at the time they replace their equipment or seek a new home, many buyers will be preoccupied with more fundamental personal concerns and may not consider energy conservation at all. Or if they do, as in the case of a broken water heater, for example, they may consider it impractical given the time necessary to install a solar unit. In the case of a solar home, an important factor is likely to be whether a solar home is seriously suggested as a possibility by the realtor, builder, or architect. The rate of buyers seeking to buy solar is expected to be much higher if it is suggested by the seller or other key agent, than if no mention of solar occurs. Separate estimates of likelihoods and contingent probabilities for these two cases were a part of our estimation of the percent who seek to buy new solar homes. Another important set of factors is technical feasibility of the buyer's own homesite for retrofitting. Many who favor the idea of buying solar may find that orientation of the house, roof slope, aesthetics, space, shading, or structural problems make it impractical for their particular home.

- o Succeed in purchase. Many who seek to buy solar homes or devices will not succeed because of contrary circumstances. This is an especially powerful factor with new homes. Only a tiny fraction of homebuyers could obtain a new solar home this year even if they wanted to, because so few are being built. Financing is another obstacle estimated to eliminate about half of the would-be solar home purchasers. For retrofit heating and water heaters, the equipment is much more available, and could be installed in most cases, but it is estimated that a substantial fraction will not go through with the purchase because of inadequate performance guarantees or warranties.

For each of the four stages, an estimate was assembled of the percent of homeowners who would pass that hurdle in 1977 and a separate estimate of each factor for the year 1985. These are shown in Table 4-1 for the assumption of zero life-cycle cost of solar compared to conventional heating. All estimates must be considered rough approximations, and those in stages 2 to 4 should be considered as preliminary and in need of more detailed examination.

The market penetration in a given year was estimated by successively reducing the base of all homeowners by the estimated percent of potential buyers who pass each hurdle. That is, the net market penetration estimate below the bottom line is the product of the four percent estimates above it. From the yearly penetration estimates of Table 4-1, we estimated cumulative market penetration in 1985 (next to last line) by assuming the intervening years to fall in a gradually accelerating growth curve of sales in the introductory period of innovation. In the case of home heating, the most meaningful cumulative penetration is that for the total population of homes; i.e., 1.2% + 0.8%, for a total by

Population Base:	Total Heating		Water Heaters	
	New Homes	Retrofit	Retrofit	
	All Homeowners	All Homeowners	All Homeowners	
	<u>77</u> 85	<u>77</u> 85	<u>77</u> 85	
% Favor Solar Heating	68 75	48 50	35 50	
% in the Market	6 6	3 4	17 27	
% Seek to Buy Solar Home	36 78	28 39	24 36	
% Succeed in Solar Purchase	0.5 10	4 30	28 54	
Net % of Market Penetration				
Estimate	.01 .35	.02 0.2	0.4 2.6	
90% Credible Interval	(.003- .016) 1.0)	(.004- .059) 1.0)	(.2-.9) (1.2-6)	
% Cumulative Penetration				
Estimate	1.2	0.8	14	
90% Credible Interval	.46-3.1	.079-8.1	10.3-19	

TABLE 4-1: ESTIMATES OF NATIONAL MARKET PENETRATION (EXCLUDING ABOUT 10% OF THE NATION UNSUITED TO SOLAR ENERGY) GIVEN ZERO EXTRA LIFE-CYCLE COST OF THE SOLAR PURCHASE COMPARED TO ITS ALTERNATIVE

1985 of 2.0%, given no greater life-cycle cost for solar than for non-solar homes, and no greater downpayment. The corresponding estimate of cumulative penetration by 1985 for retrofit water heaters is 14%.

In order to assess more accurately the degree of uncertainty of these estimates for each entry in Table 4-1, we also estimated a 90% credible interval (i.e., that interval within which we believe there is a 90% probability the true value falls). The credible intervals (CI) were then combined by techniques developed by Brown¹ in order to provide the CI shown at the bottom of Table 4-1 for net market penetration and for 1985 cumulative market penetration. The technique for combining CI's is presented in Appendix C.

Tables 4-2 and 4-3 show the comparable estimates (without CI's) of market penetration of total heating in new homes and retrofit water heaters, assumptions that life-cycle costs are not equal for solar and its alternative. Table 4-2 shows the estimates where solar heating is assumed to cost more and Table 4-3 shows the estimates where solar heating is assumed to cost less. The first row in each table (% favor solar energy) is taken directly from our survey results for 1977, projecting estimates for 1985. The second, third, and fourth rows were transposed directly from Table 4-1 in the belief that these values would not vary appreciably within the range of costs considered here. Credible intervals were not calculated but would be quite similar in width to those shown in Table 4-1.

The estimated cumulative penetration by 1985 for new homes rises only slightly (1.2 to 1.3%) with savings of \$20

¹Brown, R. V., Research in the Credibility of Estimates (Boston: Harvard University Graduate School of Business Administration, 1968).

	Total Heating		Water Heaters	
	New Homes		Retrofit	
Population Base:	All Homeowners		All Homeowners	
	<u>77</u>	<u>85</u>	<u>77</u>	<u>85</u>
% Favor Solar Energy	44	49	22	31
% in Market	6	6	17	27
% Seek to Buy Solar	36	78	24	36
% Succeed in Solar Purchase	<u>.5</u>	<u>10</u>	<u>28</u>	<u>54</u>
Net % of Market Penetration	.005	.23	.25	1.6
% Cumulative Penetration		0.8		8.5

TABLE 4-2: ESTIMATES OF NATIONAL MARKET PENETRATION
(EXCLUDING ABOUT 10% OF THE NATION UNSUITED TO SOLAR ENERGY)
GIVEN EXTRA LIFE-CYCLE COSTS OF \$20/MONTH FOR NEW HOMES
AND \$5/MONTH FOR RETROFIT WATER HEATERS,
COMPARED TO NON-SOLAR ALTERNATIVES

	Total Heating		Water Heaters	
	New HOMes		Retrofit	
Population Base:	All Homeowners		All Homeowners	
	<u>77</u>	<u>85</u>	<u>77</u>	<u>85</u>
% Favor Solar Heating	79	87	47	67
% in Market	6	6	17	27
% Seek to Buy Solar	36	78	24	36
% Succeed in Solar Purchase	.5	10	28	54
	-----	-----	-----	-----
Net % of Market Penetration	.009	.41	.54	3.5
% Cumulative Penetration		1.3		18

TABLE 4-3: ESTIMATES OF NATIONAL MARKET PENETRATION
(EXCLUDING ABOUT 10% OF THE NATION UNSUITED TO SOLAR ENERGY)
GIVEN LIFE-CYCLE SAVINGS OF \$20/MONTH FOR NEW HOMES
AND \$5/MONTH FOR RETROFIT WATER HEATERS,
COMPARED TO NON-SOLAR ALTERNATIVES

per month, but drops considerably to 0.8% if solar homes cost \$20 per month more. For retrofit water heaters, a \$5 per month saving increases estimated 1985 cumulative penetration from 14% to 18%, while a \$5 per month added cost lowers it from 14% to 8.5%.

Although we did not collect survey data on costs greater or less than zero for retrofit home heating, let us assume that a \$20/month added cost changes attitude towards retrofit in the same way as toward new homes. We then derive an estimated 1985 cumulative penetration of 0.5% for retrofit homes. Combining the 0.5% for retrofit homes with 0.8% for new homes yields an estimated 1.3% cumulative penetration by 1985, given \$20 per month added life-cycle cost for 20 years. Thus, the \$20 per month cost lowers estimated penetration by about one-third (from 2.0% to 1.3%).² The corresponding estimate, given a \$20 per month saving, is that 2.2% of all homes would have solar space and water heating by 1985.

4.2 Comparison with Other Studies

Several agencies have convened small groups of residential and commercial energy users to discuss solar energy. Issues and concerns expressed at those discussions were quite similar to those reported here. At least two other investigators have also collected systematic data on consumer receptivity to solar energy as a basis for estimating market penetration. Both drew their samples from the population of single-family homeowners of moderate to high affluence. Both used sample sizes similar to those of the present study. The results were generally consistent with those of the present study.

²A cumulative estimate of 1.3% combined with a projected inventory of 85 million homes in 1985 yields an estimate that 1.1 million homes would have solar space and water heating by 1985.

The earlier of the two studies was conducted in 1975 by a California gas and electric utility company. They found a high awareness of solar energy in general. At that time, respondents grossly underestimated the price of solar home heating systems, a median estimate being about \$2,500, or 1/2 to 1/4 the current estimates of average solar home heating system costs. Given their own economic assumptions, 59% of the homeowners said they would be willing to buy a new solar home and 21% said they would be willing to retrofit the heating system of their present home. These estimates are a little lower than the present study, perhaps because of the two-year interval in which solar energy applications have become more widely known. If the respondents had known the actual estimated installation costs, the difference across this two-year period might have been even greater.

Sound and thorough studies of consumer receptivity and market penetration of solar space and water heating devices have been conducted by Jerome Scott.³ These data were collected during the year 1976, and, as in the present study, a high percentage of respondents favored some kind of Federal financial help to residents purchasing solar devices; most of these preferred a tax credit to either a low-interest loan or a tax deduction. He found, as have others, that when prices are stated in terms of years to pay back initial cost, the majority state their maximum acceptable payback period to be less than ten years.

³Scott, Jerome, Solar Water Heating. Economic Feasibility, Capture Potential and Incentive, Final Report to National Science Foundation, Grant No. APR 75-18330. (Newark: University of Delaware, 1977).

Scott obtained estimates of willingness to buy solar devices by direct questions similar to ours, except that he presented respondents a greater variety of economic conditions and stated explicit assumed initial costs, alternate fuel costs, financing conditions, and government incentives. In a conjoint utility analysis, he asked respondents to rank order the 32 different purchase options combining different combinations of these variables; and then by regression analysis, he determined the relative weight of each variable in each respondent's judgments of the values for a solar water heater (a similar study was done earlier on solar heating of homes).

He also used the data to project demand curves for both retrofit and new home installation of water heaters as a function of different initial prices of the water heater (\$500 to \$2000).

Using the above data to estimate initial market penetration, and estimates of the number of years required to reach this level, he then derived estimates of market penetration each year by assuming a logistic growth curve for sales of solar water heaters. In choosing the theoretical curve for estimating time to achieve initial and maximum penetration, he gave careful consideration to the similarity of solar water heaters to other new products in the heating and air conditioning fields.

Using his expected product sales growth curve for annual projections, Scott estimates that 3.1% of the single-family homes will have retrofit solar water heaters by 1985, if there is no tax incentive or other Federal financial help. The estimate for 1985 (cumulative) is 10.2% with a tax incentive of \$350 applied to a \$1400 solar water heater. This is quite consistent with our own market penetration

estimate of 8.5% derived by entirely different methods. That is, converting Scott's economic assumptions to a ten-year life-cycle cost (including utility bill savings) with initial purchase distributed over that interval, gives a cost of about \$5/month if an immediate \$350 tax credit is augmented by its discount value, and \$10/month with no tax credit. Our 1985 estimate with Scott's \$350 tax credit (\$5/month cost) is about 8.5% cumulative penetration, and with a \$700 credit (zero monthly cost) about 14% cumulative penetration by 1985 (see Tables 4-1 and 4-2). Thus, our 8.5% cumulative penetration corresponds to Scott's 10.2% under similar economic assumptions. Although there appears to be fairly close correspondence, there has to be a good deal of coincidence in this correspondence in view of the speculative nature of the estimates and the wide uncertainty ranges we attribute to our estimates.

Another major study of solar market penetration by Arthur D. Little Company⁴ was nearing completion concurrently with the present study. They project cumulative market penetrations by 1985 of 1.1% for home and water heating, and 2.8% for hot water only (in new homes as well as retrofit), given implementation of President Carter's national energy plan, and much smaller percentages with no Federal intervention. It is not clear what cost levels for the homeowner these two cases entail. If the estimates for the national energy plan case are similar in cost level to Scott's \$350 tax credit and our \$5 per month life-cycle cost, then the Arthur D. Little estimates of market penetration are clearly more pessimistic than ours.

⁴Arthur D. Little, Solar Heating and Cooling of Buildings (SHACOB) Commercialization Report, Part B: Analysis of Market Development, Arthur D. Little Report #C-80440 (Cambridge, Massachusetts, August, 1977).

Our analysis is based on the assumption that costs are incurred by the householders evenly over the life of the equipment. This might be achieved by a lump-sum tax credit covering the downpayment or by a no-downpayment loan. In the event that, as at present, a substantial portion of the cost is borne at installation, penetration would no doubt be materially slowed down.

APPENDIX A

LETTER TO RESIDENTS SAMPLED

FEDERAL ENERGY ADMINISTRATION

WASHINGTON, D C 20461

June 13, 1977

Dear Citizen:

Within the next two weeks, you will probably get a telephone call asking for your views on solar energy. The U. S. Government is taking action to help meet the future energy needs of the country. Knowing more about the views of the American people will help us do a better job of planning. Your household has been selected as part of a small random sample with the hope you will be willing to answer a few questions. Everything you say will be treated as confidential and anonymous. Your cooperation is entirely voluntary, of course, and would be greatly appreciated. The purpose of this letter is to give you some background information prior to calling you on the telephone.

Solar Energy Systems

Direct use of the sun's energy to provide hot water and space heating for homes and other buildings is now practical in many regions of the U. S. It promises to become even more economical as the costs of fuel continue to rise and as solar units are mass-produced on a larger scale.

The most common solar energy unit, shown in the enclosed picture, uses a solar collector on the roof and a storage tank for hot water within the building. Such a system is used for both space heating and to provide hot water. The collector is usually a flat metal plate enclosed in an insulated case in which water flows through tubes or channels under a glass or clear plastic cover. The sun heats this fluid, and a pump circulates the heated fluid from the collector to the storage tank. From there, the heat is then distributed throughout the home for space heating by conventional means, i.e., air ducts or hot-water baseboard radiators. After losing its heat, the cooler water is then circulated back to the solar collector. A smaller system will provide for the hot water needs of the home.

Advantages

Solar energy will probably cost less than oil and electricity in the long run. Utility bills will then be lower in solar homes, and resale values may be higher.

The solar heating concept is rather simple; some homeowners install their own units, and little maintenance is expected for properly designed systems.

World gas and oil resources are being used up rapidly, can never be replaced, and need to be conserved. Solar energy is a renewable resource.

Solar energy can help us become more self-reliant and independent as a nation. We depend heavily now on foreign nations for oil, and they can put great pressure on our economy and our international policies unless we become more self-reliant in energy.

Solar energy does not pollute like fossil fuels and so helps keep the environment clean.

A home with solar heat can be less dependent on utility companies, more self-sufficient.

Disadvantages or Problems

Solar heating initially costs much more than conventional heating; but as electricity, oil and gas prices rise, the total operating costs of solar heating remain about the same over the lifetime of the equipment. No one knows, however, how fast prices of electricity, oil and gas will rise. Consequently, even with such fuel savings, it may be ten to twenty years before you have paid back the extra costs of solar heating.

New types of heating and cooling systems, which are better or less expensive than today's solar units, may come along in a few years.

If a solar home looks odd or was poorly done, it might lower the resale value of a home rather than raise it.

Economical solar units do not provide all the space heating needed in cold climates, and backup conventional heating would be a required additional expense.

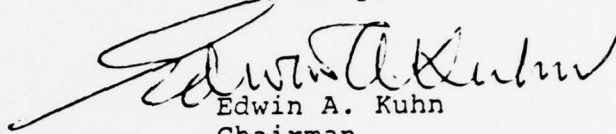
New buildings or nearby trees might shade the solar units and reduce their effectiveness.

Solar units, like any heating system, might be defective or need maintenance. There is a question at present about the availability of warranties and quick service.

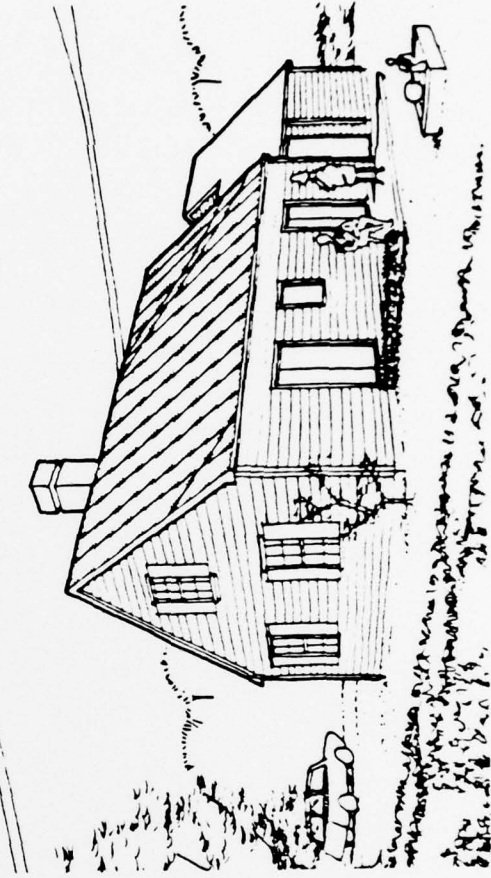
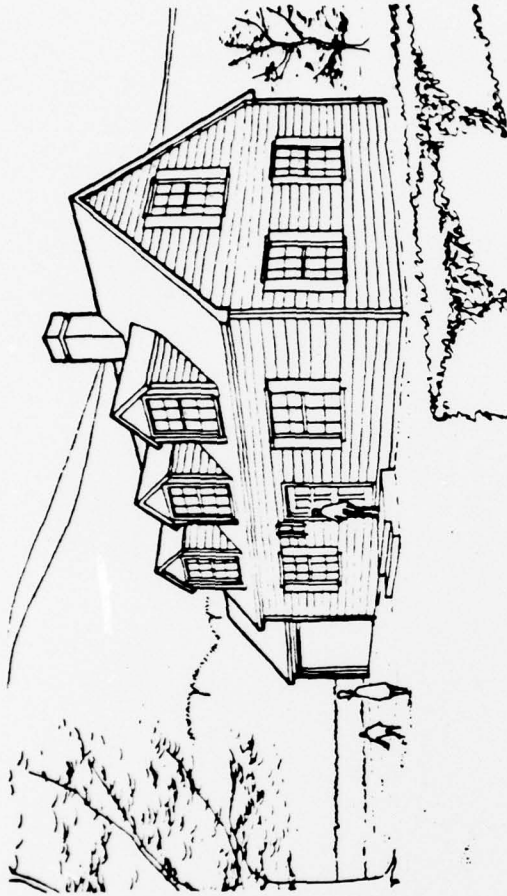
Solar homes or units may not be available when or where they are wanted. Cooperation of manufacturers, builders, utilities, lenders, local government and other supporting agencies may be slow at first.

Thank you for reading the above information on solar energy. It appears that solar homes can help relieve the national energy crisis. However, the widespread use of solar energy depends, first of all, on how the American consumer feels about its use. We will be calling you to learn your own views.

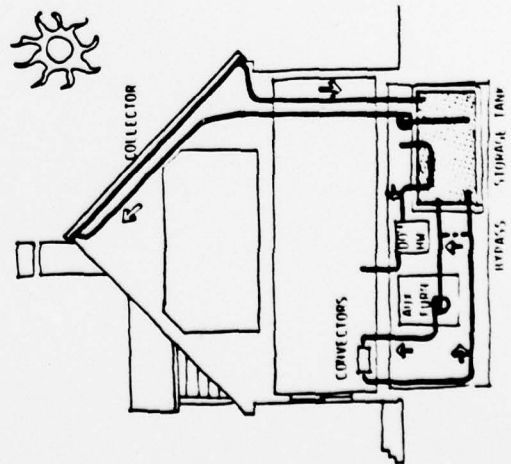
Sincerely,

A handwritten signature in cursive script, appearing to read "Edwin A. Kuhn".

Edwin A. Kuhn
Chairman
Solar Energy Commercialization
Task Force



Schematic representation of a solar energy system installed in a single family detached house, with the solar collectors on the south facing back roof.



APPENDIX B

RESIDENT SURVEY QUESTIONNAIRE

C or L

Phone number

Hello. My name is _____. I'm calling for the Federal Energy Administration. The Government is planning ways to meet the future energy needs of the country, and would like to know how Americans feel about using solar energy in their homes. You were chosen as part of a random sample of homes that are being surveyed on solar heating.

We would appreciate it very much if we could ask someone in your home a few questions about solar heating. Could I talk to the head of the household or someone who would help decide how to heat your home? IF SPEAKER VOLUNTEERS, THANK HIM/HER & SKIP TO ★
NAME OF PERSON TO TALK TO: _____

IF NOT THERE, ARRANGE CALLBACK AT (TIME): _____

IF DIFFERENT PERSON, REPEAT TOP PARAGRAPH ABOVE, THEN: We would appreciate it very much if we could ask you a few questions on this topic.

★ Your answers will be confidential and anonymous. (OK?)

LETTER GROUP: SKIP TO NEXT PAGE

CONTROL GROUP: READ THE SUMMARY BELOW

SUMMARY

Before I ask any questions, I'd like to tell you what we mean by solar heating in the home. Most solar collectors are flat panels, usually on the roof of the building. The sun shining into these collectors heats a fluid, which can provide part of the heat for the home. Or a smaller unit can be used just as a hot water heater. O.K.?

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Decisions and Designs Inc.
Solar Heating,
Telephone Interview
June, 1977

Note: Numbers in parentheses indicate percentage of respondents answering each question who gave each answer.

1. (INDICATE GROUP)

- 1 Letter (70)
2 Control SKIP TO #3(30)

2. Did you get a chance to read the letter from the Federal Energy Administration telling about solar heating in homes?

- 1 Yes (59)
2 No READ SUMMARY ON FRONT PAGE (41)

3. Do you own or rent your present home?

- 1 Own SKIP TO #6(67)
2 Rent (33)

4. Do you expect to buy a home in the next 2 years, or will you probably be renting then?

- 1 Buy SKIP TO #7 (25)
2 Rent (62) → } ASK ONLY * QUESTIONS (5, 27, 29, END)
3 Don't know } (14)

*5. Do you favor solar heating of homes, based on what you know now?

- 1 Yes (88) 3 Don't know (7)
2 No (3) 4 Depends (2)

6. Do you think you might buy a different home at any time in the future? (IF YES:) How many years from now might be the soonest you would buy a different home?

- _____ years (44) 99 Never (56)

7. Suppose you were shopping for a different home and found 2 homes you liked equally well, one with solar heating and the other with the same type of heating you now have. One thing affecting your choice might be costs. The solar equipment would cost more to buy, but in the long run your heating bills might be lower. Let's suppose that considering equipment, loan interest, heating bills, and all other costs, the 2 homes break even exactly, so that you would pay the same amount every month for the next 20 years. In this case, would you probably buy the solar home or the other one?

- 1 Solar (68) 3 Don't know (14)
2 Non-solar 4 Depends (6)
 (12)

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8. What would be the main things affecting your decision?
AFTER EACH ANSWER: Are there any other reasons? UP TO 3 ANSWERS

IF SOLAR IN #7, SKIP TO # 12

9. (IF NON-SOLAR IN #7) So at this time you would not choose the solar home. Now I'd like you to take a minute to think about what might change your mind in the future. Suppose the facts changed, so that the reasons you just told me no longer applied. Would you then choose a solar home? In other words, what facts or feelings of yours would have to change before you would change your mind? (IF QUANTITIES, HOW MUCH? E.G. \$/mo. OR %HOME HEAT)

10. (IF NON-SOLAR IN #7) If these things changed (READ BACK #9 ANSWERS), would you then probably choose the solar home, or would you still probably choose the non-solar home?

1 Solar (54)
 2 Non-solar } (13)
 3 Don't know } (25) → What doubts might you still have? _____
 4 Depends (7) }

11. (NON-SOLAR IN 7) Going back to solar heating as it is today, suppose the solar home would cost \$20 a month less than the other one, for the next 20 years. Would you buy the solar home or the other one?

1 Solar (44) 3 Don't know (25)
 2 Non-solar (20) 4 Depends (12)

12. (IF SOLAR IN #7) Suppose that the solar home would cost \$20 a month more than the other one, for the next 20 years. Would you probably buy the solar home or the other one?

1 Solar (49) 3 Don't know (15)
 2 Non-solar (21) 4 Depends (15)

13. How much would the difference in monthly cost have to be to make the 2 houses about equally attractive to you?

\$ _____ per month Then, if the solar home cost \$ _____
per month (more/less CIRCLE ONE) than the other home,
the 2 homes would be about equally good buys, for you?
(IF NO, ADJUST \$ UNTIL EQUAL)

*27. The Federal Government is thinking of offering homeowners financial help to install solar units. Tax credits, or low-interest loans, for example. Are you for or against the Government doing this?

- 1 For(favor) 3 Don't know (6)
2 Against (78) 4 Depends (6)
(10)

28. For those interested in solar water heaters, or solar home heating, the Federal Energy Administration would like to encourage you to pursue it further to the extent you are interested. I'm going to ask a couple of questions about your degree of interest. Feel free to say yes or no to each.

- a. Are you willing to have your name put on a mailing list for more information on solar energy from the Government?
1 Yes (70) 2 No (29) 3 Other (1)
- b. Are you willing to talk to a Government representative at a public meeting place sometime in the next month about the advantages and disadvantages of solar energy for your home?
Yes (39) Depends(16)
No (45)
- c. Would you be interested in talking to someone who sells or leases either solar water heaters or solar heated homes?
1 Yes (20) 3 Water heaters (1) 5 Don't know (7)
2 No(69) 4 Home heating (0) 6 Other(4)

*29. Finally , a few questions to help us describe our sample of homes.

- a. How many persons live in your home? _____
- b. What was the last grade or level you completed in school?
1 None to 7 (1) 4 Some colleg or trade school (29)
2 8-11 (16) 5 College grad (26)
3 H.S. grad (29)
- c. In which age agroup are you? READ ANSWERS
1 Under 40 (44) 2 40-60 (38) 3 Over 60 (18)
- d. Is the total income of your household more or less than \$10,000 per year? (IF MORE:) More than \$20,000.
1 Under 10,000 (28) 2 10,000-20,000 (42) 3 Over 20,000 (30)
- e. Do you live in (READ ANSWERS)?
1 City (53) 2 Suburb (21) 3 Small town(15) 4 Rural area(12)

*END: Thank you very much for your cooperation. We really appreciate your help.

COMPLETE THE FOLLOWING AT END OF INTERVIEW

- Sex: 1 M (53) 2 F (47)
- Town or City: _____
- Respondent Serial No. (ENTER IN BOX)
- Date (ENTER DAY OF MONTH IN BOX)
- Interviewer's initials _____

CODE NAME SHEET, INCLUDING SERIAL NUMBER

CROSS SERIAL NUMBER OFF NUMBER LIST

INSPECT COMPLETE PROTOCOL FOR ERRORS, OMISSIONS, AND LEGIBILITY

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Solar Heating Study

NOTES FOR INTERVIEWERS

Initial phone contact

The main thing is to get to talk to the person who would actually make decisions about buying heating systems, or at least someone who would help decide, e.g. the spouse who pays utility bills and shares in budget decisions. If the person who answers doesn't normally live at that address but owns a home somewhere in the same general area, you can interview him about his(her) own home. In this case ask what town his own home is in & note on p.7.

The purpose of the study is to get objective estimates of what percent of various segments of the American population would opt for solar heating, and if not, why not. The results will be used by FEA to advise Congress while the latter is deliberating energy legislation this summer. If you should chance upon a citizen who is angry and demands to know who is responsible, feel free to let him contact Dr. Jeffrey Milstein, FEA, Federal Building, Washington D.C. (202) 566-9641. We are employed by Decisions And Designs Inc., a private research company in McLean, Virginia, who has a contract with FEA to do the study.

Every 4th name on the sample list should have a "C" beside it, meaning they are in the Control Group and received no letter in advance telling them about solar heating. These people can be called immediately. The rest should not be called until 4 days after the letter was mailed.

To preserve anonymity, the front page will be torn off and destroyed as soon as we have processed the data. Thus any information identifying a person's phone #, name or address should be on the front page, while any information to be included in the study should be on another page.

We would like to get at least 100 completed interviews from each of the four general areas (Washington, New York, Minnesota, San Jose). We hope 2 or 3 callbacks to non-answering phones will be enough to get that quota. Please call back more if necessary to get that number. On the other hand, if 2 callbacks give you more than enough, wrap it up when you have used up all the interview forms sent to your area, even if you have a few names left over. Re-use forms which aborted on the front page (before usable data collected.)

If a child answers, it may save time to ask for the father first, or "head of the household" if older child.

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Keeping records

We would like a record on the sample name list of what happened as follows: If an interview was completed, please enter the information called for on p.7 and immediately re-examine the interview protocol to see that writing is legible and to elaborate from recall any cryptic phrases that otherwise might not be intelligible to the scorers.

As noted on p.7, for a completed interview enter on the name list (just below the name) the serial number you assign, and your initials. Assign serial numbers from the block of numbers given you and cross off each number as you use it to avoid duplicate number errors. *Also, note "A", "B", "C" for the first three letters of the name.*

If you call a number and get no answer or no interview we would like the following information below the name on sample list: The reason you got no interview, and your initials. Use the code below rather than writing out reasons, if easier:

- N1 No answer
- N2 Wrong number or no longer lives there
- N3 Unwilling to cooperate
- N4 No knowledgeable adult available (arrange callback?)
- N5 Interviewer judged respondent incompetent
- N6 Interview interrupted (complete later if possible)

If the person who answers says you should talk to Mr. Jones, enter Mr. Jones in the space after paragr. 2 on front page, try to arrange a good time to call back to reach Mr. Jones, and code "N4" on the sample list, for example.

On the interview form, pages 2-6, ignore the boxes, just circle the answer given, or write it in. After some questions there is a solid line where comments can be recorded even though none are asked for (e.g. #5, #11, #12, etc). The purpose is to record interesting comments (not verbatim) which might add flavor to interpreting the results, even though not analyzed quantitatively.

Last, but not least, each day record the number of hours worked, and when finished give to your area supervisor along with your name and address where your check should be mailed.

Branching sequence

Practice the interview on each other or friends before collecting data, to get familiar with both content and sequence. Branching or skipping items is meant to adapt the interview to the following groups: Letter Group vs. Control Group; renters vs. owners; and those who would vs. would not buy solar units under certain conditions.

Renters who don't plan to buy in the next 2 years get only questions 5, 27, 29 and EMD, from Question 4 on. Takes about 5 min. total. All renters skip #15-26 because those items concern installing units in the present home. The homeowner interview takes about 15 min.

Specific Items

#8 On this and all other open-end questions, we are interested in feelings, doubts and other subjective factors, as well as factual reasons. Examples: "Too new", "I just don't know enough about it yet", "It's a hassle", "Likes feeling of not being dependent on gas co.", etc.

#9 The purpose is to get at their priorities, i.e. are there reasons so important that unless those conditions were met they would not choose solar, while other reasons are less critical. The nete, "IF QUANTITIES..." means how much would that have to be changed before they would consider solar, e.g. if one reason is "it only heats part of what I need in winter", find out what % of home heat solar would have to provide to change their minds-- perhaps no amount would. If a reason is cost we get at the exact amount in Items #11 and #13, so it doesn't need to be pursued in #9. If no one reason by itself in #8 could be changed enough to convert them to choosing solar, ask if all 3 (or however many they gave) were changed, would that change their minds. # 10 is simply to summarize the perhaps complex interchange in #9, and by reading back their conditions, confirm their answer, and pick up afterthoughts about lingering doubts.

#11, 12 & 13 The purpose here is to find out how much more or less solar heating would have to cost per month in order for the 2 homes to be about equally good buys for them. The question following their answer in #13 is to confirm there was no mixup in the numbers and the direction of the difference.

#7, 18, 24 If they want more detail on what costs we mean, say all costs, including the purchase cost, maintenance costs, interest, taxes, inflation discount factors, or anything else they might think of. Same with savings, though lower heating bills is the only obvious saving.

#28 The main purpose here is to get a sort of check on whether they are really interested in solar, or were just saying so to be polite earlier. We will probably follow this up by actually arranging for mailings, contacts with Gov't or sales representatives, etc., though plans for that are not final. In 28c, if they say they will arrange it if they do, implying "don't call me, I'll call you", circle "No".

General

The questions need not be read exactly verbatim, but stick as close to that as feels comfortable, and be careful not to sound as though you are pushing solar heating (or the opposite) either by your wording or tone of voice.

APPENDIX C

CREDIBLE INTERVAL

The DDI project team has on file notes underlying the basis for each quantitative estimate underlying the market penetration projections. Following is a table of 90% credible intervals for the parameters in Table 4-1 of the text:

	New Homes		Retrofit Heating		Water Heating	
	<u>'77</u>	<u>'85</u>	<u>'77</u>	<u>'85</u>	<u>'77</u>	<u>'85</u>
1	53-78	35-90	35-65	20-80	25-50	20-80
2	4-8	4-10	1-9	5-46	12-25	19-39
3	18-58	40-92	12-62	10-90	13-43	20-60
4	.3-.7	2-47	1-26	10-80	20-38	39-69

Net Penetration

.0034-.016%	.12-1.0%	.0044-.059%	.054-1.0%	.2-.9%	1.2-6%
-------------	----------	-------------	-----------	--------	--------

Cumulative

.46-3.1%	.079-8.1%	10.3-19%
----------	-----------	----------

The total and cumulative credible intervals in the last two lines are derived from the component credible intervals using theory and formulas given in Chapter 9 of Brown¹ (an assumption of independence and log-symmetry is made).

¹Op. Cit.

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