DIRECT HOUSEHOLD ENERGY CONSUMPTION, 1973-74, 1975-76: THE IMPACT OF FAMILY MICRODECISIONS UPON LEVELS OF CONSUMPTION

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ABSTRACT

DIRECT HOUSEHOLD ENERGY CONSUMPTION, 1973-74, 1975-76: THE IMPACT OF FAMILY MICRODECISIONS UPON LEVELS OF CONSUMPTION

By

Joanne Goodman Keith

The development of this research was based upon the assumption that decision making is the main adaptive feature of human systems and that the family is one critical societal unit where this process occurs. The focus of the study was upon one area about which families make decisions: the consumption of direct household energy.

Two major questions were evaluated. Did households reduce their consumption of direct energy since the year of the Arab Oil Embargo, 1973-74? Did the conservation measures (i.e., household microdecisions) reported by heads of household contribute significantly to reduced levels of consumption?

Energy consumption data from utility and oil companies and conservation measures reported by household members were the basis for the evaluation. The household was the unit of analysis for the sample of 130 families.

Dependent t-tests and multiple regression analyses were the statistical procedures employed.

An overall reduction of 6.3 percent in direct household energy consumption was found between the years 1973-74 and 1975-76 ($t = -5.62$, $p = .000$). The decreases occurred in fuel oil and natural gas, the major sources for space heating. Electrical consumption increased 2.2 percent.

The second major objective was to evaluate the impact of household conservation measures upon levels of consumption. Insulation in the walls or ceiling, installation of storm windows and lowering the thermostat setting on the hot water heater were each reported by 15 percent or less of the sample.

Questions were asked concerning nine daily or seasonal household conservation behaviors. Moderate to high levels of increased adoption were reported for most of the sampled practices. The collective impact of these behaviors on levels of consumption was hypothesized as a major variable in this research. A family scale was developed to reflect the extent to which the behaviors were practiced and the number of adult heads of households who reported their adoption.

Through stepwise regression the behavioral and structural conservation measures that took place within households between June, 1974, and June, 1976, were analyzed for their impact upon the levels of consumption in 1976. Consumption 1973-74 was used as the baseline from which change was evaluated. Alternate explanations for variation in consumption were included as variables: changes in family size, addition of appliances, and replacement of the furnace.

Previous level of consumption, 1973-74, was the best predictor of consumption during 1975-76 ($t = 29.12$, $p = .000$). Three change variables met the minimum criteria for inclusion in the regression equation: the installation of a new furnace ($t = -3.16$, $p = .002$), increased intensity of conservation behaviors ($t = -2.99$, $p = .003$), and installation of insulation in the ceiling ($t = -1.19$, $p = .235$). The importance of energy-efficient technology in the reduction of household energy was demonstrated. The role of the behavior of household members was equally significant, i.e., the accumulation of many microdecisions was important in the overall reduction of consumption.

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By

Joanne Goodman Keith

A DISSERTATION

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Dedicated to Robbie and Julie

and their cousins--

whose energy future is important to me.

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The completion of this graduate degree represents the time and commitment of many people other than the graduate. The acknowledgments written here in no way adequately express the appreciation for the differing contributions of each person.

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CHAPTER I

INTRODUCTION

> Actually the world's present problems are by no means unmanageable in terms of present biological and technological knowledge. The real crisis confronting us is, therefore, not an energy crisis, but a cultural crisis. During the last two centuries, we have evolved what amounts to an exponential growth culture, with institutions based on the premise of an indefinite continuation of exponential growth. One of the principal consequences of the cessation of exponential growth will be the inevitable revision of some of the tenets of that culture (Hubbert, 1973, p. 37).

A major concern of the 1970s was the rapidly increasing interdependence of the American lifestyle and fossil fuel energy, contrasted with the emerging recognition of the finiteness of this energy source. This strong interrelationship between energy[1] and lifestyle has led many to the observation that the energy crisis is really a cultural crisis (Hubbert, 1973; Energy Policy of the Ford Foundation, 1974; Fritsch, 1974; Mazur, 1974; Odum, 1974; Hannon, 1975; Boulding, 1976; Downs, 1976; Lapp, 1976; Caldwell, 1976).

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[1]Energy is used as a generic term meaning fuels, such as natural gas and petroleum and fuel equivalents such as electricity.

The finite fuels of petroleum and natural gas have become the major sources of energy worldwide. The United States received more than 75 percent of its total energy in the early 1970s from these liquid fuels. Although the information reported has varied as to the extent of the fossil fuel reserves, there is agreement that fuel oil and natural gas supplies are finite and demand may exceed supply as early as the mid 1980s (Hubbert, 1973; Odum, 1973; Koenig, 1976; F. Murray, 1976; Lapp, 1976). The projected capital costs required to develop remaining fossil fuel resources and alternate sources are exorbitant and in some cases may be prohibitive. Net energy gains are also questioned (Odum, 1974; Lovins, 1974; Commoner, 1976; Koenig and Edens, 1976).

Even if the development of alternate sources of energy were feasible and the capital to develop them were available, the length of time required for them to become operational and make substantial impact on energy supplies is not projected to be within this century. It is probable that liquid fossil fuels may become very short in supply prior to the year 2000 (Hubbert, 1973; Fritsch, 1974; Koenig, 1976; Lapp, 1976). Time is needed to seek alternate energy solutions while making necessary social, economic and structural changes.

Through conservation, the period when the dwindling resources are available can be extended. Therefore, conservation of fossil fuels (i.e., policies and practices that reduce consumption) has been advocated for all levels of society (Odum, 1974; Hannon, 1975; Downs, 1976).

Conservation: A Macrodecision

The need for conservation of fossil fuels, although of worldwide importance, is particularly relevant within the United States. Estimates during the early 1970s were that the United States with six percent of the world's population consumed thirty percent of the total amount of energy used worldwide. It also had the highest national per capita use of energy (Rocks & Runyon, 1972; Fritsch, 1974).

In 1960 the United States imported 19 percent of its oil; this increased to 41 percent in 1976 (U.S. Bureau of Mines, 1976). This growing dependence on foreign oil has made conservation a matter of national political importance.

Substantial conservation could be realized without difficulty for it has been estimated that Americans waste half of the energy they use (Hayes, 1976; Ross & Williams, 1976). Koenig hypothesized that the United States could reduce consumption one-third without lowering the standard of living (Downs, 1976). Some European countries have standards of living comparable to the United States but have lower energy consumption (Schipper & Lichtenbert, 1976).

Two diverse approaches to the energy problem have been advocated: increasing collectivism and centralized governmental control or decreasing centralized control and increased dependence upon free enterprise and individual responsibility. A strategy which would incorporate both approaches has been outlined by Harman of Stanford Research Institute:

> If the basic problem is the unsatisfactory macrodecisions arising from microdecisions based on self-interest, then the obvious thing to do is reverse the situation, that is to identify the appropriate macrodecisions--perhaps by selecting appropriate national and planetary goals that are most in accord with the best available knowledge concerning human fulfillment--and then see what patterns of microdecisions would be necessary to achieve those macrodecisions (Harman, 1977, p. 10).

Based upon the available evidence, energy conservation warrants selection as one major national goal.[1] The implementation of this macrodecision involves microdecisions from all sectors of society--business, industry, local and national government, and households. These decisions entail both the amount of direct energy consumed and indirect energy embodied in goods. Monitoring and understanding actual consumption as well as decisions and behaviors leading to conservation are imperative and complex (Hannon, 1974; National Research Council, 1977).

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[1]At the time of this writing, President Carter had sent to Congress a proposed National Energy Plan with emphasis upon conservation and conversion to alternate energy sources.

Conservation: Microdecisions Within the Household

The household is one of the most important sectors in society in relation to energy conservation. Many of the microdecisions related to energy consumption are made within the context of this unit primarily for the welfare of its members. Energy is consumed directly in households for uses such as space and water heating, cooling, transportation, or indirectly in the purchase of goods and services.

It has been estimated that American households are responsible for over 30 percent of the consumption of direct energy and an estimated additional 40 percent in the form of indirect or embodied energy. Both the direct and indirect dimensions of energy consumption present major opportunities for evaluation of potential conservation of energy (Hannon, 1975; National Research Council, 1977). Indirect or embodied energy reflects the amount of fossil fuels or other energy sources used in production and distribution of goods and services. This research examined only the direct energy consumed within the household, i.e., mechanical energy derived or transformed from fossil fuels, namely, fuel oil, natural gas, liquid propane and electricity.

Conservation in existing household structures is a staggering problem. Harrje (1977) reported there are 60 million homes already built that will be occupied for many years. Choices open to households in these structures are in many cases circumscribed; many basic housing features such as furnaces and major appliances (hot water heater, range, refrigerator, freezer) represent sizable economic investments; often they are already present within the house when purchased or rented (Newman and Day, 1975; Williams, Kruvant and Newman, 1976; Morrison and Gladhart, 1976).

However, Grot and Socolow carefully controlled for structural and technological housing variables and found considerable unexplained variance in residential energy consumption. Their conclusion was that lifestyle decisions accounted for the additional variation.

> In our study, where many of the technological factors are standardized, we were prepared to discover that nearly all of the "lifestyle" effect had vanished, in which case we would have been in a position to emphasize the role of technology and to deemphasize the role of individual behavior. It is already clear that the truth lies somewhere in the middle. As each technological variable is separated out, the observed variation in gas and electric consumption is reduced, but when many of the technological variables of which we are currently aware are separated out, considerable variation remains (Grot and Socolow, 1974, p. 489).

Conservation measures are a part of those lifestyle decisions affecting variation in energy consumption. In general, these measures can be classified as structural or behavioral. Structural conservation measures are relatively permanent once they have been implemented, but they may require considerable economic investment. Installation of insulation and storm windows are examples. In contrast, behavioral conservation measures are repetitive requiring seasonal or daily implementation by one or more members of the household with little or no economic investment. Turning out lights and lowering the thermostat setting are two examples.

It has been documented that households report both structural and behavioral conservation measures (Tables 1, 2, and 8, pages 37, 38, and 54). Some of these represent potential conservation of considerable impact; however, most contribute only a very small amount individually to the total household energy consumed. The impact of these reported measures on actual reduction of direct household energy consumption, individually or collectively, has not been reported. Specifically, are families' reported perceptions of how they have conserved reflected in lower levels of energy consumption? It was hypothesized that examination of the relationships between longitudinal patterns of energy consumption and reported microdecisions related to energy conservation could provide insight into the feasibility of energy conservation within the household as one means of meeting the cultural crisis.

Conceptual Framework

In the development of this research, the family was viewed from an ecological systems perspective. Major concepts deemed particularly relevant included: the family perceived as a living system within the hierarchical organization of society and decision making as the family's main adaptive feature.

In an ecological systems approach, the family is conceptualized as a living system interacting with its environment. Emphasis is not only upon the family as a social, psychological system processing information, but also as a system dependent upon and impacting on the natural and man-built aspects of the environment (Hook and Paolucci, 1970; Bubolz and Paolucci, 1976; Morrison, 1975; Andrews, 1977; Bubolz, Eicher and Sontag, 1977). As with all living systems, the family must have inputs of both information and matter energy to remain viable (Miller, 1971).

Hierarchal theory views the universe as organized in levels from elementary particles to global and supra-global systems. Each level demonstrates increasing complexity and is composed of independent stable subsystems each of which is actually a system encompassing lower levels of organization. This concept of wholeness and interdependence, yet uniqueness of parts, has been derived from General System Theory (Bertalanffy, 1968; Koestler, 1969; Miller, 1971; Laszlo, 1972; Odum, 1977). Within this framework the hierarchy of living systems includes the following levels of organization: cells, tissues, organs, organisms, groups, societies, nations and supranational systems (Miller, 1971). Within the hierarchy including human beings, the family is perceived as a critical system at the group level; the family is also inextricably linked with higher level systems and also with its subsystems.

Decision making is viewed as the main adaptive feature of human systems; it is the process of selecting and implementing responses under conditions where the stimulus situation, the valences, and/or possible responses are complex. Decisions are selected by complex interactions of preferences and perceptions (Kuhn, 1974, 1975). Decisions are affected by the availability of resources--human resources (e.g., knowledge, skills, values) and nonhuman resources (e.g., economic and natural resources).

From a managerial perspective, the family is viewed as a basic decision-making unit where members, interrelated with each other, are involved in crucial decisions, affected by the environment surrounding the family, but also making an impact on the environment through their decisions or nondecisions.

Household energy is considered one resource to be managed. The household has become increasingly dependent upon inputs of liquid fossil fuels and their transformations to provide heating, cooling, lighting and work. With increasing prices and potential shortages, energy conservation is viewed as a necessary management strategy for American households. The decisions within the household related to energy consumption, although microdecisions, are assumed to be a crucial part of the overall macrodecision of energy conservation. The testing of this theoretical assumption was the major objective of this research.

Research Questions

The purpose of this study was to provide empirical evidence for answers to the following research questions:

1. Have households reduced their consumption of direct energy since 1973-74, the year of the Arab Oil Embargo? The time periods for making the comparisons were the two years July 1, 1973, through June 30, 1974, and July 1, 1975 through June 30, 1976.[1]

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[1]Throughout the research report these specific dates were the reference points for the years 1973-74 (or year ending 1974) and 1975-76 (or year ending 1976).

One national study has documented a 1.8 percent decrease in annual household consumption between the years 1972-73 and 1974-75; natural gas was reduced by 3.9 percent, but electricity showed an increase of 1.2 percent (Grier, 1976; Williams, Kruvant and Newman, 1976). Replication of these results for these years or succeeding years has not been reported.

On the basis of this information it could be hypothesized that the level of consumption of direct household energy consumed within the household changed from July 1973-June 1974 to July 1975-June 1976 in the direction indicated:

> A decrease in total Btu's[1] of energy used within the household with electricity adjusted or unadjusted for conversion and transmission loss.
>
> A decrease in Btu's of energy derived from natural gas.
>
> A decrease in Btu's of energy derived from fuel oil.
>
> An increase in Btu's of energy used in the form of electricity with or without the adjustment for electrical conversion and transmission loss.

2. What conservation measures (microdecisions) did households report having taken within the two years prior to June, 1976? Did the reported conservation measures singly or collectively contribute significantly to reduced levels of consumption?

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[1]Definition of Btu, p. 54.

The development of the specific research model and hypotheses to answer these research questions was an iterative process encompassing a review of the literature, data availability and research methodology. These topics have been reported sequentially in Chapters II and III. The model that was developed as a result of this process has been presented here to give the reader an overview of the research problem. The testing of the hypotheses and empirical results have been presented in Chapter IV.

The Research Model

The theoretical approach advanced in this dissertation and review of the household energy literature suggested that total direct household energy consumption is a function of several major groups of variables:

> Natural environmental variables such as temperature, wind and humidity variations, natural resource availability.
>
> Human regulatory environmental variables such as the social, economic and political structure.
>
> Man-built environmental variables, such as land use patterns and unique structural dwelling unit variables (housing type and size, energy using equipment type and size).
>
> Family structural variables and resources such as size of household, human and non-human resources.
>
> Family behavioral variables such as energy consuming/conserving practices or decisions.

This research focused only upon a part of these variables: the reported implementation of decisions related to energy conservation within households and the effect of these decisions upon levels of consumption. Both behavioral and structural conservation measures were evaluated. Although variables such as price increases and changes in income may be related to changes in energy consumption, they were perceived as antecedent variables which may have prompted behavioral or structural changes and were not examined.

Careful attention was given to evaluate or control for confounding variables which could have affected direct energy consumption. Because of the overpowering effect of the dwelling structure on consumption, only families who resided in the same dwelling units from July, 1973, through June, 1976, were evaluated. Weather variations are critical to assessing total household energy consumption. However, this study was conducted in a geographic region in lower Michigan covering a radius of less than 100 miles; therefore, the weather variations were considered constant across the sample but not over time; i.e., the years 1973-74 and 1975-76 were not assumed equal in severity of cold weather. Both models were evaluated--changes in absolute consumption and changes when adjusted for weather effects.

Since energy is consumed by the household as a whole, it was concluded that the appropriate unit for analysis was the household.

The specific model tested in this research was derived from the following equations:

For any household at a given point in time (t),

$$BTU_t1 = f(NATENV_t1;\ HOUSE_t1,\ FAMSTRUC_t1,\ FAMBEH_t1) + e$$

$$BTU_t2 = f(BTU_t1,\ \Delta NATENV_t1,_t2;\ \Delta HOUSE_t1_t2,\ \Delta FAMSTRUC_t1,_t2,\ \Delta FAMBEH_t1,_t2) + e$$

where

BTU = Total annual direct Btu's of household energy

NATENV = Natural environmental variables such as wind, temperature

HOUSE = Individual structural dwelling unit variables

FAMSTRUC = Structural characteristics of occupants in household such as number of people, time spent at home

FAMBEH = Behavior of occupants in household.

Specifically, these groups of variables were broken down into individual variables based upon previous research findings and available data, and the model to be tested became:

$$BTU76 = f(BTU74,\ \Delta WEATHER_{74-76};\ \Delta STRUC_{74-76}\ \ \Delta AIRCON_{74-76}\ \ \Delta APPLNDX_{74-76}\ \ \Delta FAMSIZE_{74-76}\ \ \Delta JOBLOSS_{74-76}\ \ \Delta INSULC_{74-76}\ \ \Delta INSULW_{74-76}\ \ \Delta HOTWATER_{74-76}\ \ \Delta CONBEH_{74-76}) + e$$

where

BTU74, BTU76 = Millions of Btu's consumed annually by households in form of natural gas, fuel oil, liquid propane and electricity

WEATHER = Heating degree days,[1] 1973-74, 1975-76, a constant across the sample

STRUC = Installation of new furnace, 1974-1976

AIRCON = Addition of air conditioning, 1974-1976

APPLNDX = Index of appliances added, 1974-1976

FAMSIZE = Change in number in household, 1974-1976

JOBLOSS = Household member retired or lost job, 1974-76.

INSULC = Installation of insulation in ceiling, 1974-1976

INSULW = Installation of insulation in walls, 1974-1976

HOTWATER = Lowered thermostat setting on hot water heater, 1974-76

CONBEH = Increased intensity of energy conservation behaviors, 1974-76.

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[1]Definition of heating degree days, p. 56.

CHAPTER II

REVIEW OF THE LITERATURE

With the growing awareness of the interrelatedness of people and the natural environment, energy and its social impacts have become a subject of concern to social scientists as well as geologists and engineers. Cottrell (1955) identified the interrelationship between social values and the energy resource base of a population.

Energy conservation has been defined as a set of policies and practices that reduce consumption. The rationale for conservation as a national priority was briefly outlined in Chapter I. An overview of the information and sources that led to the statement of that position has been included in this chapter. Two comprehensive bibliographies of energy/society literature have been prepared by D. Morrison et al. (1975, 1976).

Energy consumption often has been divided by economic sectors and end use. The three major economic sectors include household, industrial and commercial/ service. This research has dealt only with the household sector and the end uses of direct energy consumed within the dwelling unit. In the literature review, emphasis was placed upon those studies concerned with direct household consumption and its structural and family behavioral correlates. Transportation, although a significant part of household energy consumption, was not included.

Virtually all the empirical studies related to household energy consumption were developed immediately prior to, or since the time of the Arab Oil Embargo, 1973. Many of the studies remain unpublished. Those that have been published have often been broadly based surveys exploratory and descriptive in nature. Several annotated bibliographies have focused upon the sociological and psychological dimensions of the energy research (Frankena, Buttel & D. Morrison, 1976; Lopraeto & Meriwether, 1976; Olsen & Goodnight, 1977; Frankena, 1977). Schwartz (1977) has reviewed the literature pertaining specifically to the social consequences of the changing energy supply.

Energy Conservation: A National Priority

In the United States consumption of energy resources (coal, oil, natural gas, falling water, and uranium) doubled between 1950 and 1970 with an annual growth rate of 3.5 percent (U.S. Bureau of Mines, 1972). By the 1970s, the two fuels--petroleum and natural gas--

were supplying over 75 percent of the total energy needs. These two liquid fossil fuels have varying projected time lines for proved reserves. However, there is general consensus that the supply is finite and that the peak production either has been reached, or will be reached in the U.S. within the next decade. World production has a somewhat longer projection period, peaking perhaps around 2000 (Berg, 1973; Hubbert, 1973; Udall, 1973; Cook, 1975).

Alternative sources include conversion to coal, nuclear fission and fusion, solar, geothermal and wind energy. The estimated supply of coal in the United States is abundant and there is available technology for conversion to synthetic gas. But coal has limitations; it is a solid fuel, requiring energy and capital investment to get it from the ground and into usable form. The environmental and pollution effects are also serious considerations (Hubbert, 1973; Udall, 1973; Walsh, 1974; Commoner, 1976).

Nuclear energy is derived from uranium, a nonrenewable resource with limited proved reserves. High levels of capital and energy investment are needed before the plants become operational. The controversy over the safety and waste problems is well documented. Some researchers have even questioned the net energy gain derived from the development of nuclear power.

Whether or not one favors nuclear power, it is clearly not a panacea for the supply of energy within this century (Lovins, 1974a, 1974b; Odum, 1974; Bethe, 1976; Koenig & Edens, 1976; Lieberman, 1976; Ophuls, 1977).

The technology for other sources, such as solar and wind, is not sufficiently advanced to make a substantial impact for several decades and will require extensive capital investment (Udall, 1973; Bethe, 1976; Lapp, 1976). Odum (1976) has asserted that solar energy has not and will not become a major substitute for fossil fuel since it requires energy subsidy from fossil fuels.

Conservation may be the most critical priority of the 1970 decade (Berg, 1973; Paolucci & Hogan, 1973). Odum (1976) suggested that the transition to a lower energy intensive standard of living is inevitable and available fossil fuel energies should be used for making a planned and orderly transition in lifestyles.

The potential savings from energy conservation have been estimated to be half of what is used currently in the United States with as much convenience and more employment (Hayes, 1976). Improved efficiency in production, product durability, changed land use patterns, and controlled rate of use are some of the suggested means for reducing consumption (Hannon, 1973, 1975; Lovins, 1974b; Teller, 1975; Hirst, 1976; Koenig, 1976).

The implementation of these ideas has been debated. Government regulation via economic incentives and taxes, higher prices, equitable distribution of resources, and socialization to produce value/behavior changes have been recommended (Hannon, 1973, 1975; Schumacher, 1973; Hirst, 1976; D. Morrison, 1976). Several trends have been projected by Hirst (1976) to be slowing the energy use growth rate: reduced population and decreasing number of households, higher prices, public laws requiring greater thermal efficiencies for new and existing building structures, and greater efficiency in appliance labeling.

Conservation Within the Household

"When anyone consumes anything, he consumes energy" (Bullard, 1975, p. 484). The household is a major consumer of energy both directly and indirectly. The indirect or embodied energy used in consumer goods has been a major dimension of the research conducted at the Center for Advanced Computation, University of Illinois (Bullard, 1973, 1975; Hannon, 1973, 1975; Herendeen & Sebald, 1975). The energy intensity of products has been calculated, including manufacturing and transportation processes as well as the end uses. Dollar and labor costs have also been considered. Automobiles, laundromats compared with home laundry facilities, and paper versus cloth towels are a few examples that have been evaluated for their energy intensity. Hannon (1975) has advocated an energy conservation tax reflecting not only direct but also embodied energy costs.

In assessing data needs for public policy, the National Academy of Science Committee on Measurement of Energy Consumption asserted that analysis was needed for both the stocks and flows approach and the embodied energy approach. It was their viewpoint that the household sector was best suited to the stocks and flows analysis concentrating on the energy associated with the size, distribution and energy-using charactersitics of equipment and rate of use (National Research Council, 1977).

The end uses of energy by the household were summarized by the Stanford Research Institute (1972) and the United States Department of Interior (1975). Space heating and cooling, water heating and electrical use all represented areas for assessment of consumption patterns and potential conservation within the household. Space and water heating used the most household energy. Air conditioning was a small percentage of the total use; however, it showed the largest relative growth, having increased by 81 percent its share of the total energy used during the '60s.

Another growing trend has been the increased substitution of electrical energy for space heating and cooking. Electricity has had an efficiency rate of about 30 percent which means that for every kilowatt generated, approximately two are lost (Hirst and Moyers, 1973). Because electricity is so inefficient, some reports included the loss in conversion and transmission when energy was converted to a standard unit of measure such as the Btu. When reading a report it was necessary to assess if this conversion factor had been used.

Empirical Studies Related to Household Consumption

Two extensive projects have become the basis for much of what is known about household energy consumption --a national study conducted by the Washington Center for Metropolitan Studies and a carefully controlled and monitored field study at Princeton University, the Twin Rivers Project. Both have made valuable but different contributions. Additional information about direct household energy consumption has been reported from the data of the Family Energy Project at Michigan State University and Center for Research on Acts of Man in Philadelphia. Experimental studies have also been conducted in attempts to reduce energy consumption. Since the political and economic situation relative to energy has been so volatile, it is especially critical to note the date the research was conducted or reported.

Surveys Related to Household Energy Consumption

The Washington Center for Metropolitan Studies collected data on a stratified national sample of 1,455 households. The respondents were asked about their dwellings and habits affecting energy use. With the permission of the respondents, the utility companies supplied the amount and cost of natural gas and electricity used by the households from the spring of 1972 to the spring of 1973 (Newman and Day, 1975; Cohen, 1976). No information was given as to how unmetered multifamily unit consumption was computed. Fuel oil consumption was estimated from aggregate data and respondents' cost estimates.

The authors Newman and Day documented the rapid increase in energy use by United States households. The average Btu's of electricity[1] and natural gas per household was 234.9 million Btu's. Significantly less energy was used by the poor, by renters, by families with less than two employed, by Blacks and by those households

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[1] 1 kwh of electricity used at home = 3,413 Btu's but it takes about twice as much energy as this to produce and transmit so 1 kwh of electricity used at home actually costs 10,910 Btu's. This conversion factor was used in Newman and Day's study.

headed by a person over 65 years of age. Income was interpreted as basic to all these variations. Energy use dropped sharply in families without children and in elderly families. Basic information about the presence of energy conserving household features and energy using equipment was reported.

Cohen analyzed a subset of this national sample that included households which paid directly for their utilities and heated their homes with natural gas. Approximately one-third of the variance in consumption was explained by number of rooms, number of persons in the household, and climatic conditions (heating degree days for space heating).

Income was not used in the analysis but was positively related to the number of rooms and the number of persons in the household. Consumption increased with income, but the relationships between income levels were quite different for natural gas and electricity. The upper income group used 50 percent more natural gas per household than the lowest income group and 160 percent more electricity.

From this data base Cohen derived two specific conservation targets. The first was to reduce consumption to 1972-73 levels and the second to reduce living space. Specific goals were projected for each household based upon the variables that were found significant in predicting variation in consumption. With his plan feedback could be given to each household as to how well its goals were being met. The higher income and the higher energy users would be asked to make the greatest reductions.

A follow-up national survey of 3,200 households was conducted in the spring of 1975. Consumption data for 1972-73 and 1974-75 were reported. This was the only household survey reviewed that evaluated annual changes in consumption. The information presented was descriptive, giving percentage change between aggregated annual means on selected demographic variables (Grier, 1976; Williams, Kruvant & Newman, 1976).

Average electricity for all households in 1972-73 and 1974-75 was 93.1 and 94.2 million BTU's per household for an overall increase of 1.2 percent. The average number of million Btu's of natural gas consumed was 141.8 and 136.3 for the two years, a reduction of 3.9 percent. Total consumption averaged 234.9 and 230.5 million Btu's for an overall reduction of 1.8 percent.

It was noted that apartment dwellers conserved the most energy but how their consumption was metered and the data collected was not reported. The poorer households and rural non-Standard Metropolitan Statistical Areas (S.M.S.A.) increased electrical consumption 10 percent or more. Central city and older households decreased about 7 percent. No group showed a significant increase in heating, with reductions as much as 17 percent in the West. When considering aggregate consumption, the energy used by the expanding number of households exceeded the energy conserved by the existing households. Grier (1976) focused on the increase in price and reported that although the costs have risen rapidly, they are still a small portion of the average household's budget.

The Twin Rivers Project conducted by researchers at the Center for Environmental Studies, Princeton University, has been ongoing since 1972. It has been a highly detailed field study in technology related to household energy consumption. In addition, this study has identified the necessity for the combination of the environmental, technological and social-psychological dimensions for household energy research.

Actual consumption records from utility companies have been correlated with house size, design, outside temperature and energy conservation resulting from the oil crisis, price increases and retrofits. Data have also been collected through detailed instrument measurement of internal temperature, appliance usage and furnace operation and household members' behaviors such as the opening of doors. The major focus has been based upon space heating, with secondary targets of hot water heating, air conditioning and appliances. It was observed that consumption for the winter of 1973-74 fell below the winters of 1971-72 and 1972-73 (Socolow, 1975). A retrofit experiment was developed which demonstrated 24 percent gas savings and 10 percent electrical savings, with a payback period of approximately three years if both heating and cooling were considered (Harrje, 1977).

The sources from which space heating was derived were measured and the relative percentages computed; heat from the furnace provided 81.7 percent of the total heat; solar energy, 11.5 percent; appliances, 6 percent; and occupants, .8 percent. Air infiltration has been identified as causing a complete change of air in one hour's time and equaling one-third of the total heat loss. The other two-thirds of the heat loss occurred from air conduction through opaque surfaces (walls and ceiling) and through windows. It was determined that a 10 percent savings could be attributed to double glass windows, 10 percent heat loss to being an end unit, and 5 percent heat loss for being on the windward side (Harrje, 1976).

Socolow candidly acknowledged that when beginning the study the researchers were prepared to discover that through controlled technology nearly all "lifestyle" effect would vanish. He considered the most significant observation of the study to be that energy consumption is influenced by technology as described above but even more so by the behavior of the occupants within their houses.

> People are far from alike, even in their use of gas and electricity. We have found wide range of variation in consumption of both gas and electricity, both winter and summer, in nearly identical townhouses. The more a technology allows expression of individuality the more the expected variation, so that indeed there is more variation in summer electrical consumption . . . than in winter electrical consumption and more variation in the latter than in gas consumption for winter. But even the variation in gas consumption for winter heating is substantial (Socolow, 1975, p. 320).

Two household behaviors thought to be major contributors to variations in consumption were thermostat settings and the opening of windows and doors; the monitoring of these behaviors was planned for the next phases of the study. This information may uncover aspects of behavior that people would want to change if they knew more about the consequences of their actions or inactions.

Family income and family size have not been found to be significant in the Twin Rivers data analyses. They were inversely related and neither was significantly correlated with winter gas nor winter electrical consumption. These variables may have been found to be less significant in this project because the households are more homogeneous than in American society as a whole. Furthermore, the variables found to be significant have been more precisely measured and these have not been included in more broadly based surveys.

The Family Energy Project is an ongoing longitudinal study in the College of Human Ecology at Michigan State University and was begun in the spring of 1973. The major thrust of this research has been an interdisciplinary study of the family from an ecological perspective. The results reported here pertain only to direct household energy consumption and its interrelationships.

Physical housing characteristics of number of rooms, windows, and exterior doors were found to be positively related to energy consumption levels. Single family dwellings used more energy than other dwelling types. Family characteristics found to be positively related to energy consumption included the number of people in the household, income, and families at the child rearing stages of the lifecycle (Morrison, 1975; Morrison and Gladhart, 1976). No significant differences in levels of consumption were found between wives who were employed full-time, part-time or unemployed (Eichenberger, 1975). No significant relationships between reported conservation attempts and sociodemographic characteristics were found (Hogan, 1976).

Using the 1975-76 data, Gladhart et al. (1977) found no evidence that families with higher or more rapidly rising fuel prices had lower rates of energy use per room or higher rates of conservation practice adoption.

Klausner (1977), a researcher at the Center for Research on the Acts of Man, Philadelphia, has developed what he calls a microsocial and microcultural analysis of energy consumption. Theoretical formulations similar to his were not reported in any other energy consumption study. From his data he drew several conclusions: increased social complexity led to increased energy consumption; the greater the complexity of roles in the household and the greater the complexity of other kin units in which the household was embedded, the greater the household energy consumption; the presence of a male in the household decreased the energy consumption which was interpreted as the introduction of order or discipline within the household. "Energy consumption is more efficient where relationships are socially ordered than where a state of anomaly exists" (Klausner, 1977, p. 5). Although his data were limited to single parent households and one month's reported household energy expenditures, his approach to the study of energy from a sociological perspective may prove to be insightful.

Two additional studies related to household energy consumption were identified, but the results were not yet available. These projects are being conducted at Washington State University (Carter, ongoing) and The Midwest Research Institute at Kansas City (Gross, ongoing).

Experimental Studies in Household Energy Consumption

Prior to the summer of 1977 less than 25 experimental studies were reported. Monetary incentives, feedback of behavioral performance, social commendation and information have been used as variables (Frankena, 1977; Milstein, 1976). The results, in general, have demonstrated some short-term effects, but minimal long-term impacts on consumption.

Studies giving monetary incentives with and without feedback about rate of energy use showed greatest reductions (Winett, 1975; Kohlenberg, Phillips & Proctor, 1976; Tuso & Geller, 1976; Hayes & Cone, 1977). Peak load pricing had an effect on electrical consumption in winter but not summer (Connecticut Power & Light, 1976). Milstein (1976) suggested that while paying people to save energy is unrealistic, the desire to save money would induce people to save energy.

When using feedback of behavioral performance as a variable, consumers have been informed how much energy they have been using relative to previous levels. The projected costs for the rate of energy use sometimes have been included (Kohlenberg et al., 1976; Seligman & Darley, 1976; Hayes & Cone, 1977; Palmer, Lloyd & Lloyd 1977). Milstein (1976) suggested that feedback was the second most effective method for reducing consumption. Seligman (1976) concluded from the few available studies that goal setting with feedback of rates of use and social comparisons could be effective strategies for energy conservation.

Exhortation and social commendation have had some effect (Seaver & Patterson, 1976; Palmer, Lloyd & Lloyd, 1977). Information has been the least effective, if effective at all (Heberlein, 1975; Battalio, Kagel, & Winett, 1976).

Reports were not yet available from studies focusing on conservation in master-metered buildings (Cook, McClelland & Belsten, 1977), impact of information upon installation of insulation (Cook et al., 1977), impact of information from infrared photography and computerized weatherization program upon conservation measures (Zuiches, 1977), and effect of information and technical assistance on farming practices (U.S. Community Services Administration, ongoing).

The National Research Council Committee on Measurement of Energy Consumption (1977) has recommended that field experiments be carried out to assess the effects of time-of-day pricing, the impact of feedback systems such as appliance labeling and metering devices, the impact of information campaigns upon retrofitting of buildings and the effect of government regulatory strategies.

Household Conservation Measures

Household energy conservation measures have been assessed in several surveys. The practices differ in the type of household decision making required. Some require a high degree of individual member participation and are reversible such as turning off lights, using less electricity, or limiting the use of hot water. Other decisions, such as installation of insulation, storm doors and windows, or replacement of appliances are less reversible and more permanent in nature but may require considerable financial outlay.

Insulation has been reported as present in 62 percent of all dwelling units and storm windows or insulating glass in 50 percent of the households. The presence of both of these energy conserving features has been found to vary with climatic conditions with the percentage greater for households in colder climates and less for those in warmer ones (Newman & Day, 1975).

The households reporting the addition of these energy conserving features since the time of the Arab Oil Embargo has been less than 15 percent (Murray et al., 1974; Warren, 1974; Doner, 1975; Hyland et al., 1975; Kilkeary, 1975; Newman and Day, 1975; Grier, 1976; Milstein, 1976; Warkov, 1976; Williams et al., 1976). Remodeling or improvements increasing energy use have been reported by less than 10 percent of the population (Grier, 1976).

The number of households having a clock thermostat to control space heating has not been reported. A specially designed dual cycle clock thermostat for heat control was used in experimental studies at Twin Rivers, New Jersey, and found to be significant in reduction of energy and satisfying to household members (Seligman et al., 1976).

The water heater accounts for 15 percent of all household energy use. Over half of the households nationwide have reported water heaters fueled by natural gas, one-third by electricity. Both have been growing in the amount of energy consumed annually (Newman & Day, 1975). Reduced consumption of hot water has been reported by a small percentage of the households surveyed (Gottlieb, 1974; Doner, 1975; Kilkeary, 1975; Hogan, 1976). Awareness of the extent of use of hot water within the household has been low (Morrison et al., 1976). A substantial percentage did not know where the temperature control or the temperature setting was located (Milstein, 1976). Twenty-six percent reported the specific behavior of turning down the thermostat on the hot water heater (Hogan, 1976). A reduction in the energy required to heat water was accomplished through placing an additional layer of insulation around the water heater (Harrje, 1976).

Appliance usage accounts for a relative small portion of personal direct energy use; however, appliance ownership, total energy usage, and income level are highly associated. This has been interpreted as well-off households having larger homes and more major energy-using appliances. An annual usage of 51 million Btu's of electricity[1] and natural gas for appliances was estimated by Newman & Day (1975) at the Washington Center for Metropolitan Studies. Nearly all electrical and natural gas appliances have increased in energy intensity since the 1950s (Newman and Day, 1975). Decisions not to buy appliances have been seldom reported (Warren, 1974; Thompson & MacTavish, 1976).

Air conditioning in some form is owned by 50 percent of the American households and is a particularly crucial variable since the efficiency varies widely

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[1]Electricity adjusted for conversion and transmission.

(Newman & Day, 1975). Approximately 10 percent of a national sample reported adding air conditioning since 1973 (Williams et al., 1976).

Adoption of repetitive energy conservation practices has been reported. A summary of the behaviors surveyed is presented in Tables 1 and 2. The reported contribution of each category towards total household energy use was given to assist in evaluating potential impact for conservation. The questions asked varied in wording as well as in timing; the intensity or frequency of the behaviors were often not asked.

It is clear that some of the conservation practices could contribute miniscule or indeterminant amounts towards conservation. No pattern of increased or de-decreased adoption of the measures was elicited from the tables. Milstein (1976) reported that from his data there appeared to be slippage away from the conservation behaviors during the years 1974 to 1976. He also stated that Americans were using about one-tenth less energy than would have been expected had the pre-embargo trend continued, but he considered most Americans to have been participating in token energy-saving behaviors.

It is known that some of these practices can contribute substantially to energy conservation and minimal, if any, investment of economic resources is needed. Pilati (1974) calculated a 4.1 percent aggregate reduction in

TABLE 1.--Summary of Research Articles Reporting Household Conservation Behaviors Related to Space Heating.

Potential Impact: Space heating is the biggest single end use of energy in the home; estimates vary depending upon how calculated and for what climate. Stanford Research Institute reported 57% (1972); U.S. Department of Interior, 68% (1975).

Estimates of the percent savings by reduction in temperature vary with climatic conditions. Figures quoted here are for climate 7000 heating degree days and a reference point of 72°F.

68° daytime, save 15%; 68°F daytime and 60°F nighttime, 28% savings (Pilati, 1974).

Conservation Behaviors Related to Space Heating[a]	Respondents Reporting Adoption[b]	Researcher and Date Reported[c]
Turn down thermostat, unspecified temperature	80%	Bartell 1974; Sears et al. 1974; Warren 1974
	49	Perlman & Warren 1975
	13	Doner 1975
	31-75	Murray et al. 1975
	62	Thompson & McTavish 1976; Gottlieb & Matre 1976
	79	Bultena 1976
Keep thermostat at		
64°F or less at night	22	Milstein 1976
60°F or less at night	40	Morrison et al. 1976
Daytime temperature 68°F	80	Hogan 1976
	65	Morrison 1976
	48	Milstein 1976
Do not heat some rooms in winter	43	Perlman & Warren 1974
	61	Hogan 1976
	48	Morrison et al. 1976

[a]Behaviors have been grouped conceptually rather than by exact wording.

[b]Some percentages have been grouped if in similar range. These are perhaps read best if in gross categories such as >50%, <25%, etc. Milstein thinks figures should be reported to nearest 10% (1977).

[c]All the research reported took place after the Arab Oil Embargo, 1973-74, but prior to the winter of 1977.

TABLE 2.--Summary of Research Articles Reporting Household Conservation Behaviors Related to Uses Other Than Space Heating.

Conservation Behaviors Related to Uses Other Than Space Heating[a]	Potential Impact	Respondents Reporting Adoption[b]	Researcher and Date Reported[c]
Limit amount of hot water for washing dishes, clothes, bathing	97% own hot water heaters,[d] 15% total direct[e] household energy	2-52%	Perlman & Warren 1974 Gottlieb & Matre 1976, Thompson & MacTavish, 1976 Doner 1975 Hogan 1976, Morrison et al. 1976
Turn down thermostat on hot water heater		26	Hogan 1976
Dishwasher full before running	25% own dishwashers,[d] ≈4 Btu×10^6/year	45-89	Perlman & Warren 1975 Milstein 1976
Air conditioning: use less	48% own air conditioning,[d] 1-194 Btu×10^6/year efficiency varies.		Perlman & Warren 1975
	2% total direct household energy	46-69	Kilkeary 1975; Gottlieb & Matre 1976 Burdge 1976 Warkov 1976
Cooking: cook several dishes at one time	97% own stoves, ≈10-13 Btu×10^6/year 5% total direct household energy	3-48	Doner 1975 Kilkeary 1975 Morrison et al. 1976
Lighting: turn off lights not in use; smaller bulbs	Lights included in "other" category which equaled 5% total direct household energy	22-98	Bartell 1974 Perlman & Warren 1974 Sears et al. 1974 Gottlieb & Matre 1976 Doner 1975 Hogan 1975 Kilkeary 1975 Milstein 1976 Warkov 1976, Morrison et al. 1976
Use electrical appliances less	Indeterminant. 51 Btu×10^6/year was used for electric and gas appliances[d]	2-90	Murray et al. 1974 Bartell 1974; Sears et al 1974; Warren 1974; Thompson & MacTavish 1976 Doner 1975
Clothes drying: cutting use of dryer--full load, clothesline	53% own dryers[d], ≈7-11 Btu×10^6/year 2% total direct household energy[e]	2-77	Murray et al. 1974 Perlman & Warren 1974 Doner 1975 Milstein 1976 Morrison et al. 1976

[a]Behaviors have been grouped conceptually rather than by exact wording.
[b]Wide variation in responses; therefore, only range of responses is reported. Milstein (1977) thinks figures should be reported to the nearest 10%.
[c]All the research took place after Oil Embargo 1973-74, but prior to winter of 1977.
[d]Newman & Day (1975).
[e]Department of Interior (1975).

total energy use by turning the thermostat from 72° to 68° during the daytime and 55° at night. However, the reversibility and required repetitive implementation of these behaviors by household members are obstacles not to be ignored (Pilati, 1974; Hirst, 1976).

In many cases the studies reviewed equated conservation with reported conservation behaviors. The pervasiveness and complexity of energy use in the household as well as the unreliability of the self-report make this position untenable. The major outcome criterion is energy consumption. Evaluation is needed as to what extent perceived conservation behaviors reduce that measure. No field study research was reviewed which assessed the extent to which these reported conservation behaviors were contributing towards energy conservation, i.e., reduced consumption.

CHAPTER III

METHODOLOGY

The description of the following steps in the research process has been included in this chapter: data collection, sampling procedures and resulting sample; description of subsample used in this analysis, measurement procedures, data reduction and analysis strategies; hypotheses to be tested; assumptions and limitations of the study.

The data were gathered as part of an interdisciplinary study entitled "Functioning of the Family Ecosystem in a World of Changing Energy Availability," also designated the Family Energy Project (FEP) and funded by the Michigan Agricultural Experiment Station.[1] This project was a field survey carried out in the greater metropolitan area of Lansing, Michigan, May and June, 1974, and repeated in May and June, 1976. The surveyed unit was the "family" defined as two or more related individuals living together, one of whom was 18 years of age or older.

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[1]Michigan Agricultural Experiment Station Project No. 3152.

Data Collection Procedures

Comparable data collection procedures were carried out in both 1974 and 1976.[1] A trained interviewer contacted the male or female head of the household, screened the household for eligibility, and obtained agreement for participation in the study. Participation was defined as (1) individual responses to a self-administered questionnaire by all qualifying members present within the household; those qualifying were male head of household, female head of household and oldest child if between 12 and 20 years of age; (2) either male or female head of household responses to interviewer-administered questions about the demographic and housing structural characteristics of the household.

Personal interviews of about two half-hours were completed with a household head from each sampled residence, one upon initial contact and one when picking up the self-administered sections. The interview data included a large number of characteristics about the housing unit, as well as details of household compositon and an array of socioeconomic and demographic characteristics. In 1976, permission was requested for

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[1]A more detailed account of 1974 procedures can be found in Morrison (1976) and Zuiches, Morrison and Gladhart (1976).

release of household consumption data from the utility and oil companies.

The self-administered questionnaire focused on beliefs, attitudes and behaviors related to energy and families. A ten dollar honorarium was given each household upon completion of the self-administered and interviewer-administered questionnaires.

The data were checked by the research team for completeness and individuality of responses. The raw data were coded, keypunched and verified by trained personnel. Ninety-eight percent of the sampled families granted permission to obtain energy consumption information. These data were obtained from Consumers' Power, Board of Water and Light and numerous oil companies and were also checked for completeness, coded, keypunched and verified by trained personnel.

The Sampled Community

The 1974 sample was selected from the greater metropolitan area of Lansing, Michigan. The Lansing S.M.S.A. is considered to be a well-defined social, economic, and political metropolitan area characterized by a diversity of functions. It is the seat of state government, the site of a major university, and the location of light and heavy industry related to the automotive industry. The Lansing S.M.S.A. is an area of commercial enterprise surrounded by an agricultural sector.

The Lansing S.M.S.A. had a total population of 378,000 persons and 89,610 families (1970 Census). A multi-stage probability sample of urban, suburban, and rural families was drawn from the tri-county area of the S.M.S.A. Some portions of Clinton, Eaton, and Ingham counties fall within the S.M.S.A. which is considered to be a viable geographic area with a heterogeneous population. Ten census tracts were randomly selected, each tract having a probability proportionate to the number of households therein. From the 34 blocks contained within the ten census tracts, over 600 houses were selected through the use of the 1973 Polk City Directory.

In the rural areas, townships with no incorporated places and specific sections within townships were selected from the counties in the S.M.S.A. The households sampled were from randomly selected addresses within the sections. Sampling procedures assured attainment of at least 150 urban and 50 rural families. The final sample contained 216 families, 160 urban and 56 rural.

In the 1976 survey the interviewers were instructed to place a priority on obtaining interviews from households surveyed in 1974. To achieve approximately equivalent-size samples for 1974 and 1976, taking into account panel attrition, additional households were chosen to be contacted for screening and interviewing. These new families were selected from the same tracts, blocks and township sections as the original families. Rather than draw a completely new sample, the additional addresses consisted of the 228 households not contacted, not at home, or listed as vacant addresses in 1974. The new rural sample consisted of all remaining households in the originally designated 12 sections.

Upon completing the second wave of interviews, the sample total was 263 families, 135 new families and 128 families contacted in 1974 and reinterviewed in 1976. This was a follow-up rate of 59 percent. A summary of the samples for 1974 and 1976 is found in Table 3 (page 46). A comparison was made between the census data of 1970 for the Lansing S.M.S.A. and the surveyed households at both points in time to assess the representativeness of the sample. In general, the area probability samples were determined to be representative of the Lansing S.M.S.A. with single member households excluded (Zuiches et al., 1975; U.S. Bureau of Census, 1975).

Lansing and Morgan (1971) observed:

> When repeated interviews use the same basic sample down to the rather small areas, added precision is provided for estimates of change even without re-interviews, because the correlation between the first interview and second in

> demographic characteristics, etc. is higher than chance . . . and the sampling error is smaller than with two completely different random samples (p. 348).

The Research Subsample

The primary objective of this present research was to assess the relationships between household micro-decisions related to energy consumption and changes in levels of consumption from 1973-74 to 1975-76. The household was selected as the appropriate unit for analysis. Three basic criteria were judged necessary for determining inclusion of a household in the sample.

To control for the effect of the change in dwelling structure upon changes in level of consumption, only those families living in the same dwelling unit 1973 through 1976 were included.

A second requirement was completeness of household energy consumption data for July 1973-June 1974, and July 1975-June 1976. Energy data were judged complete for each household if not more than four months of electricity and natural gas were missing, and both winter heating seasons (November-March) were complete for the fuel used to supply space heating. Two percent of the data needed estimation. (See Appendix A for computation procedures for calculating and estimating household energy.)

TABLE 3.--Family Energy Project Sample Comparisons, 1974, 1976.

Household Respondents	1974				1976			
	Families		Individuals		Families		Individuals	
	%	N	%	N	%	N	%	N
Male and female respondents	63.4	(137)	57.5	(274)	65.8	(173)	60.3	(346)
Male/female and child respondents	26.9	(58)	36.6	(174)	23.2	(61)	31.9	(183)
Single parent and child respondents	3.2	(7)	2.9	(14)	6.1	(16)	5.6	(32)
Single parent respondent	6.5	(14)	2.9	(14)	4.9	(13)	2.3	(13)
	100	(216)	100	(476)	100	(263)	100	(574)

The third criterion was completeness of a self-administered questionnaire by either male or female head of household on reported conservation behaviors. Respondents were asked a series of questions regarding energy conservation practices, i.e., microdecisions by household members. Data were judged complete if at least one household member had given a response. Less than one-half of one percent of the items were not answered by either husband or wife. These items were examined and given an appropriate value based on other questionnaire information or were assumed not to have increased in the two years prior to the survey.

The data base contained 130 households meeting these criteria; these households were used as the research sample for the analysis in this report.

Basic demographic and structural characteristics of the surveyed households used in this research are presented in Tables 4, 5, and 6. The same descriptive measures are reported for the larger area probability sample. This provides a basis for understanding the generalizability of this research to the larger Lansing S.M.S.A.

In the research sample, approximately half the males had at least some college education and over one-fourth were college graduates; 44 percent of the females had attended college. The median income was $17,300

TABLE 4.--Selected Characteristics of Households: A Comparison of the Family Energy Project Sample, 1976, and Research Subsample.

Household Characteristic	Family Energy Project Sample		Research Subsample	
	100%	(N=263)	100%	(N=130)
Family Type				
Husband/wife with children	60.5	(159)	57.7	(75)
Husband/wife no children	29.3	(77)	32.3	(42)
Female heads with children	9.9	(26)	9.2	(12)
Male heads with children	.4	(1)	.8	(1)
Household Income, 1975				
Less than $4,999	7.6	(20)	6.2	(8)
$ 5,000 - $ 9,999	15.2	(40)	14.6	(19)
$10,000 - $14,999	24.0	(63)	16.9	(22)
$15,000 - $24,999	34.2	(90)	40.0	(52)
$25,000 or more	14.1	(37)	17.7	(23)
Missing	4.9	(13)	4.6	(6)
Median Income	$15,100		$17,300	
Housing Tenure				
Owner	78.7	(207)	90.0	(117)
Renter	20.5	(54)	10.0	(13)
Missing	.8	(2)		
Residential Location				
Urban	65.0	(171)	73.8	(96)
Rural	35.0	(92)	26.2	(34)

TABLE 5.--Selected Characteristics of Respondents: A Comparison of the Family Energy Project Sample, 1976, and the Research Subsample.

Respondent Characteristic	Family Energy Project Sample		Research Subsample	
Male Respondents	100%	(N=236)	100%	(N=118)
Age level:				
18 - 29 years	18.6	(44)	6.8	(8)
30 - 44 years	41.5	(98)	38.1	(45)
45 - 64 years	26.7	(63)	38.1	(45)
65 years or more	11.9	(28)	15.3	(18)
Missing	1.2	(3)	1.7	(2)
Educational level:				
Less than high school	19.9	(47)	22.9	(27)
High school graduate	32.2	(76)	26.3	(31)
1-3 years of college	21.2	(50)	22.0	(26)
College graduate	26.7	(63)	28.8	(34)
Female Respondents	100%	(N=261)	100%	(N=128)
Age level:				
18 - 29 years	28.0	(73)	12.5	(16)
30 - 44 years	32.2	(84)	35.2	(45)
45 - 64 years	29.1	(76)	38.3	(49)
65 years or more	8.8	(23)	12.5	(16)
Missing	1.9	(5)	1.6	(2)
Educational level:				
Less than high school	18.0	(47)	15.6	(20)
High school graduate	42.1	(110)	40.6	(52)
1-3 years of college	24.5	(64)	26.6	(34)
College graduate	15.3	(40)	17.2	(22)

TABLE 6.--Selected Characteristics of Dwelling Units: A Comparison of the Family Energy Project Sample, 1976, and Research Subsample.

Dwelling Unit Characteristic	Family Energy Project Sample		Research Subsample	
	%	(N=263)	%	(N=130)
Type of Dwelling Unit				
Single family dwelling	84.8	(223)	94.6	(123)
Single converted to multiple	1.5	(4)	2.3	(3)
Mobile home	3.8	(10)	.8	(1)
Duplex	2.7	(7)	1.5	(2)
Apartment	6.8	(18)	--	(0)
Missing	.4	(1)	.8	(1)
Number of Rooms				
1 - 5	35.4	(93)	25.4	(33)
6 - 7	39.5	(104)	43.8	(57)
8 or more	25.1	(66)	30.8	(40)
Type of Energy Used in Home (Primary source)				
Natural gas	59.3	(156)	69.2	(90)
Fuel oil	31.6	(83)	28.5	(37)
Electricity	3.4	(9)	1.5	(2)
L.P. gas	3.4	(9)	.8	(1)
Wood	2.3	(6)	--	(0)

with 40 percent of the sample earning between $15,000 and $25,000. The sample was comprised predominantly of home owners living in single family dwellings. Nearly three-fourths were urban residents. The median age of the male head was 47 years. Two-thirds of the households had children living in the home.

Compared to the larger area probability sample, the households in this research had achieved comparable educational levels and were similar in family type. The median income and median age were higher than those of the larger sample, and the proportion of home owners and urban residents was greater.

The structural aspects of a dwelling unit are critical in energy consumption. The type and size of dwelling and kinds of energy used within the households are reported in Table 6 (page 50). Ninety-five percent of the dwellings used in the study were single family units with a median of seven rooms per house. Natural gas and fuel oil were the primary sources of energy used for space heating. The larger project sample had fewer single family dwellings and they were smaller in size, but the major space heating fuels were the same.

In summary, the research sample over-represented home owners and single family households with higher incomes. It is likely that the criterion of three years in the same residence was the selective factor; it is also likely that this explained the higher median age. Although the households using wood as a primary fuel were few, the criterion of complete energy consumption data eliminated them from the study. The major differences noted between the research and the area probability sample were not extreme; only in home ownership and lower age of household heads did the differences exceed 10 percent.

The stock of appliances reported by the households is presented in Table 7, along with the percent of appliances added between July, 1974, and June, 1976. Many of the appliances were reported by nearly all sampled households. Few reported addition of major appliances between 1974-76.

The energy conserving features of the Lansing subsample and percentage that reported addition between July, 1974, and June, 1976, are presented in Table 8. More than three-fourths of the sampled households reported having some insulation and storm windows. Less than 15 percent installed these features between 1974 and 1976.

Measurement Procedures

The measurement procedures were developed and distributions computed for all variables. The consumption variables included those calculations related to Btu's consumed during the years 1973-74 and 1975-76. The change variables involving household microdecisions

TABLE 7.--Sample Households With Major Appliances, 1976; Sample Households Adding Major Appliances, 1974-76.

Appliance	Present in Household 1976 %	(N=130)	Added[a] July'74-June-76 %	(N=130)
Hot water heater	100	(130)	4	(5)
Electric	37	(48)	2	(2)
Natural gas	62	(80)	2	(3)
Other	2	(2)		
Range	100	(130)	5	(7)
Electric	65	(84)	3	(4)
Gas	35	(46)	2	(3)
Dryer	82	(107)	4	(5)
Electric	54	(70)	2	(3)
Gas	29	(37)	2	(2)
Dishwasher	43	(56)	6	(8)
(Missing data)	2	(3)		
Television[b]	95	(123)	10	(12)
(Missing data)	5	(7)		
Black and white	52	(68)	5	(6)
Color	75	(97)	5	(6)
Washing machine	84	(109)	2	(2)
(Missing data)	2	(3)		
Refrigerator[b]	96	(125)	8	(10)
(Missing data)	4	(5)		
Self-defrost	62	(81)	6	(8)
Without defrost	39	(50)	2	(2)
Freezer[b]	63	(82)	10	(12)
(Missing data)	5	(17)		
Self-defrost	14	(18)	5	(6)
Without defrost	50	(65)	5	(6)
Air conditioning	35	(45)	2	(2)
(Missing data)	2	(3)		
Central	9	(12)	0	(0)
Room	26	(33)	2	(2)

[a]Question: "Have you added any major appliances in the last two years?" This question may have been too inexact and replacements may be included.

[b]Some families have more than one.

TABLE 8.--Sample Households With Energy Conserving Features, 1976; Households Adding Energy Conserving Features, 1974-76.

Energy Conserving Feature	Present in Household 1976		Added July'74-June'76	
	%	(N=130)	%	(N=130)
Ceiling insulation	84	(109)	15	(19)
Wall insulation	72	(93)	12	(16)
Storm windows	80	(104)	12	(15)

included both behavioral and structural changes occurring within the households between June, 1974, and June, 1976. Additional information related to these variables has been included in Appendices A and B.

Consumption Variables

Annual direct household energy.--For each household, the amount of energy used annually within the dwelling unit in the form of cubic feet of natural gas, gallons of fuel oil, cubic feet of liquid propane, and kilowatt hours of electricity was converted to Btu's.[1]

The following conversion factors were used:

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[1]Btu (British Thermal Unit) is the amount of energy needed to increase the temperature of one pound of water one Fahrenheit degree when the water is 39.2° originally (Murray, 1976).

1 cubic foot natural gas = 1,032 Btu's
1 kilowatt hour of electricity = 3,412 Btu's[1] or
10,910 Btu's[2]
1 gallon fuel oil = 138,800 Btu's
1 cubic foot liquid propane = 2,572 Btu's
(Energy . . . Ford Foundation, 1974).

As noted above, two very different conversion factors for electricity have been included. Although there is energy lost in converting and transmitting any fuel, the loss with electricity is so great that studies often have used the factor including transmission and conversion loss. Since the focus of this research was the energy used within the home, unless otherwise indicated, electricity was not adjusted for transmission and conversion, but only for energy consumed within the household.

The resulting distribution of each source of energy and the totals for both years under study were used in the analysis and are reported in Table 10 in Chapter IV.

Weather-adjusted direct household energy consumption.--If all other factors were held constant, for each household the total number of Btu's used for space

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[1]This conversion factor is the amount of Btu's consumed in the home.

[2]This conversion factor takes into account the energy used to create electricity in a power plant and transport it, as well as energy used in the home.

heating would vary with the severity of the winter weather. For this study, in the year 1975-76, there were 1.8 percent more heating degree days[1] between September 1 and May 31, than for the same months during 1973-74.

Space heating is the largest single end use in the home with estimates from 57 percent (Stanford Research Institute, 1972) to 68 percent (Department of the Interior, 1975). These represent national averages and vary with the geographical area. It was concluded that a better estimate of the relative amount of energy used for space heating in this geographical area could be calculated from the research sample. A mean of 80 percent of the total household energy was found; when electricity was adjusted for transmission and conversion, the mean was 56 percent, comparable to the national percentages cited above.

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[1]Heating degree days are the number of degrees that the daily average temperature is below 65°F. Normally heating is not required in a building when the outdoor average daily temperature is above 65°. Heating degree days are determined by subtracting the average daily temperature below 65° from the base 65. The heating degree days for this study were obtained from the Guardian Oil Company, Lansing, Michigan. The Johnson Degree Day System used by the oil company measured temperature, wind and sun effects in calculating the degree days. From September 1 through May 31 there were 7,579 heating degree days, 1973-74; 7,712, 1975-76.

The percentage increase (decrease) of heating degree days multiplied by the proportion of the direct household energy used for heating would give a rough approximation of the increase (decrease) in consumption due to weather. Therefore, if all factors other than weather were held constant, an increase of approximately 1.4 percent Btu's for the year 1975-76 could have been expected when compared to 1973-74.

Percent change in annual consumption.--The percentage difference between Btu's consumed during 1973-74 and 1975-76 was computed for each household. This gave an estimate of the relative extent to which the consumption of each household had changed, given the previous level of consumption. Approximately one-fifth reduced consumption between 10 and 20 percent, and one-tenth reduced consumption more than 20 percent.

Structural and Behavioral Change Variables

These variables, based on previous research, were selected for their potential effect on levels of direct household energy consumption. The questions used and a summary of the distributions have been included in Appendix B.

Furnace change.--It was hypothesized that a new furnace would be more efficient than an old furnace and would therefore cause a decrease in consumption. This was used as a dummy variable[1] where those households reporting a new furnace installed between June, 1974, and June, 1976, were given a value of one and those not installing a furnace a value of zero. Six percent reported having a new furnace installed between June, 1974, and June, 1976.

Installation of air conditioning.--Air conditioning has often been reported as a major factor in the variability of electrical use. It was hypothesized that those households reporting installation of air conditioning would have increased household energy consumption. The number of rooms air conditioned was the assigned value to those households reporting addition of air conditioning between June, 1974, and June, 1976; other households were given a value of zero. Two percent reported having added air conditioning.

Index of additional appliances.--Number and type of appliances have been associated with levels of household energy consumption. The appliance index used

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[1]Dichotomous or "dummy" variables have come into widespread use in survey analysis. When a dummy variable is used to represent a simple dichotomy, all cases which fall into the category are given the value of one; also, those not falling into the category are given a value of zero (Lansing & Morgan, 1971).

by the Washington Center for Metropolitan Studies (Newman & Day, 1975) was modified slightly, adding more detailed information, assigning each household the sum of the estimated annual usage of Btu's for the appliances added between June, 1974, and June, 1976. Since the major purpose of this research was to understand energy used within the household, the electricity was not adjusted for conversion and transmission. Thirty-two percent of the households reported the addition of at least one appliance.

Changes in family size.--Family size has been found to be related to levels of consumption (Cohen, 1976; Morrison, 1976). Changes in family size were included to determine if they affected levels of consumption. For those households resurveyed in 1976, the number of persons present in the household during 1974 was subtracted from the number present in 1976.

Precise data were not available for the households surveyed only in 1976. The information had to be derived from demographic data throughout the questionnaire. Dates of events that occurred between June, 1974, and June, 1976, were available for the following: births of children and divorce or death of a spouse. It was also recorded if a child had left home during the year prior to the survey. These items were used to calculate the variable change in family size. Sixty-nine percent of the sample were calculated to have no change in family size; 20 percent decreased and 11 percent increased.

Change in employment status.--An increase in the amount of time spent in the home may increase the amount of energy used. It was hypothesized that a major change in employment status, which increased the likelihood of time spent in the home, could result in increased levels of household energy consumption. Twelve households had at least one member retire or lose a job between June, 1974, and June, 1976. No information was available about those persons who might have become newly employed during this time period and decreased the time spent at home.

Installation of insulation.--The Princeton study estimated that approximately one-third of the heat loss occurred through opaque surfaces of ceilings and walls (Harrje, 1976). Insulation has been projected as a major structural change that can reduce heat loss and hence energy consumption. Insulation in ceilings and insulation in walls were used as separate dummy variables. Those households reporting the conservation measures were given a value of one and those not reporting the conservation measures were given a value of zero. Fifteen percent reported adding insulation in the ceiling and 12 percent in the walls.

Lowered thermostat setting on hot water heater.--Hot water heating represents the second largest end use of energy in the home. It was hypothesized that reducing the temperature of the hot water would result in a reduction in total consumption. This variable was used as a dummy variable with those who reported having lowered the setting on the water heater thermostat being given a value of one and those not lowering the setting a zero. Fifteen percent reported having lowered the thermostat settings on the hot water heater.

Intensity of repetitive household conservation practices.--The conservation measures previously described represent permanent changes not requiring repetitive behaviors by household members. There are many conservation measures that do require daily or seasonal implementation with minimal technology or economic investment.

Questions concerning some repetitive conservation practices were asked of each male and female head of the household: To what extent did the family practice the behavior and had they increased the practice in the two years since the Oil Embargo? Several measures were reported by more than 75 percent of the households:

covering, sealing, caulking around windows with plastic or installing storm windows; reducing daytime temperature to 68 degrees or less; having heating equipment cleaned or serviced, and turning out lights not in use. For other practices moderate levels of adoption were reported. These included not heating some rooms in winter, limiting hot water use, reducing nighttime temperature to 60° or less, and cooking several dishes in the oven at one time. Less than 20 percent reported using clotheslines rather than dryers. (See Table 9.)

The reported increase in behavior clarified which practices had received the most emphasis recently. Of the people who turned their thermostats down, day or night, nearly all had increased that practice within the past two years, whereas covering windows and having furnace equipment cleaned and serviced were practiced by a substantial percentage prior to the time of energy emphasis.

Insights were gained by looking at these behaviors individually but any single behavior could have only a small effect on total consumption. It seemed more productive to analyze these practices in a holistic manner. A scale to measure the composite effects of the household microdecisions was developed.

The items were conceptualized as a sampling from a pool of possible microdecisions that could be made by

TABLE 9.--Reported Adoption and Increase of Household Energy Conserving Practices, 1976.[a]

Energy Conserving Practice	Adoption[b] 1976 %	(N=130)	Increase[c] 1974-1976 %	(N=130)
Cover or seal windows and doors with storm windows or plastic	93	(121)	45	(59)
Both adults	82	(106)	26	(34)
One adult	12	(15)	19	(25)
Have heating equipment cleaned and serviced	79	(102)	37	(48)
Both adults	63	(82)	15	(20)
One adult	15	(20)	22	(28)
Turn down thermostat while sleeping to 60 degrees or less in the winter	60	(77)	52	(67)
Both adults	39	(51)	23	(30)
One adult	20	(26)	29	(37)
Maintain daytime temperature at 68 degrees or less in the winter	76	(99)	65	(84)
Both adults	59	(76)	40	(52)
One adult	18	(23)	25	(32)
Do not heat some rooms in winter	60	(78)	41	(53)
Both adults	47	(61)	19	(24)
One adult	13	(17)	22	(29)
Turn off lights not in use	99	(128)	79	(103)
Both adults	95	(124)	46	(60)
One adult	3	(4)	33	(43)
Dry clothes on clothesline rather than in dryer	39	(50)	20	(26)
Both adults	25	(33)	7	(9)
One adult	13	(17)	13	(17)
Limit amount of hot water for bathing, dishwashing and washing clothes	67	(87)	46	(60)
Both adults	36	(47)	15	(20)
One adult	31	(40)	31	(40)
Cook several dishes in oven at one time	76	(99)	45	(58)
Both adults	48	(62)	20	(26)
One adult	29	(37)	25	(32)

[a]Figures have been rounded.

[b]Includes categories all/most of the time.

[c]Includes categories increased July 1974-June 1976 to the extent of all/most of the time.

household members and each item was examined for its scalability into a unified measure. Three dimensions were considered when developing the scale: frequency of the practice, its increase within the two years following the Arab Oil Embargo, and the proportion of adult heads of households reporting adoption of the practice.

A family score was developed for each item in the following manner: each adult head of household who reported an increase in the practice to the extent of all or most of the time was given a value of one; each who did not report an increase or did not practice it all or most of the time was given a value of zero; the husband's and wife's scores were added together giving values between zero and two.

2 = Husband/wife both reported increase (all/most of the time)

1 = Husband or wife reported increase (all/most of the time)

0 = Neither husband nor wife reported increase (all/most of the time).

Single parent households comprised 11 percent of the sample. The single person's response was calculated as outlined above but the scoring was adjusted to make the range of values similar.

2 = Single parent reported increase (all/most of the time)

0 = Single parent did not report increase (all/most of the time).

Two percent of the items had missing responses from one adult head of household. The missing data were assigned the values of the response of the adult head whose answer was not missing.

A summary table of the distribution of the family items and the inter-item correlations have been reported in Appendix B. The range of values from zero to two was well distributed for all items; the inter-item correlations were positive and moderate.

Another step to understand the collective contribution of the set of variables was to examine the gross relationship of each element with the dependent variable to be sure its effect was in the expected direction (Lansing & Morgan, 1971, p. 282). Using change in Btu's from 1973-74 to 1975-76 as the dependent variable, the mean for each category of each conservation practice was plotted. In general, the directions of the relationships were as expected: the greater the intensity of the practice, the greater the reduction in Btu's. These means are presented graphically in Figure 1.

A final step taken in determining the scalability of the items was to compute Cronbach's alpha reliability coefficient. It was found to be .79. This coefficient is one indication of the extent to which various items answered by the same persons are measures of the same attribute (Nunnally, 1967). A coefficient in the range

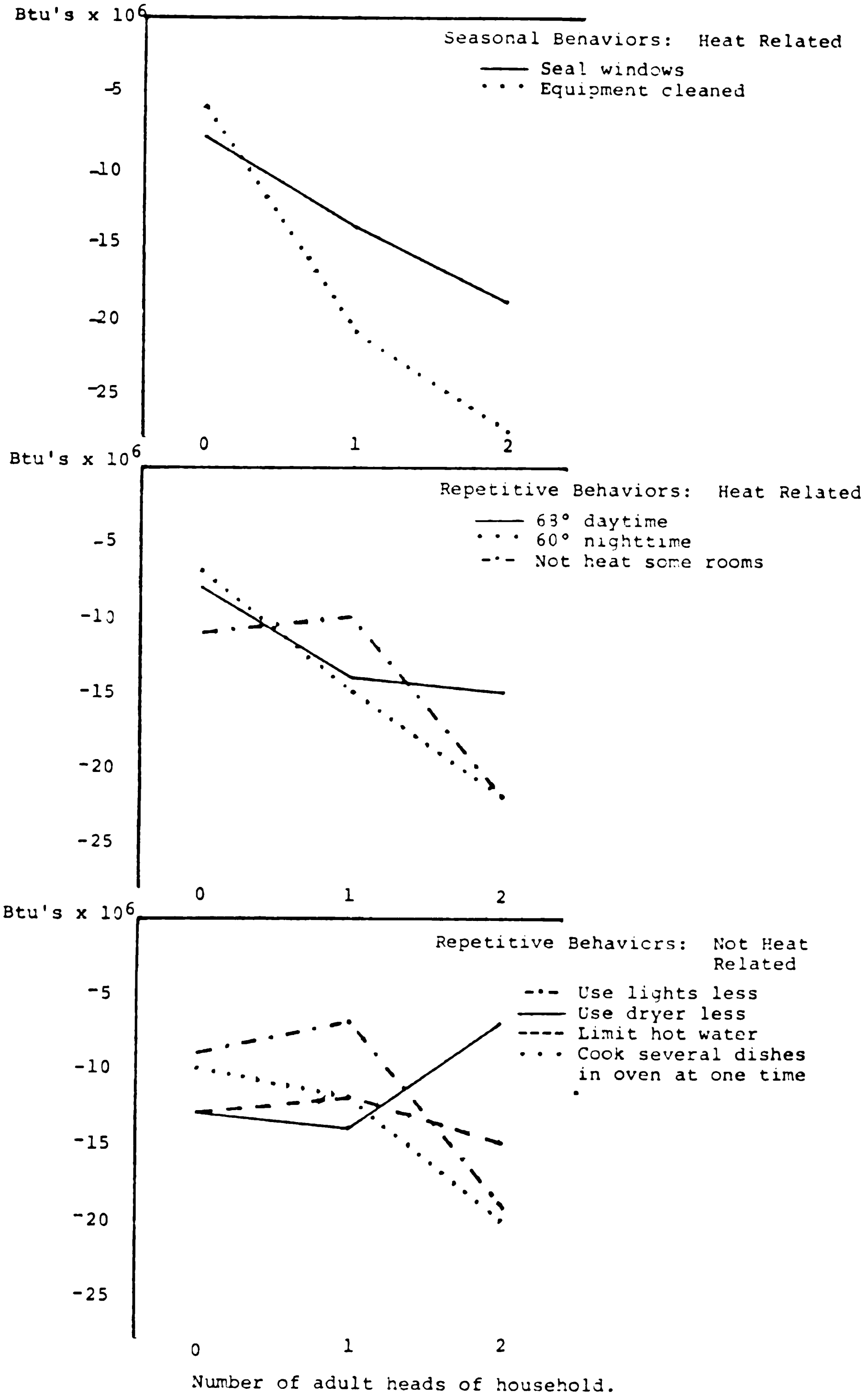

Figure 1.--Number of Adult Heads of Household Within one Family Who Reported an Increase in Conservation Practices to the Extent of All or Most of the Time by the Mean of Milions of Btu's Decrease from 1973-74 to 1975-76.

of .80 has been considered by Rodgers (1975) as reasonable for fairly critical variables in survey research.

As the final step in developing the scale, the nine items were combined into a total family score. This was used as the variable designated increased intensity of conservation behavior. The values ranged from 0 to 17 and the mean was 6.4.

Research Hypotheses

From the theoretical position advanced in this research, the review of the literature, and the examination of the available data, the following hypotheses were developed. They have been stated in the null form according to standard statistical procedure.

Hypothesis 1

1.1 There is no difference between the means of the Btu's of direct household energy consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

1.2 There is no difference between the means of Btu's of direct household energy consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76 when adjusting for conversion and transmission of electricity.

1.3 There is no difference between the means of the Btu's of natural gas consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

1.4 There is no difference between the means of the Btu's of fuel oil consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

1.5 There is no difference between the means of the Btu's of electricity consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

Hypothesis 2

Given the total Btu's of direct energy consumed within households during 1973-74, there is no linear relationship between the Btu's consumed during 1975-76 and the following independent variables:

2.1 The installation of a new furnace between June, 1974, and June, 1976.

2.2 The number of rooms per household to which air conditioning was added between June, 1974, and June, 1975.

2.3 The annual Btu's of energy consumed by appliances added to the household between June, 1974, and June, 1976.

2.4 The change in family size between June, 1974, and June, 1976.

2.5 Loss of job or retirement between June, 1974, and June, 1976.

2.6 The installation of insulation in the ceiling of the house between June, 1974, and June, 1976.

2.7 The installation of insulation in the walls of the house between June, 1974, and June, 1976.

2.8 Lowered thermostat setting of the hot water heater between June, 1974, and June, 1976.

2.9 The increased intensity of conservation behaviors by household members between June, 1974, and June, 1976.

Statistical Analysis

Analysis was done on the CDC 6500 Computer, Michigan State University, using the Statistical Package for the Social Sciences program.

The two major purposes of this research were to elicit what changes in levels of household energy consumption had occurred since the Arab Oil Embargo, and if household microdecisions related to energy conservation had affected the levels of consumption.

To address the first question, dependent t-tests were computed to determine if consumption levels for 1975-76 were significantly lower than 1973-74.

Multiple regression was selected for analysis of relationships between levels of household consumption and microdecisions related to structural and behavioral changes within households. This procedure allowed examination of the collective and individual contributons of independent variables on the variance in the dependent variable.

In many regression analyses this is the major objective; however, in the present analysis, the focus was not upon explaining variance in consumption for 1975-76. The major purpose was to examine to what extent microdecisions related to household energy conservation had contributed to reduction in consumption, taking into account the confounding effects of other potentially energy-related changes within the household. It was also of interest to know whether the relationships between the conservation measures and consumption for 1975-76 were significantly better than chance.

Assumptions

1. Survey research is an appropriate means for gaining both structural and behavioral measures to be examined in relationship to direct household energy consumption.

2. Data obtained from utility and fuel oil companies as to amounts of natural gas, oil and electricity consumed are reliable, and can be converted to a standard measure, in this case, British Thermal Units, without significant loss in measurement reliability.

3. Multivariate regression is an appropriate statistical analysis procedure for testing a system's model of energy consumption.

Limitations

The characteristics of the sampled community should be kept in mind when evaluating the results. The definition of "family" excluded single member households from the study. The criterion of three years in the same residence may have eliminated most renters and families living in multifamily dwellings. The median income and age were also somewhat higher than the median for the Lansing S.M.S.A.

It has been well documented that higher income households living in single family dwelling units use more energy than lower income households and thus represent a major target for conservation. This sample, therefore, may have over-represented a primary target for potential conservation, but caution must be taken in generalizing the results to the larger community.

The excluded or omitted variables were not deemed to be a serious problem in this research; insights gained through the processing of the consumption data have suggested that more extensive analyses could have been done if there were documentation of major energy-related activity patterns and household changes. Several examples have been suggested: dates when beginning employment; dates of vacations; detailed usage of major appliances; dates and amount of insulation or other major structural changes, whether energy-consuming or energy-conserving; estimates of time spent at home for individual members; dates of family size changes such as children leaving home or an older relative moving into the household; variations due to stages of the family life cycle; and items to develop indices of social activity occurring in the home.

CHAPTER IV

FINDINGS AND DISCUSSION

Two statistical procedures were employed to test the hypotheses: dependent t-tests and multiple regression analysis. The findings from these procedures have been reported in this chapter in two major sections: changes in household energy consumption and impact of household microdecisions upon levels of consumption.

Changes in Household Energy Consumption

Since the energy consumption of a household at two points in time cannot be considered independent observations, dependent t-tests were employed to test the null hypotheses. Two assumptions were involved when justifying the use of the t-distribution: the populations sampled were normal and the population variances were homogeneous (Glass & Stanley, 1970). According to Hays (1963), both these assumptions can be violated with small effect if the sample size is adequate and both groups being tested have the same number of observations. In this analysis using a dependent-t, the sample sizes were of necessity equal and a sample of 130 would be considered large. No testing of the two assumptions was deemed necessary.

The major hypothesis of interest was to examine changes in total direct household energy consumption. Since two different conversion factors have been frequently used in calculating Btu's of electricity, both have been presented and tested statistically to clarify the effect of the different methods of measurements. Results taking into account weather adjustment were reported, but not tested statistically. The hypotheses related to specific energy sources were examined to clarify where changes in consumption had occurred. In each case the alternate hypothesis was that the Btu's consumed during 1975-76 would be less than those consumed during 1973-74.

Hypotheses 1.1 and 1.2

$H_0$1.1 There is no difference between the means of the Btu's of direct household energy consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

$H_0$1.2 There is no difference between the means of Btu's of direct household energy consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76 when adjusting for conversion and transmission of electricity.

Findings.--Both hypotheses were rejected. There was a statistically significant difference between the means of Btu's consumed within households for the two years considered with or without the adjustment for transmission and conversion of electricity. The means were lower during 1975-76 than during the 1973-74 with probability levels of .000. The overall percentage reduction was 6.3 percent, but when considering electrical transmission and conversion, the overall percentage decrease was reduced to 4.2 percent. These results have been summarized in Table 10.

Discussion.--Empirical evidence from these data supported the idea that households have begun reducing consumption. These measures of reduction in consumption were considered of greater significance when weather factors were evaluated. The winter of 1975-76 included 1.8 percent more heating degree days. Space heating was found to represent a mean of 80 percent of the direct household energy for a subset of this sample. If weather had been the only variable between years, an estimated increase of approximately 1.4 percent in Btu's could have been expected. Thus the overall percentage reduction in consumption of 6.3 percent during a winter that was slightly colder than the previous winter strengthened the observation of a movement towards conservation. These findings for 1975-76 were consistent with

TABLE 10.--T-test of Difference Between Annual Means of Millions of Btu's for Total Direct Household Energy, 1973-74, 1975-76. (N = 130.)

Category	Btu × 10^6 1973-74	1975-76	Difference (1976-1974)	t-Value	df	p
Household Total, All Sources						
Mean[a]	207.83	194.82	-13.01[c]	-5.62[c]	129	.000
Standard deviation	68.55	65.55	26.42			
Standard error	6.01	5.75	2.32			
Household Total, All Sources, Electricity Adjusted[b]						
Mean	275.47	263.90	-11.56[d]	-4.00[d]	129	.000
Standard deviation	84.57	82.34	32.96			
Standard error	7.42	7.22	2.89			

[a]Electrical conversion factor 3,412 Btu.
[b]Electrical conversion factor 10,912 Btu.
[c]Overall 6.3% reduction.
[d]Overall 4.2% reduction.

those found by the Washington Center for Metropolitan Studies for 1974-75 (Grier, 1976, Williams et al., 1976).

Hypotheses 1.3, 1.4, and 1.5

$H_0$1.3 There is no difference between the means of the Btu's of natural gas consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

$H_0$1.4 There is no difference between the means of the Btu's of fuel oil consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

$H_0$1.5 There is no difference between the means of the Btu's of electricity consumed within dwelling units during 1973-74 and the Btu's consumed within the same dwelling units during 1975-76.

Findings.--Two of the null hypotheses were rejected with probability levels of <.002. The means for natural gas and fuel oil were significantly lower for 1975-76 than for 1973-74. An overall percentage reduction of 6.6 percent was noted for natural gas and 11.1 percent for fuel oil.

The null hypothesis related to electricity was not rejected. There was an overall increase from 1973-74 to 1975-76, but this was not statistically significant. The results of these analyses have been summarized in Table 11.

Discussion.--The reductions in natural gas and fuel oil can be interpreted as reduction of fuel used in space heating since that was the primary end use

TABLE 11.--T-test for Difference Between Annual Means of Millions of Btu's for Natural Gas, Fuel Oil and Electricity, 1973-74, 1975-76.

Energy Source	1973-74	1975-76	Difference (1976-1974)	t-Value	df	p
Natural Gas (N = 94)						
Mean	180.34	168.50	-11.84[b]	-5.05	93	.000
Standard deviation	68.48	65.65	22.74			
Standard error	7.06	6.77	2.35			
Fuel Oil (N = 38)						
Mean	159.61	142.05	-17.56[c]	-3.32	37	.002
Standard deviation	60.06	55.69	32.58			
Standard error	9.74	9.03	5.29			
Electricity[a] (N = 130)						
Mean	30.77	31.45	.68[d]	1.08	129	.28
Standard deviation	14.83	15.78	7.17			
Standard error	1.30	1.38	.63			
Electricity Adjusted (N = 130)						
Mean	98.41	100.54	2.13[d]	1.06	129	.29
Standard deviation	47.41	50.45	22.92			
Standard error	4.16	4.42	2.01			

[a]Includes two households heating electrically.
[b]Overall % change - 6.6%.
[c]Overall % change -11.1%.
[d]Overall % change 2.2%

for both fuels. Evidence for this speculation was apparent when compared with electricity where no overall decrease occurred. In this sample only two houses were heated electrically, providing an empirical basis for comparison between space heating end use, and end uses other than space heating. These findings were also consistent with the national survey reported by Grier (1976) and Williams et al. (1976).

The percentage reduction was greater for fuel oil than for natural gas. When interpreting this result, two factors need to be considered. First, the measurement of the annual fuel oil usage was not as precise as the natural gas. Fuel oil was delivered at irregular intervals; this required the implementation of some estimation procedures which are presented in Appendix A. Second, fuel oil was used to provide space heating only, except in two households. Natural gas totals often contained energy used by the hot water heater, stove, and dryer. Before concluding that fuel oil users conserved more, households which use different fuels for space heating should be compared on the total amounts of energy consumed within the household and not with these subtotals only.

Impact of Household Microdecisions Upon Levels of Energy Consumption

The second major objective of this research was to examine the impact of conservation measures or practices upon levels of consumption. Stepwise multiple regression was judged to be an appropriate analysis mode to test the hypothesis. The significance tests associated with multiple regression were based on the following assumptions: sample selection was random; each array of the dependent variable for a given combination of independent variables followed the normal distribution; there was a linear relationship between independent and dependent variables; there was homogeneity of variance of the arrays of the dependent variable (Nie et al., 1970; Blalock, 1972; Kerlinger, 1973).

The assumptions of random selection and normality of the distributions can be violated without serious consequences. In addition, this sample was randomly selected and the size was large enough not to be concerned with the assumption of normality.

However, violation of the assumption of homogeneity of variances is important and was tested through the examination of residuals.[1] The cases were ordered

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[1]Residuals are the difference between the actual and estimated value of the dependent variable for each case.

by level of consumption 1974 and a scattergram of the residuals for the regression equation was plotted. No pattern emerged. This suggested independence of errors and no violation of homogeneity of variance.

A violation of the assumption of linearity would mean some relevant information might have been obscured if a nonlinear relationship existed between an independent variable and the dependent variable. Tests for nonlinearity were made. No significant nonlinear relationships were elicited.

Hypotheses 2.1-2.9

$H_0 2$: Given the level of Btu's consumed within the household 1973-74, there is no linear relationship between the Btu's consumed within the household 1975-76, and the selected independent variables related to structural and behavioral changes 1974-76.

The alternate hypothesis or the hypothesis of interest has been stated below with the expected direction of the relationship indicated following the variables.

Hypothesis 2: Given the total Btu's of direct energy consumed within households 1973-74, there is a linear relationship between the level of Btu's 1975-76 and the following independent variables:

2.1 Installation of new furnace: There is a negative relationship between installation of a new furnace 1974-76 and the level of consumption 1976.

2.2 Installation of air conditioning: The greater the number of rooms air conditioned 1974-76, the greater the level of consumption 1976.

2.3 Addition of energy consuming appliances: The greater the level of Btu's consumed by appliances added 1974-76, the greater the level of consumption 1976.

2.4 Number of persons: There is a positive relationship between change in family size 1974-76 and level of consumption 1976.

2.5 Loss of job or retirement: There is a positive relationship between change in employment status which increased the likelihood of time spent at home 1974-76 and the level of energy consumption 1976.

2.6 Installation of insulation in ceiling: There is a negative relationship between installation of insulation in the ceiling 1974-76 and level of consumption 1976.

2.7 Installation of insulation in walls: There is a negative relationship between installation of insulation in the walls 1974-76 and the level of consumption 1976.

2.8 Changed thermostat setting on hot water heater: There is a negative relationship between having lowered the thermostat setting for the hot water heater 1974-76 and level of energy consumption 1976.

2.9 Intensity of conservation behavior: The greater the level of reported increase in household energy conservation behaviors 1974-76, the lower the level of consumption 1976.

Findings.--The overall F-test was computed and found to be 218.68 which has a probability of .000. With this level of probability the null hypothesis was rejected and it was concluded there was a significant linear relationship between dependent and independent variables.

These results have been presented in two steps. First, the forward regression procedure forcing all variables into the equation has been reported to give an understanding of the relationships of all the variables in the proposed model, but <u>not</u> to test the hypotheses (Table 12). By comparing the results in Table 13 with the overall model, the stepwise regression process was clarified.

Previous level of consumption 1973-74 was forced into the regression on step one. This was included as a baseline measure from which change could occur and was

TABLE 12.--Regression Analysis--Forward Inclusion Method: Standard Errors, Regression Coefficient, T-Values, Probability of Sampling Error, and Multiple Correlation of Independent Variables on Millions of Btu's Consumed, 1975-76.

Independent Variables	Std. Error	Std. Beta	T-Value	Probability of Sampling Error
BTU 74	.32	.94	28.4	.00
CONBEH	.51	-.11	-3.16	.002
STRUC	9.03	-.09	-2.85	.005
INSULC	7.49	-.04	-1.1	.270
JOBLOSS	6.50	.03	1.00	.315
HOTWATER	5.98	.03	.95	.341
APPLNDX	.74	.01	.33	.738
INSULW	7.98	.01	.28	.780
FAMSIZE	2.87	.007	.21	.832
AIRCON	5.87	.005	.16	.875

Overall F = 85.02 df regression = 10
Multiple R = .94 df residual = 119
R square = .88

TABLE 13.--Stepwise Regression Analysis: Regression Coefficients, Standard Errors, T-Values, Probability of Sampling Error, and Multiple Correlations of Independent Variables on Btu's Consumed, 1975-76.

Independent Variables[a]	Btu's Consumed, 1975-76				
	Raw Beta	Std. Error	Std. Beta	T-Value	Probability of Sampling Error
BTU 74--Btu's consumed 1973-74	.90	.31	.94	29.12	.000
STRUC--New furnace added 1974-76	-27.51	8.72	-.10	-3.16	.002
CONBEH--Intensity of conservation 1974-76	-1.44	.48	-.09	-2.99	.003
INSULC--Insulation in ceiling 1974-76	-7.19	6.03	-.04	-1.19	.235
Overall F: 218.68					.000
Multiple R: .94	R Square: .87		df regression: 4 df residual: 125		

Variables not in the equation: JOBLOSS, FAMSIZE, APPLNDX, INSULW, AIRCON, HOTWATER.

[a]Minimum univariate F to enter equation 1.32, 1,128 df; F to leave equation 1.0.

not the primary observation of interest. The strong correlation (r = .92) between consumption 1973-74 and 1975-76 was apparent with the very large t-value of 29.1 which was significant at the .000 level. In terms of prediction, the one best indicator of consumption was the previous level of consumption.

The primary interest of this research was not to predict but to assess the relative contribution of other selected variables on the level of consumption 1975-76. These independent variables were permitted to enter the equation only if they met certain statistical criteria. The order of inclusion was determined by the respective contribution of each variable to the explained variance. The minimum criterion for a variable to enter the equation was set at an F of 1.32 which is the F-value at the 75th percentile point of the F-distribution with 1,128 degrees of freedom.

By comparing the overall model (Table 12) with the stepwise regression (Table 13), the relative strength of the independent variables was apparent through observation of the univariate levels of significance.[1] Three variables in addition to

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[1]The t-value for the univariate tests is often reported since the degrees of freedom are 1,N-2; $t = \sqrt{f}$ and the direction of the result is clear from the t-value.

consumption level were found to meet the minimum statistical requirements for inclusion in the model: new furnace added ($t = -3.16$; $p = .002$); increased intensity of conservation behaviors ($t = -2.99$; $p = .003$); and insulation in the ceiling ($t = -1.19$; $p = .235$). No other changes in household structure or behavior, given the four previously entered variables, contributed significantly to the overall model.

Discussion.--There were only eight households which added new furnaces, but this was very significant in the model. Two speculations have been suggested: the new furnace was no doubt highly efficient; probably those households getting new furnaces had very old and inefficient ones, making a pronounced comparison between the two. The significance of this variable clearly indicated the importance of energy efficient technology.

The second variable which was included in the model was not limited to a few households, but was distributed across households. This variable, increased intensity of conservation, was not correlated with previous level of consumption ($r= -.08$) suggesting that conservation behaviors were reported or not reported across all levels of previous consumption. This behavior change variable was developed to represent an overall household conservation behavior pattern;

although most of the items were heat related, others not heat related were included.

Elements included in the scale building seemed relevant for interpreting the results. The greater the number of people and the greater the intensity of the practice, the higher the level on the conservation scale. From these findings it can now be added--the greater the increased intensity in conservation behaviors, the greater the reduction of energy.

Overall reduction was 6.3 percent; therefore, it cannot be assumed from these findings that the behavior change produced phenomenal results. It can be concluded that what change did occur was significantly impacted upon by increased intensity of conservation behavior. It was also noted that this finding reflected behavior change which was not tied to technology. At least for this sample, microdecisions as a whole did make some significant impact on consumption.

The third variable that entered the model was less significant. The effect of insulating the house has been well documented; it was therefore surprising that the insulation variable did not demonstrate a stronger level of significance. Several factors may have reduced its effectiveness here; it is only one measure of a reported behavior and the effect of error in reporting could be great. No information was elicited as to the amount of the insulation added or the date of installation.

Two other conservation variables were not significant enough to be included in the regression equation--installation of insulation in the walls or reduction of the temperature setting for the hot water heater. The reasons for this may be similar to those cited for insulation in the ceiling.

The hot water heater has been evaluated as 15 percent of the total household energy, the second largest single end use within the household; this figure includes the energy used by electric water heaters with adjustment for conversion and transmission of electricity included. When evaluating the contribution of the hot water heater to the total energy consumed within a dwelling unit only, the percentage is reduced to within the range of five percent. Viewed in this manner, reduction of the temperature of the hot water becomes one small microdecision within the context of total household consumption and would need more detailed analysis to demonstrate its effect.

In the process of analyzing these data it was thought that the structural conservation measures would be powerful enough by themselves to make a significant difference. This was not supported by this analysis.

The development of a summary index of permanent conservation measures might demonstrate more impact.

Although not a part of the overall plan for this research, two additional statistical procedures were carried out. The results helped clarify the meaning of the data analyses. The first analyzed the same regression procedure as described previously, using as the dependent variable the Btu's with adjustment for transmission and conversion of electricity. The second compared the effect of the behavioral and structural change variables on changes in Btu's, omitting the previous level of consumption.

Stepwise regression was performed including the adjustment factor for electrical conversion and transmission in the consumption variables. The analyses were compared; the results were nearly the same for the model using electricity adjusted as those using electricity unadjusted. The regression table is included in Appendix C.

For both models the same three variables were entered first--Btu's 1973-74, new furnace, and increased conservation. In the unadjusted model where electricity was unweighted and heat appeared more important, the conservation behavior of insulating the ceiling met the minimum criteria for inclusion in the model. In contrast, in the model where electricity was more heavily weighted, the change in the number of people in the household met the minimum requirements for inclusion in the model. This was consistent with the idea that the number of people affects electrical use more than heat use. In both analyses the increased intensity of conservation behavior was significant. This observation helped confirm the speculation that the measure was an overall assessment of conservation rather than solely a reduction in space heating energy.

When using the change in Btu's from 1973-74 to 1975-76 as the dependent variable and excluding the previous level of consumption as an independent variable, the same three household changes were significant and had comparable levels of probability. However, the entire set of structural and behavioral changes explained 18 percent of the variance when the previous level of consumption was not included and only three percent when it was included. This demonstrated the moderate negative correlation ($r = -.30$) between change in Btu's and previous level of consumption; the more energy that a household had used, the more it had reduced consumption. It was also noted that the more energy a household had consumed, the more latitude it had to reduce.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Overview of the Study

The development of this research was based upon the assumption that decision making is the main adaptive feature of human systems and that the family is one critical societal unit where this process occurs. This study examined one area about which families make decisions: the direct consumption of fossil fuels within the household.

It has become increasingly apparent that fossil fuels are finite and may become short in supply and more expensive within this century. The family has become dependent upon fossil fuels to provide energy for heating, cooling, lighting and work. It is within the context of the household that many decisions are made to consume or conserve energy. These observations give support to the perspective that energy conservation is an important and urgent management strategy for households.

Decision making is a complex process of perceiving, selecting and implementing a variety of responses under widely ranging circumstances. This research examined one aspect of the decision making process in the context of energy conservation: the reported implementation of family conservation measures and their impact upon direct household energy consumption. It was hypothesized that the relationships observed between longitudinal patterns of energy consumption and reported household conservation measures could provide insights into the potential contribution of voluntary conservation as one means of reducing overall energy consumption.

Energy consumption data from utility and oil companies and conservation measures reported by household members were the basis for the evaluation. The household was the unit of analysis. The data used were a part of an ongoing interdisciplinary study, The Family Energy Project,[1] conducted within the College of Human Ecology, Michigan State University. From the total area probability sample of 263 households, 130 were selected for this research. The self-report measures were taken from the 1976 survey; the energy consumption data were for the years 1973-74 and 1975-76.

The major objectives were to determine if households had reduced levels of energy consumption and if reported conservation measures had contributed significantly to levels of energy use. Careful attempts were

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[1]Michigan Agricultural Experiment Station Project 3152.

made to control for what might be alternate explanations that could have affected household energy patterns. The effects of the dwelling structure on total household energy were controlled for by including only those families living in the same residence for the years studied. Weather variations, although considered constant across the sample, were examined for their impact over time. Family change in size, loss of job, addition of major appliances, and replacement of furnace were used as variables to control for their effect on changes in consumption.

The conservation measures which were evaluated for their impact included installation of insulation in ceiling or walls, lowered thermostat setting on hot water heater and an overall scale measuring increased intensity of household conservation behaviors.

Conclusions

Did households reduce their consumption of direct energy since the year of the Arab Oil Embargo? Did the conservation measures reported by households contribute significantly to reduced levels of consumption? Several conclusions can be drawn from the analyses.

Levels of Energy Consumption, 1973-74, 1975-76

An overall reduction of 6.3 percent in direct household energy consumption was found between the years 1973-74 and 1975-76. When adjusting for electrical conversion and transmission, the reduction was 4.2 percent. These results were statistically significant at the .000 probability level. When examining consumption by specific energy sources, it was apparent the decreases had occurred in fuel oil and natural gas. A 2.2 percent increase in electricity was noted but this was not statistically significant. The reductions in natural gas and fuel oil can be interpreted for this sample as reductions in space heating since this was the largest single end use for these sources.

Statistical significance is a minimum criterion in social science research, but another question must also be addressed: were the results meaningful? The average decrease was 13 million Btu's. In order to achieve this average, 31.5 percent of the households had lowered their consumption 10 percent or more; one-tenth of the sample had reduced energy use by at least 20 percent. These results seemed very meaningful.

The direction of lowering consumption in a slightly colder winter strengthened the suggestion of a movement towards conservation. This was a higher income sample which consumed greater than average amounts of energy. It can be concluded that some household conservation has occurred at these levels.

Impact of Conservation Measures

The second major objective of this research was to evaluate the impact of conservation measures reported by households since the time of the Arab Oil Embargo, 1973-74. Fifteen percent of the households reported installation of insulation or storm windows. Fifteen percent reported lowering the thermostat on the hot water heater.

Questions were asked concerning nine conservation behaviors. Moderate levels of increased adoption were reported for these seasonal or daily repetitive behaviors. When considering the impact of a repetitive behavior, two factors were thought to be of significance: the extent to which the behavior was practiced and the number of people within the household who reported its adoption. For each item a family score was developed which reflected the number of adult heads of household practicing the behavior all or most of the time.

When considering the report of both adults for all the practices, two items were reported by more than 80 percent of the households: caulking, sealing windows with plastic or storm windows, and turning out lights when not in use. For all other practices the range of adoption reported by both adults was from 25 percent to 63 percent. This suggested that there were areas where substantial behavior change could be realized. Two behaviors which represented the greatest potential reductions were related to space heating: 59 percent reported keeping the daytime temperatures at 68 degrees or less, and 39 percent, the nighttime temperature at 60 degrees or less.

The collective impact of these behaviors on levels of consumption was hypothesized as a major variable in this research. A family scale was developed to reflect the composite effects of increased intensity of household behaviors, using the conservation items from the self-administered questionnaire.

Through stepwise regression, the reported behavioral and structural changes that occurred within the households between June, 1974, and June, 1976, were analyzed for their impact on the level of consumption in 1976. The specific conservation measures that were included were installation of insulation in the walls or ceiling, lowering the thermostat setting on the hot water heater, and increased intensity of conservation behaviors. Other household changes which were not specifically conservation measures but thought to affect consumption were included as variables:changes in family size, addition of appliances and replacement of furnace. Consumption during 1973-74 was used as the baseline from which change was evaluated. Two variables were clearly statistically significant: the installation of a new furnace ($p = .002$) and the increased intensity of conservation behaviors ($p = .003$). Installation of insulation in the ceiling was the next variable to enter the equation, but the probability level was .235. All three change variables--installation of new furnace, increased intensity of conservation behaviors and installation of insulation in the ceiling--were negatively related to levels of consumption, which can be interpreted as changes which were significant in the reduction of consumption.

When using the consumption variables with electricity adjusted for conversion and transmission, the results were very similar except for a variable which was marginally significant. In the model in which electricity was weighted more heavily, the change in family size was included; in the analysis in which heat was the predominant end use, insulation in ceiling was more important. Although these variables were not highly significant, they did suggest that the impact of family size is greater on the level of electrical consumption than upon space heating.

Previous level of consumption was the best predictor of consumption at the later point in time (r = .92). However, energy use during 1973-74 and change in Btu's for the two years under study had a moderate negative correlation (r = -.30). This provided empirical evidence that conservation occurred somewhat more at higher levels of consumption than at lower levels. Intensity of conservation behavior was not correlated with previous consumption (r =-.08). This indicated that reported behavioral change was not related to previous energy use.

The only structural change that contributed significantly towards lowered consumption was the installation of a new furnace. In the designing of the research problem this was not included as a conservation measure, but was entered into the model as an alternate explanation of reduction in consumption. Its significant relationship clearly demonstrated the importance of energy-efficient technology. The permanent structural conservation measures of insulation and reduced thermostat settings of water heaters were entered individually into the regression model assuming that each could have significant impact. The data analysis did not support this and it was concluded that a summary measure of structural change should be considered in further research.

Implications

It can be said of many problems, however complicated, that when they are looked at intensively they become increasingly more complicated. This is especially true of the energy problem which is inextricably tied to economic, environmental and social issues. From the myriad of possible implications for the family and energy policy, a few basic ideas were selected for discussion.

Energy Policy and Educational Implications

The voluntary nature of conservation has been discussed extensively. People in general have reported that they do not want forced conservation (Olsen, 1976; Zuiches, 1976). Seventy-seven percent of this sample was against conservation through government imposed controls. But will voluntary conservation work?

> We often hear that Americans need to be compelled to change their habits, that patterns of waste are too deeply ingrained to expect much voluntary change; if this is so, then we may expect that pricing, taxes, and other forms of disincentive are necessary to implement conservation. I believe the potential for voluntary change is largely unexplored and may be underestimated, e.g., water conservation in California (Unseld, 1977, p. 4).

Voluntary conservation is a relative concept and not an either-or situation. It seems reasonable to assume that with the increasing shortage of fossil fuels, prices will rise. The relevant question then becomes, given the context of rising prices, will people conserve voluntarily? The analysis of these data has suggested that a substantial percentage of people have already begun to do so.

In view of the urgency of the energy problem it must be assessed whether the reduction that occurred was enough. Population increases, formation of new households and rising expectations of lower level energy users can be expected to increase levels of consumption. When considering such factors, based on a national sample for the years 1972-73, 1974-75, what appeared to be a decrease was actually an aggregate increase in household consumption (Grier, 1976). Given this information, the reductions demonstrated by this research sample and the national sample would not be enough.

If estimates are accurate that reductions of one-third to one-half can be made without seriously affecting lifestyles, much more reduction can be realized by households (Downs, 1976; Hayes, 1976). Harrje (1976) has set a goal of 50 percent reduction in household energy. If reductions of this magnitude are necessary, what insights could be gained from this research for their implementation?

The largest reductions were in the area of space heating. This can be interpreted several ways. In addition to the impact of increased prices, it can be argued that households changed what was easiest and this had minimal effect on lifestyle (Milstein, 1976). Also, a major emphasis after the Oil Embargo via the media had been to reduce fuel for space heating and lower the thermostats to 68 degrees. Therefore, it can also be maintained that households responded to what had been emphasized. If one accepts this interpretation, clarification of further dimensions to the public looks hopeful.

Space heating does offer the greatest potential savings and additional ways of conserving space heating energy need to be identifed and disseminated (Harrje, 1976; Pilati, 1976). However, the emphasis upon space heating only is too narrow. Electricity represents another major target area for conservation, especially when understanding the amount of primary fuel used to generate the electricity. This study has dealt with direct energy used within the house, but limiting the emphasis to direct energy only may be insufficient and even counterproductive. The generalization to be understood by the public is basic: we are dealing with a finite supply of fossil fuels; the direct and indirect uses of these fuels must become apparent to households as well as to other users if energy conservation is to enter into decision making at all levels (Bullard & Herendeen, 1975; Hannon, 1973, 1975).

In various experimental studies information has been found to be ineffective in reducing consumption. It is not assumed that information alone would bring about the behavior change, but it is maintained that broadening the information base could help reduce the alienation that rising prices may bring. Economic values force people to make certain choices; ecological understanding would give people a basis for making and accepting those choices.

A broadened understanding of energy issues would help clarify that households' limited choices are inextricably tied to institutional decision making. This information is basic if households are to impact on public policy.

Although the role of the individual household has been emphasized throughout this research, the contribution of the household is clearly limited, but can be a significant part of the overall situation. In Sweden the success of the lower energy-intensive lifestyle without a reduced quality of life has been attributed not only to the cooperation of the individual households (persons), but also to government and institutional planning (Schippper and Lichtenbert, 1976). The task of additional behavior change is not to be understated.

Increasing prices, information, exhortation, feedback and incentives, as well as legislative and institutional support, have all been identified to varying degrees as elements to bring about reduced consumption. The most difficult and least researched dimension of the problem may have been identified by Leik & Kolman (1977): getting people to do more conserving now.

Implications for Family Theory

The increased intensity of conservation behavior within households was a significant variable in the regression equation ($p = .003$). The amount of change that this variable represented was not of great magnitude, but it was one of two change variables that were significant in explaining reduced levels of consumption. The importance of energy-efficient technology was demonstrated clearly. But the role of the behavior of household members was equally significant, i.e., the accumulation of many microdecisions was important in overall reduction of consumption.

While this seems like a truism needing no support, the role of the individual family in society has been increasingly de-emphasized; nearly one-half of the research sample reported that the amount of energy all American families could save is unimportant compared to the amount of energy that government and industry could save. Although this research focused upon decisions related to energy consumption, the theoretical position was that decision making is the main adaptive feature of human systems. This study supported the perspective that a family's microdecisions may have a small, but significant impact upon a complex process like energy consumption.

Implications for Further Research

Time series analysis was recommended as an optimal method for analyzing these data. This was deemed too costly and extensive for an individual research project, but appropriate for a research team analysis. This procedure would be more sensitive to seasonal and monthly variations such as weather, holidays and vacations. This analysis could clarify the effect of conservation measures such as insulation and other retrofitting. The environmental influences such as price increases and political/historical events could be assessed with greater precision.

From this research it has been established that some households have reduced consumption through structural as well as behavioral changes, but are there demographic correlates that "explain" these behavior changes? Discriminant analysis would be one appropriate strategy.

Households in this sample have demonstrated reduction in consumption. Continued monitoring of total direct household energy over time as well as for more broadly based samples seems imperative. Other dimensions of household energy use such as transportation need to be examined as well.

Microdecisions were found to contribute significantly to change in consumption. Technological analyses about additional microdecisions that can be implemented by families to reduce consumption would assist households. Evaluation of the methods for disseminating the information is equally important.

Observational studies or detailed self-reported documentation of energy use and behavior patterns within the household could be insightful. These studies could assist in helping families recognize areas for behavioral change and bring about immediate as well as future reduction in consumption. One hypothesized long-term impact would be the socialization of children and youth towards a more conserving lifestyle.

This study has focused upon direct household energy consumption. Less is known about the impact of microdecisions upon dimensions such as transportation and indirect household uses of energy. Models similar to the one tested here could be applied to these areas.

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APPENDICES

APPENDIX A

CONSUMPTION VARIABLES

APPENDIX A

CONSUMPTION VARIABLES

Fuel Oil Calculations

Fuel oil was delivered at irregular intervals; it was necessary to determine the amounts of fuel oil that were used during the years under study and not to include amounts from the preceding or succeeding heating seasons. The heating season was determined to be from September 1 through May 31; that period included 96 percent of the heating degree days for this section of Michigan. To determine what amounts were used during 1973-74 and 1975-76, the following decision rules were implemented:

If the first oil fill-up in the fall of 1973 was preceded by a fill-up in the summer, the fall fill-up was the usage from September 1 until the date of the fill-up.

If the first fill-up of the fall occurred without a preceding summer fill-up, the amount used between September 1 and the first recorded fill-up was calculated on a unit-per-degree-day measure derived in the following manner:

F_1 = Gallons of fuel oil for first fill-up, Fall 1973

F_2 = Gallons of fuel oil for second fill-up, Fall 1973

DD_1 = Number of degree days from 9/1/73 to date of first fill-up (F_1)

DD_2 = Number of degree days between first fill-up and second fill-up, Fall 1973

PDD = Fuel used per degree day for second period $PDD = F_2/DD_2$

F_1 = $PDD \times DD_1$ Calculated fuel usage for September 1 until date of first fill-up

F_1 was then considered fill 1 and put into the date of the first fill-up.

For each succeeding period from one fill to the next, the fuel oil was distributed on a fuel-per-degree-day basis by the number of degree days between the fill-up dates, excluding the months of June, July and August. Heating degree days were recorded for those months but including these heating degree days made the estimate per degree day unstable; it seemed probable that people did not heat their houses even though heating degrees were recorded occasionally.

If the first fill-up in the spring of 1976 was followed by a fill-up in the summer, that fill was considered the usage from the last spring fill-up to May 31, 1976.

If there was not a summer fill-up recorded, a fuel estimate was calculated on a degree day usage in the following manner:

F_f = Gallons of fuel oil for final fill-up, spring 1976

E_{f-1} = Gallons of fuel oil for next to the last fill-up, spring 1976

DD_{f-1} = Number of degree days from date of F_{f-1} to F_f

DD_f = Number of degree days from F_f to 5/31/76

PDD_{f-1} = Fuel oil per degree day calculated for next to last period

$$F_{5/31/76} = PDD_{f-1} \times DD_f$$

This was considered the final fill-up and put into the date of May 31, 1976.

The one household using liquid propane was treated in the same manner. The fuel oil and liquid propane were converted to Btu's.

Natural Gas and Electricity Calculations

Consumers' Power of Lansing, Michigan, and the Board of Water and Light, Lansing, Michigan, were the utility companies which provided the monthly natural gas and electricity data for the respondent households, from July 1973 through June 1976. These data were converted to Btu's.

The data were collected at different points in time and inadvertently the month of July 1973 or June 1974 was missing for some respondents; also, some families moved into the houses between July 1, 1973, and November 1, 1973; this missing data equaled less than 2 percent of the monthly data. The missing data were estimated by using the following proportion:

$$\frac{M1_t}{M1_{t+1}} = \frac{M2_t + M3_t}{M2_{t+1} + M3_{t+1}}$$

where

t = year data were missing

$t+1$ = year following t

$M1_t$ = the missing data month

M2, M3 = the two months immediately following missing data.

APPENDIX B

STRUCTURAL AND BEHAVIORAL

VARIABLES

APPENDIX B

STRUCTURAL AND BEHAVIORAL VARIABLES

Questionnaire Items

STRUC: Have you replaced your furnace in the past two years?

If respondent answered YES, STRUC = 1.

AIRCON: Have you added room or central air conditioning in the past two years?

If respondent answered YES, AIRCON = number of rooms air conditioned.

APPLNDX: Have you added any of the following appliances in the last two years?

If respondent answered YES, the household was assigned the annual estimated usage of Btu's for each appliance added between June 1974 and June 1976. The values were summed to form an appliance index.[1]

Appliance	Btu's × 10^6 /Year
Electric stove	4
Gas stove	10
Dishwasher	1
Television--black and white	1
Television--color	2
Electric clothes dryer	3
Gas clothes dryer	7
Refrigerator--self defrost	7
Refrigerator--no defrost	6
Freezer--self defrost	6
Freezer--no defrost	4

[1]Not adjusted for electrical conversion and transmission. To estimate for conversion and transmission, multiply values for electrical appliances by 3.2.

FAMSIZE: (A) For households resurveyed in 1976 (n = 79):

FAMSIZE = the number of persons in the household during 1976 minus the number in the household 1974.

(B) For those households newly surveyed in 1976 (n = 51):

If a child was born between June 30, 1974, and June 30, 1976, FAMSIZE = 1.

If a divorce or death of spouse occurred between July 1, 1974, and December 31, 1975, or if the household respondent answered YES to any of the following questions:

Has your family experienced the following events during the past year? (1) Marriage of son or daughter; (2) Son or daughter leaving home (other than marriage). FAMSIZE = -1.

No household had both a gain and a loss of members.

All others: FAMSIZE = 0.

JOBLOSS: If an adult head of household retired or lost a job between June 30, 1974, and December 31, 1975, JOBLOSS = 1.

INSULC: Have you installed insulation in the ceiling in the past 2 years?

If respondent answered YES, INSULC = 1. If NO, INSULC = 0.

INSULW: Have you installed insulation in the walls in the past 2 years?

If the respondent answered YES, INSULW = 1. If NO, INSULW = 0.

HOTWATER: Have you ever lowered the setting on the dial of the hot water heater?

If the respondent answered YES, when did you do this? If within the past 2 years, HOTWATER = 1. All others, HOTWATER = 0.

CONBEH: The following questions were asked of both male and female heads of household.

For each head of household for each question:

If the respondent checked YES, INCREASED, and checked ALL or MOST OF THE TIME, the conservation practice = 1. All other combinations = 0.

For each question a family score (FINC) was formed: FINC = value for the male head plus value for female head.

	All the time	Most of the time	Once in a while	Never but would try	HAVE YOU INCREASED THIS PRACTICE IN THE LAST TWO YEARS? YES	NO
Cover or seal windows and doors with storm windows or plastic	___	___	___	___	___	___
Turn down thermostat while sleeping to 60° or less in the winter	___	___	___	___	___	___
Maintain daytime temperature at 68° or less in the winter	___	___	___	___	___	___
Have heating equipment cleaned and serviced	___	___	___	___	___	___
Turn off lights not in use	___	___	___	___	___	___
Dry clothes on clothesline rather than in dryer	___	___	___	___	___	___
Do not heat some rooms in winter	___	___	___	___	___	___
Limit amount of hot water for bathing, dishwashing and washing clothes	___	___	___	___	___	___
Cook several dishes in oven at one time	___	___	___	___	___	___

FREQUENCIES

STRUC NEW FURNACE 74-76

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	122	93.8
	1.	8	6.2
	TOTAL	130	100.0

AIRCON ADDED AIR CONDITIONING 74-76

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	85	65.4
	1.	45	34.6
	TOTAL	130	100.0

APPLNDX INDEX APPLIANCES ADDED 74-76

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	89	68.5
	1.	6	4.6
	2.	4	3.1
	3.	3	2.3
	4.	7	5.4
	5.	1	.8
	6.	7	5.4
	7.	4	3.1
	8.	2	1.5
	9.	1	.8
	10.	6	4.6
	TOTAL	130	100.0

FAMSIZE CHANGE 74-76 NUMBER PEOPLE IN FAMILY

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	-3.	2	1.5
	-2.	4	3.1
	-1.	20	15.4
	0	90	69.2
	1.	12	9.2
	2.	2	1.5
	TOTAL	130	100.0

FREQUENCIES

JOBLOSS DID H OR W LOSE JOB IN 74-75

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
NO	0	114	87.7
YES	1.	16	12.3
	TOTAL	130	100.0

INSULC INSULATION CEILING 74-76

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	111	85.4
	1.	19	14.6
	TOTAL	130	100.0

INSULW INSULATION WALLS 74-76

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	114	87.7
	1.	16	12.3
	TOTAL	130	100.0

HOTWATER

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	110	84.6
	1.	20	15.4
	TOTAL	130	100.0

CONBEH INCREASED INTENSITY CONSERVATION 74-76

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)
	0	11	8.5
	1.	6	4.6
	2.	11	8.5
	3.	9	6.9
	4.	14	10.8
	5.	10	7.7
	6.	14	10.8
	7.	5	3.8
	8.	7	5.4
	9.	6	4.6
	10.	10	7.7
	11.	9	6.9
	12.	5	3.8
	13.	5	3.8
	14.	4	3.1
	15.	2	1.5
	16.	1	.8
	17.	1	.8
	TOTAL	130	100.0

* * * * * * * * * * RELIABILITY ANALYSIS FOR SCALE (CONBEH) * * * * * * * * * *

1. FINC159
2. FINC160
3. FINC161
4. FINC162
5. FINC163
6. FINC164
7. FINC165
8. FINC166
9. FINC169

RELIABILITY COEFFICIENTS 9 ITEMS

ALPHA = .79302
STANDARDIZED ITEM ALPHA = .79004

		MEANS	STD DEV	CASES
1.	FINC159	.71538	.85576	130.0
2.	FINC160	.74615	.90993	130.0
3.	FINC161	1.04615	.87037	130.0
4.	FINC162	.52308	.74932	130.0
5.	FINC163	1.25385	.78069	130.0
6.	FINC164	.26923	.58121	130.0
7.	FINC165	.59231	.78450	130.0
8.	FINC166	.61538	.74067	130.0
9.	FINC169	.64615	.79593	130.0

CORRELATION MATRIX

	FINC159	FINC160	FINC161	FINC162	FINC163	FINC164	FINC165	FINC166	FINC169
FINC159	1.00000								
FINC160	.30877	1.00000							
FINC161	.25715	.54458	1.00000						
FINC162	.46366	.39930	.27173	1.00000					
FINC163	.43387	.17626	.27924	.31457	1.00000				
FINC164	.27934	.08044	.05187	.15472	.20698	1.00000			
FINC165	.42626	.21407	.15265	.20734	.33483	.19159	1.00000		
FINC166	.32739	.26242	.22015	.37927	.34443	.31444	.27503	1.00000	
FINC169	.36314	.34058	.26994	.42972	.45756	.09023	.33825	.45113	1.00000

N OF CASES = 130.0

STATISTICS FOR	MEAN	VARIANCE	STD DEV	N OF VARIABLES
SCALE	6.40769	18.47591	4.29836	9

ITEM-TOTAL STATISTICS

	SCALE MEAN IF ITEM DELETED	SCALE VARIANCE IF ITEM DELETED	CORRECTED ITEM-TOTAL CORRELATION	SQUARED MULTIPLE CORRELATION	ALPHA IF ITEM DELETED
FINC159	5.69231	13.99761	.59500	.40019	.75750
FINC160	5.66154	14.81479	.48199	.39489	.77287
FINC161	5.36154	14.91479	.41703	.33450	.78313
FINC162	5.88462	14.90354	.54009	.35737	.76521
FINC163	5.15385	14.75134	.51945	.33979	.76767
FINC164	6.13846	16.87990	.26345	.15717	.79659
FINC165	5.81538	15.23697	.42836	.24642	.78009
FINC166	5.79231	14.97203	.51559	.32267	.76855
FINC169	5.76154	14.41556	.56698	.39645	.76084

A VALUE OF 99.0 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED

APPENDIX C

CORRELATION MATRICES AND REGRESSION TABLES

VARIABLE	MEAN	STANDARD DEV	CASES
BTU76	194.8156	65.5457	130
BTU74	207.9308	69.5520	130
FAMSIZE	-.1395	.7145	130
APPLNOX	1.6231	2.9208	130
STRUC	.0615	.2412	130
AIRCON	.0385	.3610	130
INSULC	.1462	.3546	130
INSULW	.1231	.3299	130
HOTWATER	.1538	.3622	130
JOBLOSS	.1231	.3298	130
CONREH	6.4077	4.2384	130
TOTAD76	263.9009	82.3364	130
TOTAD74	275.4647	84.5532	130
BTUCG	-13.0151	26.4170	130

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	BTU76	BTU74	FAMSIZE	APPLNOX	STRUC	AIRCON
BTU74	.92335					
FAMSIZE	-.09813	-.09612				
APPLNOX	-.03486	-.02334	.06137			
STRUC	-.06374	.04899	.04781	.09819		
AIRCON	.00846	-.00054	-.06557	-.02291	-.02739	
INSULC	.11519	.18453	-.01084	.04611	.16589	-.04425
INSULW	.13289	.16751	-.05634	-.05608	.00150	-.04007
HOTWATER	.00095	-.03168	-.00663	.04058	-.10919	-.04561
JOBLOSS	-.05462	-.09418	.00680	-.03999	-.09593	.02505
CONREH	-.08020	.01852	.09771	.12471	.02047	-.01018
TOTAD76	.91474	.86036	-.08656	-.02817	-.04349	-.02563
TOTAD74	.94523	.93059	-.12692	-.02933	.03742	-.02489
BTUCG	.08511	-.30398	.00597	-.02595	-.28527	.02239

	INSULC	INSULW	HOTWATER	JOBLOSS	CONREH	TOTAD76
INSULW	.57410					
HOTWATER	-.11506	-.09485				
JOBLOSS	.04385	.07346	.03494			
CONREH	.02163	.07917	.15857	.07370		
TOTAD76	.13455	.14622	-.04854	-.07437	-.07007	
TOTAD74	.19087	.18910	-.06825	-.10013	.00407	.92235
BTUCG	-.19305	-.10496	.08456	.10887	-.24706	.03702

	TOTAD74
BTUCG	-.30779

* M U L T I P L E   R E G R E S S I O N *

DEPENDENT VARIABLE..   TOTAD76   TOTAL BTUS 76 ELECT ADJUSTED

VARIABLE(S) ENTERED ON STEP NUMBER 4.. FAMSIZE   CHANGE 74-76 NUMBER PEOPLE IN FAMILY

MULTIPLE R	.92942	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F	SIGNIFICANCE
R SQUARE	.86382	REGRESSION	4.	755435.72947	188858.93237	198.22993	.000
ADJUSTED R SQUARE	.85946	RESIDUAL	125.	119090.82930	952.72663		
STD DEVIATION	30.86627	COEFF OF VARIABILITY	11.7 PCT				

------------------- VARIABLES IN THE EQUATION -------------------

VARIABLE	B	STD ERROR B	T / SIGNIFICANCE	BETA / ELASTICITY
TOTAD74	.90647405	.32432672E-01	27.949410 / 0	.9310453 / .94619
STRUC	-26.898717	11.290066	-2.3825119 / .019	-.0788131 / -.00627
CONBEH	-1.4640072	.63544833	-2.3038976 / .023	-.0764283 / -.03555
FAMSIZE	4.7380563	3.7029335	1.2795423 / .203	.0428440 / -.00249
(CONSTANT)	25.891475	10.096307	2.5644590 / .012	

---------- VARIABLES NOT IN THE EQUATION ----------

VARIABLE	PARTIAL	TOLERANCE	F / SIGNIFICANCE
APPLNCX	.03564	.97429	.15773199 / .692
AIRCON	-.00691	.99391	.59233027E-02 / .939
INSULC	-.07824	.93801	.76373946 / .384
INSULW	-.05888	.95642	.43143758 / .513
HOTWATER	.05207	.95736	.33706596 / .563
JOBLOSS	.04565	.97561	.25891915 / .612

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE.. BTUCG CHANGE IN TOTAL BTU

MEAN RESPONSE -13.01513 STD. DEV. 26.41705

VARIABLE(S) ENTERED ON STEP NUMBER 1..

FAMSIZE	CHANGE 74-76 NUMBER PEOPLE IN FAMILY
HOTWATER	
JOBLOSS	DID H OR W LOSE JOB IN 74-75
APPLNDX	INDEX APPLIANCES ADDED 74-76
AIRCON	ADDED AIR CONDITIONING 74-76
INSULC	INSULATION CEILING 74-76
CONBEH	INCREASED INTENSITY CONSERVATION 74-76
STRUC	NEW FURNACE 74-76
INSULW	INSULATION WALLS 74-76

MULTIPLE R	.42548
R SQUARE	.18103
ADJUSTED R SQUARE	.11961
STD DEVIATION	24.78691

ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F	SIGNIFICANCE
REGRESSION	9.	16297.06477	1810.78497	2.94728	.003
RESIDUAL	120.	73726.92136	614.39101		
COEFF OF VARIABILITY	190.4 PCT				

------------------- VARIABLES IN THE EQUATION -------------------

VARIABLE	B	STD ERROR B	T / SIGNIFICANCE	BETA / ELASTICITY
FAMSIZE	1.4471386	2.9655840	.48797762 .626	.0407857 .01540
HOTWATER	5.8210053	6.2033749	.93836117 .350	.0798102 -.06981
JOBLOSS	8.7804962	6.6947910	1.3115415 .192	.1096177 -.08303
APPLNDX	.31357263	.76199083	.41151759 .681	.0346705 -.03910
AIRCON	.81806385	6.0808172	.13453199 .893	.0111779 -.00242
INSULC	-10.892675	7.7223313	-1.4105424 .161	-.1462251 .12232
CONBEH	-1.6487231	.52516121	-3.1394610 .002	-.2682665 .81171
STRUC	-26.390341	9.3619799	-2.8188847 .006	-.2410012 .12478
INSULW	.38377813	8.2493623	.46522157E-01 .963	.0047912 -.00363
(CONSTANT)	-1.5980870	4.2477209	-.37622221 .707	

------------------- VARIABLES NOT IN THE EQUATION -------------------

VARIABLE	PARTIAL	TOLERANCE	F / SIGNIFICANCE

ALL VARIABLES ARE IN THE EQUATION.