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A STUDY OF RELATIONSHIPS BETWEEN LIFE STYLES AND RESIDENTIAL ENERGY CONSUMPTION

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A STUDY OF RELATIONSHIPS BETWEEN LIFE STYLES AND RESIDENTIAL ENERGY CONSUMPTION

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

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A STUDY OF RELATIONSHIPS BETWEEN LIFE STYLES

AND RESIDENTIAL ENERGY CONSUMPTION

APPROVED BY

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DISSERTATION COMMITTEE

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TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES--Continued

A STUDY OF RELATIONSHIPS BETWEEN LIFE STYLES

AND RESIDENTIAL ENERGY CONSUMPTIONS

CHAPTER I

INTRODUCTION

In the 1970's a surge of interest in energy conservation arose in the United States. For many, the winter of 1973-74 brought the startling revelation that the American life style was heavily dependent upon reliable and inexpensive sources of energy.[1] The general problem, referred to as "the energy crisis," has been one of increasing costs and decreasing availability of energy resources coupled with increasing demands from industry, commerce, and individuals. Concern about increased energy prices and limits on energy supplies has motivated individuals and organizations to consider the problem, to reduce consumption levels, or at least to slow the rates of increase.[2] Subsequent research has led to a clearer understanding of energy problems, and a

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[1]Demand and Conservation Panel of the Committee on Nuclear and Alternative Energy Systems, U.S. Energy Demand: "Some Low Energy Futures," Science 200 (April 1978) pp. 142-144.

[2]Federal Energy Administration, Project Independence, A Summary, (Washington, D.C.: Government Printing Office, Nov. 1974), pp. 20-21.

variety of conservation strategies have been adopted by many organizations and individuals.[1]

Conservation strategies are usually based on recognizing and eliminating wasteful patterns of energy consumption. These wasteful patterns arose in the United States in response to inexpensive energy supplies. Total energy consumption in the United States in the fifty years prior to 1970 increased by three and one-half times, while the Gross National Product rose more than five times. The energy consumption per dollar of the Gross National Product decreased between 1920 and 1965 but rose dramatically after that date. Energy consumption per capita rose rapidly from 1940 and in the decade of the 1960's recorded a thirty percent increase. Several facets of these energy consumption patterns will be presented in tables and discussed in detail in the next chapter.

The increased per capita consumption occurred simultaneously with technological advances which brought to the consumer more flexible and environmentally acceptable fuels. Electricity consumption per capita increased by fifteen hundred percent from 1920 to 1970 accounting for one-quarter of the total power in that year. The shift from coal to petroleum, natural gas and electricity changed consumer behavior with respect to transportation, residential location, living place amenities, and was associated with a rise in expectations concerning living standards and the quality of life.[2]

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[1]Douglas M. Lambert and James R. Stock, "Organizing and Implemeting the Corporate Energy Plans," MSU Business Topics (Summer 1979), pp. 10-15.

[2]Harry W. Richardson, Economic Aspects of the Energy Crisis, (Lexington: Lexington Books, 1975), p. 8-9.

After World War II energy prices relative to the costs of most other goods showed a steady decline up until the petroleum embargo of 1973-74. During that period, per capita income increased, placing more money at the disposal of consumers.[1] One effect of the growing affluence was an increased demand for large single family homes in suburbs and in urban fringe areas. The exodus of residents from the urban central core to suburbs and exurbia was sustained partly by the low cost of automobile travel. As a result, urban sprawl has increased demand for energy to maintain accustomed life styles.[2] Traditionally, residential design and the engineering of household equipment paid little attention to energy use.[3]

The American life style formed after World War II was in large measure supported by the abundance of inexpensive energy. Factories and commercial centers used inexpensive fuels to increase productivity and make shopping places more attractive and comfortable for consumers.[4] The industrial and commercial sectors came to consume about fifty-five percent of all energy produced. Two other major consuming sectors, transportation and residential, came to use about twenty-two percent and nineteen percent respectively.[5]

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[1] Richardson, p. 8.

[2] Jean Gottmann and Robert A. Harper eds., Metropolis on the Move, (New York: John Wiley and Sons, Inc. 1967), p. X.

[3] Eric Hirst, "Reducing Residential Energy Growth." ASHRAE Journal, (January 1976): p. 44.

[4] Eric Hirst and John C. Moyers, "Efficiency of Energy Use in the United States," Science 179, No. 4080 (March 30, 1973) p. 1304.

[5] John M. Flower, Energy and the Environment, (New York: McGraw-Hill Book Co. 1975), p. 80.

The residential sector deserves specific attention because the decreased energy availability and the increased costs have affected every household. Research lending insight into the relationships of housing characteristics, family activities and energy consumption offers the prospect of contributing towards the resolution of this social and economic problem.[1] Recognizing the dependence on energy intensive appliances that cook, heat, cool, wash, light and clean residences, provides a motive to understand better the relationship between American life styles and residential energy consumption.

Recently, research into consumer behavior and residential energy consumption has increased. Newman and Day's[2] work has illuminated aspects of residential energy consumption related to poverty, wealth, family size, and family background. Keys and Peterson's[3] research on energy consumption and metropolitan development helped to integrate the concepts and data characterizing the influence of residential consumers on energy consumption. A research program of the Center for Environmental Studies (Princeton University) has generated information leading to greater understanding of the consumer's role in possible solutions to the "energy crisis."[4] Still, relatively few

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[1]Hirst and Moyers, pp. 1299-1304.

[2]Dorothy K. Newman and Dawn Day, The American Energy Consumer (Cambridge: Ballinger Publishing Co., 1975).

[3]Dale L. Keys and George E. Peterson, Metropolitan Development and Energy Consumption, Land Use Center Working Paper: 5049-15. (Washington, D.C.: The Urban Institute, March 23, 1977).

[4]Richard Grot and Robert Socolow, Energy Utilization Win a Residential Community, Presented at M.I.T. Sumposium, February 1973, pp. 483-499.

social scientists, have tried to relate energy consumption and patterns of social behavior.[1]

Bringing into clearer focus a small part of the complex residential energy system is the objective of this study, which addresses the relationships of certain types of human behavior and energy consumption in residential dwelling units. An important goal is to identify and measure the interacting components comprising household energy systems, which in turn affect energy consumption in residential structures. Because of the complexity of a household energy system, only key segments can be studied. The specific purposes, therefore, must be further specified and amplified.

Goals and Purpose

The major purpose of this study is to establish and examine relationships between structural and site specific characteristics of dwelling units, life styles, and family life cycles of the inhabitants, and the magnitude of residential energy consumption. Much of the information about residential energy consumption has been generated in the physical-technical disciplines. Combining research on human behavior with physical characteristics of the dwelling unit should lead to a better understanding of how these various elements interact and how they combine to influence energy consumption.

Of special importance to achieving these research goals is an understanding and application of the concept of "life style" and how

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[1] Laura Nader and Stephen Beckerman, "Energy As It Relates to the Quality and Style of Life" Annual Review of Energy 3 (1978) p. 1.

it relates to physical and demographic attributes which influence residential energy consumption. The life style element has received very little attention with respect to its impact on either energy consumption or energy conservation. Therefore, another purpose of this project is to amplify the understanding of the magnitude of the impact of different life styles on residential energy consumption. For the purposes of this study, a measure of life style is based on an orthodox definition of life style, namely how families and family members choose to spend their time. There are other discretionary definitions of life style such as how consumers spend their money. The personal expenditure of time definition was chosen because of the measurable awareness of time allocation on the part of consumers.

Scope of the Study

The scope of this research is narrowly focused, but includes many variables suspected to be major influences on the amount of energy consumed by individual households. The variables considered include physical attributes as well as behavioral and demographic characteristics. The life style variables attempt to measure the use of the residence, the types of activities in which the occupants are engaged, and family life cycle stages.

The specific research design, described in chapter three, stipulates controls on the residences and occupants to be surveyed and analyzed. For example, only all-electric residences (single-family dwellings, condominiums and apartments) constructed within one municipality in a specific year were sampled, and only those occupants who lived in the residence for at least one year were considered. Such controls help to eliminate variance caused by changes in technologies and family life style.

The results and implications of this study have certain limitations. One, common in studies of this nature, is that the results are valid only for the time and place where the data were gathered. Still, the conclusions will hopefully be of general use in furthering the understanding of the relationships among the physical character of the dwelling, the families' living patterns and the consumption of energy. This study cannot hope to formulate a model which predicts with precision residential energy use by reducing that variable to a few key structural, behavioral, or demographic attributes. Energy use, even at the household level, is a result of a very complex interplay of personal and physical characteristics, including many personal choice opportunities which defy measurement. Still, it should be possible to identify key characteristics which explain a large percentage of variance in household energy use.

Problem Justification

A greater understanding of the relationships between how residents choose to spend their time and energy consumption in the home could have far reaching and beneficial effects on the future development and spatial patterning of residential construction and life style choice. This greater understanding of the role of consumer behavior with respect to residential energy consumption could have benefits which take the form of new living patterns, dwelling units, housing amenities, recreational facilities and the overall improvement of the quality of life in the face of restricted energy use. Rather than extrapolating present solutions for future energy shortages, this study is based on a hope to facilitate the creation of living environments which promote human growth and personal and social satisfaction.

Presentational Sequence

The first major division of this study addresses the accumulated literature on the overall energy problem and the specific problem of this research. It is further divided into three main parts: further delineation of the problem, a review of the life style constructs and a review of studies concerned with residential energy consumption. The literature on residential energy consumption can generally be classed as "technical-engineering" inquiries or "consumer behavior" inquiries. Seldom have these two channels been integrated in the form outlined for this study.

Chapter Three, "Research Methodology and Data Collection," addresses three main topics: 1) the research design, the data survey and implementation; 2) the data analysis procedures; and, 3) conclusion comments on improving the efficiency of the research project.

Chapter Four, the "Analysis and Results" chapter, discusses similarities and differences in single family and multifamily residential units selected for study. The relationships in these data are displayed in factor analysis dimensions with their respective discriminant coefficients, and discriminant classification tables. In this chapter, the objective is to identify significant variables and to measure their importance to residential energy consumption. In the "Summary and Conclusions" chapter, the results of the study are compared with the initial objectives. A summary of important relationships is offered with possible implications of the findings with respect to future development of residential design, family life styles, personal and policy alternatives, and, finally, energy conservation strategies are offered for consideration.

CHAPTER II

THE PROBLEM DELINEATION AND THE LITERATURE REVIEW

Attention is given in this section of the research project to (1) the presentation of data showing the development and current status of the problem of high energy consumption in residential units; (2) the meaning and use of the life style construct, with emphasis on the application of the concept to residential energy consumption; and (3) a review of literature and current studies focusing on research done within the context of residential consumption of energy.

Residential Energy Consumption

In 1876, electricity illuminated the Philadelphia Centennial Exposition; yet in 1907, only eight per cent of the families in large American cities were using it. By 1925, over one half of all homes, most of them in urban and rural non-farm places, were wired for electricity. In a relatively short time thereafter, nearly 100 per cent of the dwelling units in America were electrically serviced. (See Table 1). It is apropros to note that by the early thirties, natural gas had also become common in urban dwellings.[1]

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[1] Barry Commoner, The Poverty of Power (New York: Bantam Books, 1977), p. 50.

TABLE 1

GROWTH OF RESIDENTIAL ELECTRIC AND NATURAL GAS SERVICE, SELECTED YEARS, 1901-1973

	Per cent of homes with electricity			Per cent of homes with natural gas
Year	Total	Urban & Rural Nonfarm	Farm	
1907	8	b	b	b
1912	16	b	b	b
1917	24	b	b	b
1920	35	47	2	b
1925	53	69	4	b
1930	68	85	10	b
1935	68	84	13	46
1940	79	91	33	47
1945	85	93	48	50
1950	94	97	78	51
1955	98	99	94	55
1960	99	b	b	58
1965	100[d]	b	b	60
1970	100[d]	b	b	61
1973	100[d]	b	b	68[c]

SOURCE: Prepared by the Washington Center of Metropolitan Studies from U.S. Bureau of the Census Historical Statistics of the U.S. Colonial Times to 1957, Series S 71-73, p. 510 and Current Population Reports p-20, No. 218, Household and Family Characteristics, March 1970, Table 20, p. 85, American Gas Association, 1972 Gas Facts, Table 58, p. 68; and for 1973, The Washington Center for Metropolitan Studies' Life styles and Energy Surveys. As found in The American Energy Consumer, p. 4.

[a]Computed using number of residential customers and total households.

[b]Not available.

[c]Households with natural gas, from Survey, see Source.

[d]Rounded to 100 percent.

The rapidly increasing supply of energy sources swiftly changed the living patterns of the American people. One example of an energy related innovation was the radio. Advertisers began using it in the 1920's to sell other electrical appliances and household aids. Not only did electricity provide the means of bringing advertising messages into American homes, but it also brought music, entertainment, political speeches, and news of the world. As Table 2 shows, the demand for electronic media grew rapidly.

TABLE 2

PER CENT OF HOUSEHOLDS WITH RADIO AND TV, SELECTED YEARS, 1923-1973

Year	Radio	TV
1923	2	0
1925	10	0
1930	46	0
1935	67	0
1940	81	0
1945	88	[a]
1950	93	9
1955	96	64
1960	95	87
1965	100[b]	92
1970	100[b]	96
1973	100[b]	97

SOURCE: Prepared by the Washinton Center for Metropolitan Studies from U.S. Bureau of the Census, Historical Statistics of the U.S. Colonial Times to 1957; and Continuation to 1962 and Revisions, Series A242 and R 97-98; Statistical Abstract of the U.S. 1972, Tables 50, 803, and 1162; 1969 Table 1088, 1968, Tables 743 and 1097, and 1965, Table 729; and the Washington Center for Metropolitan Studies' Life styles and Energy Surveys for 1973. As found in The American Energy Consumer, p. 5.

[a]Less than 0.5 per cent.

[b]Rounded to 100 per cent.

As energy sources became more usable, the technology of transportation, food preparation, communication, medical treatments, sewage disposal and a myriad of other amenities came into existence and improved the quality of life. For example, the number of passenger cars grew from about two hundred thousand in 1910 to almost two million in 1920.[1] The American style of life changed rapidly with the availability of inexpensive fuels. These changes were reflected in many ways, including the role of government; for example, the Federal Aid to Roads Act helped to increase the length of hard surfaced roads from 70,000 miles in 1904 to 700,000 miles in 1930. Low cost energy also helped the American consumer become accustomed to a life style involving increased choices of appliances and household amenities. Table 3 shows the increases in ownership of some appliances. The rapid consumption of the non-renewable fuels used to build a life style of abundance is now threatened to come to an abrupt halt. The next part examines the non-renewable fuel situation.

Residential Fuels Availability

There is no exact inventory of the petroleum reserves; however, Hubbert and others have estimated that the United States will exhaust its supply of petroleum early in the 21st Century.[2] Of late there has been renewed activity in petroleum exploration. High crude oil prices sustained by world wide demand has encouraged some exploration and production companies to search for new domestic petroleum deposits and rework old deposits.

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[1]Flower, pp. 69-79.

[2]Commoner, p. 46.

TABLE 3

PERCENTAGE OF HOUSEHOLDS HAVING SELECTED
MAJOR APPLIANCES AVAILABLE, SELECTED
YEARS, 1922-1978

Year	Refrigerator	Clothes Washer	Dish-washer	Color TV	Clothes Dryer	Home Freezer
1922	a	8	a		0	b
1925	1	13	b	0	0	b
1930	9	24	b	0	0	b
1935	23	32	a	0	b	b
1940	46	44	b	0	b	b
1945	53	49	b	0	b	b
1950	77	b	2 2	0	1	6
1955	91	b	4 4	a	9	16
1960	98.2	55.4	7.1	a	19	23
1965	99.5	57.4	13.5	10	26	27
1970	99.8	62.1	26.5	43	45	31
1975	99.9	73.3	38.3	74.4	57.7	43.5
1978	99.9	75.2	41.9	85.2	60.3	44.9

SOURCE: Prepared by Washington Center of Metropolitan Studies using saturation of appliances data and estimates of wired homes from February 28, 1972 issue of Merchandising Week, applied to Census estimates of all households for the years shown. Census data are from Historical Statistics of the U.S. Colonial Times to 1957, Series A242, p. 15, and Statistical Abstract of the U.S. 1973, Table 51, p. 40. U.S. Bureau of the Census, Statistical Abstract of the United States: 1979. (100 edition) Washington, D.C., 1979 Table No. 1308, p. 788.

NOTE: The data for 1922-1955 are from Merchandising Week which reports sales and may not account for availability of more than one appliance in the home or for those discarded.

[a]Less than 0.5 per cent.

[b]Data not available.

The American consumer's demand for petroleum products increases continually. The demand is satisfied by importing more crude petroleum, as shown in Table 4.

Coal, at one time the favored fuel of residential energy consumers, was gradually replaced by petroleum, natural gas and

TABLE 4

CRUDE PETROLEUM, U.S. PRODUCTION, EXPORT, AND IMPORTS

Sources	1960	1965	1970	1975	1978a
Domestic Production mil bbl.	2575	2849	3517	3057	3178
Export mil bbl.	3	1	5	2	58
Imports mil bbl.	372	452	483	1498	2275
Total Available mil bbl.	2944	3300	3995	4553	5511

SOURCE: U.S. Bureau of the Census, Statistical Abstract of the United States: 1978. (100th edition) Washington, D.C., 1979, Table No. 1329, p. 759.

[a]Preliminary.

electricity. Partly because coal is abundant in the United States, its use for electrical generation is increasing. Table 5 shows the coal consumption by use trends since 1960.

Natural gas gained acceptance as the primary heating fuel for residential and commercial structures; however, its use has declined somewhat in industrial establishments and its use for electricity generation. It is illegal to build new generating plants which are fueled by natural gas, and present natural gas fueled plant must change to coal. The household category's consumption of natural gas is approximately two-thirds of the figures shown for the residential-commercial category in Table 6.

Petroleum consumption has also declined in use for heating residential and commercial structures. Petroleum, on the other hand,

TABLE 5

COAL CONSUMPTION BY USE

Use	Consumption in Million Short Tons (Per Cent Used Shown in Parentheses) 1960	1965	1970	1978[a]
Total	407	473	524	624
Fuel Use	393 (99%)	467 (99%)	518 (99%)	624 (100%)
Non-Fuel Use	3 (1%)	5 (1%)	6 (1%)	z (z)
Household and Commercial	37 (9%)	26 (6%)	16 (3%)	10 (2%)
Industrial	175 (44%)	201 (43%)	187 (36%)	133 (21%)
Electrical Generation	177 (44%)	245 (52%)	321 (61%)	481 (77%)
Miscellaneous	9 (3%)	1 (z)	z (z)	z (z)

SOURCE: The U.S. Fact Book, The American Almanac for 1978, Table No. 1283, p. 752; U.S. Bureau of the Census, Statistical Abstract of the United States: 1978, (100 edition). Washington, D.C., 1979. Table No. 1325, p. 757.

[z]Less than 500,000 short tons of 1 per cent.

[a]Preliminary.

[b]Totals do not always add to 100 percent because of rounding error.

TABLE 6

NATURAL GAS CONSUMPTION BY USE

Use	Consumption in Billions of Cubic Feet (Per Cent Used Shown in Parentheses)				
	1960	1965	1970	1975	1978[a]
Total	12269	15598	21367	19537	19420
Fuel Use	11949 (97%)	15216 (97%)	20815 (97%)	19008 (97%)	NA NA
Non-Fuel Use	320 (3%)	382 (3%)	552 (3%)	529 (3%)	NA NA
Residential and Commercial	4132 (34%)	5347 (34%)	6894 (32%)	7192 (37%)	7280 (37%)[b]
Industrial	4535 (37%)	5958 (37%)	7889 (37%)	6979 (36%)	6520 (34%)
Electrical Generation	1725 (14%)	2318 (14%)	3894 (18%)	3147 (16%)	3220 (17%)
Pipeline Fuels	347 (3%)	501 (3%)	722 (3%)	583 (3%)	520 (3%)
Lease and Plant Fuel	2137 (10%)	1156 (10%)	1399 (7%)	1396 (7%)	1620 (8%)
Miscellaneous	302 (2%)	318 (2%)	569 (3%)	240 (1%)	260 (1%)

SOURCE: U.S. Bureau of the Census, Statistical Abstract of the United States: 1978. (100 edition). Washington, D.C., 1978. Table No. 1325, p. 757.

[a]Preliminary.

[b]Totals do not always add to 100 per cent because of rounding error.

NA Not Available.

has shown an increased consumption rate in the transportation, industrial, and electrical generation sectors. This is shown in Table 7.

TABLE 7

PETROLEUM CONSUMPTION BY USE

Use	Consumption in Millions of Barrels (Per Cent Used Shown in Parentheses) 1960	1965	1970	1975	1978[a]
Total	3611	4202	5365	5958	6870
Fuel Use	3301	3802	4787	5299	NA
	(91%)	(90%)	(89%)	(89%)	NA
Non-Fuel Use	310	400	578	659	NA
	(9%)	(10%)	(11%)	(11%)	NA
Residential and Commercial	853	978	1129	1007	1106
	(24%)	(23%)	(21%)	(17%)	(16%)
Industrial	644	740	961	1046	1401
	(18%)	(18%)	(18%)	(18%)	(20%)
Transportation	1934	2272	2903	3336	3703
	(54%)	(54%)	(54%)	(56%)	(54%)
Electrical Generation	90	119	334	518	660
	(2%)	(3%)	(6%)	(9%)	(10%)
Miscellaneous	90	93	38	51	65
	(2%)	(2%)	(1%)	(1%)	(1%)

SOURCE: U.S. Bureau of the Census, Statistical Abstract of the United States: 1978, (100 edition). Washington, D.C., 1979. Table No. 1325, p. 757.

[a]Preliminary.

NA Not Available.

The scarcity of energy has brought higher prices to consumers because of the dramatic price rises brought about by the Organization of Petroleum Exporting Counties (OPEC), the decreased domestic production and the devalued dollar in the international market. The following table shows the extent of some of the increased fuel prices for selected years:

TABLE 8

PRICE INDEXES FOR VARIOUS ENERGY SOURCES
IN 1967 DOLLARS, 1955-1977

Year	Electricity	Gas	Gas and Electricity	Fuel, Oil and Coal	Fuel, Oil number 2
1955	95.2	81.0	87.5	82.3	85.8
1960	99.8	97.7	98.6	89.2	89.6
1965	99.1	99.6	99.4	94.6	95.4
1967	100.0	100.0	100.0	100.0	100.0
1970	106.2	108.5	107.3	110.1	109.3
1975	167.0	172.5	169.6	235.3	230.6
1977	189.5	239.3	NA	NA	280.2

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Retail Prices and Indexes of Fuel and Utilities, Washington, D.C., September 1977, Table 1, a found in Building Energy Use Data Book, first edition, Oak Ridge National Laboratory, ORNAL-5363, April 1978, Table 11, p. 189.

NA Not Available.

American consumers have steadily increased expenditures in order to maintain their living standards and life styles. Table 9 suggests the extent to which the American consumers are willing to pay in order to gratify their demands for energy consuming amenities.

The per capita consumption of energy in America has continued to increase dramatically even though numerous pleas for a reduction in usuage have been made by a myriad of concerned individuals and groups throughout America and the world. Table 10 presents the statistics showing this consumption increase.

TABLE 9

PERSONAL CONSUMPTION EXPENDITURES BY PRODUCT
(Current $\$10^9$)

Product	1960	1970	1975	1977
Total Personal Consumption	324.9	618.8	979.1	1206.5
Housing	48.1	94.0	150.2	184.6
Household Operations[a]	46.1	87.8	142.3	176.9
Electricity	5.1	9.9	20.0	25.6
Gas	3.3	5.6	9.3	12.4
Transportation	42.4	78.0	125.5	172.1
Recreation	17.9	41.0	66.5	81.2

SOURCE: U.S. Bureau of the Census, Statistical Abstract of the United States: 1979 (100 edition). Washington, D.C., 1979, Table 723, p. 440.

[a] Includes item not shown separately.

TABLE 10

ENERGY CONSUMPTION IN THE UNITED STATES, SELECTED YEARS, 1920-1978

Year	Total U.S. Energy Consumption[a] (Trillions of BTU's)	Per Capita U.S. Energy Consumption (Millions of BTU's)
1920	19,768	185.7
1930	22,253	180.6
1940	23,877	180.1
1950	33,992	223.2
1960	44.569	246.7
1970	67,698	327.7
1971	68,698	331.8
1972	72,108	345.3
1973	75,561	359.1
1975	70,706	328.6[c]
1977	78,014	349.5[c]
1978[b]	78,000	NA

SOURCE: Energy Policy Project of the Ford Foundation, Exploring Energy Choices: A Preliminary Report, Washington, D.C., Energy Policy Project, 1974, Table 1, p. 74. U.S. Bureau of the Census, Statistical Abstract of the United States: 1978, (100 edition). Washington, D.C., 1979. Table No. 1009, p. 600.

[a]Includes coal, petroleum and natural gas and primary electricity. Firewood, animal wastes and most other noncommercial fuels are excluded.

[b]Preliminary.

[c]Calculated using population estimates from Population Estimates and Projections, U.S. Department of Commerce, Bureau of the Census. April, 1979.

NA Not Available

It seems that an increase in energy consumption, as shown in Table 11, could be the result of using more electricity within the residence. Most researchers hope that the many conservation strategies now being used will result in a leveling of the demand curve. The costs to the consumer, however, will probably continue to rise.

TABLE 11

RESIDENTIAL ELECTRICITY USE, 1960-1975

Use	1960	1965	1970	1975
Revenue ($\$10^3$)	4,855,799	6,328,756	9,415,707	18,803,156
Energy Sales (10^6 KW/hr)	196,400	280,970	447,795	586,149
Number of Customers	51,446,472	57,596,016	64,017,662	72,570,187
Average KW-hr Used by Customer	3,854	4,933	7,066	8,176
Average Annual Bill of Customer ($)	95.19	110.99	148.39	262.45
Average Revenue Per KW/hr Sold (¢)	2.47	2.25	2.10	3.21

SOURCE: Edison Electric Institute, Statistical Year Book of the Electric Utility Industry, 1975, New York, October 1976, Tables 19s, p. 31; Table 27s, p. 37; Table 33s, p. 43; Table 44s, p. 52; Table 45s, p. 53. As found in Buildings Energy Use Data Book, 1st edition, Oak Ridge National Laboratory, ORNL-5363, April 1978, Table 7.8, p. 202.

NOTE: All monies are in terms of current dollars.

These tables have been presented to delineate the energy problems of the residential consumer. The importance of the consumer's role in the energy crisis will be shown in the following segments of this chapter. Next is a discussion of the life style construct and how it lends insight to the consumer's behavior toward energy consumption.

Afterwards will follow a review of the literature and studies of residential energy consumption. In the last segment special attention will be paid to the use of the life style construct with respect to residential energy consumption.

Consumer Behavior: Life Styles

The comp.exity of residential energy consumption problem becomes more obvious by the addition of the consumer's behavior. One approach to the study of such behavior is the examination of family life styles. Life style has been a respected construct with a rich history in the behavioral sciences and marketing literature. An appreciation of the term "life style" and its flexibility is helpful in this research.

The origin of the use of the term in the behavioral sciences goes back to Weber and Adler.[1] Some of the terms that have been used interchangeably are "life style," "style of life," "life plan," "pattern of life," "life scheme," and "line of movements." These concepts are all meant to explain the individual or group ways of life. The "life style," or "style of life," is not merely on attribute. It _is_ the individual as an ongoing process, an individually unique way of living and goal striving.[2]

The life style construct has been used in the behavioral sciences to measure and explain social class, stratification, individual

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[1] _International Encyclopedia of the Social Sciences_, 1968 ed. s.v. "Adler, Alfred," by Alevandra Adler; p. 59 and _International Encyclopedia of the Social Sciences_, 1968 ed., s.v. "Stratification, Social: Social Class," by Seymour M. Lipset, p. 302.

[2] _International Encyclopedia of the Social Sciences,_ 1968 ed., s.v. "Individual Psychology," by Heinz L. Ansbacher and Rowena R. Ansbacher, p. 215.

motivations, and consumer behavior.[1] However, life style measurement scales have not been proven absolutely reliable.[2] Accounting for a person's expenditure of time is one approach which has been used with some success. The "time budget," though, has lost some favor among researchers because it relies too much upon the accuracy of the respondent's recall of how time was allocated.[3] Life style research is actively used in the field of marketing. "Psychographics," one method of measuring life style emerged in marketing research in the mid-1960's and flourished in later years.[4]

Marketing researchers have found the usual descriptors of behavior such as personality types, inadequate when trying to assemble a consumer profile. The early interest in life styles was exemplified by many of the papers presented at the 1963 meetings of the American Marketing Association. Lazer presented life style as an all inclusive term. For example, he said, "Such topics as mobility, leisure, social class, life cycle, status, conformity, mass, and the family as a

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[1] International Encyclopedia of the Social Sciences, 1968 ed., s.v. "Stratification, Social: Social Class," by Seymour M. Lipset, p. 302; International Encyclopedia of the Social Sciences, 1968 ed., s.v. "Consumers: Consumer Behavior," by Herbert Krugman, p. 349; and International Encyclopedia of the Social Sciences, 1968 ed., s.v. "Workers," by Robert Dubin, p. 571.

[2] International Encyclopedia of the Social Sciences, 1968 ed., s.v. "Stratification, Social: Measurement," by Robert W. Hodge and Paul M. Siegel, p. 321.

[3] International Encyclopedia of the Social Sciences, 1968 ed., s.v. Time Budgets," by Philip E. Converse, p. 46.

[4] William D. Wells, Life Style and Psychographics, (Chicago: American Marketing Association, 1974), p. 3.

consuming unit are all part of the life style fabric."[1] Sidney J. Levy, in his paper entitled "Symbolism in Life Style," asserted also that life style has multiple meanings including characteristics of life space.[2] David Moore pointed out in the same proceedings that life styles influence the family's meaning and belief systems, and that a family's life styles change and adapt through time.[3]

By the early 1970's the term "life style" had evolved from a sociological descriptor to an aspect of personal construct theory. Reynolds and Darden point out that life style is construed from the view of the persons; that is, it is a psychological as opposed to a sociological, construction.[4] They state, "Although persons allow us to notice their life styles, we never fully comprehend them."[5] In expanding their views of life style definition, they make the following statement:

> In essence, then we view a person's life style to be the construction system that he characteristically evolves for himself. Since life style is considered to be the construction system it is composed of construction subsystems each of which are made up entirely of personal construct.[6]

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[1]William Lazer, "Life Style Concepts and Marketing," American Marketing Association Proceedings (Winter, 1963), p. 132.

[2]Sidney J. Levy, "Sumbolism and Life Style," American Marketing Association Proceedings, (Winter, 1963), p. 140.

[3]David G. Moore, "Life Style in Mobile Suburbia," American Marketing Association Proceedings, (Winter, 1963), pp. 151-163.

[4]Fred D. Reynolds and William R. Darden, "Construing Life Style and Psychographics," in Life Style and Psychographics, ed. William D. Wells, (Chicago: American Marketing Association, 1974) p. 82.

[5]Ibid., p. 83.

[6]Ibid.

Emanual Demby has traced the development of psychographics. He has quoted Alan Andreasen as defining life style as follows:

> Life style is a social science concept connotating the totality of behaviors which comprise the characteristic approach to life of a particular individual or group . . . . Life style, in one important sense, can be looked upon as an allocation problem: given fixed resources of time, how do different groups apportion available time across various activities.[1]

There is a lack of consensus as to which definition fits life style best. Wind and Green have stated that in general life style refers to the overall manner in which people live and spend time and money. They go on to state:

> More specifically, a person's life style (or psychographic profile) has been measured and described in a number of ways including:
> (1) The products and services the person consumes . . .
> (2) The person's activities, interest and opinions . . .
> (3) The person's value system, especially his dominant system . . .
> (4) The person's personality traits and his concept of "self" . . .
> (5) The person's attitudes toward various product classes which may include the benefits he seeks in buying items in the category, special problems that items in the category might solve or general attitudes toward brands within the product class.[2]

Certainly Wind and Green have brought the definition back to a place where the life style definition is about what the researcher wants it to be. ". . . it seems that the procedure followed by most researchers is somewhat humble, hazardous and imperfect.[3]

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[1]Emanuel Demby, "Psychographics and from Whence It Came," in Life Style and Psychographics, ed. William D. Wells (Chicago: American Marketing Association, 1974), pp. 21-22.

[2]Yoram Wind and Paul E. Green, "Some Conceptural, Measurement, and Analytical Problems of Life Style Research," in Life Style and Psychographics, ed. William D. Wells (Chicago: American Marketing Association, 1974), p. 106.

[3]Ibid., pp. 106-107.

Aside from the marketing approach to the measurement of life styles, work is continuing in two directions. One is sociological and is based on the popularly accepted definition that life style is that ". . . pattern of eating and dressing, cultural and recreational activities, [and] relationships between parents and children."[1] This tack is useful when describing the living patterns and social class strata relationships such as that used by Caplow and Chadwick.[2] Their study focused on "working class" and "business class" shifts over time, and effects of class differences with respect to life styles.

Information gathered concerned the working day, the unemployment of family heads, the employment of married women, housing quality, the marital relationship and the parental role. By concentrating on these descriptions, the sociological inquiry requires a large amount of discussion to describe social class and differences.

Powell and Royce have taken the concept of life style and made it a basic definition in a comprehensive philosophy of human experience. In so doing, the term life style was elevated from consumer behavior and sociological descriptions to become a critical element in defining the philosophical basis of how humans live. Much of their inquiry centered on work life. They state: "Since work is inextricably tied to what it means to be alive, it becomes a focal

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[1]Metta Spencer, Foundations of Modern Sociology, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1978), p. 267.

[2]Theodore Caplow, and Bruce A. Chadwick, "Inequality and Life Styles in Middletown, 1920-1978," Social Science Quarterly (December, 1979), pp. 367-386.

point for humans attempting to find meaning in life."[1] Their interest in occupation went beyond job analysis to Icarism and Altruism. These philosophies, they content, lie at the base of human patterns of living and thus occupations fulfill personal concepts of meaning of life.

Such an elevated use of the life style concept is promising. However, from the point of view of a pragmatic researcher, it presents many measurement problems. The most straightforward approach to life style meaning and measurement still rests on the accounting of how persons choose to spend their resources -- chiefly their time and money. Inferences of these expenditures brings one to psychographic, sociological, or philosophical descriptions.

Residential energy consumption is partially a function of family decision making. Schiffman and Kanuk have stated: "Family life style commitments greatly influence consumption patterns. For this reason, marketers should be aware of trends concerning family allocation of time, for how time is spent reflects changing family life styles."[2]

As stated previously, the term "life style" is defined in this study as how persons and families choose to spend time. Within the context of other research problems, life style could be defined more broadly.

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[1] Arnold Powell, and Joseph R. Royce, "Path to Being, Life Style, and Individuality," Psychological Reports (June 1978), pp. 987-1005.

[2] Leon G. Schiffman and Leslie Lazan Kanuk, Consumer Behavior, (Englewood Cliffs, N.J.: Prentice Hall, Inc., 1978), p. 236.

Other social factors might also have an impact on residential energy consumption. Specifically, those constructs and topics familiar in sociology, such as social class, role orientation, family life cycle, and time constraints are related in as yet unexplainable ways to energy consumption.

A Review of Current Studies and Pertinent Literature

The literature relative to energy conservation clearly points out that the two major variables in energy consumption are life style and technical-engineering attributes. One way to conserve energy in residences is through change in life styles; another is to continue the same life style but change the physical attributes of the residence.

While the physical scientist and the engineer have conducted basic and applied research in the use of energy for many decades, the research done by the social scientists has appeared in the literature only since the latter part of the 1950's. Nader and Beckerman point out:

> Energy is becoming a multi-disciplinary concern. What was once the province of physicists and engineers is now the growing concern of a wide variety of people, but energy research is not yet peopled by the full range of talent that society can bring to bear.[1]

These two anthropologists argue persuasively that social scientists must become involved with the "energy crisis" so that the eventual solutions to the crisis will not be harmful to the advancement of society and individuals.

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[1]Nader and Beckerman, p. 1.

Nader and Beckerman also examined the life style construct. They sought to examine how life style has been affected by technological changes and the likely effect these changes could have on life style should the current level of energy availability be decreased substantially. They concluded by stating: ". . . there is no evidence that increasing energy use will increase the quality of American life."[1] They include the following in their final remarks:

> . . . there is a very wide range of choice of life styles that is available in any plausible energy future. Furthermore, it is commonplace that individuals are able to change their life styles with or without a change in energy policy or even a change in level of energy use.[2]

The "oil crisis" situation will bring about changes in population growth, city growth, production, and consumption. Bruce Hannon states that coping with the changes should follow a philosophy and policy of not trying to provide the "greatest good for the greatest number" with the dwindling energy resources but should follow a philosophy and policy of "life styles of elegant frugality."[3] The changes needed according to Hannon, can be thought of as efficiency improvements in our current life styles.[4]

Current life styles are in a large part a function of the persuasive tactics of the producers and marketers of goods and services. However, ". . . it is clear . . . that consumers are in control of a

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[1]Ibid., p. 25.

[2]Ibid.

[3]Bruce Hannon, "Energy Conservation and the Consumer," Science 189 (July 11, 1975); p. 95.

[4]Ibid., p. 96.

significant portion of the decisions that affect [energy] consumption directly or indirectly."[1]

Builders and building material suppliers, as well as others in the industry who conserve energy through design and construction methods, sometimes fail because their efforts are in conflict with the consumer's wants. Attitudes of the consumer toward housing and the energy crisis are at the base of the resident's life style. A change in the consumer's life style must start with a change in his behavior.[2] Therefore, a thorough understanding of consumer behavior and energy conservation in the home is needed.

Recognizing that life styles and consumption are linked, researchers Mazur and Rosa conducted a world-wide statistical correlation research project that consisted of correlating 27 variables, which seemed to be indicative of certain aspects of life style and electricity consumption per capita of 55 different countries. Nineteen of the countries were considered to be developed; 7 had centrally planned economies; and 29 were still developing. Both Canada and the United States were excluded from the computations. The life style indicators chosen by Mazur and Rosa included indicators of four main categories: health and health care, education and culture, general satisfaction, and economics. The researchers reported: "The most striking feature of the first correlation array [for all nations] is

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[1]Congress of the U.S. Office of Technology Assessments, Residential Energy Conservation, Vol. 1., (Washington, D.C., July 1979), p. 65.

[2]Nader and Beckerman, p. 19.

that nearly all the life style indicators correlate highly with all measures of energy consumption."[1] The researchers examined only the variables and correlations concerned with the developed market economies. They wished to research the following proposition: "Among the developed market nations, do the nations with relatively low consumption have a 'lower' life style than those with higher energy consumption?"[2] The correlation analysis indicated that variation in consumption within the range of developed nations is not significantly reflected in most of the life style indicators. However, the economic indicators provide a different picture: the majority of the indicators retained a high correlation with the measures of energy consumption, which lend credence to the assumption that high energy consumption is related positively to economic productivity. They admit, though, that these life style indicators may be only indicators of industrialization. Mazur and Rosa conclude their article by stating: "Of the life style indicators examined here, only the economic indicators show a consistently high association with energy consumption."[3] This research, then, has helped establish a link between energy consumption and life style.

A more empirically based study was conducted by Doerberg of the Brookhaven National Laboratory, who begins his Comparative Analysis of Energy Use in Sweden and the United States with this statement:

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[1]Allen Mazur and Eugene Rosa, "Energy and Life Styles," Science 186 (November 15, 1974), p. 709.

[2]Ibid., p. 609.

[3]Ibid.

> There is general agreement that energy conservation is an extremely important component of the nation's energy programs from now to beyond 1985, yet there is considerable disagreement concerning the extent of conservation that is feasible without severe effects on life style and the economy.[1]

Doerberg selected Sweden to compare to the United States because Sweden's per capita energy consumption was 217.8×10^6 BTU in 1970 compared to America's 345.6×10^6 BTU for the same year. The point that Doerberg argued was that a country could sustain a quality of life equal to, or better than, that of the United States and maintain a much lower energy consumption rate. However, there are several physical characteristics of the dwelling units and several life style attributes which cause the comparison to be more complex than Doerberg suggests. When making the comparison, he reported that Sweden's average climate is far different from that of North America. Moreover, on the average, Sweden's family size is smaller, the dwelling units are smaller, and proportionately there are more dwelling units within multi-family complexes. A larger portion of Swedish homes have been built since World War II. Few homes in Sweden have central heating and very few are air conditioned; and, fewer Swedish dwelling units have baths or showers. There are also fewer household appliances used. The Swedish housing stock included substantially more "second homes" that are not used year around; and, finally, Swedish homes are insulated much better than those in America because of that country's harsh climate.[2]

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[1] A. Doerberg, Comparative Analysis of Energy Use in Sweden and the United States, (Upton, N.Y.: Energy Technology Assessment Group, Engineering and Systems Division, Brookhaven National Laboratory, September 1975), p. 1.

[2] Ibid.

Although Doerberg's comparisons are not on equal ground, his main point is clear--a life style which promotes a high quality of life does not require a high rate of energy consumption, but does require energy efficient dwelling units.

Different locational patterns of dwelling units is one way suggested that could help in residential energy conservation. Deane Morris states that: "The uses of energy is all pervasive in the life styles of people in the highly industrial societies like that of the United States."[1] Morris predicts, that because of the energy shortage, a possible effect on the way we live would be that people will want to live closer to their places of work and shopping which, of course, will cause changes in the spatial form of urban development. This could mean a return to the central city, to increased high-rise apartment living. Perhaps it would mean a proliferation of smaller communities that provide jobs, have commerical shopping centers, as well as decentralized schools and governmental services. Morris contends that at present southern California is exhibiting all of these changes.[2]

Another empirically based study which has yielded several important research reports, is the Twin Rivers project. The Center for Environmental Studies at Princeton University managed the research programs that were conducted to study energy use in an actual community. Twin Rivers is a Planned Unit Development (PUD), it has

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[1]Deane N. Morris, Effects of Energy Shortages on the Way We Live, (Santa Monica: The Rand Corporation, Dec. 1974), p. 1.

[2]Ibid., p. 13.

single-family houses, town houses, garden apartments, and high-rise apartments. With the cooperation of developers, builders, homeowners, and occupants, the researchers from the architectural and engineering disciplines and also from several disciplines within the social sciences, have studied the relationships of building designs, building materials, family characteristics, and style of life of the occupants. The Twin Rivers project is especially important because of the controls that were used on the building types and features, the availability of actual energy consumption data furnished by the utilities companies, and because the study has been ongoing since 1968. Changes in family composition and external economic and political variables can be included in some analyses. The Twin Rivers project allows researchers to understand better the complex relationships of many of the variables which influence residential energy consumption.[1]

Clive Seligman and other behavioral scientists from the Center for Environmental Studies have identified strategies to allow occupants to have more control over the amount of energy they consume. Seligman's report focused on two outcomes of their study: (1) the homeowner's attitude toward residential energy conservation, and (2) the use of feedback as a strategy of keeping the decision-maker informed about his energy consumption.[2]

Analysis of responses to a questionnaire pointed to one main factor which proved reliable in predicting residential energy

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[1]Grot and Socolow, p. 484.

[2]Clive Seligman, et. al., "Behavioral Approaches to Residential Energy Conservation," Energy and Building 1 April 1978, pp. 325-330.

consumption; it was named "comfort and health." High scores on the questions making up this factor dimension indicated higher residential consumption.

The same researchers also created strategies whereby the residents could be better informed about how much energy they were using and when it was being wasted in the pursuit of their goals of "comfort and health." Each of the electricity usage feedback devices was somewhat successful, with the most successful being the one indicating when the outside temperature was below 68 degrees. Such a reading meant, of course, the air conditioning system was not needed.[1] The researchers concluded that for homeowners to practice energy conservation effectively, feedback mechanisms were essential. Retrofit strategies were also suggested by the researchers; however, the choice of which retrofit devices to use would be dependent upon the structure and its location, along with the adeqaute knowledge by the consumer about the costs and benefits involved.[2]

Morris explained it is evident that energy conservation policies aimed at cutting residential consumption of a given form of energy would have quite different consequences in different parts of the country. The researcher goes on to state that the homeowner has three options available to reduce the use of energy for space heating and cooling: (1) changes in operating procedures, (2) changes in equipment, and (3) changes in the building itself.[3] Morris also

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[1] Ibid., pp. 334-335.

[2] Ibid., p. 336.

[3] Morris, p. 16.

emphasized that the potential savings in home energy use will not require decreases in the standard of living or great changes in life style. Morris emphasized that the potential savings will mostly involve upgrading the thermal efficiencies of the homes.[1]

Seligman's research group would presumably argue that feedback strategy devices would also be needed. Otherwise, the consumer simply could not know at any given time how their behavior is affecting their energy consumption and therefore could not know when to change their consumption behavior.

In a study entitled The Cost of Sprawl, conducted by the Real Estate Research Corporation, considerable effort was directed at finding the types of housing patterns which would be most cost effective. As might be expected, the conventional single-family structure is one of the most costly, while multi-family structures are some of the least expensive.

Of interest to this research project was information in The Cost of Sprawl concerning how various types of housing affect life styles. The research stated:

> After making allowances for time devoted to sleeping, work, meals, personal use and travel, the remaining time is available for either household tasks or leisure--a total of 36 hours per week for the working adult and 74 hours for the non-working adult.
>
> While one-third to two-thirds of this discretionary time of the working adult is needed for household tasks in single-family conventional housing (twelve to twenty-four hours per week), much less is needed in apartments (six to sixteen hours). The non-working spouse (assuming primary housing maintenance responsibility), devotes over 50 per cent of discretionary time to

[1]Ibid.

> household tasks in single family (forty hours) compared to less than one-third in apartments (twenty-four hours).[1]

The Cost of Sprawl did not suggest how this discretionary time affects residential energy consumption. The expenditure of time is a chief life style descriptor and discretionary time may prove to be an important residential energy consumption variable.

Life styles do not change swiftly so it is easy to find persons uncomfortable with the prospect of being forced to change their patterns of living. Also, many persons in the technologically advanced areas of the world have come to expect problems to be solved through the application of new technologies. One scientist of considerable reputation has looked at this problem. Particularly with respect to changes in life style and quality of life, A.A. Landsberg prophesies:

> One can contemplate with equanimity a prolonged period during which U.S. energy costs will be higher, utilization more efficient, and consumption patterns somewhat different, all without a profound sacrifice of welfare although surely with temporarily painful adjustment and crisis-like phenomena. Possibly such a period may be followed by one of low cost and abundant energy, if and when the technologies of either nuclear fusion or solar energy have been solved.[2]

Landsberg seems to hope for a return to "normalcy" through the advancement of science and technology. The next section of this review is devoted to the reported activities of technology engineering and the physical science community of researchers.

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[1]The Council on Environmental Quality; Department of Housing and Urban Development, Office of Policy Development and Research; and Environmental Protection Agency, the Office of Planning and Management, The Cost of Sprawl, by Real Estate Research Corporation (Washington, D.C.: U.S. Government Printing Office, April 1974), p. 51.

[2]H.H. Landsberg, "Low-Cost Abundant Energy: Paradise Lost?" Science 184 (April 19, 1974), p. 253.

Technology-Engineering References

Hirst and Moyers' stand and thrust of research and publications is clearly stated in the conclusion of their article entitled "Efficiency of Energy Use in the United States." They state: "It is possible--from an engineering point of view--to effect considerable energy savings in the United States."[1] The researchers offer the following energy-saving prescriptions to the homeowner: By increasing the amount of building insulation and in some cases by adding storm windows, energy consumption can be reduced. If all homes in 1970 had the amount of insulation called for in the FHA standards of that time, energy consumption for residential heating would have been reduced 42 per cent, or more, which would have amounted to a savings of 3,100 trillion BTU. Also, should the homeowner use "energy efficient" air conditioners and add insulation, significant savings would occur, thereby helping reduce peak power demands during the summer.[2]

Project Independence spawned a great many research projects.[3] One of the largest and most comprehensive projects undertaken in the area of residential consumption was done by Hittman Associates, Inc., for the Department of Housing and Urban Development. The residential sector was of great interest in this project and the increasing rate of energy utilization per capita was a central focus. The Hittman program of research was instituted to identify means for obtaining

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[1] Hirst and Moyers, p. 1304.

[2] Ibid.

[3] Federal Energy Administration, Project Independence, A Summary (Washington, D.C.: Government Printing Office, November 1974), preface.

greater efficiencies in the utilization of energy in dwelling units in order to obtain lower per capita consumption without modification of existing life styles.

The two objectives of the research program were:

(1) to identify and quantify the total energy balance in single-family and multi-family dwellings in the Baltimore/Washington D.C. area.

(2) to evaluate the adaptation of various technical innovations which have the potential of minimizing energy consumption in dwellings.

The technologies and technical innovations considered were limited to those presently available and those that would not be detrimental to the life styles of the occupants of the dwelling units. The researchers conducted detailed thermal analyses on a "characteristic house" typical of the single family residences in the Baltimore/Washington area. The research design of the project involved thermal modeling techniques.[1]

The study proved that the infiltration of air was the greatest load component on the residential energy consumption. Conductive heat gains and losses through the walls and windows both account for large losses of energy, and these ranked second and third respectively. The study also revealed that the internal load including appliances and

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[1]Department of Housing and Urban Development, Office of the Assistant Secretary for Policy Development and Research, Residential Energy Consumption, Single Family Housing, Final Report, by Hittman Associates, Inc., (Washington, D.C.: U.S. Government Printing Office, March 1973), p. 1.

occupants, contributed only 16 per cent to the heating requirement in winter but added 35 per cent to the summer cooling requirement. The heat gain from the occupants themselves added 25 per cent to the load; electric lighting 19 per cent; and appliances, 56 per cent. The greatest energy savings could be obtained through reduction of air infiltration and a reduction of conductive heat transfer through the walls and windows.[1] The principal conclusion of the Hittman study was: "The annual energy consumption of a good quality, single-family residence could be reduced up to forty per cent without affecting the life style of the occupants."[2]

A companion research project of Hittman and Associates, Inc., addressed multi-family housing. The study of energy consumption was approached by dividing multi-family residences into three groups: townhouses, low-rise apartments, and high-rise apartments. The research design called for careful identification of the characteristics of multi-family residences in the Baltimore/Washington area. It also called for a clear definition of a characteristic townhouse, a low-rise apartment, and a high-rise apartment, each being typical of the current housing trends in the study area. Annual heating and cooling requirements of the characteristic structures were calculated, and the effects of the various designs were evaluated. Finally, total energy savings for modified versions of these same structures were estimated.

The complex model worked efficiently and the results indicated that modifications in low-rise and high-rise apartment design could

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[1]Ibid., p. 4.

[2]Ibid., p. 14.

minimize energy consumption if the design included the following: (1) elimination of all windows on the end wall in corner apartments; (2) increasing roof insulation, thereby raising the R value to 20 or 30; (3) increasing insulation in the bottom floor of high-rise apartments to minimize energy consumption for heating and cooling; (4) minimizing lateral heat transfer to the surrounding ground by insulating the footings; and (5) for all other apartments in the structure, maximizing the insulation R value.[1]

Another Hittman report concluded that: (1) installation of storm doors and windows is cost and conservation effective; (2) installation of a furnace energy recovery device is cost and conservation effective; (3) open-air-cycle air conditioning systems are not cost effective; (4) ventilation recovery systems save very little energy and have limited applicability; and (5) double glazing can achieve only modest energy savings.[2]

In 1977, the National Association of Homebuilders constructed a "demonstration" energy efficient house. It was expected to use less energy than the typical single family home of comparable size. Energy

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[1]Department of Housing and Urban Development, Office of the Assistant Secretary for Policy Development and Research, Residential Energy Consumption, Multifamily Housing Final Report, by Hittman Associates, Inc., (Washington, D.C.: U.S. Government Printing Office, June 1974), p. 0-7.

[2]Department of Housing and Urban Development, Office of Policy Development and Research. Technology Assessment of Residential Energy Conservation Innovations, Final Report, by Hittman Associates, Inc., (Washington, D.C.: U.S. Government Printing Office, May 1975), pp. 1-5.

saving amenities built into the dwelling are now available to be added to existing houses.[1]

The popularity of articles concerned with retrofit strategies remains high because of the money saving remedies they espouse. Generally, retrofit articles ask the homeowner to survey the dwelling and add insulation if needed, stop air infiltration, eliminate unused appliances, and lower the thermostat.[2]

One of the most important research programs was undertaken by Hirst and Carney, aided by the residential energy consumption model developed at Oak Ridge National Laboratory. The model simulated household energy use, at the national level, for four fuels, eight end uses, and three housing types.

Of the nine energy futures they reported, the most energy conserving included retrofit strategies authorized by the 94th Congress and a 40 percent increase in fuel costs by the year 2000. Combining all retrofit strategies, without fuel cost increases, will cut energy growth to about 0.8 per cent per year.[3]

The expected outcome of effective conservation programs is a decrease in demand for residential energy. This conclusion lies at

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[1] "From NAHB: An Energy House that Makes Sense Today," House and Home, August 1977, pp. 44-48.

[2] Eric Hirst, "Save Energy--Save Money," Consumer Research Magazine, February 1979, p. 27. "Living With Those Growing Fuel Bills At Home," Business Week, March 19, 1979, pp. 164-166.

[3] Energy Research and Development Administration, Residential Energy Use to the Year 2000: Conservation and Economics, by Eric Hirst and Janet Carney, ORNA/CON 13 (Oak Ridge, TN., Oak Ridge National Laboratory, September 1977), p. 2.

the base of Lovins' "Soft Energy Paths" recommendations.[1] Lovins argues that the present policy of building larger energy producing and delivery systems will not be needed and will be an intolerable burden on the economy.

Lovins' terms "soft and hard energy paths" describe the centralization of producing and delivery systems. The "hard" path is an extrapolation and intensification of the present capital intensive systems. The "soft" path refers to decentralized producing and distribution systems. Soft paths use the appropriate technology for the end use. These rely mainly on self-replenishing energy sources such as the sun, water, biomass, and the wind. Also, Lovins suggests that decentralization could encompass households and neighborhoods with centralized soft power systems and community power plants.[2]

It has been suggested that Lovins' paths represent a new paradigm that holds a view that human growth should be in the social and cultural areas rather than in areas of technical-engineering growth.[3] This view of social growth versus material growth has drawn criticism. Established institutions such as public utilities are obviously committed to a continuation of hard energy paths to assure adequate power needs expected from the extrapolation of demand curves. A point of agreement between the two paths is the immediate need for less energy waste by the end users.

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[1] Amory B. Lovins, "Energy Strategy: The Road Not Taken?" Foreign Affairs (October 1976), p. 76.

[2] Ibid., p. 80.

[3] Michael Stiefel, "Soft and Hard Energy Paths," Technology Review, (October 1979), p. 63.

Governmental Action with Respect to Residential Energy Consumption

The National Energy Plan given to Congress in 1977, included specific legislative proposals to affect the energy consumption of residences. The plan clearly stated that:

> Although conservation measures are inexpensive and clean compared to energy production and use, they do sometimes involve sacrifices and are not always easy to implement . . . these sacrifices, however, need not result in major changes in the American way of life or in reduced standards of living.[1]

With sacrifices on the part of American consumers being necessary as part of the energy plan, the plan outlined very specific ways of reducing the waste of energy in dwelling units.

In the summary of the National Energy Plan, there were listed several ways to reduce waste of energy in existing buildings. The plan included a major program containing the following elements:

1. A tax credit of 25 per cent of the first $800.00 and 15 per cent of the next $1,400.00 spent on approved residential conservation measures.

2. A requirement that regulated utilities offer their residential customers a "turn-key" insulation service, with payments to be made through monthly bills, other fuel suppliers would be encouraged to offer a similar service.

3. Facilitating residential conservation loans through opening a secondary market for such loans.

4. Increase of funding for current weatherization programs for low income households.[2]

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[1]Executive Office of the President Energy Policy and Planning, The National Energy Plan, (Washington, D.C.): U.S. Government Printing Office, April 1977), p. X.

[2]Ibid., p. XV.

A major part of the National Energy Plan was to create a single Department of Energy. This department consolidated the activities of the government dealing with energy.[1]

Some of the remainder of the energy legislation was enacted in 1978. None of the proposed legislation was enacted as specifically recommended by the President. The one law enacted for immediate implementation was the Energy Tax Act of 1978 (PL 95-618) which provided tax credits for certain retrofit installations. Final Congressional action was taken on the other Presidential energy policy bills on October 15, 1978. The others passed, but in a weakened form, were: the Public Utility Regulatory Act of 1978 (PL 95-617), a reform bill aimed at electric utility rates; the National Energy Conservation Policy Act (PL 95-619), a mandatory energy efficiency standards act; an omnibus energy bill which included the Power Plant and Industrial Fuels Act of 1978 (PL 95-620), which provided the authority to force utilities and industries to convert from oil and gas to coal, and the Natural Gas Policy Act of 1978 (PL 95-621) allowing the decontrol of natural gas prices.

The effectiveness of the energy bills will depend to a great extent on the utilities. The National Energy Conservation Policy Act of 1978 (NECPA) requires utilities to establish conservation programs for residential building of four units or less. The utilities must inform their customers of conservation measures and ways of financing.

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[1]U.S. Congress, Senate, Committee on Interior and Insular Affairs, Land Use and Energy: A Study of Interrelationships. Committee Print, 94th Congress, 2nd Session, January 1976 (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 60-75.

Additionally, the utilities must offer on-site energy audits and assist their customers in finding materials, installers, and lenders. Should the customers choose, the utilities must permit them to make regular repayments to the utility for those conservation measures they decided to purchase.[1]

Under the Public Utility Regulatory Policies Act, the federal government increased its involvement in the rate making policies governing the utilities. One of the promising aspects of the act is it encourages the utilities to develop and test the effectiveness of various load management strategies. Load management programs are deliberate manipulations of electricity demand. Load management has been practiced in parts of Europe for many years. Closely akin to load management is "Rate Demonstration Programs." This was created to examine the behavior of consumers with respect to price elasticity, load management, time-of-use rates and other rate structure strategies.

Effects of Price and Income Changes on Residential Energy Consumption

The basic laws of supply and demand hold that, other things equal, changes in price will elicit inverse changes in quantity demanded. Also, changes in income will call forth changes in consumption, however in this case characteristics of the product will determine whether consumption will increase or decrease.

The absolute amount of electricity consumed is affected by the level of energy prices. Higher prices can cause consumers to reduce

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[1] Congressional Quarterly Almanac, 1979. (Washington, D.C.: Congressional Quarterly, Inc., 1979), p. 645.

their electricity consumption. The reduction may be effected by lowering thermostats or increasing the thermal integrity of the dwelling. "Changes in relative energy prices principally influence future patterns of consumption as more economical fuel sources are gradually adopted in new housing."[1]

Macroeconomic conditions affect personal income. Personal income in turn affects energy consumption in regard to the amount of income consumers choose to spend for electricity. In general, growth in real income leads to increased energy consumption.[2]

Of more concern is the extent to which consumption varies with changes in prices or incomes--the price and income elasticities of demand.[3] A study by Berman and Graubard confirms that the income elasticity of demand for electricity is positive.[4] This means that

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[1]U.S. Department of Energy/Energy Information Administration, Annual Report To Congress 1978; 2; 279-80.

[2]Ibid., p. 280.

[3]Price elasticity of demand, and income elasticity of demand as used here conform to the prevalent economic definitions. The coefficient of <u>price elasticity of demand (e)</u> measures the proportional change in the quantity demanded per unit of time resulting from a given proportional change in the price of the commodity. Demand is said to be elastic if $e>1$, inelastic if $e<1$, and unitary if $e=1$. The coefficient of <u>income elasticity of demand (e_m)</u> measures the proportional change in the amount of a commodity purchased per unit of time resulting from a given proportional change in the consumer's income. When e_m is negative, the good is considered inferior, if e_m is positive the good is normal. If the coefficient of a normal commodity is greater than 1, the good may be considered a luxury; if the coefficient is less than 1, the good may be considered to be a necessity. Depending upon the level of the consumer's income e_m for a good is likely to vary a great deal. What may be considered a necessity for one family income level may be a luxury for another.

[4]M.B. Berman and Marlie Hammer Graubard, <u>A Model of Residential Electricity Consumption</u>, (Santa Monica: The Rand Corporation, July 1973), p. 13.

for a given change in income, consumption of electricity will increase. Further, it was found that the coefficient of elasticity increases as income increases. Therefore, families in the upper income brackets will increase consumption of electricity more than families in lower brackets.

Demand for electricity was found to be inelastic with respect to changes in price. Hence, for a small change in price, changes in quantity demanded will be proportionally less. A companion study by Acton found all coefficients of price elasticity to be in the inelastic range, varying from -.3 to -.7 depending upon the type of analysis used.[1] Hence a small increase in price of electricity reduces consumption by a relatively small amount.

Acton's study also confirms that electricity is a normal good, having a positive coefficient of income elasticity of around .4.[2] Since this is in the inelastic range, it means that for a given change in real income, the change in consumption will be relatively small, that is proportionately less than the change in income.

Prior to the 1973 oil embargo, U.S. projections of energy needs continued to trend upward. In the latter part of that decade, estimates of future energy needs changed drastically. The Council On Environmental Quality expects this trend to continue because of demographic trends and the evolution of the economy to less energy

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[1]J. Acton, B. Mitchell, R. Mowill, Residential Demand for Electricity in Los Angeles: An Econometric Study of Desaggregated Data, (Santa Monica: The Rand Corporation, September 1976), p. 50.

[2]Ibid., p. 51.

intensive activities.[1] A May 1979 issue of Business Week reported an unforeseen drop in electricity demand growth which may lead to ". . . a dark future for utilities."[2]

For years, utilities have attempted to avoid "brownouts." In the past few decades the "no brownout" goal had lead to a projected annual demand growth of about 7 per cent per year. Since the oil embargo of 1973-74, the average price of electricity jumped from 2.38 cents per kilowatt hour to 4.03 cents, (the largest is Consolidated Edison N.Y. at 6.89 cents). In addition to price increases the media have disseminated information on the means for reducing energy consumption.[3] For the last few years annual electricity demand growth has been between 3 and 4 per cent. Total electricity demand grew 3 per cent between 1978 and 1979. Demand growth for the residential sector was 2.2 per cent.[4]

The price of energy should be based on its true value and one way to arrive at that price is to calculate its replacement cost. For some time, there has been agreement ". . . that price may be the most important policy tool. . . [for controlling] energy [consumption]."[5]

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[1]U.S. Council on Environmental Quality, The Good News About Energy, 1979, pp. 1-2.

[2]"Energy," Business Week, (May 28, 1979), p. 108.

[3]Ibid., pp. 108-109.

[4]Electric Perspectives, (Edison Electric Institute, Spring 1980), p. 35.

[5]Council for Environmental Quality, p. 41.

Recent price elasticity studies suggest that long-term energy demand may be about twice as sensitive to price as was previously estimated.[1]

Caves and Christensen reported on cross elasticity of demand. They stated that a significant number of consumers substituted off-peak time-of-use for peak time when the price of electricity was doubled.[2] They also found that there were different elasticities of substitutions for customers with different appliances and the patterns of the customers' use of them.[3]

The Battalio experiments included increased prices for electricity, training on how to eliminate residential electricity waste, and weekly feedback on electricity consumption. His experiment showed that ". . . although the short run [one month] price elasticity for space cooling and heating is not zero, at current price levels demand is not very responsive to price increases as high as 235 per cent or to educational materials by themselves."[4] Residential energy consumption was decreased with a program of tripled price, conservation education, and quick feedback on the cost of electricity consumed.

Several useful inferences may be drawn from these studies. There is no doubt that the price of electricity is very important.

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[1] Ibid.

[2] Douglas W. Caves, and Lauritis R. Christensen, Residential Substitution of Off-Peak for Peak Electricity Usage Under Time of Use Pricing," The Energy Journal, (International Association of Energy Economists, 1980), p. 98.

[3] Ibid., p. 93.

[4] Raymond C. Battalio, et. al., "Residential Electricity Demand: An Experimental Study," The Review of Economics and Statistics, (May 1979), p. 88.

Increases in price of two or more times its 1973 level have effected lower consumption levels. The extent to which price only has effected consumption is not clear. Since 1973, the high rates of inflation have changed many economic relationships of commodities and services. Moreover, real income has continued to rise, more efficient appliances have become available, and consumer behavior has been altered by conservation education efforts. Also, consumer decision making is seldom as econological as the law of supply and demand indicates.

Isolation of the effect of price on consumption of electricity has to be determined by experiments, most of which cannot completely control all important exogenous variables. Also, since electricity rates are controlled by government agencies, "price increases" usually take the form of cash discounts to consumers for a given decrease in electricity consumption; the effect on family income is the same, but the consumers' attitudes may be different.

Land Use and Residential Energy Consumption

The energy crisis has begun to affect the shape and use of American cities. A frequently suggested solution to the energy shortages is the revitalization of central areas of the cities, with public transportation networks moving the population to the places of employment and shopping. At the ends of the transportation routes will be the residential areas, which will be of high density.[1] Bacon expects the outpouring from the cities to the suburbs to continue. He

[1] Edmond N. Bacon, "Energy and Land Use," Urban Land, (July/August 1973), p. 73.

also predicts the future city forms to be similar to the old streetcar corridors but the lateral dimension of the residential development will be determined by the capacity of an electrically driven transit systems to deliver a person where he wants to go. These transit systems, according to Bacon, could be either vertical or horizontal elevators. He also predicts that local shopping, and community and home oriented recreational centers will be located near the transit stations which should be sited near the geographical center of the residential areas.[1]

O'Donnell and Parker report on energy efficient site planning. Residences can be situated on slopes in order to take advantage of breezes and be protected from dampness and cold air in the winter; the building can be positioned so that the trees already on the site will protect it from weather and provide natural air conditioning. The trees can be sun screens and can reduce the evaporation of surface moisture. They are also invaluable as wind breaks, visual barriers, and noise buffers.

The planning of a new community provides the opportunity to design efficient utility and transportation systems. The final land use densities and community components, when pre-planned, can have the same effect for the new outlying community as the central city has had for years in the city itself. Increased amounts of low energy consuming

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[1]Edmond N. Bacon, "Energy: Shaper of Future Living Patterns," AIA Journal, (December 1973), pp. 39-40.

recreational amenities, pre-planned and built into a large scale development, can have a long term energy conservation payoff.[1]

Summary and Conclusions

This chapter has outlined the national energy problem and surveyed research concerning the current status of problems with energy consumption within individual residences. Since the turn of the century when virtually every household operated without electricity, today virtually every American household has access to electric power. The availability of electricity to the American consumer stimulated a demand for home appliances. The demand for energy using appliances still grows although nearly all household have radios, televisions, and refrigerators. Other appliances continue to appear in the American home. The availability of electricity and the home appliances and the heating and air conditioning systems which followed, changed the life styles of the American households and the patterns of energy consumption.

The demand for energy and the decreasing supply of fossil fuels reached a crisis point in the mid 1970's. The most devastating aspect of the energy crisis for the American consumer has been the rapidly increasing costs of energy. The personal consumption expenditures by residents in the seventeen years from 1960 to 1977 has been dramatic. Personal consumption expenditures percentages for housing increased 283, household operations 283, electricity 292, natural gas 182, and transportation 305. The costs of household operations

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[1]Robert M. O'Donnell and James E. Parker, "Large-Scale Development: A Breeder for Energy Conservation," Environmental Comment, (Washington, D.C.: The Urban Land Institute, July 1977), pp. 4-5.

increased largely because of basic energy costs, and because consumption in general increased greatly. Residents depending upon the traditional fuel sources for heating and household operations are caught in a dilemma which will require radical changes in the technology of bringing energy to the residence and using it conservatively, or changes in the life style and demand of the residents, or both.

Current Studies and Pertinent Literature

The literature devoted to solving the energy crisis comes mainly from the engineering and physical science disciplines. Contributions to the energy crisis solution from the social sciences can be traced back to the early 1960's.

As the public became convinced that the energy crisis was real, policy makers turned to those institutions in the forefront of the energy resources and policy research. These included private research groups and universities. Many of the research reports contain general statements supporting technological adjustments as a solution to the energy problem without disruption of the consumer's life style and quality of life.

Most of the reports point to structural modifications as an immediate solution. The suggested retrofit technology includes storm windows and doors, additional insulation, and more efficient electric motors, compressors, compactors, and more efficient structural design and orientation. All these short term solutions could come about by changes in the physical structure of residential units. The long term solutions are based on advanced technical-engineering, the "hard" solutions criticized by Lovins. These solutions would allow the uninterrupted continuation of present life styles.

The research methods of the Hittman studies allowed for close observation of a controlled "characteristic" single family house, townhouse, low-rise apartment, and high-rise apartment dwellings. The result of the studies suggested ways to stop air infiltration, block the sun to reduce heat gain, and several other modification which could produce substantial savings of energy without change or inconvenience to the occupants or their life styles.

Energy savings can be achieved through residential area development designs. Clustering dwelling units with commerical, industrial, and other buildings reduces infrastructure costs. Siting residences to maximize climatic benefits is another way land use planning reduces energy consumption.

Those studies which hinted or suggested that a life style change is a necessary ingredient for conservation to be effective have not enjoyed public acceptance. Doernberg's comparison of Sweden and the United States did not stress the differences in life styles. Conservation of energy works well in Sweden (and other countries) because the prevalent life styles emphasize energy conservation. In Sweden it is commonplace to find fewer rooms used in the winter, no central air conditioning, and fewer household appliances.

Lovins advocates soft paths as a solution to the energy crisis. He suggests that these will not necessitate changes in life style. However, such a view seems difficult to substantiate when he insists that energy conservation is a necessity and that the soft path is based on having individuals, households, neighborhoods or small communities become technically competent to operate solar or wind powered electricity generating devices. Such solutions would require not only a great amount of training but also the ability to capitalize such plants.

National energy policies of the late 1970's have had a great effect on residential energy consumption. The various policies are the results of the recommendations of the technical-engineering oriented research institutions, so it is not surprising to find that the thrust of new legislation is aimed at retrofit measures, and the continuation of the present American life style.

The growth in the demand for electricity has declined from the 7 per cent per year level of a decade ago. The growth rate for recent years is near the 3 to 4 per cent level and residential demand growth is even lower. Much of the decrease in demand growth can be attributed to increased prices and educational efforts aimed at conserving energy.

Consumer Behavior

Several empirically based studies concentrated on understanding the effects of the consumer's behavior on residential energy consumption. One study isolated a factor named "comfort and health," which is at the locus of consumer behavior with respect to energy consumption.

It has been established that identical single family houses and identical apartment units can exhibit diversity in the amounts of energy consumed. The physical attributes of the dwellings cannot explain such differences. These must be explained by attitudes and the consequent behavior of the occupants. The factor "comfort and health" was the principal factor causing the consumption of energy. This finding lends credence to the earlier research cited establishing the price inelasticity. Apparently, electricity is considered a necessity in today's society.

It has also been established that the behavior of occupants in one type of dwelling differs greatly from the behavior in another type; that the life style of an apartment dweller for example differs significantly from that of the occupants of a single family dwelling. The main differences between the occupants of different dwellings seems to be the amount of discretionary time available. In other words, how time is spent, a life style descriptor, is one of the principal measures of the occupants of different dwelling types.

In contempory research, life style and consumer behavior apparently affect residential energy consumption. The engineering and physical science emphasis far exceed the volume of literature directed at understanding the human role in the residential energy consumption equation. The role of the social scientists can be to help others realize that houses, townhouses, and apartments do not use energy--but that the occupants of those dwellings consume energy. Energy conservation may ultimately rely on a changed style of life, and the resultant energy conserving behavior, to solve the current energy crisis and to build a society related harmoniously with natural resources.

CHAPTER III

RESEARCH, METHODOLOGY AND DATA COLLECTION

This study is designed to examine the relations between human behavior and the energy consumed in single family and multi-family dwellings. The methodology appropriate to examining these relationships must be broad enough to analyze structural characteristics found in different dwelling types and their affect on energy consumption, broad enough to examine the energy consumption attributed to family life cycle stages, and broad enough to study the effects of the occupant's life style on energy consumed within the dwelling types. The methodology should lead to an analysis of all the effects of the interrelationships of all energy consumption components selected for this study.

A residential dwelling unit is a complex thermal system which includes both the physical aspects of the structure and the social interactions that occur within the dwelling itself. The literature is repleat with studies on residential structures and the energy consumption effects of building materials, site situations, appliances, and dwelling types. It is known that considerable energy conservation can be achieved by following the appropriate engineering prescriptions for window exposure, insulation, roof color, heating systems, and so forth. Moreover, it is known that certain social attributes affect residential energy consumption. For example a large and relatively young family is likely to use more residential energy than families in other life cycle stages. Also, the amount of discretionary time available to the occupants has been suggested as a key life style attribute which affects residential energy consumption. The amount of time at the residence is used for various family activities, as well as the types of activities, affects energy consumption.

This study will hopefully further the understanding of the relationships between life styles and residential energy consumption. For example, it is likely that one finding will be that the more intensively a dwelling is used by the occupants the more energy will be consumed. Families present for all meals will most likely consume more energy than those with life styles which do not include eating meals in the dwelling.

In addition to life style influences on energy consumption, it can be anticipated that differences in personal characteristics, such as stage of life cycle, may affect energy consumption. For example, a young single apartment dweller without a family will likely have a much different life style from a person living as a part of a family in a single family dwelling. Such differences should be reflected in the amount of energy consumed within the dwelling. It would be expected that the apartment dweller in this case would use the smaller amount of energy. These hypothesized relationships are examples of what may be established by this research. It is impossible to specify all relationships which may emerge, indeed one of the purposes of the study is to ascertain unexpected relationships. In this sense, the study is to a degree inductive.

In addition to the expected life style influences, and those of the life cycle stage, it is expected that structural differences will help explain energy consumption differences. The energy consumption in these dwellings that have adequate insulation and double glazed windows should show less energy consumption than those which are not adequately insulated.

The overall result should point out that life styles and life cycle stages do play a very important role in the energy conservation problem. Moreover, the multiple relationships of structural and social variables should point to ways of modifing family or individual behavior so that less energy will be consumed within dwelling units.

The research methodology appropriate to measure all the interrelationships of the physical and social aspects of residential dwelling units is a serial combination of commonly used data collection and analysis methods. The data collection design should include a survey schedule which lists the bill-paying occupants of the following dwelling types: single family, two attached units, four attached units, low-rise apartments, and high-rise apartments. In order to control for technological and building requirement differences, all dwellings should have been constructed within a specified time period and located within the same municipality. Additionally, the occupants should have lived in the residence for at least one year so that direct comparisons can be made with the results of the questionnaire and the actual energy consumption at the residence. The sample size should not be less than 30 and should ideally be larger. The sample should be selected at random from the total list of residences meeting the requirements for inclusion.

The dependent variable is energy consumption. There could be two or more energy sources serving a dwelling. In order to control for this possibility, the study will include only those dwelling units with a single energy source -- electricity. The cooperation of the providing source, a public utility, to furnish usage data for the twelve month study period is critical to this study. The electric usage data is to be compared with data from the questionnaire results, which constitutes the independent variable matrix. These data include site specific information about structural characteristics, life style measurements, and demographic information. The questionnaire should contain some of the same variables used by Newman and Day. The questionnaire could be administered in a face-to-face interview or mailed out and self administered.

The data analysis of the properly completed questionnaires should begin with cross tabulation and contingency table analyses appropriate for the type of data being examined. The contingency analysis should include several tests to determine the degree of independence and association which may exist among the dependent and the independent variables.

Next, factor analysis is to be used to reduce variance within the matrix of identified variables as being associated with electricity consumption. Factor analysis is used to cluster the related variables, to identify related variables, and to minimize the number of reflective variables. For ease of interpretation and for consistancy, the same number of dimensions should be produced for each dwelling type sample. It should now be possible to compare directly the cluster of variables which are associated with residential energy consumption.

It would not be expected that the variables selected would all indicate the same degree of association with electricity usage; however, for a final analysis comparing the similarities and differences of building types and life styles, it is imperative that the same variables be used in each factor analysis.

This analysis should give some answers to the questions: How much variance in residential energy consumption can be explained by the factors? What is the relationship between life styles, structural, and life cycle stage factors for different dwelling types. What is not accounted for in these factors and how important are the "residual" variables?

Factor scores are to be used subsequently in an analysis utilizing discriminant analysis. The factor scores summarize much of the variation in the data so that the scores are the value of the original observation data for a particular factor. The factor scores behave in much the same way as do standardized data thus allowing the discriminant coefficients to be used as a measure of relative importance.

The usual purpose of discriminant analysis is to classify cases. In this instance, the cases would be dwelling units and the classification would be high or low electricity usage. The efficacy of this technique is that the factors selected will probabilistically predict electricity consumption.

The discriminant function is the principal product of the discriminant analysis and is based on the least squares procedure. The results of the analysis is to know which variables cluster together into dimensions and their importance in the task of predicting energy consumption. The factor's importance is noted by the discriminant coefficient.

Research Procedures

This study took place within Oklahoma City. The study period was from November 1977 to October 1978.

Oklahoma Gas and Electric Company (O.G.&E.) made available their list of dwelling units constructed in 1975 within the municipal limits of Oklahoma City. The list clearly designated which dwellings were total electric ones with resistance heating. It listed 370 single family dwellings, 319 low-rise apartments, 4 two unit attached dwellings, and 60 condominium townhouses.

O. G. & E. also furnished an exact account of the kilowatts used in the dwellings within the immediate 12 month study period. The utility has a standing policy prohibiting the release of information concerning any of its customers without the written consent of the customer. It was necessary to have the respondents sign a consent form before the study could proceed. This meant selecting the sample and gaining consent from individual consumers before electric usage data would be released.

Questionnaire Development

The questionnaire used for this study (See Appendix A) focused on four types of variables. One of the four measured physical structure; another measured demographic and life cycle stage variables; a third, the life style variables, dealt with the use of the dwelling by the household and the activities of the household members that took place primarily outside the dwelling; and, the fourth type measured the attitudes of the household members toward the energy situation and energy conservation.

The physical structure variables selected for inclusion in the questionnaire are the following:

a. The type of dwelling unit
b. The construction material
c. The directional orientation of the dwelling
d. The various kinds of energy saving amenities including the presence of storm windows, the number of windows facing each direction, the adequacy of ceiling insulation
e. The size of the dwelling unit
f. Whether or not the dwelling unit is in a position to receive brisk breezes
g. The number and types of rooms within the dwelling unit
h. The color of the roof
i. Whether the structure has a second story

The demographic and life cycle variables included the following:

a. The family size
b. The number of children
c. The number of adults
d. The family income
e. The age of the head of the household
f. The number of household members over 65
g. The number of household members who work full time
h. The number of household members who work part time
i. The occupation of the head of the household

The variables dealing with the household members' use of the residence included:

a. The amount of time during the work week that someone is occupying the house
b. The amount of time during the weekend that someone is occupying the house
c. The number of hours per day that the television set is on
d. The number of persons per week who have breakfast in the residence
e. The number of persons per week who have lunch in the residence
f. The number of days per month that the evening meal is served in the dwelling unit
g. The number of days per month that the dwelling unit is used for entertaining guests
h. The number of nights per week that someone is at home

The non-residential and non-employment activities included the following:

a. Errands, shopping, and car pooling, etc.
b. Recreational activities
c. Church or synagogue activities
d. Social enjoyment groups
e. Business and professional associations
f. Board of Trustees or Director of Organizations
g. Economic service and civic service clubs
h. Formal education classes
i. Political party organizations
j. Neighborhood or community organizations
k. Parent-teacher organizations
l. Fraternal or sorority groups
m. Athletic teams or clubs
n. Children or youth activity groups
o. Cultural groups
p. Charitable organizations
q. Welfare or humane organizations
r. Community groups

The questionnaire also contained attitudinal questions concerning the energy consciousness of the household and whether or not the energy situation had affected the life styles of household members. This was included to recognize the possibility that attitude and values might significantly affect energy consumption.

Data Collection Procedure

The population from which the samples were drawn was the finite populations of dwellings from the list provided by the utility. The duplexes were not sampled because there were only four. The sampling design consisted of 100 randomly selected single family units, and 100 randomly selected apartments and the entire population of the condominium townhouses.

In order for the occupants of a dwelling unit to qualify to be interviewed they must have lived there for the preceding twelve months.

In this way the relationship of household activities and kilowatt consumption of the residence could be analyzed.

The person-to-person interviewing began in August, 1978 and was completed in October, 1978. During this time, 144 single family dwellings were successfully contacted. Of those contacted, 48 valid interviews resulted. Every occupant of the 159 apartments in a South Oklahoma City apartment complex was contacted; however, only 6 of the residents had lived in that complex for a year or more thus qualifying them as respondents for the study. Another apartment complex containing 12 units had only one occupant who had lived there for more than a year. The third complex survey had 149 apartments; however, only 33 of them had occupants who met the length of stay criterion. The interviewers met considerable resistance at each of the complexes and few valid interviews were obtained.

The interviewers also met resistance at the two condominium complexes which contained a total of 66 dwelling units. In both places the interviewers were ejected before many occupants could be qualified. Since the personal interviewing strategy did not work at either the condominium or apartment complexes, an alternate interviewing strategy was developed. The questionnaire was redesigned so that it could be self administered. A list of potential respondents was made available for one apartment complex, but an interview schedule had to be developed for the condominiums from the Oklahoma County ownership records. The mail-out questionnaires met with success and the final number of valid interviews obtained from the apartments and condominiums were 28 and 34 respectively.

Each property represented by a valid questionnaire was located in the County Clerk's records in order to find the square footage of the dwelling. The size of each apartment was found by searching the apartment complexes' blueprints on file with the Oklahoma City Planning Department. The square footage for each dwelling was noted on the appropriate questionnaire.

All the consent forms were forwarded to the accounting department at the public utility, which then recorded the kolowatt usage for each during the study period. This was then recorded on the corresponding questionnaire.

The original data were divided into four groups. One group, having 110 observations, was the aggregate of the three building types surveyed. The other three data groups were: single family residence, 48 observations; condominiums, 34 observations; and, apartments, 28 observations.

Preliminary Data Analysis Procedure

Crosstabulation and contingency analyses including Chi Square and measures of association were the first statistical analyses performed. The Chi Square statistic was the first test used in estimating whether the variable was not independnet from the kilowatt consumption. The tests of association included the Phi, Cramer's V, Contingency Coefficient, Lambda, Uncertainty Coefficient, Kendall's Tau b and Tau c, Gamma, Somer's D, Eta, and Spearman's Rho. Because of the types of data used, most of the decisions to retain or delete a variable for or from further analysis were based on the test results of Chi Square, Cramer's V, Contingency Coefficient, and Spearman's Rho. Only those variables which indicated dependence with the electricity consumption or showed strength of association with the dependent variable or both were retained. In some instances a variable met the retention criteria in all samples and sometimes a variable only met the criteria for one or two of the samples.

The apartment sample did not meet the criteria for retention because all its cases fell within the first classification interval of the dependent variable and therefore none of the statistical tests could be performed. The apartment variables used in later analyses were the same variables found to be significant from the single family, condominium, and total samples and which were retained for further analysis.

Those variables which were retained were used in the R-mode factor analysis with orthogonal rotation. The factor analytic technique enables the researcher to reduce the number of variables to some underlying pattern of relationship that exists among the variables so that the data may be rearranged or reduced to a smaller set of factors or components. For this research, factor analysis was used to explore and detect patternings of variables with a view to discovering a concept or construct which would serve as a significant variable in the understanding of residential energy consumption.

Four factor analyses were performed, one for each of the data sets (the aggregate of the samples, the single family, condominium, and the apartment samples). The number of dimensions was limited to six because in preliminary tests usually six dimensions had an eigenvalue of 1.0 or more. Also, with fewer dimensions the task of interpreting and identifying accurately the construct can be accomplished with more ease. Factor scores were produced as the raw data input for the next analysis step -- discriminant analysis.

In this research discriminant analysis was used to distinguish those factors which were best able to predict whether a particular case was a high energy user or a low energy user. The low and the high were both defined by the median annual kilowatt observation for the sample. The discriminant analysis was performed for each of the data sets.

The selection of the most important factors was made with a step-wise procedure. The selection procedure itself was based upon the partial multivariate F ratio. A variable was included if it satisfied the entry criterion of having an F statistic of 1.0 or more for each iteration.

One of the most important aspects of discriminant analysis for this research was the use of the weighting coefficients. The weights, or the discriminant coefficients, serve to identify those variables that contribute to the differentiation among the group being analyzed. The unstandardized coefficients were reported. Only standardized coefficients report the relative strengths of the variables. The discriminant coefficients for this study do, however, behave much like standardized ones because the raw data were the standardized factor scores. The coefficients do, therefore, report the relative strengths of the factors.

Concluding Comments

The research design worked well because of the controls available for type of dwelling, year built, type of heating system, construction requirements, and exact accounting of electricity consumption. In retrospect, however, the efficacy of the design could have been enhanced.

Some of the weaknesses encountered in the methodology included:

1) A money spending life style descriptor could have been added. Although the allocation of time spent inside and outside the dwelling is very important, perhaps another important variable is what electric or other type of appliances or tools were owned and how often they were used by the respondent.

2) A mail out questionnaire for the entire survey would have been a faster and less expensive method of obtaining the desired information. The face-to-face interviewing was very time consuming and expensive because occasionally the interviewers had to make return calls at odd hours in outlying fringe areas.

3) Neither the exact square footage nor the exact kilowatt usage were needed because only class intervals were used in the contingency table analyses. Estimates of these data would have provided essentially the same results.

4) Should this study be replicated it would be better to divide the interviewing among the four seasons. It seems reasonable that differences of life style and life cycle stages are also affected by seasonal changes. It might be enlightening to analyze seasonal changes and their impact.

5) The design could also be made more longitudinal. A methodology keeping much of what was used with this study but adding diaries and a time span limit could produce yet more information on behavior and residential energy consumption.

In general, the methodology worked efficiently. The analysis and findings are presented in the following chapter.

CHAPTER IV

ANALYSIS AND RESULTS

Residential energy consumption reflects both the nature of the dwelling and the life styles of its occupants. This chapter presents the research findings by focusing on the interrelationships of the structural attributes and occupants' life styles. Appropriate statistical tests were used to isolate those variables which were significantly associated with electricity consumption. Those identified variables were then factor analyzed. Factor scores were used in discriminant analysis to isolate more clearly those variables which predict residential electricity consumption in the study area. These techniques unfold a better understanding of the dynamics of energy consumption within dwelling types. Comparing the results from each dwelling type has provided a better understanding of the way that living patterns and structural attributes affect residential energy consumption. Understanding these relationships may lead to modifications of structures and/or life styles.

Relatedness Tests -- Electric Consumption, Life Style and Structural Attributes

The questionnaire measured 37 independent variables previously described. The dependent variable was the exact kilowatt consumption of the surveyed dwellings. Independent variables were first tested for statistical relatedness to the dependent variable. The variables deleted failed to generate test statistics indicating that they were associated with electricity consumption in one or more of the samples. The "apartment" sample could not be tested because the variables for all cases fell within the first class interval of the dependent variable.[1]

Of the 37 variables, 10 were deleted as a result of the relatedness analyses. Those variables deleted were:

1. storm windows
2. dwellings facing south
3. light colored roof
4. adequacy of insulation
5. presence of young children
6. presence of persons with full-time jobs
7. occupation of household head
8. number of persons eating lunch at the dwelling
9. number of persons eating breakfast at the dwelling, and
10. nighttime occupation of the dwelling

In most cases these variables were not statistically related to the dependent variable because the nature of the questionnaire did not measure such behavior accurately, or perhaps, because the population exhibited unusual traits beyond the scope of this study. For the question concerning "adequate insulation," most of the respondents answered "don't know." To the "occupation" question a disproportionate share of the respondents answered "professional," indicating that they did not know how to classify their occupation.

Other variables deleted were home centered, including: "lunch at home," "breakfast at home," and "nights at home." Almost none of the respondents ate breakfast or lunch at home. Almost all of the

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[1]Resultant relatedness test statistics are presented in Appendix B.

respondents were in their dwelling at night. Because of such homogeneous responses, there was insufficient variance to relate to energy usage. The deletion of "children under 6," was made because very few respondents had children in that age bracket.

The deletion of "storm windows" is more difficult to explain. About one-half of the dwellings had storm windows or some other type of window insulating treatment. The literature consistently indicates that storm windows installed to decrease air infiltration effectively reduces energy consumption. There is no significant relationship between this variable and electricity consumption. Such conflicting results may be understood in the frame of this explanation: air infiltration is more affected by opened doors than closed windows, and carelessness on the part of the occupants about air infiltration could quickly negate the positive effects of storm windows.

The directional exposure of the front door was not significant and therefore the variable was deleted. The orientation of the dwelling was important according to the literature, however, a question about heat gain or air infiltration potential should have been included rather than directional exposure of the front door.

The literature is clear that white roofs reflect heat, thus affecting energy consumption. The "light colored roof" variable, however, was deleted because the test results showed no relatedness. An explanation for this statistical result was the questionnaire did not refine the definition of just how "light" a "light colored roof" might have been, therefore the respondents were unable to respond accurately.

The "full-time job" variable was deleted. Almost all respondents had at least one household member with a full-time job, hence there was not enough variance to allow any detection of relationship between this variable and the electricity usage variable.

Had the sample size been larger, and some of the questions more definite, for example the roof color, insulation, and orientation, some of the deleted variables might have been retained. Further refinement of the questionnaire would be worthwhile in future studies. Twenty seven variables were retained for further analysis. The variables which generated test statistics adequate for the retention criteria were:

1. children aged 6-18
2. family size
3. presence of children
4. non-work activities
5. part-time job
6. hours per day television was watched
7. times per month guests were entertained at the dwelling
8. size of dwelling
9. number of rooms
10. number of north windows
11. number of south windows
12. number of bedrooms
13. family income
14. inside the dwelling more than one-half the time
15. weekdays hours spent at the dwelling
16. weekend hours spent at the dwelling
17. age of household head
18. presence of persons over 65
19. number of times per month the family dined out
20. receives breezes
21. household's energy consciousness
22. number of east windows
23. number of west windows
24. facade type
25. presence of a second floor
26. life style unaffected by the energy situation, and
27. the dwelling receives shade.

Each of these variables were significant in one or more of the data sets.

Relating these variables to each other for each building type is the subject of the remainder of this chapter. This study hopes to establish whether life style and stage of life differences are related to structural attributes and energy consumption. The results may be useful in energy conservation strategies.

Energy Consumption in Apartments

Apartment dwellers tend to be short term residents. In this study, it was difficult to isolate a sample group that had been in residence during the study period. This suggests that apartment residents may have different life styles from residents of single family and condominium dwellings. These life style differences, if they exist, should be reflected in the way in which energy is consumed in apartment dwellings.

Due to the absence of previous research relating energy consumption in various dwelling types and of life styles of the occupants, it has been impossible to hypothesize how apartment dwellers' life styles affect residential energy consumption or which aspects of apartment living explain energy consumption patterns.

The results of this study indicate remarkably clear relationships of life style patterns and electricity usage by apartment dwellers. It is obvious, that energy consumption in this housing type is largely dependent upon a very small, interrelated cluster of variables.

Beginning the dwelling types analyses with the apartments was advantageous because the apartment sample exhibited natural controls on most of the physical variables surveyed. Since there was very little variation among the apartment sizes, building materials, heating systems, and construction techniques, the analysis concentrated on life cycle stages and life style variations.

The analysis results presented in Table 12 show that each factor isolated exhibits a significant amount of variance ($\pm.40$ or greater for factor loadings, and .30 or greater for communalities). Any complex variable was shown only with the factor for which it had the highest loading.

From Table 12 it is obvious that energy consumption in apartment units is dependent upon: the amount of television viewing done by the occupant, the amount of time that at least one person occupies the dwelling, the occupant's energy consumption consciousness, household size, and levels of family income.[1] Clearly, most of these variables indicate basic patterns of the life styles of the occupants. Television viewing in dwellings occupied more than one-half the time, and energy consciousness are life style variables. Also, the household size and family income influence life style.

The "domesticity" factor describes life styles which influence energy consumption. The more time spent within the dwelling unit by the occupants, the greater the energy consumption; therefore, high scores on the "domesticity" factor indicate high energy consumption. This factor was the only one selected in the discriminant procedure and had a discriminant coefficient of +.95. This finding strongly reinforces the research and speculation of other researchers.[2] That

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[1]Resultant factor matrices for the apartment sample are presented in Appendices C and D.

[2]Grot, p. 489.

TABLE 12

FACTOR ANALYSIS AND DISCRIMINANT ANALYSIS OF APARTMENT DWELLERS' LIFE STYLES, DEMOGRAPHICS; AND STRUCTURAL CHARACTERISTICS, 1978

Number	Factor	% of Total Variance	Number of Variables	Loading	Variables	Discriminant Coefficient	F Statistics	d-f	Significant Level
1	Domesticity	23.4	6	.77	Family Size	+.98	9.62	1,26	.005
				.90	Hours TV Watched				
				-.48	Family Income				
				.43	Home $>\frac{1}{2}$ Time				
				.69	Weekday at home				
				.65	Energy Conscious				
2	Weekend, Age Household Head West Window	14.1	3	.68	Weekend at home	-0-	-0-	-0-	NA
				.93	Age Household head				
				-.46	West Windows				
3	Employment, D.U. Size	10.1	3	.60	Part-time job	-0-	.33	-0-	NA
				.92	D.U. Size				
				.72	Number of Bedrooms				
4	Shade, Family Activities	8.4	3	-.43	Non Work Activities	-0-	.35	-0-	NA
				-.79	Dine Out				
				.65	D.U. receives shade				
5	Structural Exposure	7.5	3	.56	North windows	-0-	.14	-0-	NA
				-.69	East windows				
				-.61	Facade type				

TABLE 12--Continued

Number	Factor	% of Total Variance	Number of Variables	Loading	Variables	Discriminant Coefficient	F Statistics	d-f	Significant Level
6	Structure	5.8	2	.45	South windows	-0-	.84	-0-	NA
				.74	Second floor				
	Total Variance Explained	83.4							

is, when all physical attributes are equal, it is the residents' life styles that greatly influence energy consumption in the dwelling.

Knowing that domesticity affects energy consumption within apartments, possible conservation strategies can be developed. For apartment dwellers, it is very important to have structurally tight dwelling units. Since those occupants that fit the domesticity profile are the highest energy consumers, a strategy which improves the structural integrity of the unit is indicated. Reducing the amount of air infiltration, heat gain through windows and the number of energy wasting appliances (such as non-transistorized television sets) would aid in energy conservation.

The domesticity factor suggests other insights into apartment dwellers' life style and electricity consumption. Those occupants scoring low in the domesticity factor also had lower electricity consumption rates. The low scoring profile was one where the occupant used the dwelling only for sleeping and basic domestic needs. Should those occupants who use larger amounts of electricity be induced to act like those occupants who score low on the factor, there is a good chance for reduced energy consumption.

Another insight suggested by this factor is that the research did not thoroughly explore other life style constructs, a line of questioning which if pursued might indicate how the occupants spent their incomes. This line of life style questioning about the occupant's feelings toward using the dwelling as a major place in their life could reveal how occupants use their dwelling space. These lines of questions could possibly add to the understanding of why electricity consumption varies between nearly identical apartments.

Other factors developed from this sample but which were not selected by the discriminant analysis were: weekend, age household head, west window; employment, dwelling size; shade, family activities; structural exposure; and, structure. Similar factors were created for other samples (to follow in this chapter) and were important in the energy consumption prediction process.

Using the factor scores of the apartment survey, the discriminant analysis correctly classified seventy-five per cent of the observations as either high or low users of residential electricity (see Table 13). Obviously there are other variables which affected the remaining uncorrectly "grouped" cases. Since those variables were not accounted for in this research, further life style investigations seem warranted.

TABLE 13

ENERGY USE IN APARTMENT CLASSIFIED INTO HIGH OR LOW CATEGORIES*

	Number of Cases	Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1	14	11 78.6%	3 21.4%
Group 2	14	4 28.6%	10 71.4%
Per Cent of "Grouped" Cases Correctly Classified:			75.00%

*Based on data generated in this study.

Energy Consumption In Condominiums

The condominium dwelling type is often mentioned in the literature as the one most suitable for a low energy future. The dwelling type is usually built in contiguous townhouse configurations or as low rise and high rise apartment buildings. Most condominium projects are high density land use complexes and are sited near a greenbelt or a recreational facility. The condominiums surveyed for this study were all townhouses and had energy saving features such as limited window exposure, contiguity with other units, and very little dead space, all of which might conserve comfort conditioned air.

The occupants on condominiums range from single persons to retired couples. Many households find that protected and maintenance-free condominium complexes fulfill needs for social interaction, security, and freedom from maintenance. Townhouse buyers have the advantages of home ownership coupled with more efficient space utilization than that found at a typical single family detached house. The occupants tend to be more stable in their tenure at one residence (almost all the condominium respondents met the length of stay criterion). These life styles are consistent with an expectation of families in a life cycle stage in which the household head is near fifty and the children are in their mid or late teens. Usually, families in this stage are not buying a home for the first time and are confident in their home management ability.

Of particular interest to this study was the surprising finding that the condominiums had the highest per capita and per square foot electricity consumption of all building types surveyed. This study thus identified one group of high energy consumers.

The findings indicate that three factors accurately predict the energy usage of the condominium units -- family activities; employment - income - breezes; and, size (see Table 14).[1] The most important factor, family activities was composed of life cycle variables, that is, the number of children aged 6 to 18, the presence of children, and the household size. Also, this factor included the number of bedrooms, (a physical variable, but a surrogate for "household size"). Additionally, the first factor included non-work activities, a life style variable. High scores on all the variables except non-work activities leads to the inference that an intensively used dwelling required a large amount of electricity.

It was expected that non-work activities would take the occupants away from the dwelling, thus reducing the need for residential electricity usage. For this conclusion to be valid however, all household members would have to be absent simultaneously. What appears to be the case in this study of condominium dwellers is that the larger the household size the greater the likelihood that a household member may remain within the unit and consume energy. Moreover, the validity of this inference is enhanced when the activity level of the household is considered. Active life styles may be such that the energy consuming amenities of the dwelling would be used extremely intensively; for example, rooms lit when not needed, kitchen appliances used frequently, and other appliances operated more frequently.

The second most important factor -- employment - income - breezes, was composed of part-time employment, family income, and the

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[1]Resultant factor matrices for the condominium sample are presented in Appendices E and F.

TABLE 14

FACTOR ANALYSIS AND DISCRIMINANT ANALYSIS OF CONDOMINIUM DWELLERS' LIFE STYLES, DEMOGRAPHICS; AND STRUCTURAL CHARACTERISTICS, 1978

Number	Factor	% of Total Variance	Number of Variables	Loading	Variables	Discriminant Coefficient	F Statistics	d-f	Significant Level
1	Family Activities	14.7	5	.94	Children 6to18	-.79	5.01	1,33	.032
				.74	Family Size				
				.89	Children Present				
				.51	Non Work Activities				
				.57	Number of Bedrooms				
2	Home Entertainment, East Windows	13.8	3	.49	T.V. Watched	-0-	-0-	-0-	NA
				.46	Entertainment at home				
				-.74	Number of East Windows				
3	Homebound	9.2	6	.70	Home > ½ time	-0-	-0-	-0-	NA
				.50	Weekdays at home				
				.65	Weekends at home				
				.62	Age household head				
				.51	Persons over 65				
4	Size	8.1	1	.92	D.U. Size	-.39	.87	3,3	.052
5	Shade	7.3	1	-.40	Receives shade	-0-	-0-	-0-	NA

TABLE 14--Continued

Number	Factor	% of Total Variance	Number of Variables	Loading	Variables	Discriminant Coefficient	F Statistics	d-f	Significant Level
6	Employment Income-Breezes	6.2	3	.45	Part-time job	-.48	3.55	2,32	.040
				-.46	Family Income (Neg.)				
				.40	Receives breezes				
	Total Variance Explained	59.3							

breezes variables. The family income variable loading was negative, thereby reversing the impact of the variable in the discriminant classification procedure. This factor shows that the greater the number of persons with part-time jobs and the smaller the family income the larger the residential energy consumption will probably be. The "breezes" variable may indicate greater air infiltration thus increasing the potential for greater energy consumption through the air comfort conditioning system. The combination of these variables for this factor also suggests that the dwelling may have been used intermittently. Such use present problems with energy consumption management.

Condominium occupants, seeing only their monthly electricity bills have recognized that their total energy costs were lower than for single family dwellings, but may not have realized that they were using more electricity per capita and per square foot than their single family counterparts. This speculation suggests a better feedback system of comparison data for the occupants.

The third most important factor was <u>size</u>. Although this factor contributes the smallest discriminant weight, it may explain the condominium energy use clearly. Energy usage increases with the size of the dwellings. Energy consumption management for the condominiums was complicated slightly because of the intermittent use of the dwelling, which was coupled with the <u>size</u> factor. The relatively small condominiums may have produced a false sense of good energy management. Such feelings on the parts of the occupants were measured. These analyses suggest that the occupants do not take great care in assuring that electricity is not needlessly used. Other factors for the sample were: home entertainment, east window; homebound; and, shade (see Appendices E and F). With the exception of the shade factor, high scores should have indicated high energy consumption, but these factors were not selected by the discriminant analysis as helpful in predicting high and low energy consuming dwellings.

The shade factor was composed of only one variable -- whether the dwelling received significant shade. This variable had a negative loading which reversed its impact on the dependent variable. In this case, higher scores on the shade factor would indicate lower energy consumption.

Even though these last three factors were not selected for the prediction process, they did confirm other findings made in this and other research. The more a dwelling is used for entertainment, or the more its occupants are housebound, the more energy was consumed. Furthermore, the more the dwelling was shaded, the less energy was needed to keep it cooled in the summer. Using the factor scores of the three factors selected from the sample of condominiums for the raw data, the discriminant analysis currently classified 74.3 per cent of the observations (see Table 15).

The relatively large amount of misclassifications suggests that further investigation of the occupant's attitude and life style is warranted. Further analyses of how condominium dwellers spend money and, perhaps what energy consuming appliances are involved should increase the knowledge of the impact of life styles on electricity consumption. The area of life style needs more attention rather than

TABLE 15

ENERGY USE IN CONDOMINIUMS CLASSIFIED
INTO LOW AND HIGH CATEGORIES*

	Number of Cases	Predicted Group Membership	
		Group 1	Group 2
Group 1	17	14 82.4%	3 17.6%
Group 2	18	6 33.3%	12 66.7%
Per Cent of "Grouped" cases Correctly Classified:			74.29%

*Based on data generated in this study.

construction attributes and life cycle stages. The questionnaire adequately covered these variables, and since they contributed little to the prediction process, new avenues of investigation seem indicated.

Energy Consumption In Single Family Dwellings

Single family dwellers have less control over residential energy consumption than do the occupants of other dwelling types. The single family structure is more vulnerable to heat gain and air infiltration through windows exposure because of freestanding and unprotected locations. Adding to the problem is larger size, (on the average two hundred and fifty per cent larger than apartments and twenty five per cent larger than condominiums). Such larger structures provide more opportunities for energy expensive conditioned air to fill hallways, utility rooms, and other non-living areas.

Single family unit dwellers are usually child-rearing families. The potential for wasting electricity increases with the presence of children due to their energy wasting habits. Moreover, child-rearing families are more home oriented. For these families, more time is spent on home oriented entertainment. For example, they dine out less frequently than the occupants of the other dwelling types. Dwellers in single family units consume far more residential energy than any other dwelling occupant.

The analysis of the single family group indicated that six factors predicted energy consumption.[1] Four of the six factors were composed of life style and stage of life variables. The most important factor, however, was composed of structural variables, and was labeled structure-income. The factor window exposure was the fifth most important factor but still significant (see Table 16).

The impact of structure-income and window exposure seem related to those variables cited in the technical-engineering literature as building variables affecting energy consumption. The factors include such variables as: size of dwelling, number of rooms and bedrooms, and the quantity and directional exposure of the windows. Also, this factor included family income, which obviously affected the size of the dwelling. The "breezes" variable, which had a negative loading indicating an inverse relationship to high energy consumption, also was a variable composing structure-income variable. These two factors confirm findings cited in the literature that residents of larger dwelling units with many windows are generally likely to consume larger amounts of energy.

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[1]Resultant factor matrices for the Single family sample are presented in Appendices G and H.

TABLE 16

FACTOR ANALYSIS AND DISCRIMINANT ANALYSIS OF SINGLE FAMILY DWELLING OCCUPANTS' LIFE STYLE, DEMOGRAPHICS; AND STRUCTURAL CHARACTERISTICS, 1978

Number	Factor	% of Total Variance	Number of Variables	Loading	Variables	Discriminant Coefficient	F Statistics	d-f	Significant Level
1	Structure Income	22.3	6	.76	D.U. Size	-.65	14.09	1,46	.000
				.78	Number of Rooms				
				.64	Number of S. Windows				
				.48	Number of Bedrooms				
				.81	Family Income				
				-.54	Breezes				
2	Family Life Cycle Stage	12.6	4	.62	Children 6to18	-.17	9.18	6,41	.000
				.79	Family Size				
				.92	Children				
				-.59	Age-Household Head				
3	Window	8.8	3	-.55	North Windows	-.23	10.57	5,42	.000
				.72	East Windows				
				.69	West Windows				
4	Second Floor	8.0	2	.68	Part-time Job	-.45	12.70	3,45	.000
				.68	Second floor				
5	Stay at Home	6.4	4	.61	At home >½ time	-.37	12.20	4,43	.000
				.64	Weekdays at home				
				.60	Weekends at home				
				-.55	Dine-Out (Neg.)				

TABLE 16--Continued

Number	Factor	% of Total Variance	Number of Variables	Loading	Variables	Discriminant Coefficient	F Statistics	d-f	Significant Level
6	Awareness of life style affect	5.6	1	.68	Life style not affected by energy	-.54	12.52	2,45	.000
	Total Variance Explained	63.7							

The "north window" variable had a negative loading, suggesting that the including of some north windows would help energy conservation, a conclusion not widely supported in the literature. East, west, and south window exposure, conversely, was deleterious to energy conservation. This finding is supported by the literature.

The life style and the life cycle stage factors were: <u>awareness of life style affect</u>; <u>second floor, part-time job</u>; <u>stay at home</u>; and, <u>family life cycle stages</u>. Two variables included in this second set of factors had negative loadings thus reversing their impact of the dependent variable. One of the variables, the "age of the household head," was included in the <u>family life cycle stage</u> factor. The other was the "dining out" variable. It was included in the <u>stay at home</u> factor. For all other variables, high scores indicated high energy usage.

A closer examination of the factors and composite variables suggested that a division into attitude, life cycle stages, and life style can be made. The first group (attitude) has but one factor with a single variable -- "life style not affect by the energy situation." Those households responding that their life style had been affected by the energy situation lived in dwelling units that were high energy users. Perhaps their attitudinal response was an acknowledgement of the higher utility costs and their reaction to those costs. Their attitudes, therefore, may have been changed by the energy crisis.

The next group (life cycle stages) appears casually related to residential energy consumption. Such variables as family size, presence of children, and age of the household head comprise this factor. It is typical for the young large family to demand larger dwelling units. More to the point is the impact of family life cycle stages on residential energy consumption. The young family uses the dwelling unit intensively, driving up the unit's energy consumption. Life style factors are closely related to family life cycle stages.

Associated life style factors were those defined as stay at home and second floor, part-time job. The first includes such variables as: being at home more than one-half the time; being at home on weekdays; spending weekend hours at home; and dining out (negatively loaded). The other factor included such variables as the number of persons with part-time jobs, and dwelling with a second floor. This factor carries about twenty per cent of the discriminant power, each of the variables were weighted similarly. These variables represent a particular life style in single family units -- namely, families with multistoried homes having a pattern of part-time employment and spending a large amount of time in the residence.

Obviously, young larger families with life styles of spending time at home demand a large dwelling unit. This life style has a built-in potential for consuming large quantities of energy. The single family dwelling units sample showed by far the largest average kilowatt consumption of the groups surveyed.

Those families which had life styles centered in the home consume greater amounts of residential electricity than those households that had non-home centered life styles. Additionally, home centered life styles appear to demand dwellings with many windows and doors, not a surprising conclusion.

Predictive power for the single family sample proved to be more accurate that the other samples. The data for the single family sample included greatly differentiated physical and social variables. This heterogeneity, combined with a larger sample size, provided greater variation and was reflected in both the factor analysis and the discriminant analysis stages of this research. The factor scores retained this variability, enabling the discriminant procedure to make more accurate classifications. The conglomerate scores correctly predicted whether a dwelling was above or below the median electricity consumption with an accuracy of 87.50 per cent. Table 17 presents the data of the classifaction results.

TABLE 17

ENERGY CONSUMPTION IN SINGLE FAMILY RESIDENTIAL UNITS. HIGH VERSUS LOW CONSUMPTION*

		Predicted Group Membership	
	Number of Cases	Group 1	Group 2
Group 1	24	22 91.7%	2 8.3%
Group 2	24	4 16.7%	20 83.3%
Per Cent of "Grouped" Cases Correctly Classified:			87.50%

*Based on data generated in this study.

The results of this analysis indicate that effective conservation strategies for single family dwellings might be implemented for the dwelling units in the study area. Such measures include building structures to take advantage of breezes; reducing the sizes of the dwellings; and, providing alternative group entertainment and recreational facilities for the household to prevent such activities from taking place within the dwelling.

Such a conservation strategy has been partially implemented. Neighborhood recreational facilities have motivated families to spend more time outside their dwelling units. Although these neighborhood facilities exist in many new residential developments, they were not built to conserve energy, rather as a selling feature to appeal to changing life styles. The inferences from this research are that these facilities can be used in energy conserving strategies, particularly when coupled with effective programs encouraging households to use their residences for domestic chores only.

Regression analysis of the single family sample. The single family sample exhibited the largest variance because three observations were above 80,000 kilowatt hours and two were below 17,000. The remaining observations ranged from 24,000 to 59,000, with a mean of about 41,000 kilowatt hours. Such a distribution could have caused the discriminant analysis to be unduly influenced by the very high and the very low values. Further analyses were performed to verify the inferences of the discriminant analysis.

Step-wise multiple regression analyses were performed on the data set first with all 48 observations, and then with the extreme high and low dependent variable's values removed. Table 18 shows the results of the analyses.

The independent variables were composite factor schores and the dependent variable was actual kilowatt hour usage for the observations. These analyses cannot predict actual kilowatt usage for

TABLE 18

MULTIPLE REGRESSION ANALYSIS OF SINGLE FAMILY DWELLING OCCUPANTS' LIFE STYLE, DEMOGRAPHICS, AND STRUCTURAL CHARACTERISTICS, 1978

Y Intercept	n=48 40015			n=43 39198		
Factor	Regression Coefficient	Order of Entry	R^2 Increase	Regression Coefficient	Order of Entry	R^2 Increase
Structure-Income	-1.54 (t=-6.00)	1	32	-1.00 (t=-7.05)	1	35
Family Life Cycle Stage	-0-			-1.37 (t=-3.11)	4	5
Second Floor-Part Time Job	-1.40 (t=-3.56)	3	12	-1.13 (t=-6.22)	2	25
Awareness of Life Style Affect	-1.32 (t=-3.80)	2	15	- .71 (t=-3.91)	3	12
R^2			59			78

another set of observations because factor analysis was first performed; however, these analyses do show the relationships of the selected factors and each case's specific kilowatt hour consumption.

For both analyses the signs of the regression coefficients were as expected. The most important factor was structure-income. The variables composing this factor with the largest loadings were size, number of rooms, and family income. These regression results verify the conclusions reported earlier. The large free-standing dwelling is vulnerable to energy waste because of greater air infiltration potential and more specialized rooms which consume comfort conditioned air. Also, the relationships of family income and energy consumption are in congruence with the economic laws of supply and demand, and income elasticity of demand. High income households that can afford large dwellings spend more, for electricity.

When the five extreme observations were deleted, the ordering of the second and third independent variable was reversed. For the larger sample the analysis for the variable "The energy situation has not really affected my life style," showed that those respondents cognizant of the energy situation and its effects on life style, consumed less electricity. This is one of the important findings of this study--recognition that life style changes take place with decreased residential energy consumption. This finding supports the literature which reported positive effects of conservation education. This same factor was third most important in the 43 cases analysis. The amount of increase in R^2 caused by this factor was about the same, therefore a different interpretation is not necessary for the second regression.

The other factor which changed places in the order of entry with the "awareness" factor was the factor <u>second floor-part time job</u>. This factor was composed chiefly of two variables -- presence of a second story, and presence of a household member holding a part-time job. Both variables had identical factor loadings.

Dwelling units with a second story may be less energy efficient, providing greater potential for energy waste and being more difficult to heat and cool. Zoned heating and cooling plants would probably reduce energy use in these cases. The part-time job variable apparently is a descriptor of a different family life style. Households with members holding part-time jobs exhibit higher residential energy consumption. A disinterest in home energy management may lie at the base of the poor residential energy management.

The same factor does not hold such a prominent place in the larger sample. The presence of those cases which had electricity consumption ranging from 80,000 to 103,000 kilowatt hours are dwellings which are used very intensively or carelessly--in either case the part-time job and the second floor variables were less important.

The <u>family life cycle stage</u> factor entered the smaller sample regression only. The factor was composed of such variables as family size, presence of children, and age of the household head. This factor added the least to the explanation of energy consumption. The interpretation of this factor is consistent with conventional wisdom; that is, the larger the family with children the greater the residential energy consumption.

The <u>window</u> and the <u>stay at home</u> factors which were important in the discriminant analysis were not significant for the regression analysis. This is not surprising since the objective of the discriminant analysis was to classify high and low energy users, while the objective of this regression analysis was to analyze the relationships between the case's factor scores and the case's actual energy consumption. A benefit of conducting these regression analyses is the selection of key variables which may be used to predict residential energy consumption for free-standing single family dwelling units. Future research focusing on these variables may prove to be very helpful.

Energy Consumption In The Aggregate Sample

Energy consumption in all studied dwellings is largely a function of structural attributes and the occupants' life styles. Residential energy consumption can obviously be achieved by changing construction methods. Many households would find it difficult to make necessary structural changes. If such households are serious about energy conservation they will have to make commitments to "retrofit" programs.

Occupant life styles that are centered on the home, thus calling for intensive use of the dwelling, result in greater energy consumption rates regardless of the efficiency of the structure. A life style which demands an intensively used residence is usually associated with a particular family life cycle stage. Younger, larger families are obviously the ones which consume the largest amounts of residential electricity.

The total sample analyzed here aggregates the three building types sampled. Five factors were selected by discriminant analysis as statistically significant (see Table 19). The composition of the factors was strongly influenced by the homogeneity of the physical variables found in the apartment and condominium samples. This homogeneity may have underemphasized the importance of life style and life cycle stages in the aggregate sample.

The aggregate sample factors which emerged were: family life cycle stage; size-north exposure; homebound; east-west exposure;

TABLE 19

FACTOR ANALYSIS AND DISCRIMINANT ANALYSIS OF ALL DWELLINGS
OCCUPANTS' LIFE STYLE, DEMOGRAPHICS; AND
STRUCTURAL CHARACTERISTICS, 1978

Number	Factor	% of Total Variance	Number of Variables	Loading	Variable	Discriminant Coefficient	F Statistics	d-f	Significant Level
1	Family Life Cycle Stage	26.5	3	.84	Children 6to18	-.57	25.89	2,108	.000
				.78	Family Size				
				.74	Children present				
2	Size-North Exposure	8.9	5	.74	D.U. Size	-.61	23.80	1,109	.000
				.73	Number of rooms				
				.70	North windows				
				.57	Number of bedrooms				
				.51	Family income				
3	Homebound	7.5	4	.68	Home >½ time	-.28	19.99	4,106	.000
				.64	Weekdays at home				
				.63	Weekends at home				
				.50	Age household head				
4	East-West Window Exposure	6.3	2	.65	No. of East windows	-.47	23.86	3,107	.000
				.65	No. of West windows				
5	Facade Type	5.4	1	.69	Facade Type	-0-	.17	-0-	NA

TABLE 19--Continued

Number	Factor	% of Total Variance	Number of Variables	Loading	Variable	Discriminant Coefficient	F Statistics	d-f	Significant Level
6	Awareness of Life Style Affect	4.9	1	.52	Life Style Not Affected by Energy	-.19	16.49	5,105	.000
	Total Variance Explained	59.5							

facade type; and, awareness of life style affect.[1] The physical characteristics of the dwellings were most important in the energy consumption prediction process, the same was true in the case of single family dwellings.

The family life cycle stage factor is key to understanding residential energy consumption in all dwellings. This factor indicates that the residents may need larger sized residences. Should the life cycle stage be that of a single person household or a retired couple the residence needed may be smaller than that of a young household with children. The family life cycle stage factor indicates not only the size of the residence, but also the life styles involved. Younger families with children tend to spend more time at the dwelling and use it more intensively, thus consuming more electricity.

Two "physical structure" factors emerged from the aggregate analysis. These factors contributed about one-half (51 per cent) of the interpretation offered by the discriminant process. The variables of these involved factors were: size of dwelling; number of rooms and bedrooms; north window exposure; family income (a demographic variable indicating the ability to own a large residence); and, east and west window exposure. Larger scores on the factors would have indicated larger energy consumption.

The extent of window exposure has consistently been associated with increased energy consumption. Heat loss (or gain) and air

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[1] Resultant factor matrices for the total sample are presented in Appendices I and J.

infiltration seem to have strong effects on all dwellings. Window exposure, however, did not seem to be associated with life styles.

Sizes of dwellings, the number of rooms and bedrooms suggested differences in life styles. Whether the total number of rooms is used intensively may not be significant. Houses with many rooms consume more energy. If each room must be heated and cooled the dwelling will likely be high in energy consumption. As was pointed out in the survey of research, it is a common practice in Sweden to use fewer rooms in the winter thus decreasing the need for heating fuels. The same practice could save energy in the United States.

Life style factors occur in the aggregate analysis but are not as important in the prediction process as are physical and life cycle stage factors. Two factors homebound, and awareness of life style affect have high discriminant coefficients. These two factors account for about 20 per cent of the predictive ability of the factor analysis dimensions. Such a finding supports most energy researchers in discounting the importance of the effects of life style on residential energy consumption.

However, when the data were disaggregated into the three building types, the life style and life cycle factors become paramount in the prediction process. In the aggregated data, the life styles seem to be obscured. An inference of this is that better understanding of residential energy consumption could come about by incorporating life style inquiry with the research design for residential structural energy research.

Even though life style factors are not major determinants of the energy consumption in all dwelling units, they have proven to be quite important in the other samples analyzed and consistent with the expectations of this study. In this sample, as in the disaggregated ones, the awareness of life style affect occurs as an attitudinal reaction to high utility costs. The factor entitled homebound is a life style factor which offers a richer area for possible energy conservation strategies.

This factor's interpretation suggests that the greater amount of time an occupant spends within the dwelling unit the greater his energy consumption. It follows then, strategies designed to keep residents out of the dwelling ought to be effective energy conservation strategies. These same strategies might be suggested for all other building types.

The factor facade type was not used in the discriminant analysis, possibly because of the low variability of the data represented in the factor scores. The factor scores of the other factors had wide variance, thus the discriminant process had a high rate of correctly classified cases (see Table 20).

One important inference from the aggregate analysis is that the life styles of the occupants and their life cycle states, is almost as important as the physical attributes of the dwelling unit with respect to residential energy consumption. Just as retrofit procedures should be applied to the physical attributes of the dwelling, a type of "retrofit" should be applied to life style's of the occupants. A life style content with smaller dwellings and fewer electrical

TABLE 20

ENERGY CONSUMPTION IN ALL DWELLING UNITS
HIGH VERSUS LOW CONSUMPTION*

	Number of Cases	Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
Group 1	55	45 81.8%	10 18.2%
Group 2	55	11 20.0%	44 80.0%
Per Cent of "Grouped" Cases Correctly Classified:			80.91%

*Based on data generated in this study.

appliances seems indicated. Should no changes be made in American style of life, there could well be a time when present life styles will lead to energy consumption expenditures beyond the means of households, causing an impoverishment of America's quality of life.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this research project has been to examine the relationships between structural and site characteristics of dwelling units, life styles and family life cycle stages, and residential electricity consumption. One major reason for conducting the study was to amplify the understanding life style and the magnitude of its impact on residential energy consumption.

Today, virtually every American residence consumes electricity. From 1900 to the late 1970's, the demand for electricity and electrically powered appliances grew steadily. Between the mid 1940's and on to the mid 1970's, the prices of electricity decreased. These price decreases encouraged greater demand. In the mid seventies, production costs and consequent prices to the consumer began to rise rapidly. The consumer, by this point in time, well acclimated to a life style supported by electricity, was caught in a dilemma -- high expectations and scarcity. He was forced to allocate larger proportions of the household budget to pay for the residential energy he consumed.

Proven reserves of domestic petroleum are decreasing while the demand for it continues to climb. Coal is plentiful, however, because of its harmful environmental effects petroleum and natural gas remain the preferred basic fuels for electricity generation. Federal laws, however, now require that new generation plants be fueled by coal, and that some older gas fired plants be converted to coal.

The increased costs of fuels are borne by the consumer. In the seventeen years from 1960 to 1977, personal consumption expenditures of the American household for electricity increased 292 per cent. This increase was greater than the increases for housing, household operations, or natural gas.

Many authorities believe that the solution to the overall energy crisis will come through technological means without sacrifices or changed life styles by the consumer. Most of the literature devoted to the energy crisis comes from the engineering and the physical science disciplines; the social sciences have only recently begun to contribute to a solution.

Most energy related research points to "retrofit" as an immediate and long term solution. Energy efficient machines and buildings could be produced by applying fairly low level technological solutions to existing structures, and building in energy efficiencies in new structure. Retrofit solutions such as storm windows and increased insulation do have the potential of decreasing energy consumption without affecting the life styles of American households. Perhaps long run solutions rest mainly with safe and efficient electricity production from alternate sources as nuclear or solar power plants.

Project Independence promised solutions to the energy crisis. As a result of Project Independence, many empirical research projects have pointed out that certain retrofit strategies and different construction techniques could drastically reduce the rate of increase in residential electricity consumption. With such solutions the quality of life can remain high at much lower per capita consumption levels.

Residential land use designs hold the potential for greater energy conservation. Locating dwelling units to take full advantage of climatic benefits is easiest in new developments; however, landscaping can enhance the micro-climate of an older residence.

The "soft path" solution emanates from the belief that demand for electricity will not grow appreciably and therefore the heavy investment of utility companies in infrastructure will not be needed. The soft path uses available technology to produce electricity on a local household scale. Solar or wind powered generation devices could connect to existing residential power sources. This path would not radically disrupt present American life styles.

The Energy Acts of 1977 and 1978 have had a great effect on residential energy problems. These Acts established the Department of Energy, and forced utilities to become more involved in energy conservation.

In recent years the growth of demand for electricity has decreased. This is in part due to higher prices and conservation education efforts. However, small changes in price and income have relatively minor effects on electricity consumption in the short-run. In the long-run consumers will be able to replace inefficient energy using devices. Households in higher income brackets tend to have coefficients of income elasticity indicating electricity is a normal good. Households in the lower income brackets, however, have income elasticity coefficients indicating the good may be a necessity.

Households on fixed or relatively small and stable incomes find it difficult to pay the increasing costs of electricity.

In addition to technological solutions, other studies have tried to isolate life style factors, such factors were principal causes of comfort in a residential environment. Another important finding was the positive effect of temperature feedback systems. Some studies pointed to the amount of discreationary time available to the occupants of different dwelling types as a significant life style variable affecting residential energy consumption. In general the volume of studies from the physical sciences and the engineering disciplines far outweigh the contributions of the social sciences. This study attempts to integrate these research perspectives.

The Research Methodology

From a finite population of "all electric" residences constructed in 1975 in Oklahoma City, samples were drawn and questionnaires were administered to residents of one year or more. With the occupant's permissions, the exact kilowatt consumption was obtained for the previous 12 months. The kilowatt usage became the dependent variable.

The questionnaire contained 37 questions. There were independent variables and were divided among physical structure descriptions, site characteristics, life cycle stages, and life style time measurements. The questionnaires were completed by the occupants of the single family residences, apartment dwellings, and townhouse condominium units.

Contingency table analysis eliminated 10 variables as not significantly associated with electricity consumption. The remaining 27 variables were statistically significant for one or more of the dwelling types. This strategy allowed the same important variables to be used in factor analysis and discriminant analysis for each building type. The examination of the factors and their ability to discriminate between high and low energy consuming dwellings proved to be significant.

Analysis and Results

The analysis and results focused on interrelationships among structural attributes and the occupant's life styles. The variables which were associated with residential energy consumption were factor analyzed and factor scores were generated. The scores were used in the discriminant analysis to find those factors which predicted residential electricity consumption.

Comparing the results of each dwelling type provided a better understanding of the relationships of living patterns and structural attributes found with different dwelling types and allowed the measurement of impacts of such variables on energy consumption.

Energy Consumption In Apartments. Apartment dwellers tended to be short term residents. Those dwellers which used the apartment for more than the barest domestic needs tended to be higher energy users.

Factor analysis produced one factor -- domesticity -- to be used in the discriminant analysis. This factor correctly predicted the energy use classification of the apartments about 75 per cent of the time.

Domesticity consisted of life cycle and life style variables. Its cluster of variables all focused on the use intensity of the dwelling. The higher measurements on this factor indicated that the unit was used more for the entertainment of the household members and domestic chores. Higher scores on the factor indicated higher electricity consumption.

All major life cycle stage variables and the major structural variables were accounted for in the questionnaires submitted to the occupants. The life style variables were limited mostly to the occupants allocation of time. Measurements of other life style attributes could have added to the precision of the discriminant procedure classification results.

Energy Consumption In Condominiums. The condominium-townhouse dwellers were on the average older and had higher family incomes than those of the other samples. The dwellers ranged from single person households to retired couples. They were stable with respect to the length of stay criterion, and many had children in their mid and late teens.

Three factors accurately predicted the energy use classifications about 75 per cent of the time for the townhouses. The factors were: family activities; employment, income, breezes; and, size. The first factor was composed mostly of life cycle variables; additionally, it included the life style variable -- non-work activities. High scores on the family activities factor indicated that the dwellings were used intensively and as a consequence consumed larger than the average amount of electricity for their sizes.

The employment, income, breezes factor consisted of the part-time employment variable, the family income variable (which was negatively loaded), and the "breezes" variable. The factor indicated that the dwelling may be used intensively intermittently and also that breezes subjected the dwelling to high air infiltration. Such variables have the potential of increasing the energy load on the dwelling.

The other factor was size. The larger the townhouse the more energy it consumed. This factor may explain the condominium puzzle. The occupants gain a false sense of good energy management because the monthly electric costs are smaller than those for the average single family dwelling, yet the consumption per square foot in townhouses is larger. The smallness of the townhouses may create an illustion of conservation which causes the occupants to be less conservation minded.

As with the apartment dwelling sample, the questionnaire thoroughly covered the physical variables and the life cycle stage variables. The life style variables concerned with time allocation was the only life style area examined. Should other life style variables have been examined, the percentage of misclassifications possibly would have fallen.

Energy Consumption In Single Family Dwellings. These types of dwelling were more affected by heat gain and loss because of their free standing characteristics. Occupants of single family dwellings have less control over their energy consumption management because the physical structure variables overwhelmed the occupants' ability to control them. The larger size usually associated with single family dwellings provided too many potential energy-wasting dead spots throughout the house such as those found in hall ways, utility rooms, hall closets and so forth.

Single family dwellers were usually child rearing family units and were subject to the energy using and wasting activities associated with a busy household. Doors and windows opened too often will increase the air infiltration potential and increase the need for more energy to recondition the air of the dwelling. Also, larger families tend to burn more lights and run entertainment appliances for empty rooms.

Almost 88 per cent of the sample cases were correctly classified by using the six factors. Life style and life cycle stage factors accounted for four of them. The other two were composed of physical and structural variables. The factors were: family life cycle stages; stay at home; second floor - part time job; awareness of life style affect; structure - income; and, window exposure.

The most important factor was structure-income. The window-exposure factor was the fifth most important. The factors included such variables as dwelling size, number of rooms and bedrooms, and, quantity and directional exposure of windows. The first factor included the variable family income, and "breezes" which was negatively loaded, thus reversing its impact.

In addition to life style and life cycle an attitude factor can be identified. The attitude factor had just one variable, an attitudinal statement of the occupant toward the energy situation and its effects. The life cycle cluster of variables indicated that the younger large family units consumed more electricity than any other family life cycle stage group. The life style group of variables pointed to a style of life which was home centered. The more intensively the dwelling is used for occupant activities the more electricity is consumed.

Energy Consumption In All Dwellings. When the data of all the dwelling types were aggregated, the physical and structural factors predominated in the classification-prediction process. The life style factors were over-shadowed by both the structural factors and the life cycle factors. The life cycle stage factor explains the presence and importance of the other factors. The five factors were able to correctly classify about 81 per cent of the cases.

The total sample factors used by the discriminant process were: family life cycle stages; size - north exposure; homebound; east - west window exposure; and, awareness of life style affect. The family life cycle stage factor was the key to understanding residential consumption in all dwellings. The larger family demands larger dwellings and uses them more intensively. The smaller households usually have smaller dwellings and do not use them intensively. The size and intensiveness of use of the dwelling are the main variables measuring the relationship of energy consumption of all dwellings.

The two "physical structure" factors contributed about 51 percent of the weight in the discriminant analysis. They included such variables as: dwelling size, number of rooms and bedrooms, window exposure, and family income.

The principal life style factor was homebound. The more the occupants stayed at home, the larger their residential energy consumption. The other life style factor was an attitudinal response reflecting the higher costs of electricity.

The cluster of variables which proved to be the most important with some dwelling types in the classification process, were not important with other types. The life style was the most important in the prediction process when there was little variability among the physical traits. Also, the life style variables were a function of the life cycle stage variables. The life style variables mainly measured the occupants expenditure of time, where and how it was spent.

Conclusions

In the decade of the seventies, 17.8 million residential units were constructed -- the most prolific period of building in the history of the country. Using the same trend indicators, the decade of the eighties will demand 19.4 million residential units.[1] The demand for housing will continue to be strong. What kind of housing, as well as how energy efficient the houses will be remains to be seen. It is clear that the quality of life of the American household need not suffer because of decreasing energy availability.

The residential dwelling unit is a complex thermal system consisting of multiple material and human subsystems. This research has brought about a better understanding of the interrelationships of these subsystems. With this understanding coupled with research and

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[1] Gurney Breckenfeld, "A Decade of Catch-Up For Housing," Fortune, April 7, 1980, p. 47.

solution scenarios already present in research literature, better solutions to the energy crisis can be formulated.

The relationship of the time allocation life style measurement and the energy consumption of various dwelling types researched is remarkably consistent. In all cases, the more time an occupant allocates to domestic chores and home entertainment the greater is the residential energy consumption. Another consistent relationship found for each dwelling type is that of family life cycle stage and the time allocation life style measurement. The younger family units with children spend more time within a dwelling unit and consume more electricity than any other occupant class.

The decade of the seventies witnessed a trend toward more lavish dwelling units with larger rooms, more baths, and even more fireplaces.[1] A life style which makes the residence the center of the household's style of life has produced this demand for more lavishness. Such expectations must change in order to effect conservation of energy. Research which suggests that the energy crisis can be handled solely through structural modifications would seem in the light of this study to be of questionable validity. Life style changes must take place along with appropriate structural modifications.

The changed life style needed to conserve energy in the home calls for a simpler style of life. One which would demand smaller dwellings, fewer energy wasting conveniences and appliances and a self reliant mode of life. These changes of life styles would not

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[1]Ibid, p. 50.

detract from the present quality of life and might even enhance it. A simpler life style can be a life style of "plenty."

Life style modifications that promote conservation have already started. Some new residences are considerably smaller than those found a decade ago. Also, the newest residences are constructed with appropriate amounts of insulation, double glazed windows, energy saving window exposure, energy efficient heating and cooling plants, and are usually located on smaller lots. However, these newest residences still have several bath rooms, fireplaces, specialized and isolated rooms, and more lavishness than that prescribed for an energy conservative life style.

A life style which would promote energy conservation would be one which uses the dwelling for the barest of domestic chores. Entertainment, family activities, and child rearing activities would have to take place elsewhere. Such occupant behavior and use of time within the dwelling would be consistent with the energy conservation findings of this research.

The "bare necessities" strategy is not a popular one and as long as present life styles demand large expensive dwellings, austere housing will not be welcomed by the large majority of housing consumers. There are however incentives available to help in the propogation of changed life styles. Some of the energy Acts of 1978 and in particular the National Energy Conservation Policy Act (NECPA) has provisions for creative planning to make new and existing residential areas more energy efficient. The direction being taken at this time is to increase retrofit activities. There are other directions, however, which can promote residential energy conservation and a life style of less demand for lavishness. One such strategy which could be facilitated by the conservation Act is the "soft path" approach advocated by Lovins.

An energy conserving scenario using the findings of this project would use these ideas: (1) Close off parts of the dwelling from the heating and cooling plants. Should some reason exist for these closed parts of the dwelling to be used, portable space heaters and coolers could provide temporary comfort. With parts of the dwelling closed off, the household would be forced to live in a smaller dwelling and thus consume less energy. (2) The use of zone heating and cooling systems regulated by outside temperature and with devices to make sure certain electrical appliances are not operated when there are not household members present. (3) Each residential area should have nearby "community center" facilities where the family's activities could take place. For instance, a "community" television room and nursery could be well equipped and maintained by a management group composed of the residents who are being served by the center. The center as well as its nearby residents could operate a "soft path" power facility. The end result would be less electricity consumed and concurrently electricity would be generated by renewable fuels. This scenario would demand a life style change but not a quality of life change.

Suggestions for Further Research

A life style description which should be explored is the use of the expenditure of household income on the residence and energy consuming appliances. This research could possibly develop specific psychographic terms enabling other social scientists to research the time allocation aspects of life style and the family income allocation with the goal of understanding these life style affects on energy consumption. Such an understanding would enhance the planning of strategies for the modification of life styles and dwellings which would result in decreased energy consumption.

Another life style attribute which needs attention is the movement of household members within the dwelling itself. Identifying the spatial movements of the members and relating the movements with energy consumption could lead to a clear understanding of the use of dwellings. It is possible that such information could influence the redesigning of dwelling structures. Greater space may be allocated for sleeping or perhaps to entertaining, or to some other combination of family needs and activities.

A research project such as this one could become more formal with specific hypotheses. By using the relationships discovered in this research, tests for significance for certain hypotheses concerning life style could be formulated. With few modifications of the research design used in this project, hypotheses tests could be coupled with seasonal variations. The electricity consumption data are available on a monthly basis. This avenue of research offers rich rewards because at this time it is still not known how the life style patterns change with the seasons and how these changes affect energy consumption in the different dwelling types.

A final observation necessary as a conclusion to this research is that the social sciences can and must bring their resources to focus on the energy crisis. This crisis involves behavior. It is a crisis which in large part has been produced by and the solutions probably lie in modified behavior patterns. These conclusions call for life style changes which may not be readily acceptable by the consuming public. Since life styles do change slowly, there will be time to construct workable and acceptable strategies. The construction of these strategies should be the product of the joint efforts of the physical scientists, social scientists, architects, developers, builders, utilities, and the marketers of residences. Social scientists, and the professional practitioners in the many fields comprising the housing industry must work together to provide the consumer with satisfying residences that will provide a high quality of life and energy efficient living spaces.

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APPENDICES

APPENDIX A

Appendix A

Questionnaire

O.C.U. - O.U. Electricity Usage Research Project

This form, when signed by you, will require O. G. & E. to furnish your residential electricity usage to the O.C.U. - O.U. electrical usage research project. The electricity usage report will be stated in kilowatts and will be limited to the past twelve months. Only the number of kilowatts used is needed for this research project. Neither your name nor address will be a part of the research data. This form will be kept by O. G. & E. after the kilowatt usage figure is noted on your questionnaire.

OKLAHOMA CITY UNIVERSITY - OKLAHOMA UNIVERSITY

Consent to Use Customer Information

I/we, the undersigned, hereby give my/our consent to Oklahoma Gas and Electric Company, a corporation, to furnish the number of kilowatts used by my/our residence for the past twelve months to O.C.U. - O.U. residential electricity usage research project.

____
Signed

Please Print

Name ________________________
Address ________________________
Apt. No. ________________________
City ________________________
Date ________________________

____

O.C.U. - O.U. Residential Electricity Usage Research

1. Yearly kilowatt usage (supplied by O. G. & E.) ______________________________

2. What is the construction material used for the exterior of your house? (Check one)
   - ☐ Brick, rock, or masonry material
   - ☐ Wood
   - ☐ A combination of the above

3. Does your house have either storm windows and/or double pane glass? (Check one)
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

4. Does your house's front door and porch face in a southerly direction? (Check one)
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

5. How many windows are on the following sides of your house?
   - (a) Windows on the south side __________________________
   - (b) Windows on the north side __________________________
   - (c) Windows on the east side __________________________
   - (d) Windows on the west side __________________________

6. Is your house sheltered from brisk breezes? (Check one)
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

7. Does your house receive some shade from trees, awnings, large overhangs, etc. (Check one)
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

8. Is your roof made of either wood shingles, or light colored (white, tan, or light gray) composition material? (Check one)
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

9. Does your house have a second story? (Check one)
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

10. How many finished rooms does your house have, not counting the bathroom(s) or kitchen? __________

11. How many rooms in your house are used for sleeping? __________

12. What is the square footage of the living area of your house (the square footage should not include the garage). ______________________
   /_7 Don't know.

13. What is the thickness, or the "R" value of your ceiling insulation?
   __________ /_7 Don't know.

14. Do you think you have the proper amount of ceiling insulation? (Check one)
   /_7 Yes
   /_7 No
   /_7 Don't know

15. How many persons are in your family and live in this house? __________

16. How many persons in your household are:
   (a) under five years old? ______
   (b) between 6 - 18? ______
   (c) over 64? ______

17. How many persons in this family normally have a full-time job? ________

18. How many persons in this family normally have part-time jobs? ________

19. What is the occupation of the head of this family? (Check one)

   /_7 Professional and/or a manager
   /_7 Skilled
   /_7 Unskilled
   /_7 Retired
   /_7 Unemployed

20. In which of the following age group does the head of this household fall? (Check one)

   /_7 Under 18
   /_7 19 - 24
   /_7 25 - 29
   /_7 30 - 34
   /_7 35 - 39
   /_7 40 - 44
   /_7 45 - 49
   /_7 50 - 54
   /_7 55 - 59
   /_7 60 - 64
   /_7 65 - 69
   /_7 70 - 74
   /_7 75 and over

21. Considering all sources of income and salaries, what (approximately) was your total family income in 1977 - the income before deductions for taxes or anything? (Check one)
  - ▱ Under $5,000
  - ▱ 5,000 - 14,999
  - ▱ 15,000 - 24,999
  - ▱ 25,000 - 34,999
  - ▱ 35,000 - 44,999
  - ▱ 45,000 - 54,999
  - ▱ 55,000 - 64,999
  - ▱ 65,000 - 74,999
  - ▱ 75,000 and over.

22. We are interested in the amount of time per day during your typical work week there is someone in the house who would be running the electrical appliances and the heating and airconditioning systems.
"There is someone in the house using the electric appliances." (Check one)
  - ▱ Almost all the time (20-24 hours)
  - ▱ Most of the time (15-19 hours)
  - ▱ About half the time (10-14 hours)
  - ▱ Not much of the time (5-9 hours)
  - ▱ Almost none of the time (4 hours or less)

23. On the average, for a typical weekend, about how much of the time is there someone in the house? (Check one)
  - ▱ Almost all the time (40-48 hours)
  - ▱ Most of the time (30-39 hours)
  - ▱ About half the time (20-29 hours)
  - ▱ Not much of the time (10-19 hours)
  - ▱ Almost none of the time (9 hours or less)

24. About how often does the family or its members entertain guests or have meetings at the house?
The number of times per week? ______________________
(If more appropriate -- the number of times per month? __________________).

25. During the typical work week, about how many hours per day do you or some members of this family watch TV?
Sign on til 12 noon ____________________
Noon til 6 p.m. ____________________
After 6 p.m. ____________________

26. On the average, how many times per week do you and/or your family dine out?
____

27. How many family members usually have lunch at this house? ____________________

28. How many family members usually have breakfast at home? ____________________

29. About how many nights per week is there someone at home? ____________________

30. On the next page, a number of non-employment activities are listed. On the lines below the list please write the number preceding the activity, the number of household members typically participating in the activity and the hours per week or month spent on the activity.

HOUSEHOLD MEMBER NON-EMPLOYMENT ACTIVITIES LIST

1. Errands, shopping, carpooling, etc.
2. Recreational activities -- golf, tennis, fishing, softball, etc.
3. Church or synagogue worship activities, study activities, and clubs.
4. Social enjoyment groups -- country clubs, squaredance clubs, etc.
5. Business and professional associations.
6. Boards of trustees or directors of economic organizations.
7. Formal education classes, and adult education groups.
8. Economic service clubs -- Lions, Rotary, the Chamber, etc.
9. Political Party Organizations, Good Government Leagues, Patriotic groups.
10. Neighborhood or community planning organizations.
11. Parent-Teacher organizations.
12. Fraternal or society groups, vocational groups, unions.
13. Athletic teams or clubs -- T-ball, coaching, etc.
14. Children or youth activities groups -- Scouts, Y.M.C.A., etc.
15. Cultural groups -- study and forum groups.
16. Charitable organizations.
17. Welfare and Humane associations, social agencies.
18. Community groups -- United Appeal, Heart Society, etc.

Activity Number	Number of Household Members	Hours/Week	Hours/Month

31. To what extent do you agree or disagree with the following?
"The energy situation has not really affected my lifestyle." (Check one)
- ▱ Strongly agree
- ▱ Agree
- ▱ Uncertain
- ▱ Disagree
- ▱ Strongly disagree

32. "This household is very energy conscious." (Check one)
- ▱ Strongly agree
- ▱ Agree
- ▱ Uncertain
- ▱ Disagree
- ▱ Strongly disagree

33. Would you say that there is someone at home more than half the time or less than half the time? (Check one)
- ▱ More than half the time
- ▱ Less than half the time
- ▱ Don't know

APPENDIX B

Appendix B

List Of Variables And Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-miniums n = 34	Apartments n = 28
No. 1. Children Aged 6 to 18 (ratio data)				
Chi Square, Sig. Level	.00	.11	.09	na
Cramer's V	.40	.35	.37	na
Mean	.48	.73	.43	.00
Std. Dev.	.85	.98	.73	.00
No. 2 Family Size (ratio data)				
Chi Square. Sig. Level	.00	.14	.02	na
Cramer's V	.48	.38	.47	na
Mean	2.29	3.02	2.05	1.18
Std. Dev.	1.16	1.14	.63	.39
No. 3 Presence of Children (nominal data)				
Chi Square, Sig. Level	.00	.23	.14	na
Cramer's V	.49	.30	.32	na
Mean	.34	.58	.26	.00
Std. Dev.	.18	.50	.40	.00

Appendix B (continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condominium n = 34	Apartments n = 28
No. 4. Non-work Activies, hrs/mo (ratio data)				
Chi Square, Sig. Level	.00	.13	.45	na
Cramer's V	.30	.31	.27	na
Mean	146.80	179.70	148.20	77.90
Std. Dev.	158.33	149.90	205.50	63.50
No. 5. Part-time Job (Nominal data)				
Chi Square, Sig. Level	.01	.01	.36	na
Cramer's V	.27	.51	.24	na
Mean	.20	.20	.26	.07
Std. Dev.	.50	.46	.61	.27
No. 6 TV Watched, hrs/day (ratio data)				
Chi Square, Sig. Level	.00	.30	.25	na
Cramer's V	.28	.27	.34	na
Mean	5.38	7.18	4.17	3.57
Std. Dev.	4.90	5.75	3.80	3.25

Appendix B (continued)

List of Variables and Statistics

	Variables and Statistics	Total n = 110	Single Family n = 48	Condo-minium n = 34	Apartments n = 28
No. 7	Entertained at Dwelling, Times/Mo. (ratio data)				
	Chi Square, Sig. Level	.00	.08	.48	na
	Cramer's V	.43	.54	.40	na
	Mean	3.81	5.13	2.43	3.14
	Std. Dev.	5.28	6.82	1.90	4.40
No. 8	Dwelling Size, sq. ft. (ratio data)				
	Chi Square, Sig. Level	.00	.03	.23	na
	Cramer's V	.47	.36	.27	na
	Mean	1548.90	2057.80	1494.90	727.30
	Std. Dev.	672.20	609.60	136.77	47.90
No. 9	No. of Rooms (ratio data)				
	Chi Square, sig. Level	.00	.01	.52	na
	Cramer's V	.56	.46	.25	na
	Mean	4.44	5.83	4.14	2.32
	Std. Dev.	1.73	1.33	.77	.48

Appendix B (continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-minium n = 34	Apartments n = 28
No. 10 No. of North Windows (ratio data)				
Chi Square, Sig Level	.00	.23	.50	na
Cramer's V	.48	.45	.35	na
Mean	2.34	3.60	1.83	.78
Std. Dev.	2.27	2.33	1.90	1.19
No. 11 No. of South Windows (ratio data)				
Chi Square, sig. level	.00	.29	.39	na
Cramer's V	.43	.46	.38	na
Mean	2.16	3.63	1.20	.82
Std. Dev.	2.37	2.39	1.66	1.68
No. 12 No. of Bedrooms (ratio data)				
Chi Square, Sig. Level	.00	.01	.02	na
Cramer's V	.54	.44	.47	na
Mean	2.25	3.04	2.05	1.07
Std Dev.	1.02	.77	.64	.26

Appendix B (continued)

List of Variables and Statistics

	Variables and Statistics	Total n = 110 n = 110	Single Family n = 48	Condo-minium n = 34	Apartments n = 28
No. 13	Family Income (ratio data)				
	Chi Square, Sig Level	.00	.07	.33	na
	Cramer's V	.48	.46	.48	na
	Mean	27063.60	31083.30	29142.90	16607.20
	Std Dev.	16320.80	16661.60	16868.20	10004.80
No. 14	At Home More than 1/2 Time (nominal data)				
	Chi Square, Sig. Level	.00	.49	.22	na
	Cramer's V	.42	.22	.27	na
	Mean	.63	.83	.63	.28
	Std. Dev.	.49	.38	.49	.46
No. 15	Weekdays, Hours at Home (ratio data)				
	Chi Square, Sig. Level	.16	.68	.38	na
	Cramer's V	.25	.26	.39	na
	Mean	29.81	82.02	61.82	57.86
	Std. Dev.	29.87	26.07	29.44	31.19

Appendix B (continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single F Family n = 48	Condo-minium n = 34	Apartment n = 28
No. 16. Weekends Hours at Home (ratio data)				
Chi Square, Sig. Level	.04	.30	.03	na
Cramer's V	.26	.27	.55	na
Mean	31.35	35.44	31.20	25.32
Std. Dev.	10.64	8.57	10.45	11.35
No. 17. Age Household Head (ratio data)				
Chi Square, Sig. Level	.59	.14	.02	na
Cramer's V	.37	.52	.80	na
Mean	42.09	40.65	47.11	39.18
Std. Dev.	13.41	12.58	12.56	14.61
No. 18. Presence of Persons Over 65 (Nominal data)				
Chi Square, Sig. Level	.56	.05	.71	na
Cramer's V	.13	.40	ø .07	na
Mean	.06	.08	.06	.04
Std. Dev.	.25	.28	.24	.19

Appendix B (continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-Miniums n = 34	Apartments n = 28
No. 19. Dine out, times/mo				
(Ratio data)				
Chi Square, Sig. Level	.45	.11	.24	na
Cramer's V	.27	.39	.51	na
Mean	2.82	2.04	3.00	4.00
Std. Dev.	2.09	1.50	1.86	2.57
No. 20. Dwelling Receives Breezes				
(Nominal Data)				
Chi Square, Sig. Level	.02	.00	.75	na
Cramer's V	.29	.57	ϕ .01	na
Mean	.69	.88	.69	.39
Std. Dev.	.46	.33	.47	.50
No. 21. Household Is Very Energy Conscious				
(Ordinal data; 1 = Stronly Agree, 5 = Stronly Disagree.)				
Chi Square, Sig. Level	.10	.06	.48	na
Gamma	.41	.61	.06	na
Mean	2.11	2.13	2.34	1.96
Std. Dev.	.98	1.00	1.00	1.11

Appendix B (Continued)

List of Variables and Statistics

	Variables and STatistics	Total n = 110	Single Family n = 48	Condo-miniums n = 34	Apartments n = 28
No. 22.	No. of East Windows (Ratio Data)				
	Chi Square, Sig. Level	.00	.00	.81	na
	Cramer's V	.60	.60	.31	na
	Mean	2.03		1.71	.71
	Std. Dev.	1.99	2.33	1.41	1.18
No. 23.	No. of West Windows	.00	.00	.52	na
	(Ratio Data)				
	Chi Square, Sig. Level	.00	.00	.52	na
	Cramer's V	.43	.60	.39	na
	Mean	2.05	2.68	2.29	.53
	Std. Dev.	2.03	2.25	1.76	1.07
No. 24.	Facade Type (Nominal Data: 1 = Brick, 0 = Frame, .5 = Combination)				
	Chi Square, Sig. Level	.66	.07	.17	na
	Cramer's V	.13	.35	.31	na
	Mean	.71	.90	.48	.14
	Std. Dev.	.29	.23	.23	.36

Appendix B (Continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-Miniums n 34	Apartments n = 28
No. 25. Dwelling Has Second Floor (Nominal Data)				
Chi Square, Sig. Level	.16	.00	.33	na
Cramer's V	.22	.68	.22	na
Mean	.33	.10	.63	.36
Std. Dev.	.47	.31	.49	.49
No. 26. Life Style Not Affected By Energy (Ordinal Data: 1 = Stronly Agree, 5 = Stronly Disagree.)				
Chi Square, Sig. Level	.73	.75	.54	na
Gamma	.25	.46	-.11	na
Contingency Coef.	.27	.39	.29	na
Mean	3.15	3.62	2.89	3.12
Std. Dev.	1.33	1.30	1.28	1.34
No. 27. Dwelling Receives Shade (Nominal Data)				
Chi Square, Sig. Level	.08	.11	.76	na
Cramer's V	.24	.35	.11	na
Mean	.36	.38	.31	.43
Std. Dev.	.48	.49	.47	.50

Appendix B (Continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-Meniums n = 34	Apartments n = 28
No. 28. Annual Kilowatt Usage (Ratio Data)				
Mean	30854.50	41056.30	31991.40	12071.40
Std. Dev.	16418.40	16090.40	7524.00	3821.10
No. 29. Storm Windows (Nominal Data)				
Chi Square, Sig. Level	.30	.62	.95	na
Cramer's V	.18	.19	.06	na
Mean	.39	.50	.43	.14
Std. Dev.	.49	.50	.50	.36
No. 30. Dwelling Faces South (Nominal Data)				
Chi Square, Sig. Level	.95	.65	.97	na
Cramer's V	.06	.18	.07	na
Mean	.33	.33	.34	.32
Std. Dev.	.47	.48	.48	.48
No. 31. Adequate Insulation (Nominal Data) [a]				
Chi Square, Sig. Level	.00	.75	.30	na
Cramer's V	.28	.19	.26	na
Mean	2.06	.92	2.51	3.39
Std. Dev.	3.21	1.27	3.61	4.27

Appendix B (Continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-miniums n = 34	Apartment n = 28
No. 33. No. of Children Under 6 (Ratio Data)				
Chi Square, Sig. Level	.62	.84	na	na
Cramer's V	.14	.17	na	na
Mean	.15	.33	.00	.00
Std. Dev.	.45	.63	.00	.00
No. 34. Persons with Full-time Jobs (Ratio Data)				
Chi Square, Sig. Level	.81	.37	.61	na
Cramer's V	.13	.26	.17	na
Mean	1.16	1.27	1.20	.93
Std. Dev.	.60	.64	.58	.47
No. 35. Occupation Household Head (Nominal Data; 1 = Pro., 4 = Retired)				
Chi Square, Sig. Level	.99	.08	.69	na
Cramer's V	.11	.22	.14	na
Mean	1.61	1.60	1.49	1.75
Std. Dev.	.92	.87	.88	1.08

Appendix B (Continued)

List of Variables and Statistics

Variables and Statistics	Total n = 110	Single Family n = 48	Condo-miniums n = 34	Apartments n = 28
No. 36. No. of Persons Lunch At Home/week (Ratio Data)				
Chi Square, Sig. Level	.23	.82	.97	na
Cramer's V	.24	.20	.06	na
Mean	.69	1.13	.42	.25
Std. Dev.	1.06	1.33	.65	.59
No. 37. No. of Persons Breakfast At Home/week (Ratio Data)				
Chi Square, Sig. Level	.19	.91	.31	na
Cramer's V	.24	.24	.32	na
Mean	1.42	1.92	1.20	.71
Std. Dev.	1.33	1.52	.93	.66
No. 38. Nights Dwelling Is Occupied/week (Ratio Data)				
Chi Square, Sig. Level	.39	.38	.68	na
Cramer's V	.24	.29	.20	na
Mean	5.91	6.40	6.17	4.75
Std. Dev.	1.54	1.18	1.04	1.97

[a] "Don't Know" keypunched as "9".

APPENDIX C

Appendix C

Apartment Sample Unrotated Factor Matrix

Variables	Factors S_1	S_2	S_3	S_4	S_5	S_6	h_2
1. Children aged 6 to 18							
2. Family size	.74	.48	-.26	.09	.07	-.18	.90
3. Presence of children							
4. Non-work activities hrs/mo	-.14	.51	.24	.23	.24	.18	.49
5. Part-time job	.76	-.01	-.05	.28	.11	.05	.67
6. TV watched hrs/day	.82	.22	-.15	-.33	.12	-.22	.92
7. Entertained at D.U., times/mo	-.04	.11	.39	-.07	.07	.26	.24
8. D.U. size, sq. ft.	.67	.24	-.11	.57	-.08	.20	.90
9. No. of rooms in D.U.	.34	.20	.05	.41	-.19	.01	.37
10. No. of north windows	.17	-.48	.13	.29	-.42	-.24	.60
11. No. of south windows	-.01	.10	.58	.06	.25	-.07	.42
12. No. of bedrooms	.52	.27	.01	.42	-.11	.17	.56
13. Family income	-.51	-.13	-.21	.23	-.31	-.12	.49
14. At home more than ½ time	.68	-.27	-.08	-.19	-.02	.00	.58
15. Weekdays - hours at home	.70	-.08	-.23	-.14	.38	-.11	.73
16. Weekends - hours at home	.51	-.60	.06	.08	.20	-.15	.70
17. Age - household head	.34	-.73	-.22	.09	.42	.15	.89
18. Presence of persons over 65	.23	-.47	.04	-.27	.09	.13	.38
19. Dine out - times/mo	-.41	.13	.12	.48	.46	-.23	.69
20. D.U. receives breezes	.27	-.28	.42	.08	.06	-.24	.39
21. Household is very energy conscious	.38	.60	-.37	-.13	-.05	-.14	.68
22. No. of east windows	-.37	.17	-.39	-.11	.34	.32	.55
23. No. of west windows	.33	.40	.04	-.35	-.37	-.14	.55
24. Facade type	-.40	.04	-.62	-.01	-.02	.15	.58
25. D.U. has second floor	.53	.15	.44	-.21	-.07	.54	.84
26. Life style not affect by energy	.06	.37	.47	-.30	.06	-.18	.44
27. D.U. receives shade	.40	-.43	-.02	-.02	-.41	.26	.59
Eigenvalues	5.57	3.18	2.07	1.73	1.50	1.07	15.12
% of Total Variance	23.40	14.10	10.10	8.40	7.50	5.80	69.30

APPENDIX D

Appendix D

Apartment Sample Rotated Factor Matrix

Variables	Varimax Rotated Factors S_1	S_2	S_3	S_4	S_5	S_6
1. Children aged 6 to 18						
2. Family size	.77	-.08	.54	-.03	-.01	-.07
3. Presence of children						
4. Non-wor activities, hrs/mo	-.05	-.26	.22	-.43	-.18	.39
5. Part-time job	.39	.34	.60	.09	.18	.06
6. TV watched, hrs/day	.90	.10	.17	.20	.13	.05
7. Entertained at D.U., time/mo	-.12	-.06	-.02	-.01	-.02	.47
8. D.U. size, sq. ft.	.22	.10	.92	.04	.03	.03
9. No. of rooms in D.U.	.05	-.-1	.57	.00	.16	-.01
10. No. of north windows	-.26	.13	.17	.26	.56	-.32
11. No. of south windows	-.04	-.02	-.04	-.33	.32	.45
12. No. of bedrooms	.17	-.02	.72	.05	.05	.10
13. Family income	-.48	-.21	-.09	-.04	-.06	-.45
14. At homr more than ½ time	.43	.39	.14	.42	.21	.00
15. Weekdays - hours at home	.69	.48	.16	.06	.04	-.01
16. Weekends - hours at home	.17	.68	.08	.13	.43	-.08
17. Age - household head	.02	.93	.02	.10	.02	-.12
18. Presence of persons over 65	.06	.46	-.19	.32	.11	.10
19. Dine out - times/mo	-.24	.02	.02	-.79	.01	-.05
20. D.U. receives breezes	.03	.21	.01	-.04	.57	.13
21. Household is very energy conscious	.65	-.33	.27	.02	.24	-.12
22. No. of east windows	-.05	-.06	-.18	-.19	-.69	.00
23. No. of west windows	.45	-.46	.05	.33	.11	.07
24. Facade type	-.15	-.05	-.11	-.00	-.61	-.41
25. D.U. has second floor	.18	.04	.28	.42	.05	.74
26. Life style not affected by energy	.28	-.34	-.18	-.12	.22	.39
27. D.U. receives shade	-.09	.26	.22	.65	.18	-.04
Discriminant Coefficient	+.98					

APPENDIX E

Appendix E

Condominium Sample Unrotated

Factor Matrix

Variables	Factors S_1	S_2	S_3	S_4	S_5	S_6	h_2
1. Children aged 6 to 18	.88	-.14	-.07	-.05	.22	.20	.89
2. Family size	.75	-.01	.06	-.13	.01	.13	.59
3. Presence of children	.88	-.07	-.14	-.02	.12	.06	.81
4. Non-work activities hrs/mo	.57	-.14	-.12	.17	-.01	-.36	.52
5. Part-time job	.38	.08	-.21	.24	.41	-.27	.49
6. TV watched hrs/day	.00	.66	-.04	-.26	-.13	-.13	.55
7. Entertained at D.U., times/mo	-.31	.21	.52	-.17	.16	.12	.49
8. D.U. size, sq. ft.	.26	-.20	.80	.35	-.19	-.23	.96
9. No. of rooms in D.U.	-.07	-.07	.51	.20	-.10	.23	.37
10. No. of north windows	.24	.26	.35	-.19	.08	-.01	.29
11. No. of south windows	-.24	.25	-.02	-.16	.13	-.12	.18
12. No. of bedrooms	.60	-.03	.32	-.15	.01	.04	.48
13. Family income	.25	.06	.16	-.01	-.53	.24	.42
14. At home more than ½ time	.14	.72	-.03	.17	-.-9	.11	.62
15. Weekdays - hours at home	.01	.68	-.17	.03	-.15	-.15	.54
16. Weekends - hours at home	.25	.46	-.14	.28	-.01	.33	.49
17. Age - household head	-.06	.61	.23	.26	.08	.14	.53
18. Presence of persons over 65	-.18	.23	-.13	.65	.10	.03	.53
19. Dine out - times/mo	.17	-.27	-.31	.00	-.25	.35	.38
20. D.U. receives breezes	.14	.57	.13	.05	.27	-.10	.49
21. Household is very energy conscious	-.09	.12	-.29	-.22	.33	.15	.29
22. No. of east windows	-.13	-.34	-.23	.61	-.01	-.13	.58
23. No. of west windows	-.06	-.46	-.09	.21	-.12	.04	.28
24. Facade type	-.11	-.25	.13	-.39	.02	-.30	.33
25. D.U. has second floor	-.07	-.04	-.32	-.17	-.41	.15	.33
26. Life style not affected by energy	-.23	-.27	.20	.02	.53	.39	.60
27. D.U. receives shade	-.28	-.06	-.01	.03	.18	.29	.20
Eigenvalues	3.61	3.22	2.05	1.70	1.44	1.15	13.17
% of Total Variance	14.70	12.80	9.20	8.10	7.30	6.20	53.30

APPENDIX F

Appendix F

Condominium Sample Rotated Factor Matrix

Variables	Varimax Rotated Factors S 1	S 2	S 3	S 4	S 5	S 6
1. Children aged 6 to 18	.94	.01	.03	-.06	-.06	-.02
2. Family size	.74	.17	.05	.07	.08	-.08
3. Presence of children	.89	-.02	.06	-.07	.13	-.01
4. Non-work activities, hrs/mo	.51	-.25	-.08	.05	.39	.17
5. Part-time job	.39	-.23	.13	-.22	.13	.45
6. TV watched, hrs/day	-.14	.49	.33	-.20	.37	.02
7. Entertained at D.U., times/mo	-.30	.46	.02	.22	-.30	.20
8. D.U. size, sq. ft.	.17	-.00	-.09	.92	.09	.27
9. No. of rooms in D.U.	-.06	.07	.09	.53	-.26	-.02
10. No. of north windows	.19	.45	.09	.16	.03	.16
11. No. of south windows	-.26	.21	.03	-.20	.03	.16
12. No. of bedrooms	.57	.28	-.05	.26	.05	.04
13. Family income	.16	.15	.16	.35	.15	-.46
14. At home more than ½ time	-.01	.24	.70	-.00	.25	-.04
15. Weekdays - hours at home	-.16	.23	.50	-.19	.42	.06
16. Weekends - hours at home	.20	.01	.65	-.07	-.02	-.08
17. Age - household head	-.14	.23	.62	.14	-.04	.22
18. Presence of persons over 65	-.20	-.42	.51	.04	-.05	.20
19. Dine out - times/mo	.23	-.23	-.02	-.08	-.08	-.51
20. D.U. receives breezes	.06	.31	.41	.08	.10	.40
21. Household is very energy conscious	.00	.10	.04	-.48	-.21	.04
22. No. of east windows	-.10	-.74	.03	.10	.00	.08
23. No. of west windows	-.01	-.34	-.23	.28	-.14	-.12
24. Facade type	-.09	.17	-.52	-.01	.09	.08
25. D.U. has second floor	-.10	-.03	-.02	-.16	.16	-.52
26. Life style not affected by energy	-.02	-.03	-.11	-.02	-.75	.17
27. D.U. receives shade	-.18	-.04	.03	-.08	-.39	-.03
Discriminant Coefficients	-.79			-.39		-.48

APPENDIX G

Appendix G

Single Family Sample Unrotated Factor Matrix

Variables	Factors S_1	S_2	S_3	S_4	S_5	S_6	h_2
1. Children aged 6 to 18	.73	.21	-.26	-.15	.22	-.02	.72
2. Family size	.74	.46	-.26	-.13	-.03	.05	.85
3. Presence of children	.65	.37	-.44	-.27	-.32	.08	.94
4. Non-work activities hrs/mo	.37	.14	-.02	-.14	.05	-.08	.18
5. Part-time job	.30	.05	-.01	.17	.53	.29	.56
6. TV watches, hrs/day	.47	.68	.05	.03	.16	-.16	.36
7. Entertained at D.U., times/mo	.45	-.06	-.03	-.13	.39	.05	.38
8. D.U. size, sq. ft.	.65	-.45	-.13	-.02	-.07	-.07	.66
9. No. of rooms in D.U.	.69	-.40	.03	-.21	-.11	-.07	.71
10. No. of north windows	-.06	-.64	-.01	-.38	.01	.07	.57
11. No. of south windows	.34	-.54	-.23	-.35	-.20	.13	.64
12. No. of bedrooms	.73	-.03	.09	-.04	.06	-.09	.56
13. Family income	.63	-.47	-.06	.22	-.27	-.36	.88
14. At home more than ½ time	.34	.40	.29	-.13	-.24	.30	.53
15. Weekdays - hours at home	.52	.23	.45	-.13	-.10	.22	.61
16. Weekends - hours at home	.20	.48	.53	-.02	-.05	-.04	.54
17. Age - household head	-.02	-.41	.57	-.08	.19	.05	.54
18. Presence of persons over 65	-.17	.15	.36	-.22	.13	-.15	.27
19. Dine out - times/mo	.22	-.16	-.39	.46	.23	-.03	.49
20. D.U. receives breezes	-.26	.49	-.27	-.14	.31	-.33	.60
21. Household is very energy conscious	.19	.04	-.21	.31	-.09	.57	.21
22. No. of east windows	.60	.15	.13	.44	-.11	-.22	.66
23. No. of west windows	.39	.23	.24	.48	-.13	-.13	.53
24. Facade type	-.27	.26	-.23	-.19	-.11	.01	.24
25. D.U. has second floor	.59	-.29	.07	-.04	.46	.00	.65
26. Life style not affected by energy	-.08	-.22	-.26	.30	.01	.02	.51
27. D.U. receives shade	.01	-.22	.11	.40	-.12	.18	.27
Eigenvalues	5.66	3.01	1.91	1.68	1.30	1.07	14.63
% of Total Variance	22.30	12.60	8.80	8.00	6.40	5.60	63.70

APPENDIX H

Appendix H

Single Family Sample Rotated Factor Matrix

Variables		Varimax Rotated Factors S_1	S_2	S_3	S_4	S_5	S_6
1.	Children aged 6 to 18	.22	.62	.15	.51	.05	-.05
2.	Family size	.12	.79	.25	.31	.21	.08
3.	Presence of children	.21	.92	.05	.02	.16	.14
4.	Non-work activities, hrs/mo	.14	.29	.10	.19	.13	-.11
5.	Part-time job	-.11	-.00	.05	.68	.00	.29
6.	TV watched, hrs/day	.08	.30	.35	.31	.14	.14
7.	Entertained at D.U., times/mo	.20	.16	-.01	.56	.03	-.06
8.	D.U. size, sq. ft.	.76	.04	.13	.24	.03	.05
9.	No. of rooms in D.U.	.78	.22	.00	.22	.07	-.01
10.	No. of north windows	.44	-.23	-.55	.03	-.08	-.06
11.	No. of south windows	.64	.19	-.41	.03	-.08	.13
12.	No. of bedrooms	.48	.29	.28	.37	.16	-.03
13.	Family income	.81	.12	.36	-.01	-.17	-.01
14.	At home more than ½ time	.01	.26	.17	.02	.61	.24
15.	Weekdays - hours at home	.23	.14	.23	.21	.64	.15
16.	Weekends - hours at home	-.12	.02	.39	.05	.60	-.11
17.	Age - household head	.28	-.59	-.09	.20	.25	-.09
18.	Presence of persons over 65	-.14	-.19	-.01	.01	.32	.34
19.	Dine out - time/mo	.06	.09	.23	.28	-.55	.20
20.	D.U. receives breezes	-.54	.27	.00	.05	-.13	-.46
21.	Household is very energy conscious	.02	-.07	.03	-.03	-.42	.18
22.	No. of east windows	.29	.19	.72	.13	.03	.08
23.	No. of west windows	.10	.04	.69	.04	.10	.14
24.	Facade type	-.31	.22	-.20	-.23	.00	-.07
25.	D.U. has second floor	.42	.01	.06	.68	-.03	-.05
26.	Life style not affected by energy	-.05	.15	.04	.12	-.06	.68
27.	D.U. receives shade	.13	.27	.18	-.05	-.12	.36
	Discriminant Coefficient	-.65	-.17	-.23	-.45	-.37	-.54

APPENDIX I

Appendix I

Total Sample Unrotated Factor Matrix

Variables	Factors S_1	S_2	S_3	S_4	S_5	S_6	h_2
1. Children aged 6 to 18	.67	-.30	.40	-.08	.27	.03	.78
2. Family size	.89	-.19	.26	-.15	-.03	.05	.91
3. Presence of children	.74	-.29	.21	-.24	.07	-.09	.74
4. Non-work activities hrs/mo	.40	-.17	.23	-.06	.15	-.08	.28
5. Part-time job	.28	.03	.37	-.04	.13	.24	.29
6. TV watched, hrs/day	.52	.14	.22	-.05	-.06	.04	.34
7. Entertained at D.U., time/mo	.32	-.08	.04	.03	.18	.26	.21
8. D.U. size, sq. ft.	.84	-.03	-.36	.25	-.02	-.01	.89
9. No. of rooms in D.U.	.85	-.04	-.35	.15	-.01	.01	.87
10. No. of north windows	.42	.13	-.49	-.11	.36	.07	.60
11. No. of south windows	.50	-.08	-.42	-.08	.19	.11	.49
12. No. of bedrooms	.88	-.06	-.11	.05	.02	-.02	.79
13. Family income	.47	-.17	-.18	.47	.11	-.32	.61
14. At home more than ½ time	.58	.46	.17	-.05	-.08	.00	.59
15. Weekdays - hours at home	.53	.44	.11	-.07	-.11	.04	.50
16. Weekends - hours at home	.46	.47	.15	-.02	-.08	-.04	.47
17. Age - household head	.05	.62	-.06	.23	.18	-.01	.47
18. Presence of persons over 65	.03	.48	.05	-.07	-.08	-.11	.26
19. Dine out - times/mo	-.32	-.31	.13	.19	.14	-.14	.29
20. D.U. receives breezes	.36	.23	.01	-.29	.06	-.08	.28
21. Household is very energy conscious	.02	-.15	.02	.06	-.08	.01	.03
22. No. of east windows	.55	-.14	.15	.25	-.32	-.12	.52
23. No. of west windows	.43	-.09	.13	.32	-.42	.02	.49
24. Facade type	.18	-.18	-.38	-.43	-.32	-.11	.51
25. D.U. has second floor	-.12	.07	.23	.41	.22	.13	.31
26. Life style not affected by energy	.10	-.24	-.12	-.02	-.24	.44	.33
27. D.U. receives shade	-.06	.09	-.13	.25	-.12	.35	.22
Eigenvalues	6.84	1.86	1.57	1.19	.93	.67	13.06
% of Total Variance	26.50	8.90	7.50	6.30	5.40	4.90	59.50

APPENDIX J

Appendix J

Total Sample Rotated Factor Matrix

Variables	Varimax Rotated Factors S_1	S_2	S_3	S_4	S_5	S_6
1. Children aged 6 to 18	.84	.19	.00	.17	-.05	-.07
2. Family size	.78	.26	.23	.36	.20	.05
3. Presence of children	.74	.25	.07	.24	.26	-.11
4. Non-work activities, hrs/mo	.48	.11	.00	.12	.01	-.14
5. Part-time job	.46	-.06	.16	-.01	-.17	.14
6. TV watches, hrs/day	.39	.09	.37	.21	.03	.03
7. Entertained at D.U., times/mo	.32	.24	.02	-.00	-.10	.19
8. D.U. size, sq. ft.	.22	.74	.22	.48	.07	.09
9. No. of rooms in D.U.	.27	.73	.24	.42	.15	.09
10. No. of north windows	.07	.70	.18	-.20	.09	.01
11. No. of south windows	.17	.64	.05	-.00	.18	.11
12. No. of bedrooms	.50	.57	.26	.40	.14	.02
13. Family income	.08	.51	-.08	.49	-.17	-.26
14. At home more than ½ time	.28	.14	.68	.18	-.00	.00
15. Weekdays - hours at home	.23	.13	.64	.16	.03	.06
16. Weekends - hours at home	.19	.09	.63	.16	-.04	-.04
17. Age - household head	-.22	.17	.50	-.10	-.36	-.08
18. Presence of persons over 65	-.13	-.08	.46	-.05	-.01	-.12
19. Dine out - times/mo	-.05	-.17	-.43	.00	-.19	-.18
20. D.U. receives breezes	.24	.15	.37	-.07	.20	-.11
21. Household is very energy conscious	.03	-.02	-.12	.12	-.03	.05
22. No. of east windows	.27	.10	.12	.65	.04	.01
23. No. of west windows	.15	.02	.12	.65	.01	.18
24. Facade type	-.05	.16	-.01	.06	.69	.05
25. D.U. has second floor	.01	-.07	-.05	.01	-.55	.04
26. Life style not affected by energy	.07	.06	-.14	.10	.15	.52
27. D.U. receives shade	-.18	.06	.02	.06	-.18	.38
Discriminant Coefficient	-.57	-.61	-.28	-.47		-.19

APPENDIX K

Appendix K.

Data List

```
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220   8698 1000030001001021 75001000000537200000 3514 4 27007172420
218   9713 1010020011001021 75011000010147300000 6034 4 23014 34120
219   10672 1000002011001121 70091000010142200000 352412 41015 52421
217   10703.5000200011001021 75091000010152100000 6034 1 54001  4510
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222   10919 1000300011001031 70091000010252100000 3534 4 33014 43221
215   11368.5010002011001131 75011000010127200000 6024 4 14017102121
201   12265.5010030001001021 70091000010147      1 6024 2 19005208210
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214   12975 1000020000001021 70001000010152200000 6024 0 24101 28420
203   13081.5000003100001121 70001000010227100000 2014 0 52012 75420
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223   14623 1000020001001021 70012000020127200C011024 1 44027131240
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207   16850.5000004000001021 700020000102221000011024 0131106 20541
322   18615.500002210001014214231200002016230000 3524 2 43026 28440
209   20129.5000201110001132 850020000011621000011043 2 91207 18211
213   21006.5100102001001132 85002000020322100000 6014 4 55024264440
318   21780.500002400001014114789200002013230000 6034 2 56007184111
313   22195.500003401001016114789200002012730000 2024 2 12025131510
324   22802 101420011101014214781200001015730000 85 5 4 71124 84421
131   23880 100450111010000611767110000101473000 6024 8 41007 30210
327   23957.501302110001004114230100001013220000 6024 2 12006 36241
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320   26124.510004410001013114789100010046710000l1043 1 23117 90321
137   26671 111444110010005317000411112022740000 6034 0 33637236111
139   27032 1012121101100063170012000100467100001104312 30127 40111
128   27122 110421110010005316810311002032210C00 053412 70301200411
123   27724 101231311010005313981200002004230000 6034 0100117 31221
133   27948 110342111110000431080141200202273000 6043 0 31047221511
121   27968 111250110010005316631200012027220000 8534 0 21027 36221
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329   29280.511220010101015314780031020101626000 8543 2 05127 36221
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334   29735.511211510001004216221100001024720C00 6024 1 22015 32220
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116   29957 101371010110005322651200002013740000 3534 1 42007148220
307   30022.511240010001014314781200001015770000 8534 4 94127 56221
120   30102 101341010010005117401100000045710000 8534 0 61117 31221
332   30509.500002410001015314789310201114020000 8534 2 51037170221
126   30891 110020111010005216541311002023220C00 6024   42017 44421
316   30898.500330400001014214201300002114730000 3534 1 13024180221
```

Appendix k (Continued)

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135	32318	110342210010005314220410201122220C00	8534 1 40145 62421
304	32827.5	1012411000100431622131010132472000	6034 1 6C01790222l
306	33259.5	111512100010153162212000000467100C0	6043 4 71017 40221
127	33432	101660111110004318280300003034740CC0	3524 1 64017408440
129	33432	111340311110005217221200002022720CC0	6024 4 33016100421
307	33561.5	10004210001014214781200002014760CC0	2034 3 34007221211
101	33830	110233010110005316601412001023220000	11043 415234714821l
146	34163	100114510010005317820311002012730000	11034 83107 08511
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335	34710	010043010011004213500100001015220000	2034 5 13016 69341
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314	35252.5	00002201001015314789200002014730000	2014 4 14005 26330
134	35508	110643310110005215601310101012720000	11043 410531710844l
143	35802	101342110110006212370200002023220000	3514 2 43005 40150
109	36414	100024510010005319211300011115220000	11043 1190127368421
326	36680.5	11132111101005116221200000047540C00	11043 8 51227 96221
325	37999.5	1002131000100421622120000102572OC00	110 5 4 52125105221
145	38346	111542110110007422601200000045720000	11043 0 32127140421
305	38495.5	0024C0100010132147812000010247400C0	11043 3180207 64131
333	38517.5	10051610001006216229200002015250C00	3543 2101006 30521
309	38553.5	00004200001014214780210101024230000	3424 1 12007 36240
330	38672	011403111001005216220200011116730000	8543 2 43126148421
312	38690	011240010001014214789210101014210000	8543 0 85006 92111
149	39904	100533410110006321000410201013720000	11043 1 60147554421
104	39966.5	00653301110006222771200001025230000	8543 4 61127243421
100	39985.5	11374511110005323901200001016250000	11043 8 41017 70421
302	40596.5	00002400101013214781310101013770000	8534 0 67017468231
114	41270	110695300110007323910311001013250C00	11043 1 30237104221
319	41808.5	00052110101003214689310201114710000	3534 2 22005 28520
303	41977.5	01040210001004316221310201024240000	6024 0 25037872220
112	43568	100322210110007318209411101113232000	6043 4 92347100431
124	44264	100206510110007326001310102024230000	8543 1 42007226421
144	44286	111954010110006321601411101024730000	8534 2101247185221
142	44825	100214711110005318871412001023230000	11034 15133714452l
113	44856	100306511110006418301512101013240C00	11043 2103446218421
132	45837	110434110110005318000410201113240000	6024 10502622654l
130	46032	100214410010006318781310102014720000	603416 62005 70531
103	47823	100451110010005318501310201023710C00	6043 812213712251l
117	48767	100125310110008438281410201023730000	8543 0 81337122421
147	50162	110250010110007326000410201013730C00	8524 8 40135232521
308	51746.5	00020411001004316220310201023730000	3543 4 25127 28541
105	53977.5	10712910110018526291410201013760C00	11034 3 93147176221
140	56720	100616601110009430041410201025280000	853416 45136 40521
119	58160.5	0021861111001642647161040121423OC00	11043281541072074 21
106	58280.5	11790201110017429941200000116230000	11043 4 41127114421
141	58920	100991010110019434001310101115240000	851420 34004180510
107	80840.5	00559210110018430261410201013780000	110431235434735222l
102	82180	111124201010005316001300001125720CC0	11034 8104117324531
118	103760.5	1097720111000943568131010101478000	8514 4 52005332441

Appendix K (Continued)

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FILE NAME        RESIDENTIAL ENERGY USE
VARIABLE LIST    CASENO,YRLYKLWT,FACADE,STRMWN,FACESU,WNDWSU,WNDWNO,
                 WNDOEST,WNDOWST,BREEZES,SHADE,ROOF,SNGLFM,CONDO,APT,
                 SCNDFL,ROOMS,BDRMS,SQFT,INSUL,FAMSZ,CHLDRN,UNDER5,
                 NINETN,OVER65,FLTJOB,PTJOB,OCCUPT,AGE,INCOME,
                 WDHOME,WEHOME,ENTERTN,TVWATCH,DINEOUT,LUNCH,BKFAST,
                 NITEHOME,LIFESTYL,ENERGYST,ENERGYCN,ATHOME
INPUT MEDIUM     DISK
N OF CASES       UNKNOWN
INPUT FORMAT     FIXED (F3.0,1X,F6.0,F2.0,15F1.0,F4.0,9F1.0,
                 F2.0,F5.0,F3.0,3F2.0,4F1.0,F3.0,3F1.0)

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE   FORMAT   RECORD   COLUMNS

CASENO     F 3. 0      1      1-   3
YRLYKLWT   F 6. 0      1      5-  10
FACADE     F 2. 0      1     11-  12
STRMWN     F 1. 0      1     13-  13
FACESU     F 1. 0      1     14-  14
WNDWSU     F 1. 0      1     15-  15
WNDWNO     F 1. 0      1     16-  16
WNDOEST    F 1. 0      1     17-  17
WNDOWST    F 1. 0      1     18-  18
BREEZES    F 1. 0      1     19-  19
SHADE      F 1. 0      1     20-  20
ROOF       F 1. 0      1     21-  21
SNGLFM     F 1. 0      1     22-  22
CONDO      F 1. 0      1     23-  23
APT        F 1. 0      1     24-  24
SCNDFL     F 1. 0      1     25-  25
ROOMS      F 1. 0      1     26-  26
BDRMS      F 1. 0      1     27-  27
SQFT       F 4. 0      1     28-  31
INSUL      F 1. 0      1     32-  32
FAMSZ      F 1. 0      1     33-  33
CHLDRN     F 1. 0      1     34-  34
UNDER5     F 1. 0      1     35-  35
NINETN     F 1. 0      1     36-  36
OVER65     F 1. 0      1     37-  37
FLTJOB     F 1. 0      1     38-  38
PTJOB      F 1. 0      1     39-  39
OCCUPT     F 1. 0      1     40-  40
AGE        F 2. 0      1     41-  42
INCOME     F 5. 0      1     43-  47
WDHOME     F 3. 0      1     48-  50
WEHOME     F 2. 0      1     51-  52
ENTERTN    F 2. 0      1     53-  54
TVWATCH    F 2. 0      1     55-  56
DINEOUT    F 1. 0      1     57-  57
LUNCH      F 1. 0      1     58-  58
BKFAST     F 1. 0      1     59-  59
NITEHOME   F 1. 0      1     60-  60
LIFESTYL   F 3. 0      1     61-  63
ENERGYST   F 1. 0      1     64-  64
ENERGYCN   F 1. 0      1     65-  65
ATHOME     F 1. 0      1     66-  66
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