CONSUMER EVALUATION OF AN EARTH-INSULATED SOLAR HOUSE

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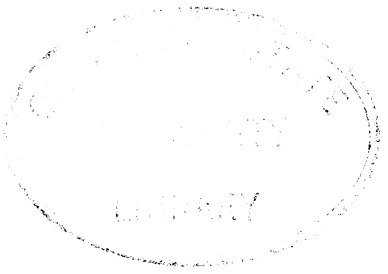

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CHAPTER I

INTRODUCTION

The concern for conservation of energy resources has become more real to consumers as prices have soared and energy supplies have dwindled. For the past 20 years, demand for energy in the United States has grown at a rate between four and five percent per year. Coal production has increased little since 1943, and since 1968, natural gas has been consumed faster than it has been discovered (Leighton, 1975, p. 79).

Space heating and cooling accounts for almost 25 percent of all energy consumed in the United States. Bligh (1975, p. 90) noted, "Energy is wasted by unwanted heating or cooling of the surroundings. By reducing heat transferred to and from the surroundings, less energy is consumed to maintain desired conditions."

Buildings constructed below the surface of the earth avoid direct sun radiation which can greatly reduce the amount of energy necessary to cool the structure in the warm summer months, and in winter, wind chill and excessive infiltration are avoided.

Scalise (1975) stated:

> The inherent advantages and availability of the earth as a building material and the existence of the sun as an unending energy supply, points to a direction that we dare not fail to pursue in developing the character of man's future environment. They are the decisive factors in the quest for a harmonious coexistence with nature (p. SU 2).

If underground housing is to become widely accepted it will first require education of the consumers to acquaint them with the many advantages of underground living.

Statement of the Problem

Underground or earth-insulated dwellings are being built in increasing numbers by families who are desirous of reducing energy costs and maintaining a good quality living environment. At present there is little research information available on consumer attitudes about underground or earth sheltered housing. Additional research is needed related to consumer reactions to earth-insulated housing so that the design of these residences can provide satisfactory living environments while reducing energy consumption.

Objectives

The specific objectives of this study were:

1. To describe consumers' attitudes toward an earth-insulated solar home in terms of: expectations about the earth-insulated home, energy and maintenance savings, the natural and artificial lighting and financing.
2. To analyze the relationship between socioeconomic/demographic characteristics (age, sex, marital status, education and income) of respondents and their evaluation of selected aspects of the earth-insulated house.
3. To analyze the relationship between the desire to live in an earth-insulated home and characteristics of consumers and

their evaluation of selected aspects of the earth-insulated prototype.

Hypotheses

Five null hypotheses were developed for this study. Objective 2 was met by testing one null hypothesis:

Ho_1: There will be no association between selected respondent characteristics (age, sex, marital status, education and income) and the evaluation of selected aspects of the earth-insulated house.

Objective 3 was met by testing four null hypotheses:

Ho_2: There will be no association between selected respondent characteristics (age, sex, marital status, education and income) and the desire to live in an earth-insulated house.

Ho_3: There will be no association between the evaluation of selected aspects of the earth-insulated house and the desire to live in such a house.

Ho_4: There will be no association between selected respondent characteristics (age, sex, marital status, education and income) and the expectation of building or buying an earth-insulated house within the next five years.

Ho_5: There will be no association between the evaluation of selected aspects of the earth-insulated house and the expectation of building or buying such a house within the next five years.

Definition of Terms

The following are terms and their definitions as they apply to this study:

Earth-insulated or bermed housing - A structure surrounded by earth on three sides, leaving one full wall exposed to the climatic elements.

Atrium type - A structure which places all openings around a central courtyard with earth surrounding the outside of the house.

Assumptions

The following assumptions were made in connection with this study:

1. A brief explanation of the advantages and disadvantages of the earth-insulated solar home and a walk through tour constitute sufficient exposure for consumers to evaluate the structure.

2. Holding the open houses on three consecutive Sundays in November was adequate control for variability due to seasons.

3. The variation in the amount of sunlight during the three days of open house did not significantly influence evaluations related to natural light.

The assumptions listed here were not considered to be serious limitations, since they are not unusual for research of this nature.

Limitations

Limitations of this study included the following:

1. The sample is purely self-selected of persons sufficiently interested to attend the open house. These respondents may or may not

be typical of the population as a whole but no inferences are made to that larger population.

2. Questionnaires were systematically distributed to the visitors to the open house and were completed and returned by some unknown percentage of persons. Those failing to complete and return the questionnaire may have evaluated the home quite differently.

3. The findings of this study are limited to a particular earth-insulated house design.

CHAPTER II

REVIEW OF LITERATURE

Historical Aspects

The use of underground space as a source of shelter is as old as mankind. Prehistoric people lived in caves as many people still do. The reasons for seeking underground shelter have always been the same, the major ones being lack of building materials, protection from climate and protection from predators.

When settlers first arrived on the Great Plains the small supply of lumber forced them to seek shelter in sod houses and dugouts. Although poorly documented, earth sheltered living has been a part of the American heritage since its early settlement. Subsurface root cellars were commonplace before the days of mechanical refrigeration and were an important feature of every farmstead. Wine cellars, too, were common locally, and those wineries which were not located near natural caves frequently were dugout, vaulted rooms covered with soil and grass (Labs, 1975, p. 9).

Cowley (1978) stated:

> Man's emergence from cave dwellings may have been the dawning of modern civilization, but these days there's a marked trend in the other direction. Although underground buildings have been around for centuries, the savings they offer in space and energy conservation have recently spawned scores of new and imaginative subterranean structures (p. 106).

Current Situation

According to Leighton (1975, p. 81) in 1973, 32 percent of all the energy used in the United States was consumed in the building sector. Of this, 70 percent was used in residential structures. This included 72,000,000 occupied housing units--single family, multi-family, low and high rise and mobile homes.

Leighton (1975) stated:

> Studies have shown that as much as 41 percent of the energy consumed in buildings is wasted due to inadequate construction, inadequate operating practices, inefficient equipment and unnecessary lighting, heating, and cooling levels (p. 81).

Reduction of home energy consumption can make an important contribution to conservation of this valuable resource, as reported by the Office of Technical Assessment of the U.S. Congress,

> successful widespread implementation of conservation programs with increased efficiency or waste reduction objectives can have both a rapid and a continuing effect. Such improvements need not be technologically complex. If ERDA is to provide near-term and mid-term energy problem solutions conservation through efficiency and waste reduction programs should be an essential ingredient (Fairhurst, 1975, p. 1).

The near-term (1985) goals of the building's program at ERDA include:

> To permit a decrease in unit energy consumption in existing building and community systems by 20 percent and in new buildings and community systems by 30 percent.
>
> To develop a more energy efficient household, commercial and recreational appliances, and equipment to achieve a reduction of 25 percent in the energy consumption of consumer products.

Mid-term (2000) goals include:

> To permit a decrease in the unit consumption of energy in existing buildings and community systems by 30 percent and in new buildings, community systems, and consumer products by 50 percent.

> To develop and demonstrate conservation technology and institutional changes which will aid the widespread utilization of solar energy for heating and cooling buildings, thereby reducing the consumption of non-renewable resources by 12 percent by the year 2,000 (Leighton, 1975, p. 82).

With the recent (July, 1979) energy policy proposed for the United States, the goal is to cut oil import levels. Mandatory conservation measures and new incentives for energy efficiency are to account for a portion of the import cut. Rate reforms such as higher costs for heavy peak time users would be included in these measures as well as long term loans for gas and electric utilities for customers to finance conservation measures. Should the "windfall" profits tax on oil companies become a reality, it is proposed that a portion of the tax be used to enable commercial banks to charge lower interest rates on loans for solar power installation.

Sterling (1978, p. 20) considers the sun to be one of the most important determinants in energy efficient building design. Boyer (1979, p. 33) stated: "the use of passive solar, in its simplest form, allows direct sunlight to penetrate into the reaches of the dwelling only in winter and to warm up the concrete floor structure." Windows facing south provide the maximum amount of passive solar heat.

Boyer (1979) further stated:

> active solar collector systems for heating and hot water are also particularly attractive in underground dwellings for additional energy savings. In some cases, these systems can completely remove any need for house heating and domestic water heating (p. 34).

Another way to conserve energy is building underground. Van der Meer (1976) noted:

> The use of substantially more insulation, double or triple glazing or more massive construction to impede heat transfer

> in above-ground structures is really an effort to oppose nature. If the energy used to manufacture and transport materials were considered, there might be a point beyond which the energy consumption of additional materials would equal or exceed the extra savings in energy for heating and cooling (p. 8).

According to Wells (1978, p. 5) earth is a poor insulator, but it is a great moderator of temperature change. Warm it up and it stays warm a long time. He further states:

> Eight or ten feet below the earth's surface the rate of temperature change is such that most of the summer heat doesn't start getting through until about November, just when you start to need it. And the winter cold arrives around May (p. 5).

Another natural phenomenon noted by Van der Meer (1976, p. 9) that is advantageous to conserving energy in an underground structure is "soils of low conductivity will build up a boundary layer of higher temperatures next to the building, thus slowing down heat transfer from the building." He further states: "The conductivity of the soil makes the heat loss relatively independent of wall construction or insulation" (Van der Meer, 1976, p. 9). The underground portions of the building are not subject to accelerated heat loss caused by winter winds or to infiltration of the cold air.

Achenbach of the National Bureau of Standards Building Environment Division estimates a $100 billion savings on energy costs of residential dwellings if their heat transmission characteristics could be reduced. This could be accomplished by placing the buildings underground. Although putting all residential dwellings underground would be impossible, the potential savings will surely increase the interest in building underground.

Advantages of Earth Sheltered Housing

Aside from the energy saving aspect of underground structures there are many other advantages to building underground. Fairhurst (1979) states:

> Space below the surface is a vast resource that has been given virtually no consideration in land use planning. The magnitude of the possibilities can be imagined by noting that the average height to which we have built structures above ground is far less than the depth to which our technology has taken us underground (p. 27).

According to Wells (1971, p. 21), "The best surprise was the quiet." The Brunson Instrument Company in Missouri built a new facility in a limestone cave 600 feet below the earth's surface. The company lists "silence" as one important advantage to being underground (Mason, 1976, p. 18). Workers escape the increasing noise pollution at the surface and enjoy the quiet below. Protection from air pollution is an important factor in many areas.

Underground living can also be added security from crime and bad weather. This protection is particularly important in areas subject to strong winds and tornadoes. It also gives greater protection from earthquakes and nuclear fallout.

Lower maintenance costs have also been cited (Mason, 1976, p. 18) as an advantage in underground structures. Since they are protected from weathering and sunlight, roofs won't need replacement and exterior painting may not be required, depending on the design of the house. There is also no need to worry about freezing pipes. Wells (1976, p. 22) states that underground housing "offers living land instead of roofing materials to the sun. It offers the proper use of rainwater

which we normally waste, percolation and slow runoff instead of erosion and flash floods." Van der Meer (1976, p. 10) also lists the creation of more open areas for water absorption and less potential for creation of unfavorable runoff patterns as an advantage to the use of underground housing.

McCrone (1978, p. 1) and Mason (1976, p. 18) list lower insurance rates as an advantage, since there is little risk of fire and storm damage. However, many insurance companies are not knowledgeable about rate setting practices for earth covered buildings. This might result in little if any difference in insurance costs at the present time.

The construction costs of underground housing have a potential for being less than above ground structures. Soil conditions are an important factor in construction costs. Sterling (1978) states:

> Determination of the soil type is mainly important for proper structural design of footings and walls. Certain types of soils can be unsuitable due to their poor bearing capacity or their tendency to expand when wet. Ground water conditions are important to determine because of their impact on waterproofing as well as structural design. A high water table may require more costly structural and waterproofing techniques (p. 26).

According to van der Meer (1976, p. 9), "a small structure located in a high water table will have significantly increased waterproofing costs as well as increased structural costs to resist the upwards hydrostatic pressures."

Mason (1976, p. 19) noted, "underground architecture is also very gentle on the environment. Space above ground is conserved, an especially important consideration in urban areas." Crowley (1978, p. 106) also lists conservation of space above ground as a reason for building underground.

Disadvantages of Earth Sheltered Housing

Crowley (1978, p. 109) sees the principal problem with underground housing to be the lack of architects and contractors who are qualified to build underground structures. When an underground structure leaks or cracks open, the repairs are not only costly but complicated.

Financing is also seen as an obstacle to persons interested in underground housing. Bligh (1975) states:

> at present there is undoubtedly a reluctance by lending institutions to finance underground buildings because of the lack of experience and fear of public unacceptance. They are concerned with initial costs and resale ability rather than life cycle costs (p. 102).

The Federal Housing Administration did not approve loans for underground houses until 1978. In the absence of widely available financing, earth sheltered housing will reach only a small percentage of the housing market (Sterling, 1978, p. 173).

The psychological aspect of being underground may also be seen as an obstacle to acceptance of underground housing. Wells (1975, p. 211) believes clients associate underground living with damp subways, caves or basements. Van der Meer (1976, p. 10) states, "negative psychological reactions might stem from a variety of conscious or subconscious factors." These could include fear of being trapped, claustrophobia or previous experience with poorly ventilated basements. Bligh (1975, p. 102) sees this obstacle being overcome through education of the public. Mason (1976) noted:

> Contrary to popular fears of living in enclosed space without natural sunlight, experiments indicate that the physical and psychological effects of living and working

> underground are positive. After 10 years of studying the underground Abo Elementary School, a combined school and fallout shelter in Artesia, New Mexico, a panel of physicians concluded that the school was not detrimental to the physical and mental health of its students, but beneficial to some (p. 19).

In some areas, building codes may be a deterrent to building underground. The Uniform Building Code, in use in over 30 states, requires an outside door or window for any room used as sleeping quarters. This is to protect the occupants in the event of fire. This regulation would need to be considered when the structure was designed.

The mention of "underground architecture" in reference to homes may be met with stares of disbelief by consumers who think of "underground" as being subways or tunnels (Dempewolf, 1977, p. 78). Consumers are not used to seeing underground houses, thus do not view them as "accepted house forms." Paul Paulus (1978) pointed out the fact that there is little research to document the psychological effects of living underground. More research is needed in the area of consumer acceptance if these unwarranted reactions to living underground are to be dispelled.

In summary, this chapter has pointed out the need to conserve energy utilized in the heating and cooling of homes. One means by which such conservation could be accomplished is through the construction of earth sheltered dwellings as one alternative to the conventional above grade structure. Some of the disadvantages as well as the advantages of earth sheltered housing have been identified and discussed. There is little research related to consumers' reactions to the idea of living in an earth sheltered dwelling or their evaluation of specific design features of such dwellings. The research presented in the following chapter addresses this area.

CHAPTER III

METHODOLOGY

In 1978 the Rural Housing Research Unit of the United States Department of Agriculture cooperated with the College of Agricultural Sciences at Clemson University in the design and construction of an earth-insulated solar research home at Clemson University. During the fall of 1978 interested persons were invited to tour the house where they were given information about the construction and the particular features designed to reduce energy consumption. An instrument was developed by the designer and researchers from Oklahoma State University and Texas Tech University to obtain the reactions of the visitors to the design and energy saving potential of the research house and the likelihood that the visitors would want to live in such a house.

Description of the House

The earth-insulated solar house was designed by Dr. Jerry Newman, an engineer with the Rural Housing Research Unit. The two bedroom house consists of 1,080 square feet of heated floor space. The unit is partially embanked in earth on three sides with the south facade exposed. The primary heating source is a 412 square foot solar collector located on the roof. The conventional exposed roof is utilized at much less cost than would be required were the roof covered with earth.

The solar collector provides heat to a rock storage area beneath the house as well as direct heat for the living space when needed. Additional heat may be drawn from a "scavenger heating system" where hot air is drawn from the kitchen and bathroom and diverted into gravel around the house during cold weather. The scavenged heat should raise the temperatures in the earth around the house by about 15 degrees, which will reduce heating bills. Water for the house is also solar heated. Electrical baseboard heating is used for the backup heating system.

Another unique feature of the house is the use of a system of pressure-treated, rot-proof wood instead of the more common concrete or concrete block construction. The wood was prefabricated into jointed panels for easy assembly. A plastic moisture barrier was placed outside the walls before the soil was bermed around them. The wooden walls with the moisture barrier prevent water condensation which is frequently found with concrete walls.

The floorplan and perspective of the house are shown in Figure 1. The bedrooms, kitchen and dining area are on the front so that they receive direct light from the outside. Some direct lighting reaches the living area while the bathroom, laundry and storage areas have no direct outside light source.

Sample and Data Collection

The sample for this study was drawn from persons who visited the earth-insulated solar house during the open house tours conducted by the designer and researchers from Clemson University. Open house tours

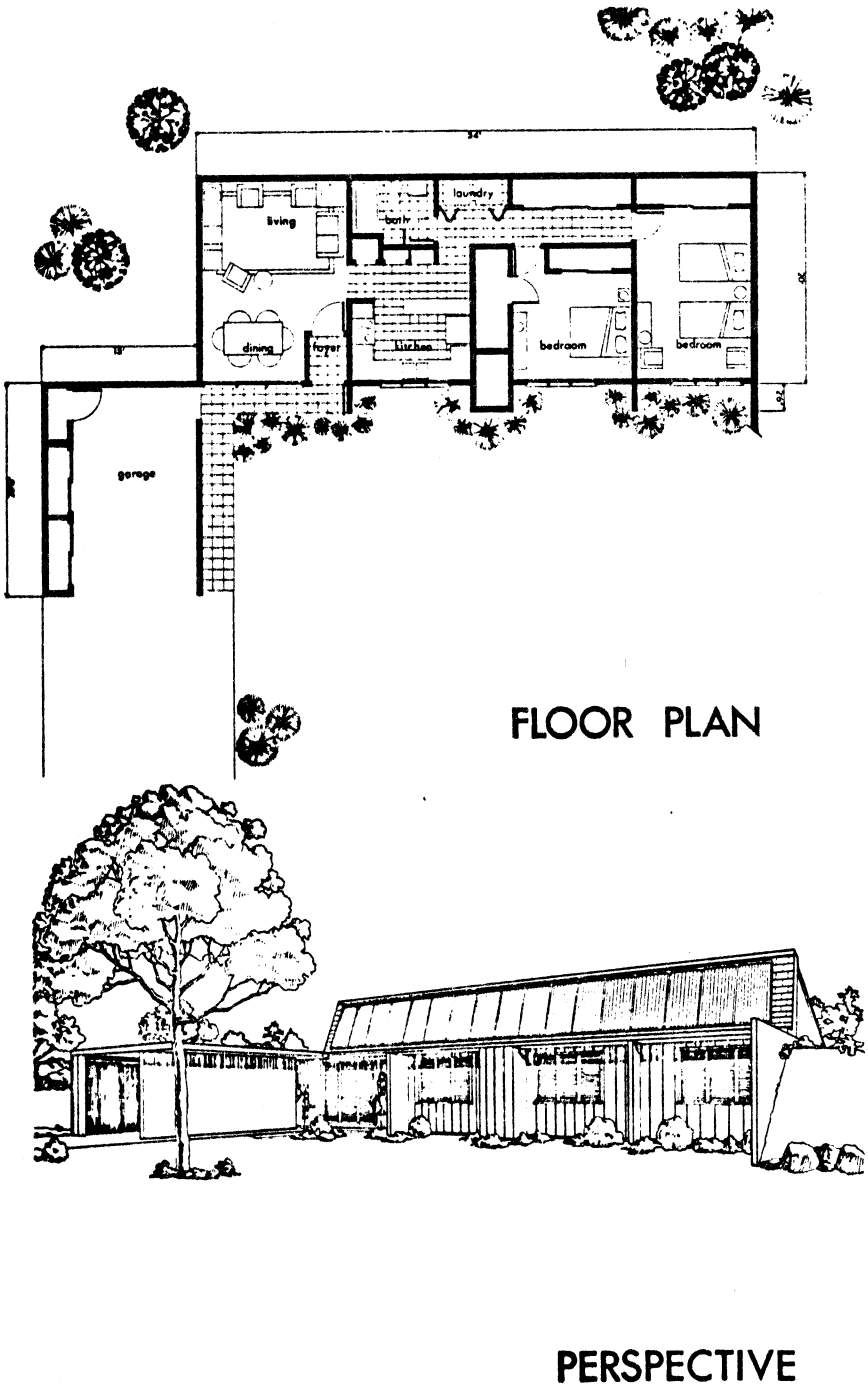

Figure 1. Floorplan and Perspective of Earth-Insulated Solar House

were provided on three consecutive Sundays in November, 1978. During these open houses, a questionnaire was given to every fourth person, excluding minors. Thus, the sample is strictly a volunteer sample composed of persons who were sufficiently interested in the research house to come for the tours. Respondents were asked to complete the questionnaire and leave it with researchers following their tour of the house. A total of 126 usable questionnaires were completed and returned.

This study is a contributing study to the S-95 Southern Regional Housing Research Project, "Quality Housing Environment for Low-Income Families." Thus, the instrument for data collection was constructed by a joint committee from the Rural Housing Research Unit, Oklahoma State University and Texas Tech University. The questionnaire included items designed to obtain sociodemographic characteristics of the respondents and their attitudes about the research house, including the likelihood that they would purchase or build an earth-insulated solar home within the next five years.

Definition of Major Variables

The major variables in the study included sociodemographic characteristics of respondents and their attitudes toward the earth-insulated solar house. The variables which measured attitudes of the respondents were: (1) evaluation of maintenance and energy conservation of the earth-insulated solar house, (2) concern for financing, (3) attitude toward light in the earth-insulated house, (4) desire to live in an earth-insulated house, and (5) likelihood of building an earth-insulated house.

Evaluation of Maintenance and Energy Conservation

The respondents' evaluation of maintenance cost was measured by item 7 (see Appendix), "What would you estimate the annual cost of maintenance and repair to be on the earth-insulated solar home, compared to that of a conventional home?".

Ability to Obtain Financing

The respondents' ability to obtain financing for an earth-insulated home was measured by item 11, "Do you think you could obtain financing to build an earth-insulated home?". Respondents could answer "No," "Maybe," or "Yes." If they answered "yes" they were asked to indicate from what source they felt they could obtain funds (item 12).

Evaluation of Light in the Earth-Insulated Solar House

The respondents' evaluation of the amount of light in the earth-insulated solar house was measured in item 3, "How did the amount of light (both natural and artificial) in the earth-insulated home compare to what you expected?" This was answered on a scale of one to seven, with "one" indicating "much less light" and "seven" indicating "much more light." In item 4 the respondents were asked to indicate the importance of having plenty of natural light in a home. Responses ranged from one to seven, with "one" indicating "not at all important" and "seven" indicating "very important." Item 5 was concerned with the amount of natural light in the bedroom, living room, kitchen and bath.

Respondents evaluated the light in each room on a scale of one to seven, with "one" indicating "not at all adequate" and "seven" indicating "very adequate."

Desire to Live in an Earth-Insulated Solar House

The desire of the respondent to live in the earth-insulated solar house was measured by item 8, "Would you want to live in an earth-insulated home if it were the right size for your family?". Response to this item was recorded on a scale of one to seven. A response of "one" indicated "definitely would not" and a response of "seven" indicated "definitely would."

Likelihood of Building an Earth-Insulated House

The respondents' interest in building an earth-insulated home was measured in item 10, "Are you likely to purchase or build an earth-insulated solar home within the next five (5) years?". Responses to this item were collected on a scale of one to seven, with "one" indicating "not at all likely" and "seven" indicating "very likely" to build an earth-insulated home.

Socioeconomic/Demographic Characteristics

Questions were asked of the respondents to gather personal data. Items 13-15 dealt with the age, sex and marital status of the respondents. The educational level of the respondent was indicated in item

16. The size of the respondents' home town was indicated in item 18, and item 19 measured the approximate income of the respondents' household.

Analysis

The characteristics of the sample and general attitudes of the respondents were described with frequencies and percentages. The differences in attitudes related to the socioeconomic/demographic characteristics of the respondents were analyzed with chi-square tests using the formula:

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

where O = the observed frequency for a cell and E = the expected frequency for a cell (Freeman, 1965, p. 222). An alpha level of $p<.05$ was used for the level of significance.

CHAPTER IV

ANALYSIS OF DATA

Introduction

This chapter reports the findings related to the three objectives of this study. The first part of this chapter describes the respondents and their attitudes toward certain aspects of the earth-insulated house. The second part reports the findings related to the five null hypotheses.

Description of the Sample

A detailed description of the 126 persons who visited the earth-insulated solar house is presented in Table I. The ages of those included in the sample ranged from 18 to over 65, with the largest group in the 25 to 34 age range (37%) followed by the 35 to 44 age group (20%). The sample consisted of 54 percent male and 46 percent female. Seventy-seven percent of the respondents were married, with the remaining 23 percent either single, divorced or widowed.

The education of the respondents ranged from some high school to doctoral degrees. The largest number of respondents (37%) indicated they had completed high school. Almost one-half of the group had some college training. Over 40 percent of the respondents indicated they were living in a town of from 1,000 to 10,000 population. Thirty-four

TABLE I

CHARACTERISTICS OF THE SAMPLE

Characteristic	Frequency n	Percent (%)
Age of Respondent		
18-24	17	15
25-34	45	37
35-44	25	20
45-54	20	15
55-64	12	10
65 and over	4	3
Total	123	
Sex of Respondent		
Male	67	54
Female	56	46
Total	123	
Marital Status of Respondent		
Married	97	77
Not married	29	23
Total	126	
Education of Respondent		
Some high school	17	14
High school graduate	45	37
1-3 years of college	25	20
College graduate	20	16
Master's degree	12	10
Doctoral degree	4	3
Total	123	
Size of Respondent's Home Town		
Rural	41	34
Village of 1,000 or less	5	4
Town of 1,000 to 10,000	53	42
City of 10,000 to 50,000	12	10
Suburb of city	10	8
City in excess of 50,000	4	2
Total	125	

TABLE I (Continued)

Characteristic	Frequency n	Percent (%)
Annual Household Income		
Under $13,999	29	26
$14,000 to $19,999	21	19
$20,000 to $25,999	24	21
$26,000 to $31,999	22	19
Over $32,000	17	15
Total	113	

percent was from rural areas and twenty percent was from cities with from 10,000 to over 50,000 inhabitants. The annual income of the respondents who answered the question ranged from under $5,000 to over $35,000, with over 70 percent indicating an annual income from $17,000 to over $35,000. Thirteen respondents left the income question blank.

For 88 percent of the respondents this was their first visit to an earth-insulated home, with only 9 percent indicating they had previously visited an earth-insulated home (Table II). None had ever lived in an earth-insulated home.

Attitudes Toward the Earth-Insulated Solar House

The first objective of this study was to describe consumers' attitudes toward an earth-insulated solar home in terms of: expectations about the earth-insulated home, energy and maintenance savings, the natural and artificial lighting and the availability of financing. Table III shows that half of the respondents indicated the house was

at least somewhat as they expected an earth-insulated house to be while one fourth were neutral in their response and one fourth indicated the house was not as they expected. The majority of the respondents felt the amount of light (both natural and artificial) in the house was more than they expected. Over 70 percent of the respondents also indicated the amount of natural light was "just adequate" to "very adequate" in all rooms but the bathroom. Forty percent felt the natural light in the bathroom was less than adequate, while 49 percent felt the light was more than adequate. As can be seen in Figure 1, the bathroom in this house plan was located at the back of the house and thus had no natural light source.

TABLE II

RESPONDENTS' PRIOR EXPERIENCE WITH EARTH-INSULATED HOUSE

	Frequency n	Percent (%)
This is my first visit to such a home.	111	88
I have visited one or two such homes.	10	8
I have visited three or more such homes.	1	1
I know someone who lives or has lived in such a home.	4	3
I have lived or am living in such a home.	0	0
Total	126	

TABLE III

RESPONDENTS' EVALUATION OF SELECTED CHARACTERISTICS OF THE EARTH-INSULATED SOLAR HOUSE

Question	Responses							Total
	1	2	3	4	5	6	7	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
In general, how does this home compare to what you thought an earth-insulated home would be like?	Not at all as Expected			Neutral			Just as I Expected	
	8 (6)	7 (6)	17 (14)	30 (24)	33 (27)	16 (12)	14 (11)	125
How did the amount of light (both natural and artificial) in the earth-insulated home compare to what you expected?	Much Less Light			As Expected			Much More Light	
	5 (4)	3 (2)	9 (7)	27 (22)	18 (15)	44 (35)	20 (15)	126
How do you feel about the amount of natural light in each of the following rooms?	Not at all Adequate			Just Adequate			Very Adequate	
Bedroom	1 (1)	2 (2)	15 (12)	19 (15)	21 (17)	31 (24)	36 (30)	125
Living Room	1 (1)	2 (2)	16 (13)	17 (14)	19 (15)	30 (24)	39 (32)	124
Kitchen	1 (1)	3 (2)	10 (8)	16 (13)	22 (18)	32 (25)	40 (33)	124
Bathroom	18 (14)	8 (7)	23 (19)	14 (11)	13 (10)	20 (16)	27 (23)	123

When asked to indicate how maintenance costs of the earth-insulated house would compare to a conventional home, over 55 percent thought the costs would be lower in the earth-insulated house. One-third of the respondents thought the costs would be about the same. Table IV shows that half of the sample indicated they thought they could obtain financing for an earth-insulated home and 17 percent said they did not think they could obtain financing.

TABLE IV

ATTITUDES TOWARD MAINTENANCE AND FINANCING

Questions	Responses						Total
	n	(%)	n	(%)	n	(%)	
What would you estimate the annual cost of maintenance and repair to be on the earth-insulated solar home compared to that of a conventional home?	Higher in This Home		About the Same		Lower in This Home		
	18	(14)	38	(31)	67	(55)	123
Do you think you could obtain financing to build an earth-insulated home?	No		Maybe		Yes		
	20	(17)	40	(33)	62	(50)	122

The respondents were asked if they would want to live in an earth-insulated home if it were the right size for their family (Table V). Sixty-four percent responded favorably to this question and only 18 percent responded negatively. When asked if they were

TABLE V

DESIRE TO LIVE IN AN EARTH-INSULATED HOUSE

Question	Responses							
	1	2	3	4	5	6	7	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	Total
Would you want to live in an earth-insulated home if it were the right size for your family?	No, Definitely Would Not						Yes, Definitely Would	
	9 (7)	5 (4)	9 (7)	22 (18)	25 (20)	20 (15)	36 (29)	126
Are you likely to buy or build any type of home within the next five years?	Not at All Likely						Very Likely	
	32 (28)	8 (7)	8 (7)	6 (5)	14 (13)	14 (13)	31 (28)	123
Are you likely to purchase or build an earth-insulated solar home within the next five years?	Not at All Likely						Very Likely	
	57 (45)	20 (16)	10 (8)	13 (10)	10 (8)	9 (7)	7 (6)	126

likely to build or buy any type of home within the next five years, 28 percent reported they were "very likely" to build or buy and a corresponding 28 percent reported they were "not at all likely" to build or buy. The respondents were then asked if they were likely to build or buy an earth-insulated home in the next five years; only six percent indicated they were "very likely" and 45 percent indicated they were "not at all likely" to build or buy an earth-insulated home.

Relationship Between Characteristics of Respondents and Their Evaluation

The second objective of this study was to analyze the relationship between socioeconomic/demographic characteristics of respondents in terms of their evaluation of selected aspects of an earth-insulated house. The following null hypothesis was developed to meet this objective.

Ho_1: There will be no association between selected respondent characteristics (age, sex, marital status, education and income) and the evaluation of selected aspects of the earth-insulated house.

The small sample size made it necessary to collapse some of the categories for variables in the chi-square tests. The category labels in each table included in the following sections in this chapter indicate the manner in which categories were collapsed.

A significant difference was found between the age of the respondents and their perceived ability to obtain financing for an earth-insulated house (Table VI). Those in the 55-64 age group were the most confident of their ability to obtain financing, with almost

three-fourths of the respondents answering "yes." Over two-thirds of the respondents 65 and over stated they could obtain financing. The largest percentage of those in the 35-44 age group indicated that "maybe" they could obtain financing. The chi-square analysis may have been distorted by the small cell size in the youngest and oldest age groups. Thus, this finding should be viewed more as a trend toward differences between age groups than as a strong difference.

TABLE VI

ABILITY TO OBTAIN FINANCING FOR EARTH-INSULATED HOME BY AGE

Age	Responses					
	n	(%)	n	(%)	n	(%)
	No		Maybe		Yes	
19-24	5	(29.4)	9	(52.9)	3	(17.6)
25-34	7	(15.6)	20	(44.4)	18	(40.0)
35-44	4	(16.0)	5	(20.0)	16	(64.0)
45-54	2	(11.0)	3	(16.7)	13	(72.2)
55 and over	2	(15.4)	2	(15.4)	9	(69.2)

$\chi^2 = 17.9$

$p < .02$

Table VII shows a significant difference between males and females in response to estimated annual maintenance and repair cost for the experimental house. Over two-thirds of the females estimated

cost to be lower, while only 44 percent of the males responded that way. More males than females thought annual maintenance costs would be about the same or higher than for conventional houses. Some reasons given for indicating maintenance would be higher included "moisture problems," "maintenance problems" and "more outside maintenance." Those indicating lower maintenance costs included "less exposure to elements," "less outside and mechanical maintenance" and "use of solar" as reasons for lower cost.

TABLE VII

ESTIMATED ANNUAL COST OF MAINTENANCE AND REPAIR OF EARTH-INSULATED HOME BY SEX

Sex	Responses					
	n	(%)	n	(%)	n	(%)
	Higher		Same		Lower	
Male	11	(16.7)	26	(39.4)	29	(43.9)
Female	7	(12.7)	11	(20.0)	37	(67.3)

$\chi^2 = 6.99$

$p < .03$

The degree to which the amount of light in a home was important differed significantly by sex (Table VIII). Over two-thirds of the females stated the amount of light was "very important," while 43

percent of the males answered that way. More males than females thought the amount of light in a house was "not important" to "neutral."

TABLE VIII

IMPORTANCE OF AMOUNT OF LIGHT IN HOME BY SEX

Sex	Responses							
	1-4		5		6		7	
	n	(%)	n	(%)	n	(%)	n	(%)
	Not Important to Neutral						Very Important	
Male	10	(14.9)	10	(14.9)	18	(26.9)	29	(43.3)
Female	5	(8.8)	7	(12.3)	6	(10.5)	39	(68.4)

$\chi^2 = 8.91$

$p < .03$

Table IX shows that responses to the amount of light in the bathroom differed significantly by income. Over 50 percent of the respondents in the under $14,000 income felt the amount of natural light in the bathroom was not adequate, while only one-third of those whose income was over $26,000 responded that way. Over one-half of those in the over $26,000 income level indicated the lighting was more than adequate. Of those in the $14,000 to $19,999 income bracket, 75 percent felt the lighting was more than adequate. Although the evaluation

of lighting in the bathroom differed significantly between income groups, the relationship was not linear. Evaluations did not consistently increase or decrease in relation to income.

TABLE IX

CONCERN FOR NATURAL LIGHT IN BATHROOM BY INCOME

Income	Responses							
	1-3		4		5-6		7	
	n	(%)	n	(%)	n	(%)	n	(%)
	Not Adequate		Just Adequate				Very Adequate	
Under $13,999	15	(51.7)	1	(3.4)	7	(24.1)	6	(20.7)
$14,000 to $19,999	4	(20.0)	1	(5.0)	8	(40.0)	7	(35.0)
$20,000 to $25,999	12	(50.0)	5	(20.8)	2	(8.3)	5	(20.8)
$26,000 to $31,999	6	(30.0)	4	(20.0)	3	(15.0)	7	(35.0)
Over $32,000	6	(35.3)	2	(11.8)	8	(47.1)	1	(5.9)

$\chi^2 = 22.6$

$p < .03$

Three variables measuring the evaluation of certain aspects of the earth-insulated solar home were found to differ significantly in relation to age, sex and income of the respondents. On this basis the null hypothesis, Ho_1, was partially rejected. No significant

differences were found for marital status or education in relation to evaluation of any of the selected aspects of the earth-insulated home.

Relationship Between Desire to Live in Earth-Insulated Home and Characteristics of Consumers and Their Evaluation

The third objective of this study was to analyze the relationship between the desire to live in an earth-insulated home and characteristics of consumers and their evaluation of selected aspects of the earth-insulated residence. Four null hypotheses were developed to meet this objective: Ho_2, Ho_3, Ho_4 and Ho_5.

Ho_2: There will be no association between selected respondent characteristics (age, sex, marital status, education and income) and the desire to live in an earth-insulated house.

Table X shows a significant difference between married and single respondents in terms of their desire to live in an earth-insulated house. Nearly one-third of the married respondents indicated they "definitely would" live in an earth-insulated house if it were the right size for their family. The single respondents were more likely to indicate they would not be interested in an earth-insulated house or were neutral in their desire to live in this type of structure.

There was no association between age, sex, education or income and the desire of the respondents to live in an earth-insulated home. Therefore, Ho_2 was not rejected for respondent characteristics other than marital status.

TABLE X

DESIRE TO LIVE IN EARTH-INSULATED HOME
IF RIGHT SIZE FOR FAMILY
BY MARITAL STATUS

Marital Status	Responses									
	1-3		4		5		6		7	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
	Definitely Would Not to Would Not			Neutral				Definitely Would		
Single	6	(20)	11	(38)	4	(14)	4	(14)	4	(14)
Married	17	(18)	11	(11)	21	(22)	16	(17)	31	(32)

$\chi^2 = 12.54$

$p < .01$

Ho_3: There will be no association between the evaluation of selected aspects of the earth-insulated house and the desire to live in such a house.

The desire to live in an earth-insulated house was found to be significantly different in relation to the evaluation of natural light in the bedroom, the living room and the kitchen. Over half of those respondents who felt the natural light in the bedroom was "very adequate" also indicated they "definitely would" be interested in living in an earth-insulated house (Table XI). Over one-fourth of those who indicated the natural light was "just adequate" or "less than adequate" stated they were not interested in living in an earth-insulated home.

TABLE XI

DESIRE TO LIVE IN EARTH-INSULATED HOME BY AMOUNT OF NATURAL LIGHT IN BEDROOM

Desire to Live in Earth-Insulated Home	Evaluation of Natural Light							
	1-4		5		6		7	
	n	(%)	n	(%)	n	(%)	n	(%)
	Not at All Adequate to Just Adequate						Very Adequate	
No Definitely Would Not to Would Not								
1-3	10	(27.0)	3	(14.3)	4	(13.3)	5	(14.3)
4	9	(24.4)	4	(19.0)	4	(13.3)	5	(14.3)
5	8	(21.6)	2	(9.5)	12	(40.1)	3	(8.6)
6	5	(13.5)	7	(33.4)	6	(20.0)	2	(5.7)
Yes Definitely Would								
7	5	(13.5)	5	(23.8)	4	(13.3)	20	(57.1)

$\chi^2 = 35.89$

$p < .003$

Table XII shows over half of the respondents who felt the natural light in the living room was "very adequate" "definitely would" want to live in an earth-insulated home, while only 13 percent of those who evaluated the natural light as "very adequate" were not interested in living in an earth-insulated home.

TABLE XII

DESIRE TO LIVE IN EARTH-INSULATED HOME BY AMOUNT OF NATURAL LIGHT IN LIVING ROOM

Desire to Live in Earth-Insulated Home	Evaluation of Natural Light							
	1-4		5		6		7	
	n	(%)	n	(%)	n	(%)	n	(%)
	Not at All Adequate to Just Adequate						Very Adequate	
No Definitely Would Not to Would Not								
1-3	14	(38.8)	0	(0.0)	3	(10.3)	5	(13.5)
4	10	(27.8)	5	(26.3)	2	(6.9)	4	(10.8)
5	5	(13.9)	3	(15.8)	12	(41.4)	5	(13.5)
6	5	(13.9)	4	(21.1)	7	(24.1)	3	(8.1)
Yes Definitely Would								
7	2	(5.6)	7	(36.8)	5	(17.2)	20	(54.1)

$\chi^2 = 47.4$

$p < .001$

One-third of those who felt the natural light in the kitchen was "just adequate" or less also stated they did not desire to live in an earth-insulated home (Table XIII). However, over one-half of those who felt the amount of natural light was "very adequate" "definitely would" want to live in an earth-insulated house. Ho_3 was rejected for evaluation of light in the bathroom, kitchen and living room. However, hypothesis Ho_3 was not rejected as related to respondents' evaluation of maintenance and repair, availability of financing and light in the bathroom.

Ho_4: There will be no association between selected respondent characteristics (age, sex, marital status, education and income) and the expectation of building or buying an earth-insulated house within the next five years.

A significant difference was found between males and females regarding their interest in building or buying an earth-insulated home. Table XIV shows over half of the females did not plan to build or buy an earth-insulated home, while only 34 percent of the males responded that they were "not at all likely" to build or buy an earth-insulated house. Sixteen percent of the males were "very likely" to build or buy an earth-insulated home within five years, but only five percent of the females responded in the same way. Ho_4 was rejected only for sex.

Ho_5: There will be no association between the evaluation of selected aspects of the earth-insulated house and the expectation of building or buying such a house within the next five years.

TABLE XIII

DESIRE TO LIVE IN EARTH-INSULATED HOME BY AMOUNT OF NATURAL LIGHT IN KITCHEN

Desire to Live in Earth-Insulated House	Evaluation of Natural Light							
	1-4		5		6		7	
	n	(%)	n	(%)	n	(%)	n	(%)
	Not at All Adequate to Just Adequate						Very Adequate	
No Definitely Would Not to Would Not								
1-3	10	(33.4)	3	(13.6)	3	(9.7)	6	(15.8)
4	9	(30.0)	3	(13.6)	5	(16.1)	4	(10.5)
5	6	(20.0)	3	(13.6)	12	(38.7)	4	(10.5)
6	4	(13.3)	5	(22.7)	6	(19.4)	4	(10.5)
Yes Definitely Would								
7	1	(3.3)	8	(36.4)	5	(16.1)	20	(52.6)

$\chi^2 = 35.19$

$p < .001$

TABLE XIV

LIKELIHOOD OF PURCHASING OR BUILDING EARTH-INSULATED HOME IN NEXT FIVE YEARS BY SEX

Sex	Responses							
	1		2		3-5		6-7	
	n	(%)	n	(%)	n	(%)	n	(%)
	Not at All Likely						Very Likely	
Male	23	(34)	11	(17)	22	(33)	11	(16)
Female	33	(59)	9	(16)	11	(20)	3	(5)

$\chi^2 = 9.31$

$p < .03$

The chi-square tests indicated there were no significant associations between the respondents' evaluation of selected aspects of the earth-insulated house and their expectation of building or buying one within the next five years. Therefore, Ho_5 was not rejected.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Dwindling energy supplies and soaring costs of imported oil make it increasingly necessary for consumers to consider alternate energy sources as well as methods for reducing the amount of energy consumed. One way this is being accomplished is through the construction of earth-insulated or underground structures.

A systematically selected sample of people who toured an experimental earth-insulated solar residence during an open house were given questionnaires to complete. They were instructed to complete this questionnaire and leave it with the researchers following the tour. The questionnaire included items to obtain sociodemographic characteristics of the respondents, their attitudes about selected features of the research house and their desire to live in such a house.

The purpose of the study was to examine attitudes of consumers toward the earth-insulated house. The objectives of this study were:

1. To describe consumers' attitudes toward an earth-insulated solar home in terms of expectations about the earth-insulated home, energy and maintenance savings, natural and artificial lighting and the availability of financing.

2. To analyze the relationship between socioeconomic/ demographic characteristics of respondents in terms of their evaluation of selected aspects of an earth-insulated house.
3. To analyze the relationship between the desire to live in an earth-insulated home and characteristics of consumers and their evaluation of selected aspects of the earth-insulated residence.

The majority of the respondents reacted favorably to the earth-insulated solar house. Over half of the respondents said the house was what they expected it to be. For over 80 percent of the respondents this was their first visit to this type of dwelling. The majority of the respondents were married and under 45 years of age. The sample was divided almost equally by sex. Over 80 percent had a high school education or better and over 50 percent had an annual income of $20,000 or more. Three-fourths of the respondents were living in towns of 10,000 or less.

Half of the respondents indicated they thought they could obtain financing for an earth-insulated house. Those in the 55-64 age group were the most likely to indicate they could obtain financing. It may well be that these respondents had not yet tried to get financing for an earth-insulated home and were basing their response on the fact that they were in their peak earning years and financially secure enough to borrow money for a house. Studies show that lending institutions are hesitant to lend money for underground housing because there is no established resale record for these structures.

The majority of the respondents indicated the lighting in the earth-insulated house was adequate or more than adequate for all rooms but the bathroom. The bathroom was on the back of the house so no natural light entered. The amount of light in a home was more important to women than to men. Women generally spend more time in the home and adequate lighting is more important for the tasks they perform such as cleaning, sewing and personal care.

More women than men indicated they thought maintenance costs would be less in an earth-insulated home. This difference could be attributed to the information presented to the respondents before they toured the house. The men may have been more hesitant than the women to accept all the information they received regarding reduced maintenance costs in an earth-insulated house, even though research has produced evidence that when properly constructed, lower maintenance costs are an advantage to living in an earth-insulated home (Mason, 1976).

More men than women indicated they would be interested in buying or building an earth-insulated house. While lower maintenance costs might appeal to women, the desire to live in a house accepted by their friends and neighbors may be more important to them than the savings in maintenance and energy consumption.

Conclusions

Attitudes of the respondents were favorable toward the earth-insulated solar house. This response was not unexpected, since those evaluating the house were interested enough in this type of structure

to attend the open house. Lighting was considered important by the respondents and is an area that needs special consideration when designing earth-insulated or underground structures. Respondents who felt the lighting was adequate were more favorable to living in an earth-insulated home.

Male respondents were more interested in building or buying an earth-insulated house. This could be because they were more interested in savings through energy conservation and lower maintenance, while female respondents were more concerned with the physical appearance of the structure and the lighting.

Recommendations

In order to better understand consumer reaction to living underground, studies evaluating design aspects of earth-sheltered houses need to be conducted with individuals actually living in such structures. These studies would provide the opportunity for analysis at much greater depth than was possible with data from visitors at an open house tour of an experimental house.

According to findings from this study, only six percent of the respondents indicated that they were very likely to build or buy an earth-insulated home within the next five years. However, this was the first visit to a home of this type for over 80 percent of the respondents and nearly one-third of the sample said they definitely would want to live in an earth sheltered home if it were the right size for their family. Their reaction might become more positive with increased exposure to earth-insulated dwellings or increased

knowledge about the advantages and disadvantages of the structures, particularly if energy costs continue to increase.

If consumers are going to be made aware of the opportunities to reduce energy consumption while still maintaining an adequate and satisfying living environment by choosing the alternative or an earth sheltered dwelling, considerable effort may need to be directed toward educational programs. These educational programs need to be directed to at least three audiences. Materials need to be designed to educate consumers as to the advantages, disadvantages and design requirements for underground housing. Educational programs utilizing these materials in group sessions could be conducted for consumers or the materials could be made available through mass media.

A second audience to be addressed through educational programs would be builders. At present there is a lack of knowledge and expertise among those in the building industry. Increasing the availability of materials related to underground housing to this audience might make a significant impact on the number of such units that would be constructed.

One of the major constraints to the adoption of underground or earth-sheltered housing is the hesitancy of financial institutions to provide mortgage funds for these homes. Therefore, it is further recommended that educational programs be designed for lending agency personnel to better acquaint them with the desirability of financing underground houses.

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APPENDIX

QUESTIONNAIRE

We are interested in your opinion of the house which you are visiting. Please take a few minutes to answer the following questions. Information obtained will be statistically treated in a large group. Your opinions will not be individually identified in any report. This study is a joint effort between Oklahoma State University, Texas Tech University and Clemson University. Your assistance in this study is greatly appreciated.

Questions refer to the earth-insulated underground home. Please answer all questions.

1. Have you ever visited an earth-insulated or underground home before? (Check the answer that best describes you.)

   ___1 This is my first visit to such a home.
   ___2 I have visited one or two such homes.
   ___3 I have visited three or more such homes.
   ___4 I know someone who lives or has lived in such a home.
   ___5 I have lived or am living in such a home.

NOTE: For the following questions, please circle the number of the scale of 1 to 7 which best expresses how you feel. For example, in question 2, if you feel that the underground house is fairly close to what you expected, you could circle 5 or 6. If you feel it is not at all like you expected, circle 1.

2. In general, how does this home compare to what you thought an earth-insulated home would be like?

Not at All as I Expected						Just as I Expected
1	2	3	4	5	6	7

3. How did the amount of light (both natural and artificial) in the earth-insulated home compare to what you expected?

Much Less Light						Much More Light
1	2	3	4	5	6	7

4. How important is it to you that a home have plenty of natural light?

Not at All Important						Very Important
1	2	3	4	5	6	7

5. How do you feel about the amount of natural light in each of the following rooms?

	Not at All Adequate						Very Adequate
a. Bedroom	1	2	3	4	5	6	7
b. Living room	1	2	3	4	5	6	7

5. (Continued)

	Not at All Adequate					Very Adequate	
c. Kitchen	1	2	3	4	5	6	7
d. Bathroom	1	2	3	4	5	6	7

6. What is your reaction to the amount of privacy the earth-insulated home provides?

	Not Enough Privacy					Too Much Privacy	
a. For family members inside the home?	1	2	3	4	5	6	7
b. For family from neighbors?	1	2	3	4	5	6	7
c. From noise outside?	1	2	3	4	5	6	7

7. What would you estimate the annual cost of maintenance and repair to be on the earth-insulated solar home compared to that of a conventional home?

___1 Higher in This Home ___2 About the Same ___3 Lower in This Home

Why?_____

8. Would you want to live in an earth-insulated home if it were the right size for your family?

No, Definitely Would Not					Yes, Definitely Would	
1	2	3	4	5	6	7

9. Are you likely to purchase or build any type of home within the next five years?

Not at All Likely					Very Likely
1	2	3	4	5	6	7

10. Are you likely to purchase or build an earth-insulated solar home within the next five years?

Not at All Likely					Very Likely
1	2	3	4	5	6	7

11. Do you think you could obtain financing to build an earth-insulated home?

___1 No ___2 Maybe ___3 Yes

12. If yes, from what source could you obtain the funds?

_____

13. Please indicate the age group to which you belong.

___1 Under 18
___2 18-24 years
___3 25-34 years
___4 35-44 years
___5 45-54 years
___6 55-64 years
___7 65 years and over

14. What is your sex?

___1 Male ___ 2 Female

15. Which of the following best describes your marital status?

___1 Single--never married
___2 Divorced or separated
___3 Widowed
___4 Married

16. What was the last year of school which you completed?

___1 8th grade or less
___2 Some high school
___3 High school graduate
___4 1-3 years of college or tech school
___5 College graduate
___6 Master's degree
___7 Doctoral degree

17. Check the appropriate category:

___Never had children
___Have children but none are living at home
___Have children living at home. (If you have children living at home, please list their ages.)

____ ____ ____ ____ ____ ____ ____

18. Which of the following describes the area in which you are presently living?

___1 Open country--rural
___2 Village of 1,000 or less
___3 Town of 1,000-10,000
___4 City of 10,000 - 50,000
___5 Suburb of a city
___6 City in excess of 50,000

19. Check the appropriate category that best indicates the total annual income for your family:

___01 Under $4,999
___02 $5,000-$7,999
___03 $8,000-$10,999

19. (Continued)

___04 $11,000-$13,999
___05 $14,000-$16,999
___06 $17,000-$19,999
___07 $20,000-$22,999
___08 $23,000-$25,999
___09 $26,000-$28,999
___10 $29,000-$31,999
___11 $32,000-$34,999
___12 Over $35,000

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Candidate for the Degree of

Master of Science

Thesis: CONSUMER EVALUATION OF AN EARTH-INSULATED SOLAR HOUSE

Major Field: Housing, Design, and Consumer Resources

Biographical:

Personal Data: Born September 24, 1937, in Union, Oklahoma, the daughter of Anthony F. and Mary C. Dries; married to Keith W. Winter.

Education: Graduated from Union High School, Union, Oklahoma, in May, 1955; received Bachelor of Science degree in Home Economics Education from Oklahoma State University, Stillwater, Oklahoma, August, 1959; completed requirements for the Master of Science degree at Oklahoma State University in May, 1980.

Professional Organizations: American Home Economics Association, Oklahoma Home Economics Association, National Association of Extension Home Economists, Oklahoma Association of Extension Home Economists.

Professional Experience: Vocational Home Economics Instructor, Bent County High School, Las Animas, Colorado, 1959-62; Oklahoma Cooperative Extension Service, Assistant Home Demonstration Agent--At Large, Kingfisher County, Extension Home Economist--4-H Program, Kay County, 1963-69; Extension Home Economist, Adair County, 1969-73; Extension Home Economist--4-H Program, Adair and Sequoyah Counties, 1973 to present.