MASTER

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SOLARIZATION/CONSERVATION
TECHNOLOGY DEVELOPMENT
PROGRAM FOR EXISTING
HOUSING

Progress Report

For
Community Development Office
City of Ann Arbor
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By
Architectural Research Laboratory
The University of Michigan
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Project Director

Sponsored By
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Project Objectives

1. Develop a method for evaluating existing residences for their energy Solarization/Conservation potential as well as carrying out the S/C work within the context of the Community Development program.
2. Demonstrating appropriate methods of utilizing solar energy in existing Ann Arbor residences beyond that obtainable in a good conservation program.

Section 1.0 INTRODUCTION

Section 2.0 TASK PROGRESS

Section 3.0 S/C SELECTION PROCESS

Section 4.0 TECHNICAL STUDY

Section 5.0 APPENDIX

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This report covers the four month period from February 1, 1981 to this date. Included is: 1) a general progress update; 2) discussion for the S/C selection process and technical evaluation; 3) a detailed report on the survey of utility data; and 4) a report on the S/C site audits. At this point in the project, the team members are intensely involved with the energy evaluation of the ten houses which have been tentatively selected for detail S/C design. The goal of these evaluations is that of developing an appropriate S/C solution for each. Implicit in this process is the assessment of the owner's attitude in relation to environmental control, i.e. to what extent will the owner be willing or able to manipulate shutters etc. Education will be an important issue in any S/C application. The knowledge of solar is practically nil at least among the homeowners in our data set.

Study of the utility data for the 63 houses indicates that indeed the Ann Arbor homeowner does have a significant heating and utility cost problem. The average gas heating usage for this group is 83,000 BTUs/sq. ft./year or approximately 12.2 BTUs/sq.ft./deg.day. The challenge for S/C is clear in that the houses being considered are in good repair and have had already reasonable attention to the quick pay-back items such as ceiling insulation. To reduce these on an average to say 4 to 6 BTUs/sq.ft./deg. day is the challenge for the retrofit-redesign process.

A detailed comparison of the audit data for both the audit and control group is included in the appendix. With the range of examples used for each step of this study and with the available data, it should be possible to identify broad S/C impact for Ann Arbor housing.

SECTION 1.0 INTRODUCTION

The present state of the project in reference to the project proposal section 3.2 Technical Description, Figure 2.0-A, is as follows:

Phase 1 Community S/C Characteristics

Tasks 1.1 Survey Audit 100% Complete

The S/C Base Set of Data is complete. It includes utility and assessors file data in addition to that obtained from the first mail questionnaire. Detail on the file and the report are included in the appendix. A report has been mailed to each of the homeowners.

Task 1.2 Unit Sampling 100% Complete

The basic set of 63 houses has been divided into two groups on a random basis. The audit groups of 29 houses and control group of 34 houses are compared in the Appendix Section 5.4.

Task 1.3 User Site/Building Audit 80% Complete

The audit of the 29 houses is complete. Summary data is included in the Appendix Section 5.3.

The follow-up survey of the 10 selected houses will be conducted after the initial computer analysis of the "as is" condition. Sufficient data was obtained from the initial audit to develop at least the "first-cut" computer model. The second follow-up audit will in effect be an investigative survey; i.e. determine 1) the reasons for discrepancies between actual utility use and the predictions from the model analysis, and 2) the detailed technical options for solar and conservation retrofit.

Task 1.3 cont.

Two concerns have surfaced in the audits and subsequent follow-up discussions. First, the R.C.S. audit is currently being implemented in the City of Ann Arbor including the houses in our data bases. Although this may be good in itself, it causes confusion with those whom we have audited in detail. Further, it probably will be more difficult to identify the "user factor" in the S/C effort. Second, some of the 29 audited homeowners are quite anxious to have results from the U of M/ARL audit and an assessment of the solar potential of their homes even though they may not be one of the residences now targeted for S/C design.

Our reaction to these concerns is as follows:

- 1) Of the audit set (29) we assume that all will receive reasonable priority attention either through the S/C program or the "normal" Community Development Office's activities. Therefore, where the questions are raised they are asked to hold their responses to the R.C.S. audit until at least September.

Of the control set (33) that were not selected for audit, no control can be maintained or expected. We can only inquire in April 1982 as to what occurred in 81-82 and relate this to their fuel consumption.

- 2) The concern for audit results is encouraging and suggests some solar potential appraisal of the 19 (29 less 10) should be supplied along with other results from the audit. The project is also exploring approaches to education to parallel the S/C effort and the subsequent report to the homeowner.

SECTION 2.0 Cont.

Task 1.4 Selection of S/C Target Residence, 90% Complete

Ten (10) residences have been targeted for detail design. These were selected by the audit teams based on their assessment of feasibility of solarization. (Refer to Section 3.0 for a discussion of the selection process.) The candidate houses have been cross checked with the community development office for the owners' eligibility for H.U.D. assistance.

SECTION 2.0 Cont.

Phase II Community System Analysis and Development

Task 2.1 Technology Survey and Selection - 50% Complete

Data files are being assembled in accordance with the classification of Construction Specification Institute (CSI) format. These include technical papers and manufacturers literature. Results from the audits and modeling have highlighted the need for information on retrofit technology for older houses. As an example, wall insulation is a major concern particularly as to its effectiveness. The U of M/Building Technology Laboratory is doing exploratory testing as back-up for the modeling and as a check on recommendations that will be made for retrofit.

Published information on solarization concepts are necessarily based on generic types of systems, which are not generally available on a product basis or necessarily relevant to Ann Arbor's location or retrofit market of older houses. Where S/C products have been developed for the existing small market, they are priced out of reasonable payback consideration. The project needs to develop innovative tailor-made solutions with low-cost components common to the trades. Data sheets are to be developed for use as guidelines by the Ann Arbor CD Office. Other comments on this subject are included in Section 4.0

Tasks 2.2 S/C Concepts Performance 25%

Purpose of the task is to prepare energy redesigns for each of the 10 targeted residences. As of this report date 1) base line energy data has determined for each and 2) a computer "as is" model and sensitivity studies have been developed for two houses. These two were used as test cases in developing appropriate residential algorithms for the U of M/BSCI thermal programs. Figure 5.1-A,B,C. Particular issues involve non-and partially heated basements, unheated crawl spaces, periodic operation of furnaces and user controlled operation of exhaust fans.

SECTION 2.0 cont.

A climate data file for the December 79 - November 80 period was assembled using the University recorded Ann Arbor daily temperatures and radiation data along with historic data from Detroit Metro. A simulation file of 36 days, 3 per month, comprise the base set used for the computer programming. This data set may well serve as a base line for generalization to be provided for the C.D. office for future S/C design activity.

SECTION 2.0 cont.

Figure 2.0-A Project Plan

Reference Page A-56 Grant Proposal

Considerable emphasis has been placed on the selection process, with two objectives: 1) the selection of houses for S/C project directed retrofit; and 2) the evaluation of a process whereby the C.D. Office of Ann Arbor might continue the same work or possibly such might be used by the informed "do it yourself" homeowner. The process followed is identified in the diagram, Figure 3.0.A. This is based on the following hypotheses: 1) that conservation and solarization can be identifiable strategies; and 2) that conservation can be carried out without specific attempts at solarization; however, the converse is normally not true.

The solarization path is being followed in the project, i.e. 1) screening first for solar potential; 2) developing "as is" models along with sensitivity analyses; and 3) evaluating S/C strategies. It is assumed that all the (10) houses can be improved with varying degrees of solarization and conservation. The actual selection was based on the combined judgements of the audit teams, consultants and staff using 1-5 rating scale. Factors considered were solar access, user attitude and solar retrofit applicability.

Sample team comments were:

a) Rating 1 - Low Potential

"Difficult site, no south sloping roof; small wall area on south side; hot water heating; difficult work space."

b) Rating 4 - High Potential

"Good south face; deciduous trees; owner receptive; 2nd floor attic space."

SECTION 3.0 S/C SELECTION PROCESS

Figure 3.0-A S/C Retrofit-Redesign Process

Characteristics of the 10 targeted S/C houses are summarized in Figure 5.2.A. General energy comparisons are included in Figure 5.4-E. It is interesting to note that the 10 targeted houses use more energy in all categories, i.e. heating, user operation, and electric. This is compared to each of the remaining data groups identified in this research. Clearly the houses were not selected for the easiest S/C solution. The only comment possible is that these homeowners do indeed need assistance and they are part of the Ann Arbor housing stock.

SECTION 3.0 cont.

The testing and technical study introduced in the previous report has been continued throughout this period. Testing of the cells has included refinement of the air collectors along with indoor tests to calibrate the cells for extrapolation of energy performance of the several systems as well as rating of the tested components.

Of particular concern is that of moveable insulation or shutters that will increase the total performance of a water wall. The project staff has modified the concept of moveable insulation, identified in Figure 4.0-E. This original invention provided for night swivel insulation in water wall enclosure. The adaption shown in Figures 4.0-A,C,D provide for either insulation on the inside of storage walls or between the storage elements and the glass enclosure. The systems provide the flexibility for 1) a "Trombe" wall heating; 2) an open direct gain wall storage combination; and 3) night and day cooling and daytime carry-over. Some technical problems have been experienced and revisions are under study. It is hoped that the system can be refined sufficiently for the projected S/C retrofit schedule. Changeable envelopes are required for the changing climates if top performance is to be achieved. A set of instructions for operation of such a shutter systems are being prepared for use by the homeowner.

Results from this testing are to be used directly in evaluating components and indirectly in supporting the computer analysis of the several passive solar components.

SECTION 4.0 TECHNICAL STUDY

General Comment

Two approaches have been discussed in reference to the retrofit-design process. One is the direct analysis approach, i.e. what are the loads and energy needs and, correspondingly, what type of passive and how much is required to achieve a certain performance objective. The other might be identified as bottom line approach, i.e. what type of system is applicable; how much can be reasonably used; and how can the system be integrated into the solution. Of course all the questions must be answered including life cycle cost evaluation. The entire process is an iterative one and the only question is the starting point.

SECTION 4.0 cont.

Figure 4.0-A Water Wall Test Cell
with moveable insulation

Figure 4.0-B Test cell series
Building Technology Laboratory

Figure 4.0-C Shutters closed to
outside

Figure 4.0-D Shutters partially
open

Note: The invention noted is by Kenneth S. Lee, Associate Professor of Architecture and presently a Doctoral Candidate at the College of Architecture, U of M. He has granted permission for project use of the invention. He also is the originator of the concept of the test cells used in the project evaluation.

INVENTION DISCLOSURE: MODULAR PASSIVE SOLAR WALLS WITH SWIVEL TYPES OF NIGHT INSULATION SYSTEMS

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This is a disclosure of the invention that has been filed for the patent application. In most commonly used passive thermal wall systems, the thermal medium warms during the day, and during the night the medium radiates the stored heat into the structure. Such a simply system unfortunately radiates heat back through the glass to the night sky. The heat radiated to the structure interior is also not controllable. To overcome these problems, movable insulated blankets have been employed to cover the thermal medium and prevent radiation to the night sky as well as to control the heat distribution into the interior space.

Disclosed are means for economically and effectively controlling the insulation and heat radiation of columnar solar thermal storage units for passive solar heating and cooling. It will be understood that heat radiation from thermal storage units for passive solar heating includes both direct radiation of heat energy to the structure interior and heat transferred by the convection of air adjacent to thermal storage units to the structure interior. For passive cooling the heat radiation is to the cool night sky and the heat absorption is from the structure interior mostly by convection during the day.

In the first embodiment disclosed vertical water filled thermal storage columns are located between exterior glazing and optional interior drywall. Each column is equipped with a rotatable insulating panel and synchronizing mechanism to control the daytime insulation and nighttime radiation from the column. The object of the embodiment is a very economical construction with superior effectiveness.

In a second embodiment both the columns and the insulating panels are rotatable. The columns include separate insulated portions. Additional control of the insulation and radiation of the columns is thereby provided.

In a third embodiment the rotatable insulating panels are positioned in concave depressions formed in thermal storage columns. The columns include individual thermal convection means formed therein. In preferred form the columns are precast concrete or masonry which can serve as the load bearing south wall of the structure or as the roof of the structure.

A prototype structure of 6'x6'x7' (inside dimension) has been constructed in order to test the invention system using this prototype enclosure, and the result of the test will be included in the paper.

B4

Figure 4.0-E Invention Disclosure

Illustrations

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SECTION 5.0 APPENDIX

1980 BSCI PROGRAM

Figure 5.1-A BSCI Computer File Organization

```

>
>WALL 11NORTH ABOVE
> 1 90.00 0.0 0.20 0.0 0 0
>WALL 12SOUTH ABOVE
> 1 90.00 180.00 0.20 0.0 0 0
>WALL 13EAST ABOVE
> 1 90.00 90.00 0.20 0.0 0 0
>WALL 14WEST ABOVE
> 1 90.00 270.00 0.20 0.0 0 0
>WALL 20EQUIVALENT FIRST FLOOR
> 2 0.0 0.0 50.00 0.0 0 0
>WALL 41ROOF/ATTIC
> 4 0.0 0.0 0.80 0.0 0 0
>WALL 51NORTH SLOPE ROOF
> 5 45.00 0.0 0.80 0.0 0 0
>WALL 52SOUTH SLOPE ROOF
> 5 45.00 180.00 0.80 0.0 0 0
>WALL 53EAST SLOPE ROOF
> 5 45.00 90.00 0.80 0.0 0 0
>WALL 54WEST SLOPE ROOF
> 5 45.00 270.00 0.80 0.0 0 0
>WALL 71CRAWL SPACE
> 7 9.0 0.0 0.40 0.0 0 0
>
>
>ROOM 222 FIRST FLOOR
> DATA 2 660.00 8.75 0.75 1.00 0.0 178.00
> WALL 11 228.75 0.15 0.71
> WALL 12 288.75 0.16 0.50
> WALL 13 175.00 0.24 0.78
> WALL 14 175.00 0.10 0.50
> WALL 20 500.00 0.0 0.0
> WALL 41 160.00 0.0 0.0
> WALL 71 160.00 0.0 0.0
> CCCU 2.00 250.00 180.00 1.00
> LSYS 1.47 0.90 3.00 20.00
> EGEL 1.35 1.00 42.00
> INFI 90.00 195.00 0.0
>
>ROOM 333 SECOND FLOOR
> DATA 2 500.00 9.37 0.75 1.00 0.0 127.00
> WALL 11 93.75 0.04 0.0
> WALL 12 188.75 0.18 0.50
> WALL 13 150.00 0.15 0.50
> WALL 14 150.00 0.13 0.50
> WALL 41 300.00 0.0 0.0
> WALL 51 178.77 0.0 0.0
> WALL 52 88.38 0.0 0.0
> WALL 53 17.67 0.0 0.0
> WALL 54 17.87 0.0 0.0
> CCCU 1.00 250.00 180.00 1.00
> LSYS 1.47 0.90 3.00 20.00
> INFI 39.00 195.00 0.0
>
>ZONE 100 NO HEAT IN BASEMENT
> DATA 0.22 0.0 2.00 11.00
> ROOM 222
> ROOM 333
>
>SECT 100 HOUSE
> DATA 0.0 0.0 0.0 2.00 20.0
> ZONE 100
>

```

House File Wall, Room,
and Systems Data

Figure 5.1-B Building Data File House #102

```

>COM BUILDING TECH LAB
>COM CITY PROJECT / SECONDARY AUDIT GROUP
>COM HOUSE #102
>COM MAY 12, 1981 BEM
>COM MAY 18, 1981 CHANGES BEM
>
>MATE 1 STUDWALL/STORM GLASS
> ASBESTOS CEMENT SHINGLES
> 0.25 120.00 19.00 0.24 4.0
> HARDWOOD/PANEL/.75IN/
> 0.75 40.00 1.10 0.33 0.0
> SANDGYPPPLAS/METALLATH/
> 0.75 105.00 5.60 0.26 10.0
> SURFACE/VERTICAL/
> 0.90 0.54 0.54 2.00
> GLASS/DSCLEAR/
> 0.87 0.90 74.60 4.00 6.00
> SURFACE/VERTICAL/
> 0.90 0.54 0.54 5.00
>
>MATE 2 EQUIVALENT FIRST FLOOR
> LINOLEUM/TILE/FLOOR/
> 0.06 80.00 74.30 0.30 4.00
> HARDWOOD/PANEL/.75IN/
> 0.75 40.00 1.10 0.33 0.0
> SURFACE/HORIZDN/
> 0.90 0.16 0.71 2.00
>
>MATE 4 ROOF/ATTIC
> ASPHALT/BUILTUPROOF/
> 0.37 70.00 1.11 0.35 4.00
> HARDWOOD/PANEL/.75IN/
> 0.75 40.00 1.10 0.33 0.0
> AIRSPACE/HORIZDN/4IN/
> 0.00 0.71 0.16 3.00 0.0
> CELLULOSE/INSUL/6IN/
> 6.00 2.30 0.27 0.33 0.0
> FIBERGLAS/BATINSULAT/6IN/
> 6.00 0.50 0.42 0.18 0.0
> SANDGYPPPLAS/METALLATH/
> 0.75 105.00 5.60 0.26 10.0
> SURFACE/HORIZUP/
> 0.90 0.71 0.16 2.00
>
>MATE 5 ROOF/CLG
> ASPHALT/BUILTUPROOF/
> 0.37 70.00 1.11 0.35 4.00
> HARDWOOD/PANEL/.75IN/
> 0.75 40.00 1.10 0.33 0.0
> FIBERGLAS/BATINSULAT/6IN/
> 6.00 0.50 0.42 0.18 0.0
> SANDGYPPPLAS/METALLATH/
> 0.75 105.00 5.60 0.26 10.0
> SURFACE/HORIZUP/
> 0.90 0.71 0.16 2.00
>
>MATE 7 CRAWL SPACE
> HARDWOOD/PANEL/.75IN/
> 0.75 40.00 1.10 0.33 4.0
> LINOLEUM/TILE/FLOOR/
> 0.06 80.00 74.30 0.30 0.0
> SURFACE/HORIZDN/
> 0.90 0.16 0.71 2.00
>

```

House File Materials

CONSTRUCTION TYPES

ID	YEAR BUILT	BUILDING TYPE	Wood Frame	Brick	Single Story	Second Story	Basement	Partial Basement	Slab on Grade	FOUNDATION	Brick or Stone	Concrete or Cinder Block	EXTERIOR WALLS	Wood Siding	Aluminum Siding	Wood Shingles	Comp. Shingles	Brick Veneer	Brick	Artificial Stone	Stucco Block	INTERIOR WALLS	Plastered	Drywall	ROOF/ATTIC INSULATION	Cellulose	Fiberglas	Wood Chips	WALL INSULATION	Cellulose	Fiberglas	Wood Chips	Cotton Batt.		
100	1970		X		X							X		X								X				X									
156	1942		X		X		X					X		X								X													
409	1958			X								X							X							X									
003	1900		X			X	X				X			X		X						X				X				X					
014	1900			X		X	X	X			X			X								X				X									
308	1870		X			X	X	X			X			X								X				X									
092	1880		X			X	X	X			X			X					X			X				X									
346	1880		X				X		X		X						X																		
102	1913		X			X		X			X						X					X				X	X								
191	1900		X								X			X								X													

Figure 5.2-A Construction Parameter Comparisons (10)

SECTION 5.2 COMPARISON OF S/C SELECTIONS

* BUILDING PARAMETERS WITH ENERGY IMPLICATIONS CITY OF ANN ARBOR *																

	AREAS						SURFACE PARAMETERS									
	ID	FLOOR	ATTIC	BASEMT	ROOF	WALL	OCCU	TO.SURF	VOL.A	SRF/FL	SH.FRM	GL.ORIN	GL.X	MBTU/SF	MBTU/OC	KW/OC
	3.	2528.	524.	1048.	1308.	4012.	10.	5320.	55.731	2.104	1.074	.289	.154	57.0	706.1	63.6**
	8.	1635.	291.	923.	1002.	2324.	2.	3328.	66.306	2.034	.984	.188	.191	64.8	1544.0	250.5
	7.	1344.	672.	672.	672.	2288.	2.	2960.	71.371	2.202	.949	.299	.137	93.4	1690.6	232.0
	14.	1724.	1143.	1143.	1143.	3036.	4.	4179.	61.998	2.424	1.018	.393	.252	68.8	2218.5	146.8**
	15.	864.	864.	0.	864.	960.	3.	1824.	97.077	2.111	.814	.116	.180	75.4	1279.2	115.2
	33.	1068.	1068.	0.	1068.	1088.	3.	2156.	94.461	2.019	.825	.098	.115	113.8	927.3	175.4
	41.	1482.	494.	988.	988.	1792.	1.	2780.	77.621	1.876	.910	.373	.154	73.5	2361.3	406.8
	44.	1208.	151.	371.	756.	2212.	1.	2968.	58.921	2.457	1.036	.281	.197	126.1	4467.6	280.8
	59.	1508.	754.	754.	754.	2420.	4.	3174.	71.813	2.105	.946	.144	.138	5.0	556.5	94.9
	85.	2702.	516.	1117.	1155.	3636.	5.	4791.	64.365	1.773	.999	.203	.169	64.8	1142.8	160.7
	92.	1960.	1076.	1076.	1076.	3000.	8.	4076.	67.301	2.080	.977	.174	.106	63.6	1470.5	78.1**
	100.	864.	864.	0.	864.	960.	2.	1824.	97.077	2.111	.814	.435	.197	74.6	1861.5	141.0**
	102.	1132.	160.	560.	712.	1918.	3.	2630.	65.094	2.323	.994	.404	.168	6.1	965.8	110.3**
	110.	704.	704.	704.	704.	1080.	4.	1784.	86.705	2.534	.861	.220	.242	113.7	1025.1	132.0
	128.	864.	864.	0.	864.	960.	3.	1824.	97.077	2.111	.814	.667	.139	91.9	912.0	205.8
	156.	683.	683.	671.	683.	1080.	3.	1763.	86.002	2.581	.864	.418	.224	108.9	1690.6	87.1**
	163.	852.	504.	672.	684.	1456.	6.	2140.	74.743	2.512	.927	.296	.127	114.3	1124.5	68.7
	191.	1091.	198.	396.	893.	1794.	1.	2687.	82.905	2.463	1.011	.278	.080	113.5	3694.9	284.1**
	208.	1224.	612.	0.	612.	1872.	3.	2484.	79.958	2.029	.896	.361	.118	47.2	1122.0	138.1
	245.	1186.	1186.	648.	1186.	990.	7.	2176.	100.295	1.835	.800	.218	.093	125.3	774.5	82.5
	290.	936.	936.	936.	936.	992.	4.	1928.	96.823	2.060	.815	.185	.242	121.8	982.4	79.2
	293.	1822.	324.	648.	850.	2340.	4.	3190.	74.252	1.751	.930	.227	.179	73.8	2188.5	191.2
	308.	1362.	816.	816.	816.	2150.	4.	2866.	73.634	2.178	.934	.205	.238	125.2	1193.4	102.2**
	323.	1122.	374.	748.	748.	1680.	4.	2428.	73.962	2.164	.932	.186	.101	115.5	469.8	58.2
	331.	1335.	819.	560.	819.	1960.	2.	2779.	77.826	2.082	.909	.268	.196	62.4	3075.3	156.0
	346.	1870.	1082.	1082.	1082.	2610.	1.	3692.	72.557	1.974	.941	.294	.127	232.1	4908.7	538.3**
	375.	1845.	264.	1054.	1054.	1995.	3.	3049.	77.549	1.853	.910	.271	.112	76.3	1517.2	154.9
	409.	1107.	1107.	1107.	1107.	1224.	1.	2331.	89.462	2.106	.848	.148	.255	120.3	4235.5	485.5**
	418.	864.	864.	0.	864.	760.	3.	1624.	109.032	1.880	.768	0.	.122	129.8	1462.0	190.2
LEGEND: ALL AREAS IN SQUARE FEET (SF)																
OCCU. OR OC.--OCCUPANT(S)																
TO.SURF--TOTAL SURFACE AREA																
VOL.A--SURFACE-VOLUME FACTOR = THE RATIO OF THE																
SURFACE OF AN EQUIVALENT HEMISPHERE TO																
THAT OF THE HOUSE (X 100)																
SRF/FL--SURFACE TO FLOOR RATIO																
***--SYMBOL INDICATES HOUSES IN FINAL																
AUDIT/DESIGN SAMPLE (10 TOTAL.)																
								SH.FRM--SHAPE-FORM PARAMETER=(SURFACE AREA/6)**.5/(VOLUME)**.33								
								GL.ORIN--GLASS ORIENTATION FACTOR, I.E. THE % OF SOUTH								
								GLASS TO TOTAL GLASS AREA								
								GL.X--GLASS PERCENT, THE % OF GLASS TO TOTAL WALL AREA								
								MBTU--A THOUSAND BRITISH THERMAL UNITS								
								MBTU/SF-- MBTU/(SF * YEAR)								
								KW/OC--KILOWATT-HOUR /(OCCUPANT * MONTH)								
								MBTU/OC--MBTUS /(OCCUPANT * MONTH)								

Figure 5.3-A Building Parameter Comparison - Audit (29)

 * ENVELOPE PROPERTIES AND INFORMATION FOR 29 AUDIT RESIDENCES CITY OF ANN ARBOR *

	AREA				GLASS AREA				ROOF.INSUL		WALL.INSUL						
ID	FLOOR	ATTIC	BASEMT	ROOF	WALL	GL.TP	SOUTH	NORTH	EAST	WEST	TYPE	THICK	TYPE	THICK	VOLUME	TOT.SURF	#OCCU
> 3.	2528.	524.	1048.	1308.	4012.	2.	113.	123.	110.	45.	2.	12.	2.	-0.	23584.	5320.	10.
> 8.	1635.	291.	923.	1002.	2324.	1.	59.	76.	131.	47.	3.	10.	2.	4.	15062.	3326.	2.
> 7.	1344.	672.	672.	672.	2288.	2.	55.	60.	55.	14.	2.	8.	2.	3.	14112.	2960.	2.
> 14.	1724.	1143.	1143.	1143.	3038.	2.	171.	83.	65.	116.	3.	-0.	-0.	0.	19226.	4179.	4.
> 15.	864.	864.	0.	864.	860.	2.	18.	0.	65.	72.	-0.	-0.	-0.	0.	10800.	1824.	3.
> 33.	1068.	1068.	0.	1068.	1088.	2.	12.	0.	54.	57.	3.	4.	2.	4.	13350.	2156.	3.
> 41.	1482.	494.	888.	988.	1792.	2.	85.	85.	10.	48.	-0.	0.	1.	2.	14573.	2780.	1.
> 44.	1208.	151.	371.	756.	2212.	2.	87.	76.	41.	55.	2.	-0.	-0.	0.	10872.	2968.	1.
> 69.	1508.	754.	754.	754.	2420.	2.	30.	76.	64.	38.	3.	8.	-0.	0.	15834.	3174.	4.
> 85.	2702.	516.	1117.	1155.	3636.	2.	93.	87.	156.	122.	3.	7.	3.	4.	25031.	4791.	5.
> 92.	1980.	1078.	1076.	1076.	3000.	2.	36.	54.	45.	72.	3.	4.	3.	4.	20964.	4076.	8.
> 100.	864.	864.	0.	864.	860.	2.	74.	78.	18.	0.	3.	10.	3.	4.	10800.	1824.	2.
> 102.	1132.	160.	560.	712.	1918.	2.	77.	30.	43.	40.	2.	6.	-0.	0.	10262.	2630.	3.
> 110.	704.	704.	704.	704.	1080.	2.	38.	23.	51.	60.	2.	8.	-0.	0.	8800.	1784.	4.
> 128.	864.	864.	0.	864.	960.	2.	80.	40.	0.	0.	2.	8.	-0.	-0.	10800.	1824.	3.
> 156.	683.	683.	671.	683.	1080.	2.	64.	39.	28.	22.	-0.	5.	-0.	0.	8538.	1763.	3.
> 163.	852.	504.	672.	684.	1456.	1.	32.	28.	24.	24.	2.	6.	-0.	0.	9258.	2140.	6.
> 191.	1091.	198.	396.	893.	1794.	2.	24.	24.	18.	20.	-0.	0.	3.	4.	10066.	2687.	1.
> 208.	1224.	612.	0.	612.	1872.	2.	52.	50.	7.	35.	2.	12.	2.	0.	12852.	2484.	3.
> 245.	1186.	1186.	648.	1188.	990.	2.	24.	8.	38.	42.	2.	6.	2.	4.	14825.	2178.	7.
> 290.	938.	936.	936.	936.	892.	2.	42.	120.	18.	47.	3.	0.	-0.	0.	11700.	1928.	4.
> 293.	1822.	324.	648.	850.	2340.	2.	74.	96.	109.	47.	-0.	0.	-0.	0.	16783.	3190.	4.
> 308.	1362.	818.	818.	818.	2150.	2.	67.	77.	73.	108.	3.	8.	-0.	0.	14841.	2986.	4.
> 323.	1122.	374.	748.	748.	1680.	2.	21.	16.	38.	38.	3.	6.	1.	4.	11033.	2428.	4.
> 331.	1335.	819.	560.	819.	1960.	2.	70.	97.	51.	44.	2.	8.	-0.	0.	14824.	2779.	2.
> 346.	1870.	1082.	1082.	1082.	2610.	2.	70.	28.	50.	90.	2.	10.	-0.	0.	20223.	3692.	1.
> 375.	1845.	264.	1054.	1054.	1995.	2.	56.	93.	14.	44.	3.	4.	-0.	0.	16739.	3049.	3.
> 409.	1107.	1107.	1107.	1107.	1224.	2.	42.	78.	84.	78.	2.	10.	-0.	0.	13838.	2331.	1.
> 418.	864.	864.	0.	864.	760.	2.	0.	0.	80.	45.	2.	15.	-0.	0.	10800.	1624.	3.

> LEGEND: ALL AREAS IN SQUARE FEET
 > GL.TP--GLAZING TYPE(NO. OF GLAZINGS)
 > THICK--THICKNESS IN INCHES
 > #OCCU--NUMBER OF OCCUPANTS
 > VOLUME--CUBIC FEET
 > TOT.SURF--TOTAL EXTERIOR SURFACE AREA

BSMT--BASEMENT AREA IN SQ.FT.
 INSUL.TYPE---TYPE OF INSULATION
 (1) BATT/FIBERGLAS INSULATION
 (2) LOOSE FILL INSULATION
 (3) RIGID (EXPANDED POLYURETHANE)

Figure 5.3-B Envelope Properties - Audit (29)

***** * SYSTEM CHARACTERISTICS FOR 29 AUDIT RESIDENCES CITY OF ANN ARBOR * *****																		
ID	HEAT.		COOLING SYSTEM			HEATING SYSTEM				HOT WATER SYSTEM				TEMPERATURE(FARENH.)				
	SB.FT	SB.FT	TYPE	CAPAC.	NO.	SOURCE	TYPE	CAPACITY	AGE	SOURCE	SIZE	CAPAC.	AGE	H.W.	SET	NIGHT	VACAT.	ACT.TP
> 3.	2956.	0.	-0.	0.	0.	2.	-0.	150000.	-0.	2.	65.	75000.	10.	150.	65.	63.	63.	-0.
> 6.	1694.	0.	-0.	0.	0.	2.	2.	150000.	3.	2.	50.	65000.	4.	130.	64.	45.	65.	65.
> 7.	1342.	500.	1.	4500.	2.	2.	2.	174000.	3.	2.	30.	45000.	3.	110.	66.	66.	63.	-0.
> 14.	1722.	0.	-0.	0.	0.	2.	1.	175000.	-0.	2.	50.	60000.	-0.	115.	62.	60.	60.	-0.
> 15.	864.	0.	-0.	0.	0.	2.	1.	82500.	10.	2.	40.	42000.	10.	130.	65.	65.	65.	70.
> 33.	1200.	150.	1.	-0.	1.	2.	1.	105000.	8.	2.	40.	40000.	45.	80.	70.	68.	65.	72.
> 41.	1619.	0.	-0.	0.	0.	2.	1.	-0.	-0.	1.	60.	-0.	7.	140.	68.	60.	60.	68.
> 44.	602.	0.	-0.	0.	0.	2.	-0.	150000.	-0.	2.	30.	53000.	-0.	120.	75.	75.	75.	-0.
> 69.	1404.	0.	-0.	0.	0.	3.	4.	-0.	60.	2.	40.	-0.	6.	130.	70.	70.	70.	71.
> 85.	2420.	0.	-0.	0.	0.	2.	1.	150000.	3.	2.	50.	50000.	3.	150.	68.	64.	68.	68.
> 92.	1044.	0.	-0.	0.	0.	2.	4.	-0.	15.	2.	50.	75000.	25.	120.	70.	68.	68.	-0.
> 100.	805.	0.	-0.	0.	0.	2.	1.	82500.	10.	2.	40.	36000.	10.	145.	70.	65.	70.	70.
> 102.	-0.	0.	-0.	0.	0.	3.	1.	10000.	50.	2.	40.	50000.	15.	140.	70.	63.	63.	58.
> 110.	1251.	0.	-0.	0.	0.	2.	4.	-0.	35.	2.	37.	60000.	8.	130.	65.	65.	65.	-0.
> 128.	864.	0.	-0.	0.	0.	2.	1.	82500.	10.	2.	40.	36000.	10.	145.	68.	68.	60.	72.
> 156.	1152.	0.	-0.	0.	0.	2.	1.	100000.	18.	2.	30.	32000.	19.	150.	73.	73.	73.	73.
> 163.	1025.	0.	1.	-0.	-0.	2.	1.	84000.	-0.	2.	40.	45000.	-0.	140.	70.	60.	73.	0.
> 181.	1500.	0.	-0.	0.	0.	2.	1.	105000.	7.	2.	30.	40000.	18.	120.	72.	65.	68.	73.
> 208.	1600.	0.	-0.	0.	0.	2.	4.	-0.	5.	2.	40.	46000.	2.	150.	68.	68.	55.	69.
> 245.	1200.	0.	-0.	0.	0.	2.	1.	125000.	-0.	2.	50.	40000.	-0.	112.	70.	70.	68.	75.
> 290.	1750.	0.	-0.	0.	0.	2.	2.	112000.	10.	2.	40.	38000.	1.	140.	66.	60.	60.	69.
> 293.	2160.	0.	-0.	0.	0.	2.	1.	60000.	20.	2.	40.	50000.	6.	130.	75.	68.	68.	70.
> 308.	1266.	0.	-0.	0.	0.	2.	1.	100000.	1.	2.	40.	46000.	1.	145.	63.	63.	63.	67.
> 323.	1100.	0.	-0.	0.	0.	2.	1.	80000.	0.	2.	30.	40000.	3.	134.	89.	62.	64.	69.
> 331.	1391.	0.	-0.	0.	0.	2.	4.	120000.	15.	2.	40.	38000.	-0.	130.	70.	65.	63.	68.
> 346.	2000.	0.	-0.	0.	0.	2.	1.	-0.	5.	2.	40.	48000.	15.	135.	70.	64.	68.	76.
> 375.	1845.	0.	-0.	0.	0.	2.	2.	132000.	30.	2.	65.	80000.	30.	140.	70.	70.	62.	71.
> 409.	2080.	0.	1.	1.	1.	2.	2.	114000.	22.	2.	30.	36000.	17.	150.	70.	65.	70.	-0.
> 418.	805.	0.	-0.	0.	0.	2.	1.	82500.	8.	2.	40.	40000.	0.	150.	75.	71.	69.	71.
> LEGEND: COOLING SYSTEM: TYPE--(1) WINDOW UNIT CAPAC--CAPACITY, IN MBTU/HOUR TEMPERATURE: H.W.--HOT WATER SET--THERMOSTAT SET TEMP. NIGHT--NIGHTTIME SETBACK TEMP. VACAT.--VACATION SETBACK TEMP. ACT.TP--ACTUAL MEASURED TEMPERATURE																		
> HEATING SYSTEM: SOURCE--(2) GAS (3) OIL TYPE----(1) FORCED AIR (2) HOT WATER/RADIATION (3) GRAVITY AIR OR OTHER																		
> HOT WATER SYSTEM: SOURCE---(1) ELECTRIC (2) GAS SIZE---GALLONS CAPAC.--INPUT CAPACITY IN BTUS/HOUR																		

Figure 5.3-C System Comparisons - Audit (29)

COMPARISONS BY HOUSE SIZE BETWEEN AUDIT GROUP AND CONTROL GROUP

		AUDIT GROUP (29 HOUSES)				CONTROL GROUP (34 HOUSES)			
		SMALL (< 1100)	MEDIUM (1100-1700)	LARGE (> 1700)	AVERAGE FOR GROUP	SMALL (< 1100)	MEDIUM (1100-1700)	LARGE (> 1700)	AVERAGE FOR GROUP
HEATING	(mbtu/sf/yr)	105.8	107.8	67.4	98.1	107.8	85.6	73.8	90.4
USER OPERATIONS	(mbtu/occu/mo)	1496.0	2105.0	1541.0	1778.0	176.4	1559.0	2027.0	1730.0
ELECTRIC	(kwh/occu/mo)	147.9	225.9	132.6	179.7	141.2	203.1	152.0	171.8

Figure 5.4-A Comparison by House Size - Audit (29) vs Control Group (34)

COMPARISONS BY AGE OF HOUSE BETWEEN AUDIT GROUP AND CONTROL GROUP

		AUDIT GROUP (29 HOUSES)										CONTROL GROUP (34 HOUSES)									
		AGE OF HOUSE (YEARS)										AGE OF HOUSE (YEARS)									
		10	20	30	40	50	60	70	80	90	100	10	20	30	40	50	60	70	80	90	100
HEATING	(mbtu/sf/yr)	99	121	95	99	78	90	65	59	232	64	92	138	74	76	61	87	-	96	-	-
USER OPERATION	(mbtu/occu/mo)	1342	2609	1321	1602	2383	993	1143	1397	4909	1471	1228	1310	2619	1093	1918	1432	-	1639	-	-
ELECTRIC	(kwh/occu/mo)	151	282	112	151	194	140	161	203	538	78	108	158	182	159	186	105	-	230	-	-

Figure 5.4-B Comparison by Age - Audit vs Control Group

COMPARISONS BY NUMBER OF BEDROOMS BETWEEN AUDIT GROUP AND CONTROL GROUP

		AUDIT GROUP (29 HOUSES)						CONTROL GROUP (34 HOUSES)							
		NUMBER OF BEDROOMS						NUMBER OF BEDROOMS						AVERAGE FOR GROUP	
		1	2	3	4	5	6	1	2	3	4	5	6	AVERAGE FOR GROUP	
HEATING															
(mbtu/sf/yr)		115.5	95.9	107.3	87.4	57.0	64.8	98.1	71.0	88.4	103.4	72.4	112.6	27.9	90.4
USER OPERATION															
(mbtu/occu/mo)		470	1191	1889	2308	706	1143	1178	1063	1803	1723	1491	1077	5536	1731
ELECTRIC															
(kwh/occu/mo)		58.2	133	176	250.2	63.7	160.7	179.7	134.3	222.9	181.9	146.4	37.7	-	171.8

Figure 5.4-C Comparison by Number of Bedrooms- Audit vs Control Group

COMPARISONS BETWEEN AUDIT GROUP AND CONTROL GROUP

	AUDIT GROUP (29 HOUSES)	CONTROL GROUP (34 HOUSES)
BUILDING ALTERATIONS 1(min) to 3(max)	2.4828	2.2941
ENVELOPE ALTERATIONS 1(min) to 6(max)	4.1724	3.6471
SYSTEM ALTERATIONS 1(min) to 8(max)	2.1379	2.0882
FLOOR AREA (square feet)	1316.6	1372.8
ATTIC AREA (square feet)	687.3	595.0
BASEMENT AREA (square feet)	582.7	618.0
ROOF AREA (square feet)	927.4	988.9
NUMBER OF RESIDENTS	3.4138	3.3529

Figure 5.4-D General Comparison Between Audit and Control Group

		AUDIT GROUP (29 HOUSES)		CONTROL GROUP (34 HOUSES)	ENTIRE SAMPLING (63 HOUSES)
		10	19	AVERAGE FOR GROUP	AVERAGE FOR GROUP
HEATING					
(mbtu/sf/yr)		107.1	93.6	98.1	94.2
USER OPERATION					
(mbtu/occu/mo)		2295	1507	1778	1754
ELECTRIC					
(kwh/occu/mo)		203.7	167.0	179.7	176.0

Figure 5.4-E Comparison of Energy Consumption (10/19/29/34/63)

College of Architecture & Urban Planning

The University of Michigan Ann Arbor, Michigan 48109 313/764-1340

Architectural Research Laboratory

29 May 1981

Dear Homeowner:

Enclosed is a report on your gas and electric consumption for 1980. This should give you a comparison with other similar houses in Ann Arbor. As you may recall from our earlier letter, we are cooperating with the Ann Arbor Community Development Office in a research study to determine the feasibility of the greater use of solar energy in heating homes like your own. Because of your special interest, we will keep you informed on the progress and results of the study. As of this date, however, we do not plan any additional direct study of your house. The Community Development Office may, however, contact you in the fall as to your interest in a follow-up effort.

We thank you for your interest and assistance with this solar research study. Should you have any question on the enclosed report or wish one of our staff to come out to your home and discuss it, call me at 764-9453.

Sincerely,

Willard Oberdick
Professor of Architecture
Director
Solarization Project

College of Architecture & Urban Planning

The University of Michigan Ann Arbor, Michigan 48109 313/764-1340

Architectural Research Laboratory

29 May 1981

Dear Homeowner:

Enclosed is a report on your gas and electric consumption for 1980. This should give you a comparison with other similar houses in Ann Arbor. As you may recall from our earlier letter and a conversation with the students, we are cooperating with the Ann Arbor Community Development Office in a research study to determine the feasibility of the greater use of solar in heating homes like your own. These comparisons of the utility consumptions are being used in this study.

We are also now studying the information obtained from the energy audit of your home. In some cases it may be necessary to obtain additional data. Should that be the case, we will call and make necessary arrangements. In any case we will furnish you with a report on the results of the audit and any recommendations that we may determine.

Of course you have no obligation for any part of this work as it is funded by the U.S. Department of Energy through the City of Ann Arbor.

May we personally thank you for your cooperation and help. Should you have any questions on the enclosed report or wish one of our staff to discuss it with you in your home please call me at 764-9453. Further, should you wish to come by the University's Building Technology Laboratory on North Campus you are most welcome.

Sincerely yours,

Willard Oberdick
Professor of Architecture
Director
Solarization Project

Figure 5.5-A Sample Letters - Ref: - Utility Survey Results

SOLARIZATION AND CONSERVATION FOR EXISTING HOUSES CITY OF ANN ARBOR

 * ENERGY CONSUMPTION REPORT FOR HOMEOWNER *

NAME : ADDRESS:
 FLOOR AREA: 864.SQ.FT. NO. OF OCCUPANTS IN 1980 : 3.

REHAB STATUS :
 NON-ENERGY RELATED: EXTENSIVE IMPROVEMENTS ON BUILDING.
 ENERGY RELATED: MODERATE INSULATION REPAIRS ON WALL/ATTIC.
 SYSTEM RELATED: REWIRING, PLUMBING AND NEW HOT WATER HEATER.

REHABILITATION DATE : IN PROGRESS.

ENERGY COST SUMMARY:

HEATING COST (GAS) : \$ 401./YEAR
 OTHER COST (GAS) : \$ 188./YEAR
 ELECTRIC COST : \$ 375./YEAR

ENERGY COMPARISON-----	YOUR HOUSE	OTHER SIMILARLY SIZED HOUSES		
		(AVERAGE)	(LOWEST)	(HIGHEST)
HEATING ENERGY (MBTU/SF/YEAR)	129.8	101.6	60.1	206.4
OTHER ENERGY (MBTU/OCCU/MO)	1462.0	1630.0	829.1	4309.3
ELECTRICAL ENERGY(KWH/OCCU/MO)	190.2	144.7	52.1	311.5

- * MBTU - THOUSAND BRITISH THERMAL UNITS. ONE GALLON OF GASOLINE CONTAINS 132 MBTU OF ENERGY.
- * KWH - A KILOWATT HOUR IS A THOUSAND WATT HOURS. THIS IS EQUIVALENT TO A HUNDRED WATT LIGHT ON FOR TEN HOURS.
- * SF - SQUARE FEET
- * OCCU - OCCUPANT
- * MO - MONTH

Figure 5.5-B Homeowners Report of Utility Survey

***** * GAS ENERGY CONSUMPTION DATA FOR 63 HOMEOWNERS CITY OF ANN ARBOR * *****																	
ID	GAS.1	GAS.2	GAS.3	GAS.4	GAS.5	GAS.6	GAS.7	GAS.8	GAS.9	GA.10	GA.11	GA.12.	GA.TOT	SQ.FT	#OC	MBTU/SF	MBTU/OC
> 3.	331.	355.	278.	178.	110.	87.	85.	63.	63.	137.	263.	314.	2243.	2528.	10.	57.00	706.09
> 6.	98.	329.	283.	92.	40.	31.	19.	22.	49.	82.	160.	198.	1401.	1635.	2.	64.76	1544.02
> 7.	318.	297.	208.	83.	55.	24.	22.	39.	48.	108.	171.	245.	1628.	1344.	2.	93.39	1690.65
> 9.	211.	149.	58.	62.	37.	42.	30.	36.	40.	105.	106.	168.	1043.	1180.	1.	51.93	3756.15
> 14.	262.	292.	299.	197.	154.	95.	99.	79.	75.	173.	241.	241.	2207.	1724.	4.	68.81	2218.50
> 15.	149.	169.	137.	84.	45.	38.	48.	32.	33.	88.	129.	140.	1091.	864.	3.	75.45	1279.25
> 19.	153.	147.	232.	167.	50.	28.	31.	47.	30.	85.	153.	171.	1294.	1120.	5.	80.69	694.11
> 20.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1128.	3.	-0.	-0.
> 33.	260.	260.	243.	120.	60.	24.	15.	16.	54.	123.	178.	168.	1519.	1068.	3.	113.83	927.35
> 38.	442.	372.	330.	193.	77.	81.	58.	72.	89.	173.	252.	303.	2422.	1430.	9.	112.75	794.75
> 38.	294.	291.	256.	154.	74.	41.	18.	20.	35.	131.	185.	278.	1779.	908.	1.	181.59	2922.30
> 41.	181.	204.	210.	118.	48.	17.	30.	16.	30.	109.	175.	209.	1346.	1482.	1.	73.55	2361.30
> 44.	413.	306.	268.	145.	43.	46.	42.	28.	80.	139.	228.	301.	2019.	1208.	1.	126.13	4467.60
> 63.	512.	501.	426.	251.	115.	57.	62.	34.	78.	235.	262.	438.	2971.	2313.	3.	100.43	1965.20
> 69.	32.	33.	31.	30.	29.	28.	29.	10.	21.	29.	29.	35.	335.	1508.	4.	4.96	556.54
> 81.	331.	320.	384.	222.	97.	62.	62.	57.	56.	178.	194.	254.	2215.	1526.	3.	100.56	2014.50
> 85.	380.	426.	375.	222.	101.	44.	48.	42.	90.	204.	240.	237.	2388.	2702.	5.	64.76	1142.91
> 92.	383.	317.	294.	193.	103.	76.	81.	87.	103.	193.	101.	330.	2260.	1980.	6.	63.61	1470.50
> 100.	159.	140.	109.	110.	83.	40.	40.	34.	32.	73.	108.	144.	1070.	864.	2.	74.65	1861.50
> 102.	44.	36.	40.	38.	30.	32.	28.	31.	23.	28.	44.	35.	408.	1132.	3.	6.09	965.60
> 103.	30.	30.	30.	25.	28.	22.	20.	23.	23.	22.	25.	28.	305.	2100.	2.	1.92	1128.37
> 107.	200.	174.	111.	129.	97.	45.	42.	43.	59.	89.	149.	252.	1369.	1056.	1.	77.55	4809.30
> 108.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1533.	3.	-0.	-0.
> 110.	147.	144.	180.	120.	87.	42.	37.	37.	45.	105.	155.	180.	1267.	704.	4.	113.74	1025.10
> 113.	212.	238.	231.	129.	78.	88.	70.	59.	68.	122.	172.	198.	1639.	864.	5.	101.36	1327.53
> 128.	166.	182.	168.	80.	28.	24.	33.	20.	31.	84.	139.	152.	1100.	884.	3.	91.87	912.05
> 137.	271.	264.	218.	89.	42.	20.	27.	11.	30.	113.	192.	182.	1468.	1186.	1.	103.74	2223.60
> 144.	153.	150.	179.	112.	43.	24.	26.	26.	38.	83.	102.	141.	1073.	863.	2.	87.00	1431.82
> 149.	-0.	-0.	138.	114.	66.	37.	49.	54.	54.	107.	145.	161.	-0.	1505.	5.	-0.	991.44
> 156.	185.	161.	178.	136.	69.	50.	45.	49.	55.	105.	137.	156.	1326.	683.	3.	108.85	1690.65
> 160.	207.	203.	144.	111.	57.	53.	76.	42.	100.	118.	128.	168.	1406.	1008.	7.	60.06	986.49

> LEGEND: GAS.1--GAS IN HUNDRED CUBIC FEET(CCF) USED
 > DURING JANUARY,1980, (MUNICIPAL)
 > GAS.2--SAME AS ABOVE,EXCEPT FOR FEBRUARY,ETC.
 > GA.TOT--TOTAL GAS USED DURING THE YEAR DECEMBER,
 > 1979,-NOVEMBER,1980, IN HUNDRED CUBIC FEET

SQ.FT.--HOUSE FLOOR AREA IN SQUARE FEET
 MBTU--A THOUSAND BRITISH THERMAL UNITS
 #OC--NUMBER OF OCCUPANTS

* ELECTRICAL ENERGY CONSUMPTION DATA FOR 63 HOMEOWNERS CITY OF ANN ARBOR *															

ID	ELE.1	ELE.2	ELE.3	ELE.4	ELE.5	ELE.6	ELE.7	ELE.8	ELE.9	ELE.10	ELE.11	ELE.12	ELE.TOT	SQ.FT	#OCCU KWH/OC
3.	1031.	770.	689.	483.	364.	533.	683.	558.	546.	593.	598.	792.	7638.	2528.	10. 63.85
6.	756.	707.	546.	483.	378.	482.	407.	444.	390.	446.	471.	492.	6012.	1635.	2. 250.50
7.	378.	360.	375.	353.	445.	462.	654.	759.	513.	434.	420.	415.	5568.	1344.	2. 232.00
8.	262.	235.	254.	237.	241.	234.	275.	303.	281.	283.	251.	263.	3119.	1180.	1. 259.92
14.	626.	629.	676.	520.	424.	462.	598.	728.	616.	520.	583.	663.	7045.	1724.	4. 146.77
15.	413.	390.	385.	337.	297.	291.	341.	302.	310.	310.	396.	376.	4148.	864.	3. 115.22
19.	757.	696.	590.	551.	376.	361.	327.	630.	418.	376.	327.	634.	6044.	1120.	5. 100.73
20.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1128.	3. -0.
33.	678.	633.	546.	527.	434.	516.	533.	533.	516.	402.	518.	480.	6318.	1068.	3. 175.44
36.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1430.	9. -0.
38.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	908.	1. -0.
41.	508.	482.	473.	428.	367.	303.	326.	338.	320.	337.	501.	499.	4882.	1482.	1. 406.83
44.	348.	279.	284.	238.	217.	216.	254.	225.	253.	297.	295.	466.	3370.	1208.	1. 280.83
63.	596.	473.	546.	568.	558.	524.	556.	564.	590.	680.	677.	679.	7011.	2313.	3. 194.75
69.	384.	357.	370.	355.	345.	343.	400.	393.	382.	406.	408.	413.	4556.	1508.	4. 94.92
81.	399.	479.	548.	422.	395.	436.	454.	401.	468.	471.	440.	385.	5298.	1526.	3. 147.17
85.	974.	972.	859.	691.	669.	691.	692.	645.	645.	818.	931.	954.	9641.	2702.	5. 160.68
92.	500.	431.	439.	412.	418.	419.	448.	505.	513.	491.	499.	547.	5622.	1960.	6. 78.08
100.	400.	375.	124.	123.	234.	226.	318.	320.	292.	293.	339.	339.	3384.	864.	2. 141.00
102.	424.	347.	349.	298.	280.	269.	274.	272.	300.	337.	389.	452.	3971.	1132.	3. 110.31
103.	274.	287.	304.	210.	217.	245.	261.	239.	231.	281.	271.	300.	3120.	2100.	2. 130.00
107.	308.	274.	298.	330.	345.	271.	338.	353.	368.	291.	261.	307.	3738.	1058.	1. 311.50
108.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1533.	3. -0.
110.	405.	671.	581.	561.	451.	487.	521.	526.	546.	538.	653.	413.	6334.	704.	4. 131.96
113.	704.	704.	680.	674.	655.	644.	1424.	993.	1043.	587.	674.	699.	9481.	864.	5. 158.02
128.	840.	820.	783.	693.	479.	461.	388.	289.	365.	675.	830.	806.	7409.	864.	3. 205.81
137.	413.	374.	389.	378.	350.	324.	321.	282.	273.	276.	253.	402.	4035.	1186.	1. 336.25
144.	339.	187.	259.	153.	163.	165.	121.	201.	209.	264.	259.	193.	2513.	863.	2. 104.71
149.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1505.	5. -0.
156.	291.	287.	249.	261.	297.	134.	203.	259.	241.	296.	335.	283.	3136.	683.	3. 87.11
160.	588.	588.	549.	549.	451.	451.	505.	443.	518.	451.	500.	592.	6181.	1008.	7. 73.58
LEGEND: ELE.1--ELECTRICITY IN KILOWATT-HOURS USED SQ.FT.--HOUSE FLOOR AREA IN SQUARE FEET															
DURING JANUARY,1980 (MONTH 1) #OC--NUMBER OF OCCUPANTS															
ELE.2--SAME AS ABOVE,EXCEPT FOR FEBRUARY, ETC. MBTU--A THOUSAND BRITISH THERMAL UNITS															
ELE.TOT--TOTAL KILOWATT-HOURS USED DURING															
THE YEAR DECEMBER,1979,-NOVEMBER,1980															

Figure 5.5-D Utility Record- Electric - Audit Group

* ELECTRICAL ENERGY CONSUMPTION DATA FOR 63 HOMEOWNERS CITY OF ANN ARBOR *															

> ID	ELE.1	ELE.2	ELE.3	ELE.4	ELE.5	ELE.6	ELE.7	ELE.8	ELE.9	ELE.10	ELE.11	ELE.12	ELE.TOT	SQ.FT	#OCCU KWH/OC
> 163.	601.	392.	429.	347.	354.	365.	319.	353.	401.	432.	437.	516.	4946.	852.	6. 68.69
> 164.	327.	313.	317.	359.	279.	273.	275.	316.	306.	340.	367.	357.	3830.	902.	2. 159.57
> 185.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1147.	2. -0.
> 191.	410.	403.	403.	200.	200.	176.	176.	189.	201.	321.	320.	410.	3409.	1091.	1. 284.08
> 208.	474.	462.	499.	435.	384.	385.	385.	333.	378.	420.	415.	400.	4970.	1224.	3. 138.06
> 214.	947.	842.	823.	754.	717.	849.	1066.	1047.	1065.	1011.	943.	915.	10979.	2044.	7. 130.70
> 215.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	2046.	1. -0.
> 217.	597.	684.	542.	242.	283.	255.	261.	295.	278.	448.	474.	525.	4884.	1242.	2. 203.50
> 217.	597.	684.	542.	242.	283.	255.	261.	245.	278.	448.	474.	525.	4834.	1242.	3. 134.28
> 233.	531.	357.	450.	431.	424.	406.	539.	630.	492.	445.	521.	522.	5748.	2190.	3. 159.67
> 237.	1002.	883.	828.	711.	640.	564.	634.	678.	652.	796.	943.	1026.	9357.	1242.	7. 111.39
> 245.	608.	607.	700.	660.	506.	500.	477.	477.	550.	504.	670.	670.	6929.	1186.	7. 82.49
> 253.	744.	691.	676.	655.	689.	663.	770.	846.	785.	750.	651.	752.	8652.	1277.	2. 360.50
> 257.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	1973.	3. -0.
> 288.	380.	369.	297.	322.	240.	241.	304.	207.	283.	258.	335.	329.	3545.	864.	2. 147.71
> 280.	431.	332.	280.	298.	298.	278.	262.	241.	247.	317.	379.	439.	3802.	936.	4. 79.21
> 292.	500.	482.	648.	410.	363.	238.	365.	328.	392.	359.	482.	430.	4988.	1008.	8. 52.06
> 293.	907.	768.	756.	749.	724.	665.	744.	754.	685.	699.	843.	883.	9177.	1822.	4. 191.19
> 308.	484.	432.	467.	391.	343.	322.	357.	370.	354.	393.	431.	561.	4905.	1427.	4. 102.19
> 320.	868.	705.	706.	588.	587.	624.	623.	694.	684.	668.	668.	668.	8292.	1584.	4. 172.75
> 321.	199.	199.	195.	176.	171.	144.	209.	257.	303.	361.	363.	215.	2792.	1122.	4. 58.17
> 326.	669.	656.	758.	764.	790.	811.	822.	714.	645.	682.	660.	711.	8682.	2069.	5. 144.70
> 328.	134.	222.	244.	207.	155.	118.	136.	233.	235.	147.	174.	183.	2188.	1619.	1. 182.33
> 331.	273.	256.	261.	242.	272.	315.	419.	417.	346.	352.	299.	292.	3744.	1335.	2. 156.00
> 346.	606.	534.	617.	501.	468.	398.	508.	512.	488.	576.	609.	847.	6460.	1100.	1. 538.33
> 348.	589.	455.	421.	337.	310.	257.	303.	301.	392.	469.	462.	580.	4876.	1260.	3. 135.44
> 349.	944.	922.	1044.	938.	758.	981.	513.	713.	892.	915.	974.	1130.	10524.	1178.	3. 292.33
> 375.	498.	466.	404.	372.	416.	386.	468.	490.	531.	579.	503.	464.	5577.	1845.	3. 154.92
> 409.	461.	413.	588.	462.	457.	411.	592.	635.	529.	386.	414.	480.	5826.	1107.	1. 485.50
> 412.	546.	459.	555.	487.	406.	418.	469.	401.	410.	420.	469.	556.	5596.	1078.	3. 155.44
> 414.	251.	180.	244.	188.	143.	205.	194.	234.	170.	194.	354.	243.	2600.	992.	2. 108.33
> 418.	640.	585.	534.	536.	408.	561.	642.	544.	619.	546.	656.	575.	6846.	864.	3. 190.17

> LEGEND: ELE.1--ELECTRICITY IN KILOWATT-HOURS USED
 > DURING JANUARY, 1980 (MONTH 1)
 > ELE.2--SAME AS ABOVE, EXCEPT FOR FEBRUARY, ETC.
 > ELE.TOT--TOTAL KILOWATT-HOURS USED DURING
 > THE YEAR DECEMBER, 1979, -NOVEMBER, 1980

SQ.FT.--HOUSE FLOOR AREA IN SQUARE FEET
 #OC--NUMBER OF OCCUPANTS
 MBTU--A THOUSAND BRITISH THERMAL UNITS

Figure 5.5-E Utility Record Gas - Control Group

***** * GAS ENERGY CONSUMPTION DATA FOR 63 HOMEOWNERS CITY OF ANN ARBOR * *****																	
ID	GAS.1	GAS.2	GAS.3	GAS.4	GAS.5	GAS.6	GAS.7	GAS.8	GAS.9	GA.10	GA.11	GA.12.	GA.TOT	SQ.FT	#OC	MBTU/SF	MBTU/OC
> 163.	229.	227.	236.	187.	93.	78.	73.	49.	68.	122.	178.	212.	1749.	852.	6.	114.32	1124.55
> 164.	144.	154.	136.	72.	38.	26.	27.	25.	34.	66.	105.	123.	950.	902.	2.	69.60	1420.35
> 185.	29.	21.	22.	21.	22.	20.	21.	17.	18.	18.	21.	20.	250.	1147.	2.	1.79	975.37
> 191.	271.	253.	236.	133.	73.	27.	41.	25.	52.	133.	199.	206.	1648.	1091.	1.	113.48	3694.95
> 208.	143.	104.	123.	81.	54.	39.	37.	36.	20.	62.	100.	164.	863.	1224.	3.	47.25	1122.00
> 214.	476.	473.	391.	235.	73.	43.	53.	38.	52.	206.	305.	447.	2792.	2044.	7.	111.48	877.57
> 215.	31.	24.	27.	529.	203.	23.	53.	72.	70.	72.	68.	42.	1211.	2046.	1.	27.92	5536.05
> 217.	189.	185.	191.	135.	53.	24.	20.	24.	57.	122.	151.	89.	1240.	1242.	2.	71.04	1593.75
> 217.	189.	185.	191.	135.	53.	24.	20.	24.	57.	122.	151.	89.	1240.	1242.	3.	71.04	1062.50
> 233.	208.	194.	206.	155.	70.	84.	93.	32.	62.	104.	163.	210.	1581.	2190.	3.	35.77	2303.50
> 237.	300.	291.	125.	87.	87.	72.	67.	65.	77.	54.	217.	260.	1702.	1242.	7.	70.55	1023.64
> 245.	319.	241.	308.	221.	102.	68.	43.	40.	81.	149.	223.	318.	2095.	1186.	7.	125.29	774.47
> 253.	286.	330.	178.	164.	78.	39.	54.	48.	46.	148.	231.	299.	1901.	1277.	2.	107.10	2382.87
> 257.	225.	150.	207.	178.	70.	43.	28.	13.	45.	115.	181.	164.	1428.	1873.	3.	53.69	1103.30
> 286.	165.	288.	171.	92.	48.	34.	31.	31.	43.	73.	109.	140.	1223.	864.	2.	95.35	1767.15
> 290.	349.	326.	157.	107.	75.	32.	29.	42.	52.	134.	70.	209.	1580.	938.	4.	121.79	982.39
> 292.	254.	291.	276.	159.	91.	51.	62.	58.	90.	127.	187.	240.	1884.	1008.	8.	111.68	829.07
> 293.	273.	356.	342.	283.	59.	101.	70.	71.	100.	148.	273.	273.	2350.	1822.	4.	73.89	2188.54
> 308.	452.	435.	329.	198.	95.	45.	44.	42.	57.	148.	230.	240.	2314.	1427.	4.	125.23	1193.40
> 320.	-0.	-0.	-0.	-0.	-0.	-0.	30.	41.	63.	137.	149.	-0.	-0.	1584.	4.	-0.	-0.
> 323.	277.	255.	230.	139.	57.	31.	27.	10.	5.	112.	142.	207.	1491.	1122.	4.	115.49	469.84
> 326.	462.	435.	518.	323.	160.	97.	64.	61.	68.	224.	342.	420.	3173.	2069.	5.	113.65	1475.43
> 328.	264.	233.	205.	121.	47.	32.	13.	22.	35.	120.	183.	203.	1480.	1619.	1.	73.88	2618.85
> 331.	281.	267.	107.	50.	52.	50.	52.	52.	87.	87.	195.	248.	1540.	1335.	2.	62.37	3075.30
> 346.	558.	464.	361.	273.	160.	64.	30.	19.	79.	224.	370.	478.	3080.	1100.	1.	232.08	4908.75
> 348.	356.	327.	243.	149.	88.	32.	24.	22.	52.	150.	165.	314.	1898.	1260.	3.	122.12	1105.00
> 349.	113.	177.	184.	105.	40.	19.	17.	8.	25.	67.	118.	72.	822.	1178.	3.	62.03	582.25
> 375.	291.	411.	203.	172.	107.	89.	33.	13.	44.	166.	199.	187.	1915.	1845.	3.	76.27	1517.25
> 409.	301.	251.	241.	160.	83.	47.	33.	30.	56.	145.	218.	242.	1804.	1107.	1.	120.30	4235.55
> 412.	432.	440.	354.	201.	111.	41.	14.	17.	70.	190.	316.	420.	2604.	1078.	3.	206.37	1199.35
> 414.	25.	23.	25.	25.	24.	23.	18.	20.	12.	15.	23.	23.	256.	992.	2.	3.45	946.05
> 418.	171.	213.	217.	166.	146.	41.	35.	37.	59.	148.	235.	148.	1616.	864.	3.	129.84	1462.00

> LEGEND: GAS.1--GAS IN HUNDRED CUBIC FEET(CCF) USED SQ.FT.--HOUSE FLOOR AREA IN SQUARE FEET
 > DURING JANUARY,1980, (MONTH 1) MBTU--A THOUSAND BRITISH THERMAL UNITS
 > GAS.2--SAME AS ABOVE,EXCEPT FOR FEBRUARY,ETC. #OC--NUMBER OF OCCUPANTS
 > GA.TOT--TOTAL GAS USED DURING THE YEAR DECEMBER,
 > 1979,-NOVEMBER,1980, IN HUNDRED CUBIC FEET

Figure 5.5-F Utility Record Electric - Control Group