# UTILITY PAYMENT PLAN CHOICE: EFFECT ON HOUSEHOLD ELECTRIC CONSUMPTION AND COST

By

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CHAPTER I

# INTRODUCTION

## Statement of the Problem

America's anxieties about energy supplies have largely diminished in the past decade. Declining oil prices and stable gasoline prices created a false sense of security about the energy future. Apathy replaced desire for a strong, aggressive national energy policy.

The American voter prior to the 1988 election consistently identified drugs, the federal budget deficit, the economy, poverty, and the threat of war as the most important issues facing the country (American Petroleum Institute, 1988). However, energy, which plays a significant role in producing a healthy economy, was excluded (American Petroleum Institute, 1988). This attitude may change with continued political instability in the major oil producing regions (Sexton & Sexton, 1987). Yergin and Hillenbrand (1982) stated that the significance of energy to society radiates past the initial concerns about supply and demand.

> So pervasive is the importance of energy in modern life that the insecurity extends beyond concerns about the price and availability of energy to fundamental

> questions about the possibilities for sustained economic growth and the stability of society, and about war and peace (p. ix).

Americans have not been attentive to energy as a national issue, regardless of the facts that growing dependence on foreign imports is high and a balance is desired between domestic energy production and exploration, and environmental protection (American Petroleum Institute, 1988). Because of the current glut of foreign oil, the public and policy makers have become complacent about energy supplies and demand. However, this complacency could once again create both long-term and short-term energy problems for America.

Insensitivity toward energy by the U.S. consumer has been reflected in recent energy use. With increased awareness of conservation and fuel alternatives, the pattern of energy usage after 1979 declined to a low of 70.5 quadrillion British thermal units (BTU) in 1983. However, this pattern reversed trend and began climbing upward in 1984. U.S. energy consumption in 1987 climbed to approximately 76 quadrillion BTU which was three percent lower than the record 78.9 quadrillion BTU consumed in 1979 (Energy Information Administration [EIA], 1988). Reversal of this trend has not been evident; thus, total energy consumption is expected to continue increasing. According to a recent EIA projection, total consumption is expected to rise, reaching a level of 90.6 quadrillion BTU in the year 2000 (EIA, 1989).

In 1986, the residential sector, which included private household establishments, consumed 20.6 percent of total energy use (Table I). Residential energy consumption escalated by four percent between 1973 and 1986 (EIA, 1986). Total energy consumption increased by two percent between 1986 and 1987 (EIA, 1987a). Residential consumption was projected to increase approximately two tenths of one percent per year between 1988 and 2000 (EIA, 1989).

Per capita consumption, one indicator of energy intensity, was the relationship of end-use consumption and population growth. Prior to the embargo period, the United States averaged an increase of 2.8 percent energy growth per year. However, U.S. per capita consumption declined an average of one percent each year between 1973 and 1986 (EIA, 1986). Although demand has increased since 1973, energy intensity relative to population growth has declined.

Three main fuel sources have contributed to energy consumption: petroleum, natural gas, and electricity. Since 1973, electricity consumption has increased while reliance on direct use of fossil fuels has declined. Between 1973 and 1986, residential electricity use grew from 46 percent to 61 percent (EIA, 1986). With the increase in demand, price of electricity rose 191 percent from an average of 2.54 cents per kilowatt hour (KWH) in

TABLE I

PERCENTAGE OF TOTAL ENERGY CONSUMPTION
BY MAJOR END-USE SECTORS, 1986

| Major End-Use Sector | Energy Consumption |
| --- | --- |
| Industrial | 35.6 |
| Transportation | 28.0 |
| Residential | 20.6 |
| Commercial | 15.8 |
| Total | 100.0 |

Note. From State Energy Data Report: 1960-1986 (p. 3) by Energy Information Administration, 1986, Washington, DC: Government Printing Office.

1973 to an average of 7.41 cents per KWH in 1986 (EIA, 1988). This substantial price increase has contributed to the increased impact of home energy expenses on all households.

Energy costs, second to rent or mortgage payments, have posed the largest housing expense for households of all income levels. Specifically, increasing energy costs could affect housing affordability for particular households. According to federal guidelines, home owners, who have paid more than 40 percent of their income in total housing costs, have homes which are unaffordable. Approximately 20 percent of a middle income family's average housing costs were for energy in 1983. In contrast, a family with income less than the poverty threshold spent on an average more than one-third of their housing costs for energy bills (Prindle & Reid, 1988). One reason for this impact was that low income families did not possess the necessary physical or financial resources to strategically manage the increase in energy costs (Cunningham & Lopreato, 1977). Questions about effects of energy consumption, particularly on residential units, prompted many researchers in the late 1970s and early 1980s to begin intensive studies of the relationship between energy consumption, housing structure, household characteristics, and consumer behavior.

Previous research has revealed that structural and family characteristics have influenced energy consumption levels (Newman & Day, 1975; Iams & Royce, 1984; Morrison, Gladhart, Zuiches, Keith, Keefe, & Long, 1978; Socolow, 1978). Newman and Day (1975) identified several structural factors in their classic study which included size of space and type of heating system. Newman and Day (1975) concluded that the larger the dwelling, the more energy consumed. A house which used electric resistance heat would consume approximately twice as much fuel per unit of heat as a home heated by natural gas. In addition, a structure that has deteriorated with age and poor maintenance would tend to use more energy than a well maintained home (Iams & Royce, 1984).

Family characteristics were identified also as key factors which influenced energy consumption levels (Socolow, 1978; Morrison et al., 1978). In the classic Twin Rivers study, Socolow (1978) observed various patterns of energy usage in identical structures. Change of ownership, when correlated with change in consumption patterns, substantiated the link between consumption of energy and the role of the resident. Morrison et al. (1978) concluded that higher energy consumption was associated with higher income, well-educated, and larger families in the middle life-cycle stage.

Although lower income families were not labeled as high energy users within these particular studies, research has suggested that the relationship between energy use and income could be more dramatic. Morrison et al. (1978)

stated that low income families who are rural residents and have a high school education or less are especially sensitive to higher energy prices and will reduce energy consumption accordingly. Lack of financial resources for these particular households stifled management of energy consumption which was heavily dependent on structural quality.

Low income and elderly households will tend to reside in dwelling units which are 40 to 50 years old and structurally unsound (Tyler, Lovingood, Bowen, & Tyler, 1984; Cooper, 1981) Ultimately, low income households have had fewer options for structure improvements than prosperous homeowners or tenants and, therefore, have lacked control over consumption (Tyler et al., 1982). Alternatively, some low income or fixed income households, specifically elderly, have foregone basic necessities such as food or medical care in order to pay electric and home heating costs; a situation known as the "eat or heat" dilemma (Cullen, Johnson, & Sommers, 1983).

To what extent have electricity prices and demand affected U.S. households' resources? Between April, 1984, and March, 1985, the EIA surveyed 86.3 million households who consumed an average of 8,400 KWH of electricity that cost an average of 632 dollars during the 1984 and 1985 time period. This survey demonstrated that several factors could influence variance in electricity usage. Metropolitan households, defined as those households within a standard metropolitan statistical area according to the U.S. Census Bureau, consumed an average of 8,200 KWH with an average bill of 636 dollars. In contrast, nonmetropolitan households averaged 9,100 KWH usage, annually, that cost an average of 616 dollars (EIA, 1987b).

Electricity usage within the 1984 and 1985 period also varied according to income level (Table II). Households with family incomes of more than 35,000 dollars consumed the greatest average amount of electricity and, likewise, had the largest average electricity bill. Households with family incomes less than 10,000 dollars used the least amount of electricity on the average and had the smallest average cost compared to other households (EIA, 1987b). Although lower income families had lower average costs compared to other families, the proportion of these households' incomes which were spent on home fuels has been projected to be greater compared to those of other households. Recent reports by the National Consumer Law Center (1989) and U.S. Bureau of Labor Statistics (1988) affirmed that low income families spend a higher proportion of household income for home fuels than other households.

Residential demand will be expected to increase an average of 1.8 percent per year in the future (EIA, 1986). Increasing use of appliances will elevate demand for electricity. As the market of electricity-intensive products approaches saturation, the trend will slow. Real electricity prices will be expected to remain flat compared

TABLE II

AVERAGE ELECTRICITY CONSUMPTION AND COST BY FAMILY INCOME, APRIL 1984 TO MARCH 1985.

| 1984 Family Income | Average Consumption (KWH) | Average Cost (Dollars) |
|---|---|---|
| Less than $10,000 | 6,300 | 469 |
| $10,000 to $19,999 | 7,300 | 542 |
| $20,000 to $34,999 | 9,100 | 669 |
| $35,000 or more | 11,500 | 879 |

Note. From Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985 (p. 158) by Energy Information Administration, 1987, Washington, DC: Government Printing Office.

to other fuels which will continue to augment demand (EIA, 1989). Electricity consumption will, thus, continue the historical growth upward which will impact electric utility bills of all households.

Utility bills have been identified as the most continuous and essential energy costs which are faced by low income and minority households (Henderson, 1979). Brown (1987) stated "The inability of low income households to meet their gas and electric bills poses, in human terms, the most compelling issue facing state utility regulators" (p. 9). Consumer advocates, state agencies, and legislators along with utility regulators have lobbied for utility rate reform and billing procedures which address the fundamental issue of distributing energy, fairly and equitably, from regulated utilities to all consumers.

The Oklahoma Corporation Commission in 1985 established a ruling requiring Oklahoma utilities under their jurisdiction to offer residential customers the option of averaging their utility bills over the period of one year (Oklahoma Corporation Commission, 1985). Average monthly payment (AMP) plans, an alternative billing procedure, were designed by utility companies to relieve low income and elderly consumers from the effects of fluctuating monthly utility bills. This payment option was a mathematical process of evenly dividing a utility customer's yearly total cost over 12 monthly billing periods (McDermott, Guldmann, Pfister, & Kumari, 1980).

A recent exploratory study which involved electric utility data has implied that consumers using the AMP plan consume more and thus pay more for electricity than consumers not on the AMP plan. Also, analysis revealed that households using the AMP plan tend to be less prosperous and live in smaller homes than other electric utility consumers according to property appraisal data and square footage information (Williams, Weber, & Routh, 1988). Because research on the AMP plan was sparse, examination of existing studies has indicated gaps where further knowledge was still needed.

A recommendation by McDermott et al. (1980) to the U.S. Department of Energy about the AMP plan and consumers which it has served was that further consideration should be given to the AMP plan's effect on energy consumption. Given this recommendation and findings of previous research, several questions surfaced. What effect has payment plan choice interacting with specific variables had on household energy consumption and cost? What was the direct effect of the AMP plan on a household's energy consumption and, ultimately, on the utility bill? What differences, if any, could be determined between total and seasonal usage when AMP plan was considered as a factor of consumption? This billing policy was enacted without any prior research or systematic review of similar established programs in other states. Since the establishment of the AMP plan, few studies have researched the effect of this policy on utility consumers or the utility industry. Analysis of this specific policy would provide consumers additional knowledge in evaluating this plan as a billing option. This consideration could be important given that households are in a dynamic state of decision making about the allocation of scarce resources. Additionally, research in this specific area would be valuable to consumer advocates, state utility regulators, and policy makers in evaluating this established policy and future policy recommendations designed to aid low and fixed income households in coping with increasing energy costs.

## Purpose of the Study

The purpose of this study is to assess the effect of payment plan choice interacting with specific housing characteristics, a household income proxy, and residential location on total and seasonal household electric consumption and cost. Specific objectives of this analysis include:

1. Identify effect of payment plan choice, specific housing characteristics, a household income proxy, and residential location on total household electric consumption and cost.

2. Identify effect of payment plan choice, specific housing characteristics, a household income proxy, and residential location on seasonal household electric consumption and cost.

3. Develop a model for the effect of payment plan choice, specific housing characteristics, a household income proxy, and residential location on household electric consumption and cost.

## Assumptions

For this study, it was assumed that:

1. The sample was representative of customers who participated in the AMP plan and those who did not use the AMP plan within an Oklahoma electric utility company.

2. Data acquired from property assessment records were representative of specific housing characteristics.

3. Appraised property values were an accurate proxy for household income levels.

4. The price variable was treated as a constant since consumption between consumers who did and did not participate in the AMP plan did not vary when considering seasonal changes and price structure variations.

## Limitations

The following limitations were acknowledged for this study:

1. The sample was limited to Oklahoma customers of an Oklahoma electric utility company which serves a large portion of Oklahoma.

2. Contact with customers was prohibited by the electric utility company. Thus, the effect of behavior and

attitudes were not included in the estimation equation. Additionally, information about appliance ownership and use was also unavailable.

3. Reference to thermal efficiency of the dwellings was restricted due to the lack of accurate information from residential energy audits.

4. Conclusions about the effects of household income were confined due to the lack of available evidence which indicated that household income and appraised land and improvements were perfectly correlated.

## Definitions of Terms

The following definitions were used in this study:

AMP consumers (Averagers): Those utility customers who have elected to use the average monthly payment plan.

Average monthly payment plan (AMP): The mathematical process of evenly dividing an electric utility customer's yearly total electric cost over 12 monthly billing periods (McDermott, et al., 1980).

Household: Consists of all individuals who reside in a dwelling.

Household electric consumption: The KiloWatt Hours (KWH) usage as measured by the electric utility company.

Household electric cost: The dollar charge assessed by the electric utility company for KWH consumption and service. In other words, the cost represented by the monthly utility bill.

Non-AMP customers: Those electric utility customers who have chosen _not_ to use the AMP plan. Their monthly electric bills have reflected actual consumption and cost for the billing period.

Property appraised value: The value of land and improvements (i.e. home and other structures) as assessed by county governments.

# CHAPTER II

# LITERATURE REVIEW

## Introduction

Research in energy consumption was very limited prior to the 1970s embargo era. Interest heightened once energy supplies were threatened; therefore, numerous studies were conducted to explore energy demand and supply, conservation incentives, and alternative fuel supplies. This literature review will consider various aspects of energy demand, specifically electricity usage, and expenditure patterns. Interaction between consumer demand and price, energy consumption factors, and political intervention will also be explored.

## Consumer Energy Expenditures

With increasing residential demand and rising home energy prices, energy and utility services have become a major cost for many households' budgets, particularly for fixed and low income families. In 1979, Brazzel and Hunter projected average energy expenditures for 1985 relative to annual disposable incomes. Their conclusion was that the proportion of disposable income spent for energy was expected to decrease (increase) as disposable income increased (decreased).

Low income families were expected to spend more of their disposable income for energy expenditures than high or middle income families were expected to spend in 1985. Additionally, white poverty level households would have higher energy costs, in absolute terms and a percent of disposable income, than black poverty-level households would have. Specifically, white and black households' expenditures for electricity were anticipated to increase during the 1980s (Brazzel & Hunter, 1979).

The 1986 Consumer Expenditure Survey (CES) reinforced the reality of the 1979 projections (U.S. Bureau of Labor Statistics, 1988). The 1986 CES revealed that housing costs, which include utilities, fuels, and public services, had indeed rose from 28.7 percent of total annual household expenditures in 1980 to 30.3 percent by 1986. On an average, households spent 1,646 dollars for utilities, fuels, and public services in 1986.

Differences were observed between income groups and tenure status. Households with less than 5,000 dollars family income in 1986 spent a higher percentage of their income for household energy costs which averaged 1,129 dollars per household. In contrast, families with incomes over 40,000 dollars spent a lower proportion of their incomes for energy costs, an annual average of 2,335 dollars. Homeowners on the average had higher energy expenditures than did renters, 2,022 dollars versus 1,035 dollars (U.S. Bureau of Labor Statistics, 1988).

The impact of energy costs on low income families has been more substantial than for middle or high income households as expected by Brazzel and Hunter (1979). Evidence of this fact was emphasized in a recent report by the National Consumer Law Center (1989). This study concluded that unlike low and fixed income households, middle and high income households have successfully adjusted budgets and expenditures for increasing energy costs. The real "energy crisis" has persisted for low income households who lack resources to compensate for rising utility costs. Even with federal assistance, a considerable amount of a poor household's income was spent for energy bills. For example, in the majority of states, a recipient of federal energy assistance had an average of 75 dollars or less remaining each week after paying utility bills during winter months to cover all other household expenses. An elderly couple who depended on Supplemental Security Income had an average of 125 dollars per week remaining for all other household necessities after paying utility bills during winter months. That amount increased to an average of 130 dollars for Social Security recipients in 30 states (National Consumer Law Center, Inc., 1989). With projected escalating energy prices, these households will be confronted with higher monthly energy bills which will continue to reduce remaining income for food, clothing, and medical expenses.

## Consumer Energy Demand

Household energy consumption has served as a research topic for engineers, economists, market researchers, and psychologists who have focused on reducing consumption (Bauer & Badenhop, 1984). McDougall, Claxton, Ritchie, and Anderson (1981) divided consumer energy research into two types: (a) studies which concentrated on understanding the consumer and (b) studies which observed energy conservation motives. McDougall et al. (1981) subcategorized research which concentrated on understanding the consumer into four groups: (a) opinion research, (b) self-reporting behavior research, (c) innovativeness research which focused on adoption and diffusion, and (d) research which modeled energy consumption. The last category will be of particular interest to this literature review and will direct the focus of this study.

Baxter, Feldman, Schinnar, and Wirtshafter (1986) stated that two approaches have been devised in analyzing influences on energy consumption: (a) economic demand functions and (b) multiple regression analysis of various factors. The demand function, derived from classical demand theory, modeled energy usage as dependent on price of the particular energy fuel in question, household income, and prices of energy-consuming appliances.

Alternatively, a variety of economic, demographic, climatic, and engineering factors were analyzed using multiple regression to determine significant influences on energy consumption. Baxter et al. (1986) concluded that the ultimate goal of both analyses was to determine energy demanded or consumed by household members.

Maurice and Phillips (1986) stated that identifying influences on quantities demanded for goods and services sold in the market place was one of the fundamental tasks of economics. A demand schedule of an individual or household for a particular good or service has been defined as the quantities of a commodity that a person or household would be willing and able to buy at each possible price during a specific time period, ceteris paribus. Maurice and Phillips (1986) further stated that consumers tend to be willing and able to purchase more goods and services as price decreases, otherwise known as the law of demand. This inverse relationship between price and quantity contributed to the fact that consumers tend to substitute between commodities. In other words, as price of one good decreases, consumers will substitute toward this good. Conversely, households will substitute away from a good as the price increases (Maurice & Phillips, 1986). Thus, consumers' demand for a product, in some situations, could be particularly sensitive to price. However, other factors which affect quantity demanded have been identified in economic literature.

Maurice and Phillips (1986) identified factors which would influence quantity demanded as: (a) price of the commodity in question, (b) household income, (c) prices of substitute goods, (d) consumer tastes and preferences, and (e) consumer expectations. Prices of other goods could either represent a price of all goods in the market place or prices of substitute goods. When deriving demand, all factors except price may be held constant to observe the inverse relationship between price and quantity demanded.

Estimating demand for any commodity, such as electricity, would appear uncomplicated when given the above stated determinants. However, characteristics of the electricity market have posed unusual circumstances in deriving consumer demand. Jaffee, Houston, and Olshavsky (1982) identified three major problems associated with estimating demand of electricity. First, because electric power has been a regulated industry, prices were set independent of market demand. Therefore, price may be viewed as controlled within this framework.

Second, through regulatory commissions, price schedules have been established as opposed to one single price for all consumption levels (Jaffee et al., 1982). The more popular multipart decreasing block price schedule has been designed to charge a higher marginal price for lower consumption levels and a lower marginal price for higher usage tiers (Taylor, 1975). Thus, consumers could have demanded electricity consumption based on a particular price block in which they have consumed.

Third, demand for electricity was classified as a derived demand (Taylor, 1975; Jaffee et al., 1982). An individual's demand for a commodity was determined by the maximization of consumer utility at a certain point which was subject to an individual's budget constraint. Household utility was, in this situation, maximized in the operation or consumption process. In other words, since electricity was purchased as an input into these processes, demand for electricity was derived from operation of an appliance stock and the dwelling (Taylor, 1975). Thus, quantity of electricity demanded was highly dependent on the dwelling characteristics and appliance ownership (Jaffee et al., 1982).

In addition to these unusual characteristics surrounding the electricity market, Taylor (1975) suggested that another clarification was needed when dealing with consumer demand for electricity. A distinction needed to be made between short run and long run demand. Electricity demand was a derived demand which was dependent on capital stock. Appliances and dwelling characteristics, otherwise known as capital stock, were classified as fixed or variable depending on the time period in which demand was analyzed.

Taylor (1975) defined short run demand as a condition in which electricity was consumed with a fixed capital stock. In other words, appliances and housing characteristics were held constant during this time frame. Thus, quantity demanded was determined from the time period in which utility was maximized given budget constraints and existing capital stock.

Alternatively, long run demand was a condition in which energy consuming capital stock were considered variable (Taylor, 1975). Demand for electricity in this circumstance was dependent on demand for capital stock in addition to earlier described factors. Taylor (1975) stated that analysis which determined quantity demanded for electricity had to consider user costs associated with electricity consuming capital stock along with price of fuel substitutes and user costs of capital stock which consumed the identified fuel substitutes.

Analyses of household demand for electricity were indeed complicated considering these unusual circumstances. Taylor (1975) criticized previous research, which considered long run demand of electricity, for inadequate coverage and quality of independent variables, particularly those which represented electricity consuming capital stock. Given these complications and limited availability of specified variables, conclusions from previous household electricity research for long run demand have been cautious.

## Price

As previously stated, the inverse relationship between price and quantity demanded was a primary influence on household or consumer demand of products and services. This relationship was confirmed in economic literature which has dealt with individual or household demand of energy. The influence of price sparked a controversy about declining marginal block price schedules of electricity during the post embargo time period. Specifically, researchers questioned the price signal about consumption that consumers were receiving with these particular regulated price rates (Blocker, 1983). Blocker (1983) stated that declining block rates were developed during a time period when energy conservation was not a significant policy issue; thus, conservation was not promoted. However, with increased concern about conservation, different forms of price schedules, known as cost of service rates, were proposed as a means of placing a higher rate or price for higher consumption levels (Blocker, 1983). Ultimately, the goal of cost of service rates was to induce consumers toward conservation by sending a proper price signal (Blocker, 1983). Questions surfaced about how different households would respond to a change in price.

Gladhart (1984) determined that price was a significant predictor in a regression analysis of household energy consumption between 1973 and 1976. The coefficient on the price variable was greatest in magnitude compared to other variables in the equation. Additionally, in an analysis of change in consumption, price change and prior consumption levels were equally important variables in the explanation (Gladhart, 1984). The price change variable had the largest regression coefficient in three of the four consumption periods and was the most stable variable. Gladhart (1984) specifically concluded that consumption was expected to change 200 to 800 BTU per day due to a one cent change in the price of a therm. This analysis concluded that household energy consumption may be significantly influenced by price of the energy source.

Price Elasticity

Price elasticity has measured a shift or change in quantity demanded which was dependent on a corresponding change in price, while all other influences were held constant (Maurice & Phillips, 1986). To apply this concept to household electricity demand, price elasticity of demand ($E_p$) for KWH demand has determined the relationship between the proportional change in quantity of KWH demanded by households as a result of a change in the price of KWH (Williams, 1984). In other words:

$$E_p = \frac{\Delta KWH}{\Delta P_{KWH}} \cdot \frac{P_{KWH}}{KWH} \qquad (1)$$

where

$E_p$ = Price Elasticity

KWH = kiloWatt Hours

$P_{KWH}$ = Price of kiloWatt Hours

Because price and quantity demanded were inversely related, price elasticity of quantity demanded was expected to be negative.

Price elasticity coefficients have qualified demand as elastic or inelastic, depending on the magnitude of the coefficient. Demand was elastic if price elasticity was greater than -1 in absolute terms. In other words, a one percent change in price induced a change in quantity demanded that was greater than one percent (Maurice & Phillips, 1986). Discretionary or luxury items, such as fine jewelry or vacations, would tend to be price elastic (Williams, 1984). Conversely, demand was inelastic if price elasticity of demand fell between zero and -1. A one percent change in price resulted in less than one percent change in quantity demanded (Maurice & Phillips, 1986). Items which were categorized as "necessities of life" or normal goods would tend to be price inelastic (Williams, 1984). The rate at which quantity was demanded for these items did not decrease as rapidly as the price increase rate.

Distinguishing price elasticity of demand as either elastic or inelastic has provided a useful piece of information in policy formation and analysis. Henson

(1984) stated that policy errors would tend to be avoided when reliable estimates of demand, particularly price elasticities, were considered in the process. For instance, if price elasticity of electricity demand was elastic, a price increase would provoke households to reduce electricity consumption; thus a price increase may have effectively induced conservation. However, if price elasticity of KWH was inelastic, a price increase would not be a practical conservation tool for policy makers (Williams, 1984).

Maurice and Phillips (1986) presented two factors which determined price elasticity of demand: (a) the availability of good substitutes and (b) the time period of adjustment. Maurice and Phillips (1986) stated that these factors were related. Given a longer adjustment period to a price increase, households would substitute away from the higher priced commodity with a good or goods which were lower priced. If households believed that a price increase was permanent and were given a longer time frame to adjust, the price elasticity of demand for the higher priced good would eventually become more elastic (Maurice & Phillips, 1986).

Newman and Day (1975) presented two perspectives about price effects on households with different income levels. With a price increase, more affluent families adjusted to purchase the same quantity of energy if price was the only barrier (Newman & Day, 1975). Alternatively, low income households could be impacted more severely. With an increase in price, these households would not easily adjust consumption in the initial time period. Thus, household members would be deprived of necessities or comfort until adjustments could be made (Newman & Day, 1975). Cunningham and Joseph (1978) found that low income families will tend to use a minimum quantity of energy for house and appliance operations. Reducing energy consumption would not be easily achieved by these households. Cunningham and Joseph (1978) concluded that low income families, defined as households with annual incomes less than 5,000 dollars, could be classified as the least price sensitive group. A specific conclusion which could be drawn from these studies was that the time frame in which influences on consumption were observed was substantially important. Initial changes in consumption due to a price increase during a short time period could be minimal because dwelling structures and appliance stocks were fixed. Thus, results could indicate that households would not be sensitive toward price as measured by change in quantity demanded.

To measure sensitivity towards price, researchers have estimated price elasticity of demand. A debate among researchers who have analyzed and measured price elasticity of demand for electricity has dealt with the correct measurement of the price variable which would be included in the estimation. Foster and Beattie (1981) argued that consumers would not be aware of block pricing structures nor the price block in which their consumption level fell. Thus, a household would not be aware of the marginal price of electricity for which they were paying. Opulach (1982) suggested that households would likely be aware of total energy consumption and total expenditure for these services, and thus, could have calculated an approximate average of price of consumption.

In previous years, several studies have analyzed price elasticity of demand for household electric consumption. Table III presented estimates of price elasticity of demand for studies which have used individual household data as opposed to aggregate level data which were not applicable in this case. The research findings presented in Table III revealed notable variations in short run estimates of price elasticity of household demand for electricity. Estimates ranged from -.06 to -1.00. These differences could be attributed to inconsistencies in the type and source of data, statistical analysis, and treatment of price variables. However, one deduction could be made from these results: Estimates of short run price elasticities fell between zero and -1. In addition, recent studies indicated that the price elasticity coefficient was quite small in absolute value. Thus, price elasticity of demand for household electricity was expected to be inelastic and small in absolute value terms.

TABLE III

ESTIMATED SHORT RUN PRICE ELASTICITIES
FOR HOUSEHOLD ELECTRICITY DEMAND

| Study | Price Elasticity Coefficients |
|---|---|
| Wilder & Willenborg (1975) | -1.00 |
| Battalio, Kagel, Winkler, & Winett (1979) | -.20 to -.32 |
| Roth (1981) | - .11 |
| Barnes, Gillingham, & Hagemann (1981) | - .55 |
| Garbacz (1983) | - .19 |
| Kohler & Mitchell (1984) | - .06 to -.20 |
| Henson (1984) | - .27 to -.30 |

Household Energy Consumption Factors

Research which has incorporated social, demographic, climatic, engineering, or structural factors in addition to economic variables has been weakened by the use of limited sets of explanatory variables (Ritchie, McDougall, & Claxton, 1981). Because of limited sets of potential predictor variables, conclusions of previous research have been inconsistent. Thus, factors identified in previous research could have a positive, negative, or no relationship to energy consumption, depending on which predictors were available for analysis (Table IV). The following review will identify potential factors which have been identified as influences on household energy consumption.

McDougall et al. (1981) concluded that structural and climatic components have consistently surfaced as the leading explanatory variables in residential energy usage. Research by Home Economists that has analyzed energy consumption has been criticized for solely focusing on interior treatment rather than the structure as a whole in relation to energy usage (Bauer & Badenhop, 1984). Such factors as house size, age of home, and physical condition could be classified as structural components. Junk, Jones, and Kessel (1988) found that structural factors were more significant in energy consumption than demographic variables. Additionally, Morrison (1975) stated that

TABLE IV

FACTORS OF HOUSEHOLD ENERGY CONSUMPTION
SUMMARY OF RESEARCH

| Factor | Positive | Negative | No Relationship |
|---|---|---|---|
| HOUSE SIZE | | | |
| Number of Rooms | Morrison et al. (1978) | | |
| | Morrison (1975) | | |
| | Ritchie et al. (1981) | | |
| | Wilder & Willenborg (1975) | | |
| | Heslop, Moran, & Cousineau (1981) | | |
| | Gladhart (1984) | | |
| | Warriner (1981) | | |
| Number of Bedrooms | Sierra Pacific Power Co. (1979) | | |
| | Stevens (1982) | | |
| Square Footage | Jaffee et al. (1982) | | |

TABLE IV (Continued)

| Factor | Positive | Negative | No Relationship |
| --- | --- | --- | --- |
| HOUSE AGE | Junk et al. (1987) | Chatelain (1981)<br>Jaffee et al. (1982) | Ritchie et al. (1981)<br>Junk et al. (1988) |
| PHYSICAL CONDITION | | Tyler et al. (1982)<br>Junk et al. (1988)<br>Sinden (1978) | |
| HOUSEHOLD INCOME | Newman & Day (1975)<br>Cunningham & Lopreato (1977)<br>Perlman & Warren (1977)<br>Morrison & Gladhart (1976)<br>Morrison et al. (1978)<br>Ritchie et al. (1981)<br>Gladhart (1984)<br>Wilder & Willenborg (1975)<br>Garbacz (1983) | Heslop et al. (1981)<br>Junk et al. (1987)<br>Junk et al. (1988) | Gladhart, Zuiches, & Morrison (1977) |

TABLE IV (Continued)

| Factor | Positive | Negative | No Relationship |
| --- | --- | --- | --- |
| HOUSEHOLD INCOME (Continued) | Stevens (1982) | | |
| | Jaffee et al. (1982) | | |
| | Chatelain (1981) | | |
| | Warriner (1981) | | |
| | Cullen et al. (1983) | | |
| | Cramer et al. (1984) | | |
| LOCATION OF RESIDENCE | | | |
| Rural | Chatelain (1981) | | Cullen et al. (1983) |
| | Warriner (1981) | | Hassoun & Hunt (1980) |

energy consumption was more closely linked to physical dwelling characteristics than attitude of the resident. In other words, the house characteristics will tend to contribute more to household energy use than the family's characteristics.

## House Size

Previous research has linked energy consumption with size of space. The significant difference between these studies has been the type of measurement used for house size. Specifically, three measurements have been used: (a) number of rooms, (b) number of bedrooms, and (c) square footage. A greater proportion of these studies have included number of rooms as a predictor variable in determining household energy usage; fewer studies have used actual square footage of the residence.

Number of rooms as a measurement of house size has been a statistically significant variable in household energy consumption. Morrison et al. (1978) concluded that the number of rooms in a dwelling influenced the amount of energy consumed by the household. In a 1973-74 sample of single family detached dwellings, number of rooms was a significant predictor which, in combination with other factors, explained 48 percent of the variation in energy consumption (Morrison, 1975). Using a 1979 Canadian sample, Ritchie et al. (1981) concluded that households in larger homes consumed more energy. As expected, size of dwelling, measured by number of rooms in a dwelling, was positively related to household consumption of all energy forms.

In a study on electricity demand, Wilder and Willenborg (1975) analyzed size of residence in addition to the stock and usage intensity of household appliances. Using micro-level data, these researchers found that size of residence which was measured by number of rooms in the dwelling was closely related to income, family size, and race. The final conclusion of this study was that size of residence had a strong, positive influence on the demand for residential electricity. In other words, household electricity consumption was expected to escalate as size of residence increased.

In a regression analysis of electricity consumption, Heslop et al. (1981) determined that number of rooms electrically heated was the most significant predictor. Using a Canadian sample, this study found that 45 percent of variation in 1978 electricity consumption was explained when number of rooms electrically heated was included as an independent variable. When this predictor was dropped from the equation, only 17 percent of the variance could be explained. When the analysis considered total electricity consumption of the sample from 1973 to 1978, the highest predictor of consumption was average number of rooms electrically heated. Analysis revealed that 54 percent of the variance was explained when this measurement of residential size was included; however, explained variance dropped to 16 percent when this independent variable was excluded. Likewise, Gladhart (1984) in a Michigan study using five continuous years of consumption concluded also that number of rooms heated was a significant predictor of annual consumption during the years of 1973 to 1978.

Warriner (1981) found home size to be a significant factor which contributed to the level of consumption for older consumers. Number of rooms was the second largest positive influence on consumption. This study of 700 Wisconsin homes in 1976-77 concluded that 23.3 percent variance of the average monthly bill for households with heads under 65 years old was explained by number of rooms. For households with heads over 65 years old, 26.7 percent of the variance in the monthly electric bill was explained by this statistically significant independent variable. Junk et al. (1988) determined that lower income elderly were paying on the average more per square foot than higher income elderly. However, these older consumers with lower incomes were living in smaller homes on the average than their counterparts.

Number of bedrooms, like number of rooms, has also been posed as a proxy variable for house size. Previous research has concluded that number of bedrooms significantly influenced household energy consumption (Sierra Pacific Power Co., 1979; Stevens, 1983). In a 1979 study, number of bedrooms and bathrooms served as a significant predictor of winter gas consumption (Sierra Pacific Power Co., 1979). Researchers concluded that 45 percent of the variance in household winter gas consumption was explained by a set of independent variables which included number of bedrooms and bathrooms. Additionally, Stevens (1983), who analyzed household electricity consumption among Florida apartment renters, stated that number of bedrooms in conjunction with other building characteristics explained 56 percent of variance in tenants' electricity consumption. In comparison with renter characteristics and household energy consumption practices, building characteristics, which included number of bedrooms, yielded the largest adjusted explained variance in electric consumption among this sample.

As stated earlier, fewer studies have used the actual measurement of the dwelling in square feet as a house size variable. One study by Jaffee et al. (1982) incorporated square feet as an independent variable in their electricity consumption analysis of an Indiana sample. These researchers concluded floor space of the housing unit was significantly and positively related to electricity consumption. Thus, one would conclude from these studies that house size, whether represented by proxy variables or actual square footage, contributed positively to the energy consumption of the residence. However, certain questions surfaced when considering houses with the same number of bedrooms and varying square footage. How accurately would number of bedrooms as a proxy variable in this situation represent actual house size?

House Age

Several studies have identified age of home as a contributing factor to energy costs and consumption (Chatelain, 1981; Jaffee et al, 1982; Junk, Junk & Jones, 1987). The relationship between dwelling age and energy usage has been found to be positive and negative. Additionally, other research has concluded that consumption may not be dependent on house age, depending on which variables were used in the analysis (Ritchie et al., 1981; Junk et al., 1988).

Ritchie et al. (1981) concluded that no relationship existed between aggregate in-home energy consumption and age of dwelling. When age of house was included in a subset of house and appliance variables, this predictor was not statistically significant. Junk et al. (1988) also concluded that no significant relationship existed between age of home and energy usage per square foot. However, lack of conservation techniques in older homes will tend to contribute to higher consumption rates.

Compared to newer homes, older homes will tend to lack conservation measures such as insulation and could have other structural defects which could augment higher energy consumption (Brandt & Guthrie, 1984). Junk et al. (1987) found that homes which were 40 years old or more were less likely to have wall insulation, storm doors and windows, and weatherstripping. Dwellings in this study used twice the mean consumption rate of energy as other homes. In this 1983 study, homes which were 10 years old or less consumed energy at a much lower rate than older homes.

Studies which used electricity consumption as the dependent variable have found that house age was a statistically significant predictor (Chatelain, 1981; Jaffee et al., 1982). However, this relationship has been negative; the newer the home, the more electricity consumed. In a Utah sample of rural and urban households, Chatelain (1981) found that families who lived in houses built between 1946 and 1974 consumed more KWH than households living in dwellings built before 1945 and less than houses built after 1975. Thus, residents of newer houses consumed more electricity compared to residents of older homes. Likewise, Jaffee et al. (1982) found that families who lived in homes built after 1973 were using significantly more electricity than those families who resided in dwellings constructed before 1973.

In summary, findings between age of dwelling and consumption tended to be contradictory. One pattern did emerge between electricity usage and age of house which suggested that this relationship could be hypothesized as negative. In addition to age, physical condition of the home must be considered as a predictor of home energy consumption.

Physical Condition

Physical condition could represent an inclusive category of all structural factors that could affect household energy consumption. Tyler et al. (1982) stated that a major influence of household energy consumption has been identified as type and quality of structure. Structural quality, otherwise known as physical condition, was determined by a number of factors: (a) absence of broken windows, (b) signs of maintenance, and (c) solid floors and roofs. In addition, installed energy conservation techniques, such as presence of insulation, storm doors and windows, and caulking and weatherstripping, contributed to the quality of the structure (Tyler et al., 1982).

Newman and Day (1975) stated that house structure and climate were major contributors to the basic level of household energy used for heating. In the classic Twin Rivers study, installation of conservation techniques and other retrofit measures reduced annual energy consumption for space heating by 67 percent (Sinden, 1978). Therefore, increasing the quality of the structure has been associated with reduced energy consumption.

Stern and Gardner (1981) advocated that energy usage could be reduced through more maintenance and purchase related behavior than usage curtailment behavior. Junk et al. (1988) found that more conserving structural features were correlated with lower energy costs per square feet. Physical condition of the structures were significantly related to reduced energy costs.

Research which has included physical condition as a contributor to household energy consumption has been limited (Stern & Gardner, 1981). Little research has appropriately demonstrated how this variable could play a role in energy usage. In addition to structural characteristics, certain demographic characteristics surfaced consistently through the literature. One such characteristic was household income.

Household Income

One family characteristic which has reoccurred as a statistically significant predictor in most micro-level analysis of household energy consumption was household income. However, analysis results have not been consistent. One study conducted by Gladhart et al. (1977) concluded that household income does not directly impact energy consumption. Household income was found to indirectly affect consumption through the housing characteristics of the sample. Other research has found that income positively affected energy consumption, while in other studies, income has been found to have a negative effect on energy use.

A greater number of studies have concluded that a positive relationship existed between income and household energy consumption. Newman and Day (1975) concluded that the higher a family's income, the more energy will be used by that family, particularly for space and water heating, appliance use, and lighting. Specifically, this study found that in comparing natural gas usage, higher income households consumed 40 percent more energy than lower income families. Considering electrical space heating, higher income households used 100 percent more energy than less affluent households. Because of the positive relationship between income and consumption, Cunningham and Lopreato (1977) advocated that conservation incentives must be focused on higher income, high consuming families. Additionally, Perlman and Warren (1977) concluded that conservation efforts among low income households were less effective due to that fact that lower income families could conserve only a minimal amount of energy spent.

A direct relationship between energy consumption and family income has been found in several other studies. Morrison and Gladhart (1976) asserted that high income families consumed more energy than low income families. In the 1974 and 1976 study of Michigan families, Morrison et al. (1978) concluded that as family income increased, energy usage climbed. Middle income families were found to reduce energy consumption by the greatest amount between the two time periods.

Family income has been a statistically significant predictor of energy consumption. Ritchie et al. (1981)

found that family income was the most significant variable among a subset of demographic variables in a 1979 Canadian study. Family income remained the most statistically significant variable of the demographic variables when included with climate and regional variables, house and appliance variables, and other demographic variables. In a longitudinal study between 1973 and 1978, Gladhart (1984) found that a difference in family income of 1,000 dollars created a difference in household energy consumption between 700,000 and 1.6 million BTU. In other words, as family income increased by 1,000 dollars, the predicted home energy consumption would increase 700,000 to 1.6 million BTU.

A few energy demand studies which have narrowed the scope of energy use to electricity consumption have also concluded that the income effect was positive. In a study using households within one metropolitan area, Wilder and Willenborg (1975) determined that the income effect was significantly related to energy use. Specifically, these researchers found that one-half of the effect directly contributed to variance in electricity consumption, while the other half indirectly affected household consumption through the household appliance stock and residence size. Garbacz (1983) using a national household data set also concluded that the income effect was a significant positive contributor to household electricity usage.

Some studies which have included extensive household demographic, climate, and structural variables have found that family income positively influenced household electricity consumption. In a 1982 study of Florida apartment dwellers, Stevens (1983) deduced that families with a higher level of income consumed more electricity than households who had lower incomes. Jaffee et al. (1982) also concluded that family income was significantly related to electricity for an Indiana household sample. In a Utah sample of rural and urban households, Chatelain (1981) found that households with incomes over 10,000 dollars significantly consumed more electricity than households with less than 10,000 dollars. In a regression analysis of households who did not have electric space heating, family income explained 3.25 percent of the variance in consumption. However, in the stepwise regression analysis, family income was not a significant variable when all variables were considered.

Warriner (1981) found that annual family income had a small but positive influence on older consumers' level of electricity consumption. For families with households heads who were younger than 65 years old, family income explained 8.2 percent of the variation in KWH usage. In comparison, family income contributed 5.6 percent variance in electricity consumption for households with heads who were 65 years old or older. Within this study, family income indirectly affected the monthly electric utility bill through home size and household appliance stock. Thus, Warriner (1981) concluded that family income could have a greater effect on the size of the electric bill through these two factors.

A few studies have restricted analysis to consider specific households for which certain energy policies were designed to assist. Cullen et al. (1983) concluded in an analysis of low income household electricity usage and lifeline rates that family income was positively related to KWH usage. Within this 1979 Michigan sample, this study found that family income was a weak but statistically significant predictor of electricity consumption using stepwise multiple regression analysis.

Additionally, some studies have limited the time period to analyze specific seasonal consumption. In a California study which considered determinants of summer electricity usage in single family dwellings, income had a strong effect on KWH usage (Cramer et al., 1984). Summer electricity consumption was significantly associated with a larger home, greater appliance load, more frequent use of air conditioning, and the likelihood of having central air conditioning for an average household. Income was significantly related to these physical dwelling factors and behavioral determinants. In this study, the physical dwelling was viewed as a fixed determinant. Behavioral characteristics of the family were considered as a short run effect on energy usage. Thus, these researchers concluded that household income possessed long run and short run effects on consumption.

Although a greater proportion of reviewed studies found that income and consumption were positively related, a few studies have concluded that this relationship was negative. Heslop et al. (1981) in an analysis of change in electricity consumption between 1973 and 1978 found that household income was negatively correlated with the change in consumption which served as a proxy variable to measure conservation efforts. In other words, the higher the family income, the lower the change in consumption between the two time periods.

Junk et al. (1987) also found a negative relationship between energy consumption and household income. In this 1983 Idaho study, households with 10,000 dollars or less annual incomes used energy at a significantly higher rate than other families. The analysis revealed that the consumption rate decreased as income increased. This trend changed slightly as income exceeded 30,000 dollars by an increase in consumption rate. Additionally, Junk et al. (1988) determined household income was negatively associated with energy costs per square foot of the home. Specifically, this study found that a greater proportion of households with 10,000 dollars or less annual incomes had average energy costs of one dollar or more per square foot of the residence.

A majority of these studies concluded that family income was a positive contributor to the level of household energy consumption. However, a few studies have contradicted these findings. Ultimately, research has continuously affirmed that income was a significant factor in household energy consumption.

Location of Residence

Another demographic variable which could contribute to household energy usage was location of residence. Unlike household income, few studies had analyzed whether a dwelling which was located in a rural or urban area significantly affected energy usage. Conclusions had not been consistent in those studies which had analyzed the relationship of this variable and consumption.

In 1987, EIA confirmed that rural and urban households had differing energy consumption patterns. Metropolitan households, those whose residences were located within boundaries of the Standard Metropolitan Statistical Area (SMSA) as defined by the U.S. Bureau of Census (1980), consumed an average of 108 million BTU in 1984. Conversely, nonmetropolitan households, those located outside of the SMSA, used approximately 95 million BTU during the same time period. Thus, when comparing average energy usage, metropolitan households consumed more on the average than nonmetropolitan households (EIA, 1987b).

Average electricity consumption presented a different perspective. In 1984, metropolitan households consumed an average of 8,200 KWH, while electricity consumption of nonmetropolitan households averaged 9,100 KWH of electricity. Thus, rural households utilized approximately 900 more KWH than urban families (EIA, 1987b). Despite these findings, results of further analyses had not been consistent as to effect of the variable, location of residence.

Cullen et al. (1983) concluded that a rural residence was not significantly correlated with low income household electricity consumption. In this Michigan study, consumption was significantly affected by household head's age, number of dependents, and homeowner status which explained 16 percent of the variance. However, rural residence did not significantly impact these less affluent households' electricity usage.

Hassoun and Hunt (1980) determined that location of residence was not significantly related to electric usage within a 1975-76 Ohio study of rural and urban households. However, other significant relationships were confirmed which could directly affect consumption. Rural households owned significantly more electric food preparation and storage appliances than urban households. Conversely, urban residents owned significantly more room air conditioning units, humidifiers, and dehumidifiers which were labeled as "comfort" appliances. These researchers contributed the difference in appliance ownership to the fact that housing types varied according to areas. Rural areas would include mostly single family dwellings as opposed to urban areas which would also include apartments along with single family dwellings.

The U.S. Department of Labor (1976) stated that rural residences' average expenditure for electricity was greater compared to other households' average electricity expenditure. Ruffin and Weinstein (1979) found that rural households were dependent upon electricity to a greater extent than other families for water heating, cooking, and space heating.

Some studies had confirmed that rural location of residence was a significant factor in household energy usage. Rural households which lived in areas populated with less than 10,000 persons used significantly more electricity than did other households in a Utah study conducted by Chatelain (1981). Specifically, families living in areas with less than 2,500 persons consumed the highest average amount of electricity of all households in populated areas with less than 10,000 persons. Warriner (1981) who compared elderly and nonelderly households deduced that rural households tended to consume more electricity than urban families. Additionally, rural elderly paid more in service charges than urban older consumers. Service charges were assessed to cover costs of administrative services and wire service maintained by utility companies. Rural residence as a demographic variable was a significant contributor to the household's average monthly electric utility bill. This factor explained 5.5 percent variation in a family's average monthly electric bill whose household head was under 65 years old. Alternatively, when the household head was over the age of 65, rural residence explained 8.7 percent of the family's average monthly electric utility bill.

Although this variable had only been considered in a few previous studies, the significance of this variable should not be overlooked. Additional information about the effect of this variable would be valuable to future energy research.

## Average Monthly Payment Plan

As stated in Chapter I, the AMP plan was an alternative billing procedure offered to utility customers. Through the advocacy of consumers and utility representatives, the AMP plan was designed to assist households, particularly low income and elderly, in managing and budgeting for monthly utility bills (McDermott et al., 1980). In Oklahoma, this plan was first approved by the Oklahoma Corporation Commission on September 26, 1979 (D. Cook, personal communication, March 2, 1988). The director of the Public Utilities Division to the Oklahoma Corporation Commission submitted the first application on April 16, 1982, for hearings to require Oklahoma utilities to offer some form of the AMP plan to consumers (Oklahoma Corporation Commission, 1985). On January 8, 1985, the Oklahoma Corporation Commission established a ruling requiring Oklahoma utilities under their jurisdiction to offer residential customers the option of averaging their utility bills over the period of one year. Utility providers were required to submit their own plans for approval by the Oklahoma Corporation Commission who allowed for some deviations in the proposals due to differences between utility companies.

A review of the calculations used for monthly AMP payments within an Oklahoma electric utility company could provide insight into the monthly bill content received by AMP consumers. The following terms would be met before a customer could qualify for the AMP plan as specified by the utility company (T. Lyons, personal communications, August, 1989). A customer would:

1. Be a residential customer as recognized by the utility company.

2. Have a 12 month billing record at the present residence.

3. Not be delinquent with a present bill when the AMP plan was initiated.

4. Pay each monthly AMP amount by the stated expected date.

5. Accept that the account would have either a debit or credit balance at any particular period. However, the

company would expect that the monthly AMP payment would be paid in full each month regardless of the account balance.

6. Recognize that participation in the AMP plan would not begin until the next month's billing period after the request had been approved.

7. Pay the account's balance in full if service was terminated due to a delinquent payment. Payment of all outstanding charges was required before electric service was restored.

Calculation of the AMP payment was based on the current month's charge, the previous account balance, and the 11 preceding months' billings totaled and divided by 12. This average amount was rounded to the nearest whole dollar for the current AMP payment. Equation 2 illustrated this calculation.

$$\text{Monthly AMP Payment} = (\text{Current Billing} + \text{Previous Balance} + \text{11 Preceding Month's Billings}) / 12. \quad (2)$$

The next billing period's AMP payment would be computed by adding the current month's charges, adding or subtracting the previous balance, eliminating the oldest month's billing, and dividing the total by 12.

As prescribed by company procedures, the AMP customer's monthly bill reflected the following: (a) previous balance (either debit or credit), (b) current monthly charges, (c) account total, and (d) the AMP payment (T. Lyons, personal communication, August, 1989). Thus, this utility's AMP consumers received a variety of information with each month's bill.

## Effects of Billing Procedures

The effect of information on monthly consumption had been closely scrutinized by previous research. Sexton and Sexton (1987) stated that consumers have undoubtedly needed more fundamental information about household energy consumption through the present system in which monthly utility bills delivered information about household usage levels and costs. The effect of feedback or information on consumer energy consumption had been extensively analyzed, particularly with regard to energy conservation. Seligman and Darley (1977) in their classic study found that consumers who received feedback which was immediately delivered numerous times during the test period reduced energy consumption by an average of 10.5 percent. This result indicated that information and delivery time significantly affected consumers' behavior and their ability to curb energy consumption. Additionally, Kasulis, Huettner, and Dikeman (1981) determined that in an Oklahoma study of over 1,400 households, feedback about electricity consumption and cost during peak and off-peak time periods influenced consumers to reschedule energy consumption activities from peak to off-peak times. However, this information did not lead to reduction in total household energy consumption.

Economic theory assumed that consumers based demand for products and services on perfect information about prices and alternatives (Fast, 1989). Previous research indicated that most consumers were aware of monthly utility bill charges but were not familiar with current electricity prices (Brown, Hoffman, & Baxter, 1975). This finding supported Foster's and Beattie's (1981) argument that households would likely not be aware of block pricing structures or the marginal price of utility services. Sexton and Sexton (1987) found that although consumers had not received immediate feedback or information about current electricity consumption with the present system, households subjectively forecasted the amount of each month's utility bill by utilizing the previous month's bill for information about consumption levels. Households would be cognizant of an approximate level of consumption although incomplete information was available to them. This research concluded that consumers' future monthly utility bills or consumption levels would approximate previous monthly bills or energy usage. However, other studies have concluded that utility consumers were not knowledgeable about utility rates, their monthly consumption, or their utility bills (Heberlein, Linz, & Ortiz, 1982).

Because information about consumption and cost had been obtained through the monthly bill, one study focused on content and format of the bill. Fast (1989) investigated a new billing format referred to as a "plain language" billing format which was initiated by a New York utility company. One conclusion of this study was that satisfaction increased among customers of the New York state utility company because more information was offered on the new monthly bill format about price and previous consumption levels. The analysis found that fewer bill related complaints were received under the new format. Specifically, fewer customers complained about not understanding the computation of their bill. Additionally, 144 customers reported that their energy consumption decreased due to the information which was provided by the new billing format. Fast (1989) concluded that billing format and content could influence consumption levels, consumer behavior, and satisfaction levels of most consumers.

Economic theory and empirical evidence emphasized the importance of information and feedback as related to energy consumption. This effect could also be relevant in analyzing the AMP plan and its impact on household energy consumption.

Projected Effects of AMP Plan

With implementation of many independent AMP plans, during the late 1970s and early 1980s, the National Regulatory Institute in January, 1980, prepared a report for the United States Department of Energy which addressed many of the issues surrounding this policy (McDermott et al., 1980). Problems were felt to be inherent due to the diverse methods used in calculating AMP payments, each plan's cost inconsistencies for consumers, and projected effects on household energy consumption. A major conclusion of this report was that the AMP plan "... may provide a false cost signal to consumers and result in overconsumption during the peak periods" (McDermott et al., 1980, p. iv).

Economic theory suggested that to achieve efficiency in energy consumption, obtaining and utilizing information about price and individual consumption was necessary for consumers to receive in their decision making process. McDermott et al. (1980) stated that consumers who utilized their monthly utility bills as signals of the true costs of energy consumption would depend on this information for accurate purchase decisions. As stated earlier, previous research about information and monthly utility bills had supported this conclusion. Any changes to this information, such as seasonal-cost differences or an averaged payment, could alter the consumption decision of a household (McDermott et al., 1980).

What price signal about consumption have AMP consumers received? McDermott et al. (1980) stated that AMP plan payments would tend to understate peak consumption and cost and overstate off-peak consumption and cost. In other words, an AMP plan utility bill would not accurately reflect true consumption for a specified time period and, therefore, an AMP consumer would not receive the correct information about household energy consumption or cost. An averaged payment could cause an AMP consumer to increase consumption during peak consumption periods because the averaged payment would be lower than the actual monthly payment which would reflect actual benefits received. Conversely, an AMP consumer would reduce consumption during an off-peak consumption period when the averaged payment was higher than the actual benefits received from consumption. McDermott et al. (1980) stated that the AMP plan could produce an effect contrary to the desired promotion of conservation and efficiency. If AMP consumers were consciously aware that lower payments during a peak consumption period were for the protection of their budget from severely high-cost months, then this projection would not be serious. However, McDermott et al. (1980) concluded that if consumers were not attentive to this situation, increased consumption could possibly result.

Few studies investigated consumption and cost differences between AMP and non-AMP households. One study which was conducted in 1988 has provided insight into these differences. As part of an exploratory study focusing on electricity consumption and cost, Williams et al. (1988) found that significant differences existed between AMP and non-AMP consumers ($\alpha = .05$). Using the t-test statistic, analysis revealed that AMP consumers used more electricity per month than non-AMP consumers. Likewise, these households had higher monthly utility bills than did other households.

To evaluate seasonal usage and cost, a mean for each was formulated for summer (May to September) and for winter (October to March) months. Between these two seasons, the summer months had the significantly higher usage and cost means. Each of the means showed significant differences in electricity usage between AMP and non-AMP consumers. Additionally, seasonal cost means and total cost means exhibited significant differences between costs paid by AMP and non-AMP households.

This study further analyzed differences in size of houses in which AMP and non-AMP consumers reside and land and improvement values which served as economic indicators (Williams et al., 1988). In assessing mean square footage of the residential units, significant differences in size were found. Non-AMP households lived in significantly larger homes than AMP households. When given conclusions of previous studies which indicated that larger homes consumed higher quantities of energy, this finding was startling since AMP households used significantly more electricity during winter and summer months.

Differences between AMP households and non-AMP households were also significant for property values. Land and improvement property values of non-AMP households were significantly greater than that of AMP households. Williams et al. (1988) concluded that AMP households will tend to be less economically prosperous than non-AMP households. This finding was surprising considering a majority of previous studies which had concluded that household income was positively related to energy consumption. In this particular study, less affluent households were higher energy consumers than more prosperous households were (Williams et al., 1988).

Further analysis of these particular data were also conducted (Routh, Weber, & Williams, 1989). A significant difference was found when square footage was assessed for variation using analysis of variance test. Using Duncan's post hoc test, a significant difference was assessed in size of house between households outside of the SMSA defined by the U.S. Bureau of Census (1980), otherwise known as rural areas. Non-AMP households in rural areas had significantly larger homes on the average than AMP households in the same areas. However, significant differences were not measured between AMP and non-AMP households whose homes were within the SMSA or urban areas.

Variance in electric usage was also assessed which revealed unusual results (Routh et al., 1989). A significant difference in electric usage between AMP and non-AMP households in urban areas was found using a Duncan's post hoc test. AMP households consumed significantly more electricity than non-AMP households consumed within urban areas. This finding was particularly surprising when given the results of the square footage analysis. One would have expected to find significant differences in energy usage between rural households rather than urban households. Routh et al. (1989) concluded that other factors, such as payment plan choice, could have contributed to the difference in energy consumption between AMP and non-AMP households within urban areas.

The results of this pilot study guided the direction of the present study. Questions which were posed in Chapter I emerged as a consequence of this exploration. In addition to the McDermott et al. (1980) recommendation, Williams et al. (1988) also concluded that further analysis was needed to identify the influence of AMP plans on household energy consumption and cost.

## Summary

Energy costs and consumption levels remained a vital concern to low income and fixed income households, although the public and policy makers gradually became less attentive to energy as a national issue. As a result, utility regulators and policy makers searched for methods to modify the impact of increasing energy costs on these households. However, financial problems with regard to energy remained for these limited resource groups.

Economic theory advocated that price significantly impacted demand and, thus, consumption levels of energy. However, price elasticity studies, particularly those which investigated electricity demand and price, concluded that demand was inelastic, especially in the short run time period. Thus, other factors would play an important role in determining household energy consumption levels.

Previous research suggested that a relationship existed between structural features, family characteristics, and energy consumption. Since conclusions were contradictory, further exploration was needed to clearly define this association.

Since the implementation of the AMP plan policy, research has been limited as to AMP plan's effect on household energy usage and cost. Recent research indicated that AMP plans could be disguising the appropriate cost signal to AMP consumers. Thus, these households experienced significantly higher consumption levels than other consumers. Because this policy was devised to assist households with limited resources, further investigation was needed to determine the consequences of this strategy.

# CHAPTER III

# METHODOLOGY

## Introduction

The purpose of this project was to assess the effect of payment plan choice interacting with specific housing characteristics, a household income proxy, and residential location on total and seasonal household electric consumption and cost. Data in this pilot study were collected and analyzed according to this stated purpose.

## Sample

A five percent sample of AMP consumers (300 households) was randomly selected from an Oklahoma electric utility company's customer accounts. Additionally, an equal number of non-AMP customers (300 household) was randomly drawn. The utility company requested that contact not be made with consumers. Therefore, other sources of dwelling and household data were explored.

To obtain information about dwellings and households, data were collected from county assessment records. Appraised property value, square footage, age of house, and physical condition data were provided by these records.

County assessment records were classified as a secondary data source. Public domain information could provide large quantities of data along with several measures of any particular variable. Babbie (1986) stated that secondary data sources were advantageous because these sources were less expensive and provided data much faster than original surveys.

County assessment records have been maintained in Oklahoma by county assessors who have been elected as officials of county governments. Records have been listed by legal description of residential, commercial, and industrial property within each county. In property assessment procedures, field appraisers have visited property sites noting improvements, listing dwelling characteristics, and rating structures according to established criteria. From these notations, appraised values of land and improvements have been calculated.

An advantage to using property assessment records as a data source was that several pieces of information such as age, square footage, and physical condition of structures could be obtained about each property. Other information about construction and dwelling characteristics were also available from these records. A disadvantage to this data source was that information lacked consistency from all counties. Some counties collected extensive information about interior and exterior structural characteristics and appliance stocks, while other counties' records were limited to exterior information. Thus, inconsistencies in these records posed challenges in obtaining sufficient and consistent data for analysis.

From the 600 records in the sample, households with incomplete utility cost and usage records were eliminated. Mobile homes, commercial property, and public housing units were deleted along with customer records which were located outside the Oklahoma service area. Additionally, a record was excluded if the utility electric meter location listing could not be translated into a legal description (Williams et al., 1988). From the 600 households, 496 records had complete cost and consumption data. These 496 records represented the sample which would be utilized in this study. Specific components of the analysis could cause the sample size to vary because of available data.

## Methodology

This project was classified as explanatory research which was defined by Babbie (1986) as the reporting of relationships. The relationship between payment plan choice, specific housing characteristics, a household income proxy, location of residence, and household electric consumption and cost was explored by using nonexperimental data. The justification for selecting these variables was previously discussed in the literature review. A model was conceptualized after review of the literature to represent this relationship between variables (see Figure 1). Variables which represented these characteristics were devised from data source information discussed above.

Quantitative methods were utilized for analysis of the project's objectives. Babbie (1986) identified survey research and data records, such as monthly electric utility consumption and cost records, as examples of quantitative methods. A notation system which counted and recorded items as measured was employed in this project.

## Dependent Variable

The dependent variables in this study were total and seasonal household electricity consumption and cost. Monthly electricity consumption data were represented by units of kiloWatt Hours (KWH). Monthly electricity costs equaled the monthly charges in dollars. These costs were recorded on actual monthly bills received by non-AMP consumers. However, AMP consumers received monthly bills which reflected averaged charges. In this study, AMP consumers' costs were recorded as actual charges that they would have received if they were not participating in the AMP plan. Thus, actual monthly costs for AMP and non-AMP consumers were utilized rather than averaged monthly charges.

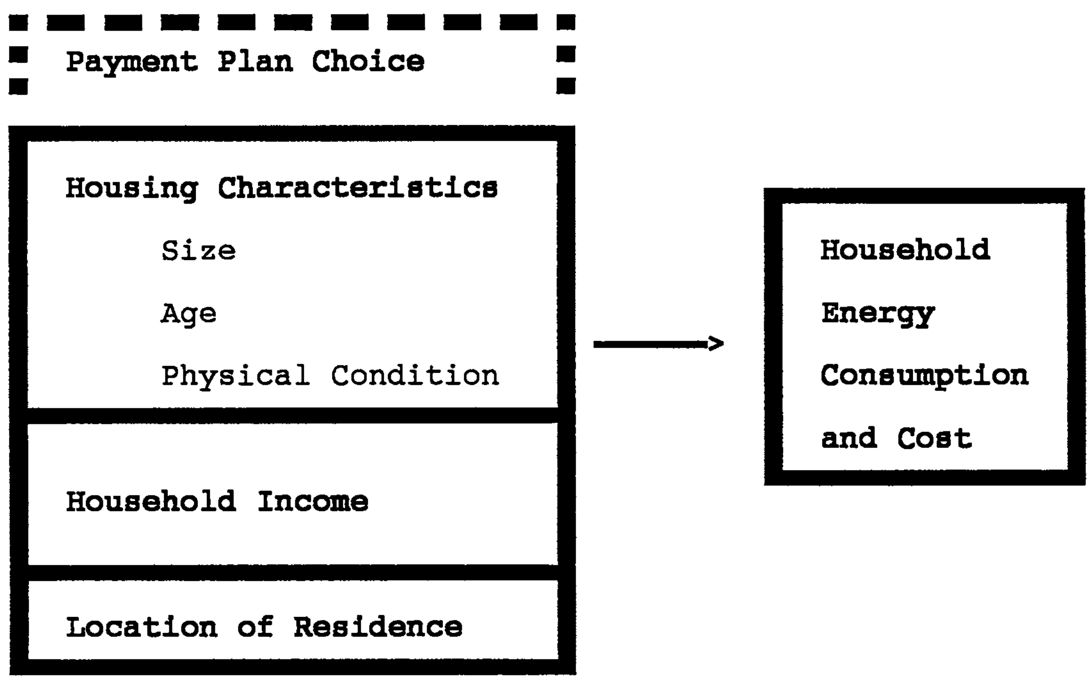



Figure 1. Conceptual Model of Influences on Household Energy Consumption and Cost.

Total consumption and cost were divided into winter and summer seasonal consumption and cost values. Winter season usage and cost were formulated by assessing a mean for each variable from the months of October to March. Likewise, summer usage and cost was devised by calculating a mean consumption and cost from the months of May to September (Williams et al., 1988).

Independent Variables

Age of house, house size, and physical condition were chosen as independent variables to represent specific housing characteristics. Additionally, payment plan choice, a household income proxy, and location of residence were included in the analysis as independent variables.

Age of house was recorded as the year that construction on the house was completed. House size was entered as the actual square feet of the residential living space. Square feet of garage areas, porches, and other buildings were excluded.

The physical condition variable was a comparison of present physical condition to a new physical condition expressed in a percentage. Field appraisers, which were representatives from county assessors' offices, assigned this percentage according to a structure's physical depreciation. Structures were graded according to maintenance and condition of exterior and interior walls, doors, windows, and roofs (K. Brunken, personal communication, September 18, 1989). A lower physical condition percentage indicated that a structure was greatly deteriorated or decaying. A higher percentage signified greater maintenance of a structure.

Payment plan choice was established as a dichotomous variable. The sample was distinguished as households who participated in the AMP plan and those who did not participate in this billing option. Each customer's household income was represented by a proxy variable which equaled the combined appraised values of land and improvements on property in which each customer resided. The proxy was utilized to indicate the relationship of income and, thus, economic status for these households. Therefore, this variable was not used as a direct measure of annual income. Appraised values of land and improvements were calculated by county assessor offices and represented approximate market values of these properties. Appraised value of house and land as a household income proxy variable was previously utilized in economic literature (Howe & Linaweaver, 1967; Grima, 1973; Danielson, 1979; Jones & Morris, 1984).

Residences were classified as rural or urban for the dichotomous variable, location of residence. Those meter listings which were located in counties outside the SMSA, as established by the U.S. Bureau of Census (1980), were categorized as rural residences. Alternatively, those addresses which were located in counties inside the SMSA were labeled urban residences (U.S. Bureau of Census, 1980). The urban area of Oklahoma City had the majority of records. However, rural areas from across Oklahoma were represented in the sample.

From the literature review, price was consistently identified as an important variable to consider, particularly for demand estimation equations. For the utility company from which the sample was obtained, a declining block price schedule had been assigned for the months of November to May. Between June and October, a flat price schedule was utilized, regardless of consumption levels of households. The price schedule, as an independent variable, was excluded from the study because of the following preliminary analysis. An analysis of variance was conducted to determine whether mean usage pattern was significantly different between the flat price schedule and declining block price schedule periods. This analysis revealed that the mean usage patterns were not significantly different across the sixteen month period between AMP and non-AMP households. The F value of .88 was not significant at the .05 level (Table V). This result indicated that the pattern of energy usage during the declining block price schedule period was the same as the pattern of energy usage during the flat price schedule period. Thus, the price

TABLE V

ANALYSIS OF VARIANCE OF PRICE SCHEDULE EFFECT ON CONSUMPTION

| Source | df | S.S. | M.S. | F | PR > F |
|---|---|---|---|---|---|
| Price Schedule | 2 | 1.354 | 0.677 | 0.88 | 0.417 |
| Error | 317 | 244.671 | 0.771 | | |
| Corrected Total | 319 | 246.025 | | | |

variable lacked magnitude and duration and, therefore, was deleted as a variable in the proposed analysis and model.

## Data Collection

McDougall et al. (1981) stated that although collection of consumption data from utility companies was quite costly and time consuming, this method was a foundation for future energy research efforts. This project employed this advocated method and collected monthly consumption and cost data from the utility company during 1987. Utility data were furnished for a sixteen month period from December, 1985, to March, 1987.

Appraised property values and square footage data were collected from property assessment records located in county seats during 1987. Age of house and physical condition data were obtained during a second visit in 1989. County assessors' offices were contacted by mail and county office visits. The data collection process involved 26 counties to which visits were made and 20 counties which sent data by mail. Data were collected from 46 counties which were over one half of the 77 counties in Oklahoma.

## Analysis

Monthly consumption and cost data were coded and incomplete records were deleted. Data from property assessment records were coded and merged with monthly consumption and cost data. Monthly consumption and cost, age of house, square footage, household income proxy, and physical condition variables were coded as continuous values. Payment plan choice and location of residence were represented by nominal level data.

To achieve the established objectives and analyze data for model development, multiple regression with stepwise techniques was utilized. Lewis-Beck (1980) stated that this statistic offered a fuller explanation of a dependent variable. Additionally, several independent variables could be incorporated into an equation, and effects of each influence were specifically determined with this method (Lewis-Beck, 1980). Lewis-Beck (1980) asserted that interaction effects existed when an influence of one particular independent variable was affected by a value of another independent variable. Thus, an equation was designed to determine the impact of independent variables whose effect on the dependent variable could interact with other variables as cross-product or interaction terms (Neter, Wasserman, & Kutner, 1983). Previous research provided the justification for these hypothesized interactions by concluding that energy consumption could be affected by structural as well as household characteristics. These effects could increase the magnitude of the explained variance in the final analysis.

A stepwise regression technique was administered to predict household electric consumption and cost with the "best" set of independent variables (Neter et al., 1983). Chatelain (1981) stated that by sequentially selecting independent variables which greatly augmented explained variance at each step, redundant variables would be eliminated from the equation. This analysis was valuable in situations where numerous variables could contribute to the dependent variable.

To assess the effect of independent variables interacting with payment plan choice on total and seasonal household electric consumption and cost, Equation 3 was devised.

$$\hat{Y}_i = b_0 + b_1PLAN + b_2SIZE + b_3(PLAN*SIZE) + b_4AGE + b_5(PLAN*AGE) + b_6CONDITION + b_7(PLAN*CONDITION) + b_8INCOME + b_9(PLAN*INCOME) + b_{10}LOCATION + b_{11}(PLAN*LOCATION) + e \quad (3)$$

where as

$Y_1$ = Total household electric consumption

$Y_2$ = Seasonal household electric consumption

$Y_3$ = Total household electric cost

$Y_4$ = Seasonal household electric cost

$b_0$ = Intercept

PLAN = Payment Plan Choice

SIZE = Square Footage of Residence

AGE = House Age

CONDITION = Physical Condition of the Structure

INCOME = Appraised Property Value as a Proxy Variable for Household Income

LOCATION = Location of Residence

e = Error term

Equation 3 was also utilized to assess the effect on seasonal household electric consumption. Additionally, the effect on total and seasonal cost was determined by Equation 3. These analyses contributed in finalizing model development.

# CHAPTER IV

# RESULTS

## Introduction

The first objective for this study was to identify the effect of payment plan choice, specific housing characteristics, household income, and residential location on total household electricity consumption and cost. The second objective was to assess these influences on seasonal consumption and cost. Models were developed to represent these effects on consumption and cost which was the third objective. To achieve these objectives, analysis was reported utilizing ordinary least squares (OLS) regression with stepwise techniques to determine significance of the predictor variables and direction of effect. Modifications were made to the model which was proposed in Chapter III.

## Characteristics of the Sample

Means were calculated to describe specific housing characteristics of the sample. The average house size was 1,604 square feet. Homes of AMP consumers averaged 1,452 square feet, while non-AMP consumers' mean house size was 1,798 square feet. Therefore, AMP consumers' houses were smaller on the average than non-AMP consumers' residential units.

The mean year of residential construction for the total sample was 1961. This year indicated that on the average, house age of the sample was 26 years in 1987. The average year of construction for houses in which AMP consumers lived was also 1961. Similarly, mean year of construction for residential units in which non-AMP consumers occupied was 1960.

Physical condition of the residential units averaged 74.95 percent for the total sample. This percentage indicated that houses had structurally deteriorated approximately one fourth of the original condition on the average. Mean physical condition of houses in which AMP consumers resided was 76.66 percent. Non-AMP consumers' houses were 72.4 percent structurally sound or good on the average.

Mean value of appraised land and improvements was 79,273 dollars for the complete sample. This value was used as a proxy for household income and the analysis determined that non-AMP households had higher incomes on the average than did AMP households. The proxy for AMP consumers' household income averaged 65,677 dollars, while the proxy for household income averaged 96,890 dollars for non-AMP consumers.

A majority of the total sample (79 percent) resided in urban areas in comparison to 21 percent of the sample who were rural residents. Of the non-AMP consumers, 71 percent occupied urban locations, and 29 percent lived in rural areas. A higher proportion of AMP households (86 percent) were also urban residents. Rural households comprised 14 percent of the non-AMP sample.

### Electricity Consumption and Cost

Seasonal and total mean consumption levels were calculated for the sample. Average total consumption was 16,875 KWH. Households used 5,864 KWH on an average during winter months compared to an average of 6,462 KWH consumed throughout summer months.

Mean monthly, seasonal, and total usage for AMP and non-AMP households are presented in Table VI. For monthly consumption levels, AMP households' electricity usage was consistently greater compared to non-AMP households' average usage levels (see Figure 2). The highest mean usage periods for both types of households were the summer months.

For seasonal average electricity consumption, AMP households' average winter consumption exceeded non-AMP households' average usage level for the same season (see Figure 3). During the summer season, AMP households utilized over 1,800 KWH more than did non-AMP consumers. Mean total KWH usage differed by 3,402 KWH between AMP and non-AMP consumers. Thus, AMP households' consumption during the total period was higher on the average as compared to

TABLE VI

AVERAGE ELECTRIC CONSUMPTION

| Period | | AMP Households n=258 | Non-AMP Households n=238 |
|---|---|---|---|
| Month | | | |
| December | 1985 | 1166.27 | 1014.87 |
| January | 1986 | 1169.55 | 999.43 |
| February | 1986 | 937.76 | 827.77 |
| March | 1986 | 849.93 | 726.17 |
| April | 1986 | 742.98 | 636.26 |
| May | 1986 | 813.68 | 647.58 |
| June | 1986 | 1119.83 | 867.34 |
| July | 1986 | 1891.53 | 1374.31 |
| August | 1986 | 2059.09 | 1505.67 |
| September | 1986 | 1484.43 | 1083.92 |
| October | 1986 | 1151.09 | 847.70 |
| November | 1986 | 863.15 | 743.77 |
| December | 1986 | 1067.39 | 977.34 |
| January | 1987 | 1163.00 | 1038.01 |
| February | 1987 | 1105.93 | 991.60 |
| March | 1987 | 922.32 | 823.39 |
| Season | | | |
| Winter | | 6272.89 | 5421.81 |
| Summer | | 7368.57 | 5478.82 |
| Total[a] | | 18507.95 | 15105.13 |

[a]averaged for the sixteen month period.

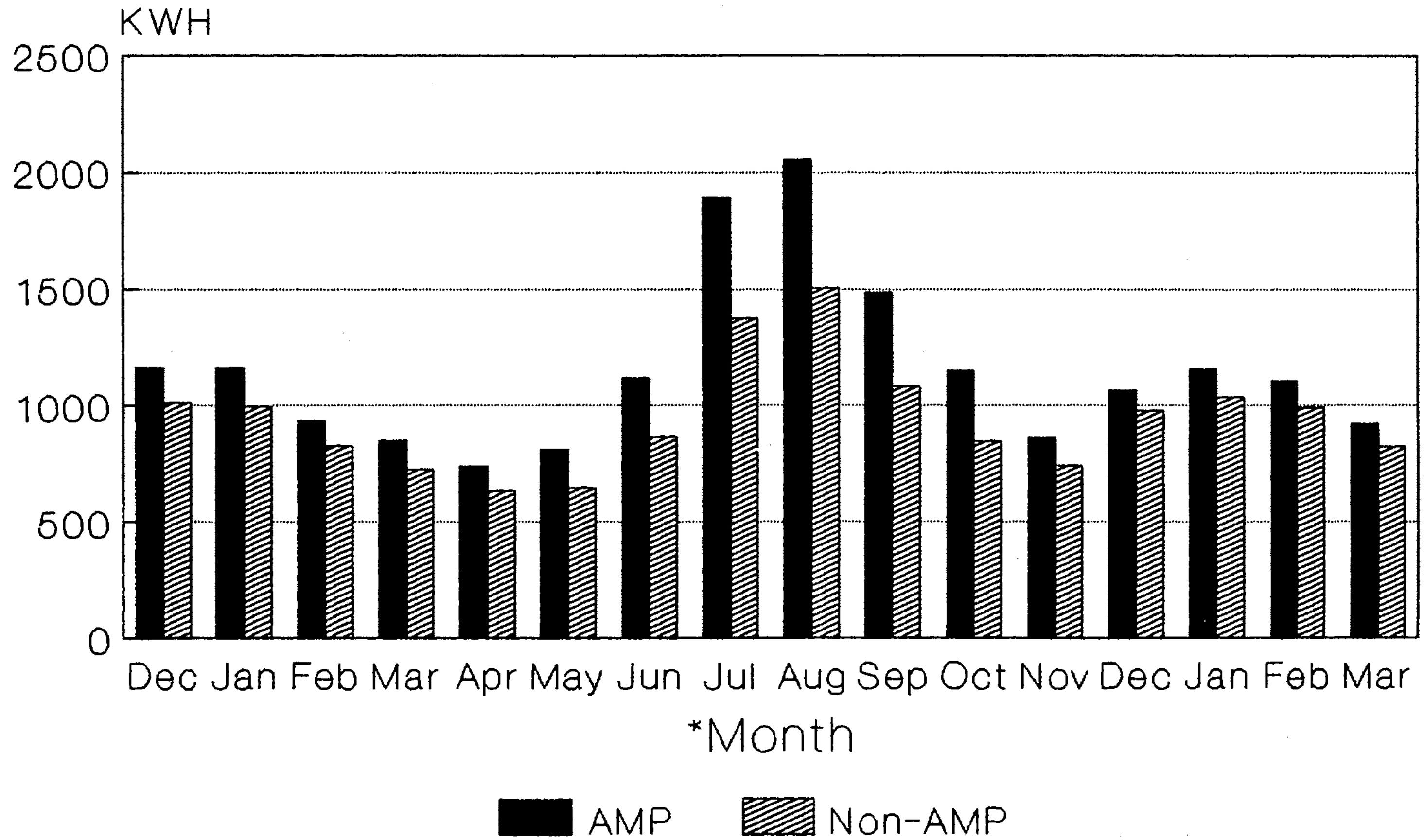



Figure 2. Monthly Mean Usage

*December 1985 to March 1987

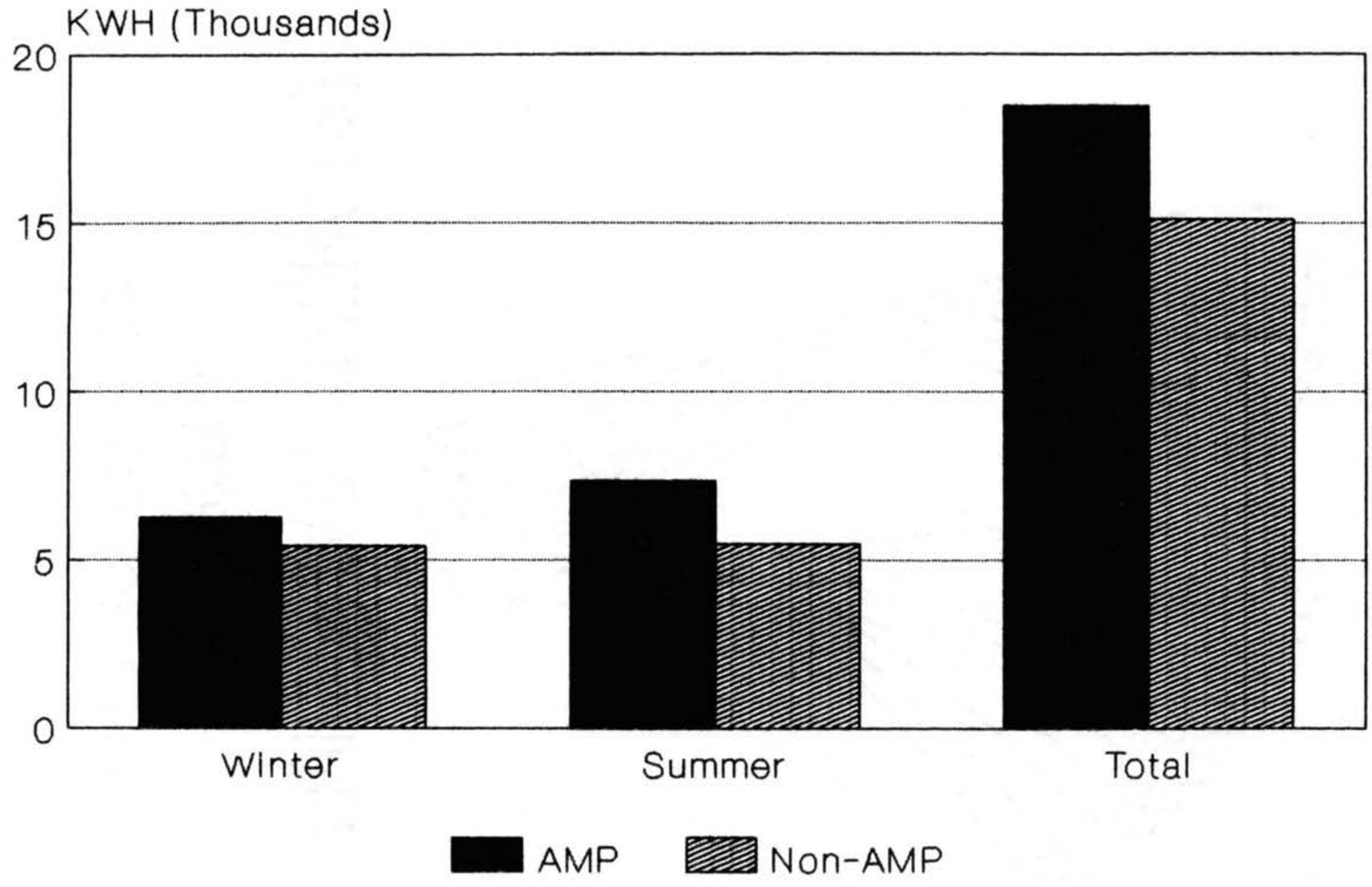



Figure 3. Seasonal and Total Mean Usage

non-AMP households' average consumption quantities.

Households in the sample paid an average of 1,152 dollars for total consumption during the sixteen month period. Winter costs averaged 370 dollars for all households, while mean summer costs were 480 dollars.

Increased average monthly electric usage was associated with higher average monthly costs for AMP households versus those of non-AMP households (Table VII). Additionally, summer monthly costs were higher than other monthly periods (see Figure 4). AMP households experienced higher seasonal costs than non-AMP households (see Figure 5). Average summer electric cost for an AMP household surpassed a non-AMP household's summer cost by approximately 122 dollars. Ultimately, AMP households faced higher total electric costs versus non-AMP households' total costs on the average.

Descriptive analysis found that on the average, AMP households' monthly, seasonal, and total electric consumption were greater than non-AMP households'. Average cost levels for these period were consistent with consumption findings. AMP households lived in smaller homes and had lower household incomes than did non-AMP households. Additionally, physical condition and age of the structures were similar on the average for both types of households.

## Statistical Analysis Process

Evaluating the effect of the predictor variables on household electricity consumption and cost involved two

TABLE VII

AVERAGE ELECTRIC COST

| Period | | AMP Households n=258 | Non-AMP Households n=238 |
|---|---|---|---|
| Month | | | |
| December | 1985 | $70.22 | $62.51 |
| January | 1986 | 73.36 | 64.44 |
| February | 1986 | 63.76 | 56.30 |
| March | 1986 | 59.45 | 51.29 |
| April | 1986 | 54.11 | 46.66 |
| May | 1986 | 56.10 | 47.20 |
| June | 1986 | 84.69 | 68.12 |
| July | 1986 | 138.44 | 103.94 |
| August | 1986 | 152.13 | 114.86 |
| September | 1986 | 107.86 | 82.66 |
| October | 1986 | 87.27 | 67.53 |
| November | 1986 | 56.79 | 49.94 |
| December | 1986 | 64.13 | 59.14 |
| January | 1987 | 65.89 | 59.57 |
| February | 1987 | 63.00 | 56.23 |
| March | 1987 | 56.94 | 51.17 |
| Season | | | |
| Winter | | 394.03 | 343.59 |
| Summer | | 539.22 | 416.78 |
| Total[a] | | 1254.16 | 1041.58 |

[a]averaged for the sixteen month period.

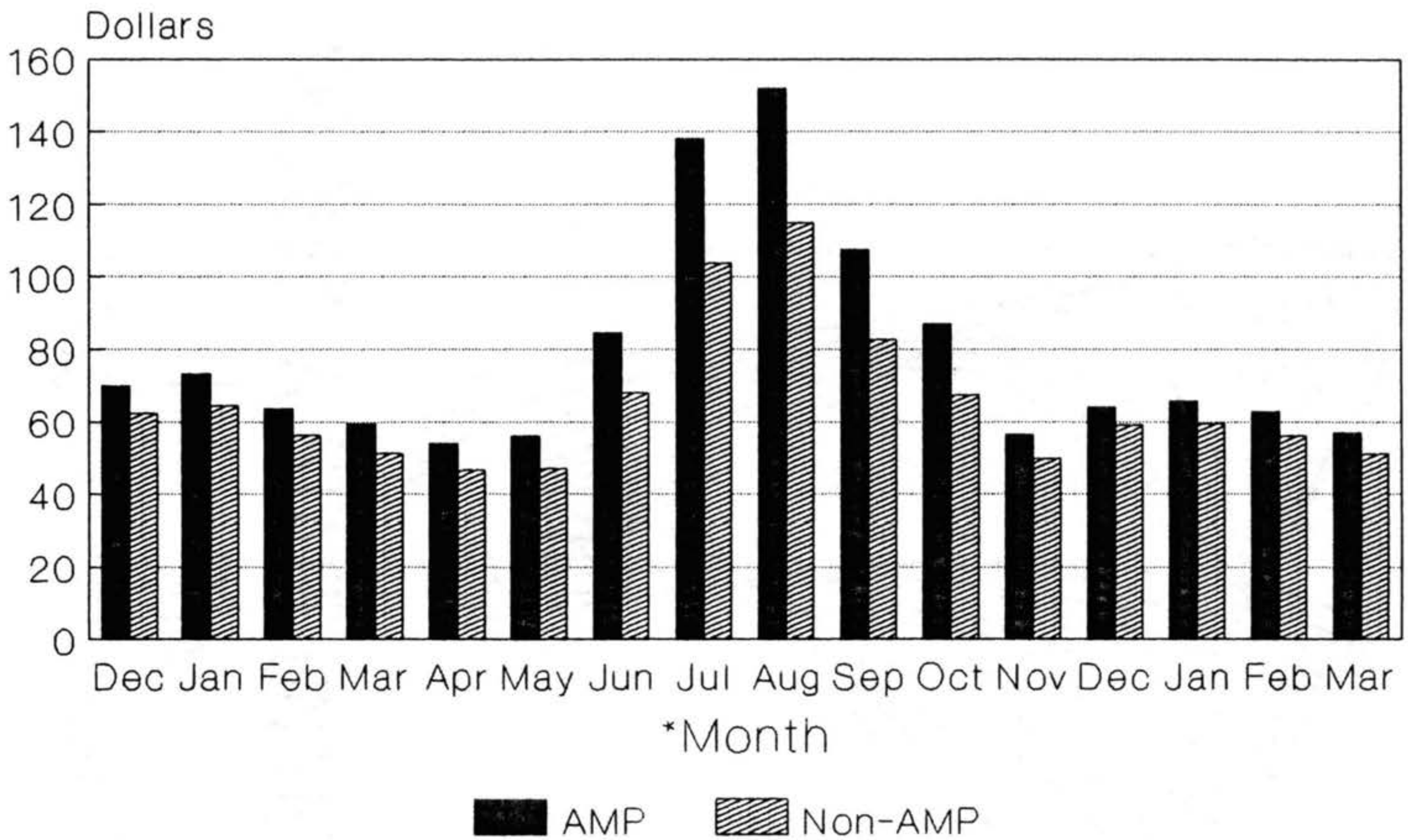



Figure 4. Monthly Mean Cost

*December 1985 to March 1987

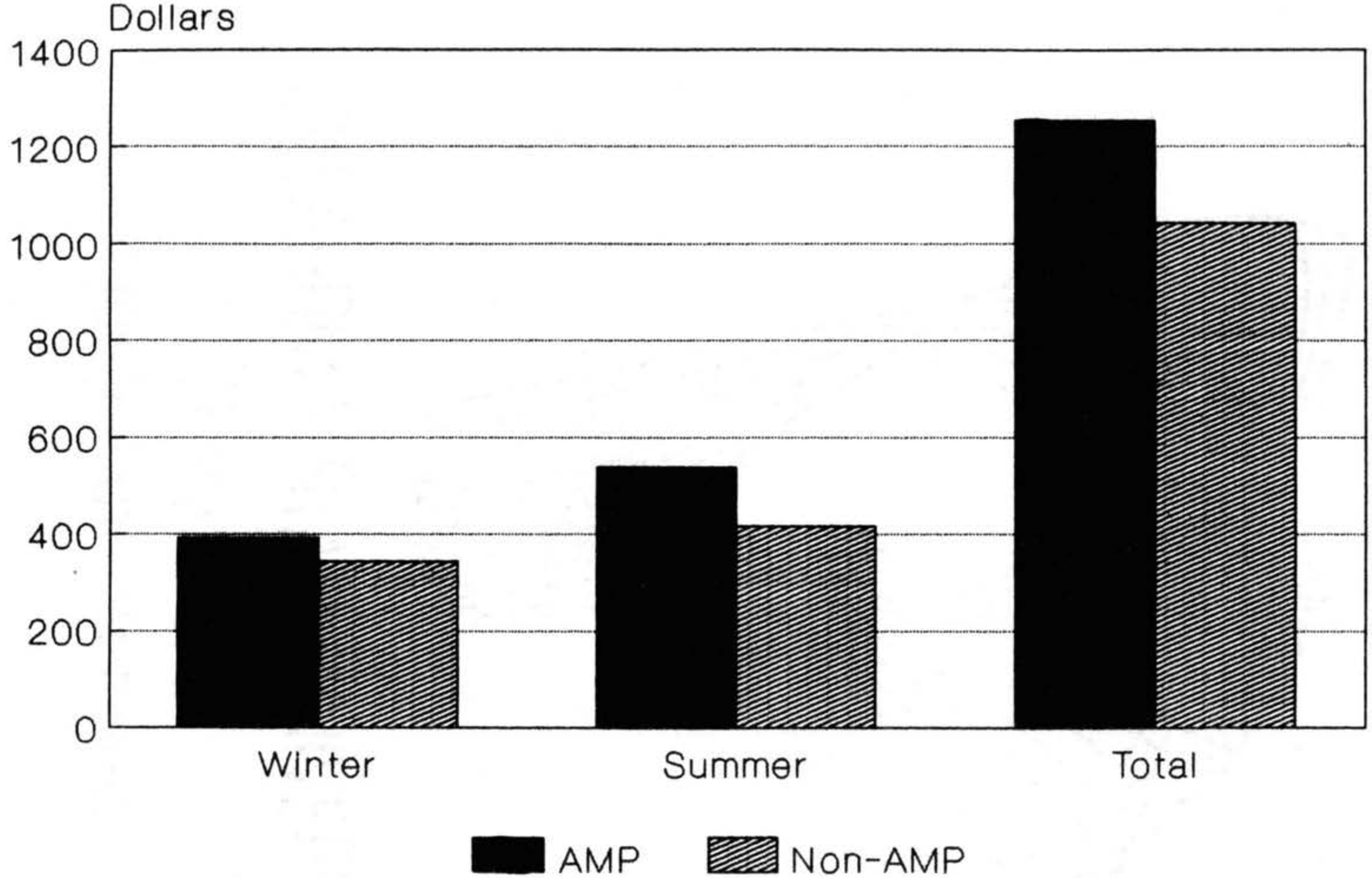



Figure 5. Seasonal and Total Mean Cost

analytical steps: (a) determination of the "best" combination of predictor variables with stepwise regression procedures and, (b) assessment of the reduced set of statistically significant variables with multiple regression analysis. The following discussion will describe these analyses in detail.

Numerous stepwise procedures were available to select the "best" set of predictors. However, one stepwise procedure, referred to as "maximum $R^2$ stepwise" technique chose the combination of variables for the regression model at each step that maximized the coefficient of multiple determination ($R^2$). $R^2$ was defined as a measurement of the proportionate reduction of total variation in a dependent variable associated with the use of the set of predictor variables (Neter et al., 1983). Within this stepwise procedure, combinations of variables were evaluated at each step with the criterion of maximizing $R^2$ to the fullest extent, regardless of the variables which were selected in the previous steps. For example, household income and physical condition could be the "best" combination of two variables among the pairs of variables in maximizing $R^2$ in step two. However, in step three, participation in the AMP plan, house size, and household income could be the "best" set of three to maximize $R^2$. Thus, maximum $R^2$ stepwise technique performed all possible regressions within each step and chose the "best" set of variables for each phase according to the maximum $R^2$ criterion. With this particular analysis, the collection of variables was more critical than the individual predictors.

For this study, the model for analysis which was derived from the maximum $R^2$ stepwise technique was selected according to the least mean squared error (MSE) criterion. Thus, from all possible combination of predictor variables, a regression model was chosen if the MSE for that particular model was the lowest or least compared to other models of variable sets. In other words, for an analysis which described the effect on total KWH consumption, the combination of independent variables which had the least MSE compared to other sets of independent variables was selected as the "best" set of predictor variables, regardless of step or entry into the procedure (Neter et al, 1983).

MSE was defined as a measure of bias and sampling variation (Neter et al., 1983). A minimal MSE was desirable because this finding indicated the degree to which the predicted or expected levels of the dependent variable departed or deviated from the observed levels of the dependent variable on the average (Neter et al., 1983).

The second step in the analyses of this project was to regress the statistically significant predictor variables, selected from the maximum $R^2$ stepwise procedure, on the dependent variables in a reduced model. Predictor variables which indicated statistical significance ($\alpha = .1$) in the stepwise procedure were analyzed with OLS regression. OLS regression which provided unbiased efficient parametric estimates identified the effect of these predictor variables on household electricity consumption and cost.

A reoccurring problem in most multiple regression analyses has been intercorrelation or multicollinearity. Stevens (1986) cited two problems associated with multicollinearity as: (a) the size of $R^2$ was severely limited and (b) determination of the importance of a given predictor was made difficult because the effects of predictors were confounded due to the high correlation among these variables. Interpretations of an analysis which was plagued by this problem could also be restricted because the analysis which included pairs of highly correlated variables would be suspect (Bieber, 1988). In addition, variables which were highly correlated would not indicate statistical significance because of the shared explanation power.

Pearson Product-Moment Correlation was utilized to determine the association between variables. Table VIII presents the results of the correlation analysis for all variables in this study. As would be expected, total and seasonal consumption and cost levels, which were the dependent variables in this study, were highly related, and all were statistically significant at the 0.001 level.

House age, physical condition, house size, and participation in the AMP plan were positively correlated with the designated dependent variables at significant degrees. Location of residence was significantly related to summer seasonal consumption and, likewise, summer cost.

## TABLE VIII

## PEARSON PRODUCT-MOMENT CORRELATION MATRIX

| | Total KWH | Winter KWH | Summer KWH | Total Cost | Winter Cost | Summer Cost | Plan | Size | Age | Condition | Income | Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total KWH | 1.00 | | | | | | | | | | | |
| Winter KWH | 0.961*** | 1.00 | | | | | | | | | | |
| Summer KWH | 0.812*** | 0.650*** | 1.00 | | | | | | | | | |
| Total Cost | 0.983*** | 0.912*** | 0.882*** | 1.00 | | | | | | | | |
| Winter Cost | 0.965*** | 0.982*** | 0.714*** | 0.947*** | 1.00 | | | | | | | |
| Summer Cost | 0.795*** | 0.629*** | 0.995*** | 0.875*** | 0.700*** | 1.00 | | | | | | |
| PLAN | 0.150*** | 0.088* | 0.255*** | 0.184*** | 0.122** | 0.245*** | 1.00 | | | | | |
| SIZE | 0.166** | 0.155* | 0.144* | 0.157** | 0.154* | 0.133* | -0.140* | 1.00 | | | | |
| AGE | 0.305*** | 0.292*** | 0.276*** | 0.318*** | 0.328*** | 0.256*** | 0.025 | 0.226*** | 1.00 | | | |
| CONDITION | 0.428*** | 0.375*** | 0.412*** | 0.446*** | 0.417*** | 0.383*** | 0.128* | 0.234*** | 0.821*** | 1.00 | | |
| INCOME | 0.019 | 0.065 | 0.063 | 0.006 | 0.063 | 0.067 | -0.071 | 0.317*** | 0.462*** | 0.529*** | 1.00 | |
| LOCATION | -0.025 | -0.003 | -0.091* | -0.045 | -0.023 | -0.090* | -0.174*** | 0.317*** | -0.038 | -0.159* | -0.091 | 1.00 |

***p<0.001
**p<0.01
*P<0.05

These relationships were negative which suggested that urban households possessed higher consumption and costs during this season.

Some independent variables in this study were significantly associated with each other; however, most were not so greatly correlated to produce concern regarding multicollinearity. One pair of variables, house age and physical condition, were highly correlated above the 0.80 level which suggested problems of intercorrelation. Literature was explored to effectively deal with this problem.

Several solutions were suggested in the literature to alleviate this problem. However, one treatment was adopted for this study. Lewis-Beck (1980) and Steel and Torrie (1980) stated that by dropping one of the variables from the highly correlated pair, explained variance of the remaining variable would be maximized in the regression model. A caution was issued that by doing so, specification error could exist. However, by analyzing models which first included the age of house variable while excluding the physical condition variable and then, vice versa, the specification error could be more fully assessed (Lewis-Beck, 1980).

As stated in Chapter II, previous literature cited age of structure as a significant predictor of energy consumption. Conversely, few studies explored physical condition as a significant contributor to this situation.

Inaccessible or unavailable data about physical condition or maintenance of the house could have posed a barrier for including this variable in previous research. Energy consumption was attributed to the structure of the dwelling beyond other influences as stated in the literature review. Additionally, engineers consistently argued that condition of the structure critically affected the heating and cooling load of the house (S. Harp, personal communication, September, 1989).

To determine whether house age or physical condition would remain in the analysis, the least MSE criterion was applied to the analyses which utilized the maximum $R^2$ stepwise technique. A consistent result occurred from these analyses. Sets of variables which included physical condition and its respective interaction term, while excluding age of house, had higher $R^2$ values and lower MSE findings when compared to those of similar analysis which included house age in addition to the respective interaction term and excluded physical condition. That is, variation in the dependent variable was not explained as fully by sets of variables which included age of house rather than physical condition (see Appendix). The combinations which included physical condition had higher variance explanation and lower prediction error than did variable sets which included only age of house and its respective interaction term. Thus, from these analyses utilizing the maximum $R^2$ stepwise techniques and the least MSE criterion, it was concluded that age of house and the respective interaction term would be deleted. Conclusions about results would be drawn from the analyses which included physical condition and the interaction term between participation in AMP plan and physical condition as variables.

This study incorporated interaction terms in order to more fully describe the linear relationship between sets of independent and dependent variables. Interaction terms allowed for the different linear contributions from each independent variable in describing the effect on total and seasonal household electricity consumption and cost. A description of the interpretation for these interaction terms was necessary to assist the reader in understanding the effect of AMP plans.

The inclusion of an interaction term or the PLAN variable in the regression model would indicate that participation in the AMP plan either could affect the constant level of consumption or cost, otherwise known as the intercept, or could influence the rate of consumption or cost associated with the specific predictor variable. Thus, the effects on consumption or cost due to the AMP plan could be different between AMP and non-AMP consumers.

A change in the constant level of consumption or cost would be interpreted when the variable, PLAN, was significant in the final regression equation. The intercept coefficient summed with the PLAN variable coefficient would yield a different constant level for AMP consumers.

A change in rate of consumption or cost would be derived when a predictor variable and the respective interaction term were statistically significant in the final model. The coefficients of each would be summed to indicate a different rate of consumption or cost for AMP consumers.

Interaction terms could also impact the number or type of predictor variables which affected consumption or cost for AMP households. For example, if the interaction term between household income and participation in the AMP plan was a statistically significant variable in the final model and household income was not significant, then household income would significantly influence cost or consumption for AMP consumers, but not for non-AMP households. Thus, the effect of household income would be considered significant for AMP households' consumption or cost, however, not significant for non-AMP households (P.L. Claypool, personal communication, October, 1989).

## Effect of AMP Plan

### Winter Electricity Consumption

The set of variables which described the effects on winter KWH usage and were chosen with the least MSE criterion was presented in Table IX. This combination of variables which included physical condition, residential location, house size, and the interaction between household income and participation in the AMP plan explained 18.68

TABLE IX

MULTIPLE REGRESSION RESULTS FOR
WINTER ELECTRICITY CONSUMPTION

| | Full | | | Reduced | |
|---|---|---|---|---|---|
| Predictor | Beta | F | Step | Beta | t |
| CONDITION | 68.121 | 18.45*** | 1 | 70.782 | 4.508*** |
| PLAN*INCOME | 0.019 | 5.67* | 2 | 0.021 | 2.678** |
| LOCATION | 1507.161 | 4.43* | 3 | 1520.477 | 2.123* |
| SIZE | 0.312 | 1.33 | 4 | | |
| Intercept | -946.111 | | | -780.27 | -0.692* |
| $R^2$ | 0.1868 | | | 0.1813 | |
| df | 4 | | | 3 | |
| F-ratio | 11.26*** | | | 14.55*** | |
| MSE | 10,951,292.70 | | | 10,969,406.70 | |

***$p<0.001$
**$p<0.01$
*$p<0.1$

percent of the variation in winter electricity usage. However, house size was not statistically significant and, therefore, was excluded in the reduced OLS regression analysis.

Analysis in the reduced model implied that physical condition, residential location, and the interaction between household income and AMP plan participation contributed to 18.13 percent in the variance of winter KWH consumption. However, the significance of the interaction term suggested that the effects on winter KWH usage were different between AMP and non-AMP consumers.

For non-AMP consumers, the regression equation which expressed the effects on winter consumption for these households was as follows:

$$\text{Winter KWH} = -780.27 + 70.782\ (\text{CONDITION}) + 1520.477\ (\text{LOCATION}). \tag{4}$$

For AMP consumers, Equation 5 was implied from the findings:

$$\text{Winter KWH} = -780.27 + 70.782\ (\text{CONDITION}) + 0.021\ (\text{INCOME}) + 1520.477\ (\text{LOCATION}). \tag{5}$$

Without participation in the AMP plan, non-AMP consumers' winter electricity usage was affected by physical condition of the home and residential location. A one percent increase in physical condition, increased winter consumption by approximately 71 KWH. The direction of effect for residential location was inconclusive due to a factor of intercorrelation. Conclusions were guarded as to the direction of this influence's effect.

As illustrated in Equation 5, the effect of participation in the AMP plan implied that the AMP consumers' winter consumption was influenced by an additional variable, household income. Furthermore, this finding indicated that as AMP consumers' household income increased by one dollar, winter consumption was anticipated to increase by 0.021 KWH. Although this influence suggested a small increase in the rate of consumption, this variable was statistically significant at the 0.01 level.

From this analysis, it was concluded that participation in the AMP plan significantly influenced winter KWH consumption. A non-AMP household's winter consumption was significantly impacted by the home's physical condition and residential location. However, household income additionally affected a AMP household's winter consumption. Therefore, household income in addition to physical condition and location of residence significantly contributed to determining a AMP household's winter electricity consumption.

Winter Electricity Cost

The results for winter electricity cost were similar to the results for winter consumption. For winter cost, findings from the maximum $R^2$ stepwise procedure with least MSE criterion were presented in Table X. According to this analysis, 23.6 percent of the variation in winter electricity cost was explained by physical condition of the house, location of residence, house size, participation in the AMP plan, the interaction between AMP plan participation and household income, and the interaction between AMP plan participation and house size. However, participation in the AMP plan and the interaction between AMP plan participation and house size were not statistically significant at the 0.10 level and, thus, were excluded from the final model. The reduced model explained 22.54 percent of the variance in winter electricity cost for AMP and non-AMP households. However, this analysis produced different significant effects on winter cost for AMP and non-AMP customers.

Similar to the findings for winter electricity consumption, non-AMP consumers' winter costs were significantly affected by physical condition of the home and residential location. A one percent increase in physical condition was expected to increase household electricity cost by approximately four dollars. Although the direction of effect for residential location was undetermined because of an intercorrelation factor, these results indicated this influence was statistically significant. Equation 6 was devised for non-AMP consumers from the results of the OLS regression analysis:

TABLE X

MULTIPLE REGRESSION RESULTS FOR
WINTER ELECTRICITY COST

| | Full | | | Reduced | |
|---|---|---|---|---|---|
| Predictors | Beta | F | Step | Beta | t |
| CONDITION | 2.889 | 15.58*** | 1 | 3.281 | 4.814*** |
| PLAN*INCOME | 0.001 | 4.26* | 2 | 0.001 | 6.60** |
| LOCATION | 61.122 | 3.93* | 3 | 59.890 | 1.947* |
| SIZE | 0.076 | 4.16* | 4 | 0.019 | 1.633 |
| PLAN*SIZE | -0.064 | 2.65 | 5 | | |
| PLAN | 66.297 | 1.37 | 6 | | |
| Intercept | 3.0151 | | | 46.994 | 0.333 |
| $R^2$ | 0.2360 | | | 0.2254 | |
| df | 6 | | | 4 | |
| F-ratio | 9.99*** | | | 14.26*** | |
| MSE | 20,161.60 | | | 20,233.04 | |

***p<0.001
**p<0.01
*p<0.01

$$\text{Winter Cost} = 46.994 + 3.281\ (\text{CONDITION}) + 59.890\ (\text{LOCATION}). \tag{6}$$

Because of the statistical significance of the interaction term between household income and AMP plan participation, these findings suggested that AMP households' winter costs were influenced by this additional factor. The results for AMP households were stated in Equation 7:

$$\text{Winter Cost} = 46.994 + 3.281\ (\text{CONDITION}) + 0.001\ (\text{INCOME}) + 59.890\ (\text{LOCATION}). \tag{7}$$

These findings implied that an increase in household income of AMP consumers significantly increased winter electricity cost. In addition, physical condition and location of the residence also impacted winter costs for these households.

Summer Electricity Consumption

Several variables combined to form the "best" set of predictors of summer KWH usage with the least MSE. Table XI presented these variables which explained 35.85 percent of the variability in summer electricity consumption of AMP and non-AMP households.

The statistically significant variables for the reduced model included household income, physical condition of the

TABLE XI

MULTIPLE REGRESSION RESULTS FOR
SUMMER ELECTRICITY CONSUMPTION

| | Full | | | Reduced | |
|---|---|---|---|---|---|
| Predictors | Beta | F | Step | Beta | t |
| INCOME | 0.032 | 13.63*** | 1 | 0.031 | 3.612*** |
| CONDITION | 55.171 | 8.88** | 3 | 39.281 | 2.873** |
| LOCATION | 2433.426 | 7.18** | 4 | 2202.992 | 2.472* |
| PLAN*LOCATION | -2561.331 | 5.01* | 5 | -2308.021 | -2.044* |
| PLAN | 3882.801 | 4.87* | 6 | 1705.717 | 4.240*** |
| SIZE | 0.681 | 9.34** | 6 | 0.682 | 3.055** |
| PLAN*CONDITION | -29.443 | 1.62 | 7 | | |
| Intercept | -962.377 | | | 225.040 | 0.248 |
| $R^2$ | 0.3585 | | | 0.3531 | |
| df | 7 | | | 6 | |
| F-ratio | 15.41*** | | | 17.65*** | |
| MSE | 6,567,466.94 | | | 6,588,324.35 | |

***p<0.001
**p<0.01
*p<0.01

house, residential location, house size, participation in the AMP plan, and the interaction term between AMP plan participation and residential location. These predictor variables in the reduced model explained 35.31 percent of the variance in summer electricity consumption.

From these findings, it was determined that a non-AMP household who had a higher level of income and lived in a larger home which was in excellent physical condition would utilize more summer electricity compared to other households. Equation 8 modeled these effects on summer electricity consumption for non-AMP households:

$$\text{Summer KWH} = 225.04 + 0.031\,(\text{INCOME}) + 39.281\,(\text{CONDITION}) + 2202.992\,(\text{LOCATION}) + 0.682\,(\text{SIZE}). \quad (8)$$

The effect of residential location was also significant; however, the direction of effect was inconclusive because of an intercorrelation influence.

Due to the statistical significance of the PLAN variable, these findings indicated that for AMP households, participation in the AMP plan significantly influenced the constant level of consumption. Additionally, rate of consumption as influenced by residential location was modified due to the statistical significance of the respective interaction term. Equation 9 was devised from these results:

$$\text{Summer KWH} = 1930.757 + 0.031\ (\text{INCOME}) + 39.281\ (\text{CONDITION}) - 105.029\ (\text{LOCATION}) + 0.682\ (\text{SIZE}). \quad (9)$$

As indicated in Equation 9, AMP consumers' constant level of consumption for the summer season was higher than the constant level for non-AMP households.

For both types of households, the effects of household income, physical condition, and size were the same. A one dollar increase in household income, escalated summer consumption by 0.031 KWH. Likewise, summer consumption was expected to increase by 39.281 KWH with a one percent increase in the physical condition of the home. The effect of house size implied that electricity consumption during the summer season would increase 0.682 KWH with a one square foot increase. These findings suggested that a AMP household who had a higher level of income and resided in a large, urban home which was in excellent physical condition utilized increasing quantities of electricity during the summer season.

Summer electricity consumption was significantly changed by an additional factor, house size, when compared to the results of winter electricity consumption. Additionally, rate of consumption and constant level of consumption were significantly influenced by participation in the AMP plan.

<u>Summer Electricity Cost</u>

In comparison with summer KWH usage, the combination of predictor variables which met the least MSE criterion was identical to those identified for summer electricity cost. These predictor variables which were presented in Table XII explained 33.04 percent of the variation in summer electricity cost. All variables were statistically significant at the 0.10 level or greater which indicated, therefore, that the results of the OLS regression analysis were identical to the findings of the maximum $R^2$ stepwise procedure.

From these regression analyses, Equation 10 was devised to represent the effects on summer electricity cost for non-AMP households:

$$\text{Summer Cost} = -26.966 + 0.001\ (\text{INCOME}) + 3.97\ (\text{CONDITION}) + 177.359\ (\text{LOCATION}) + 0.045\ (\text{SIZE}). \qquad (10)$$

These results inferred that non-AMP households' summer electricity costs were significantly influenced by household incomes, physical condition of the homes, location of the residences, and size of the houses. A non-AMP consumer who had a higher level of income and resided in a large house which was in excellent physical condition had a greater summer electricity cost compared with that of other

TABLE XII

MULTIPLE REGRESSION RESULTS FOR
SUMMER ELECTRICITY COST

| Predictors | Full Beta | F | Step | Reduced Beta | t |
|---|---|---|---|---|---|
| INCOME | 0.001 | 12.00*** | 1 | 0.001 | 3.465*** |
| CONDITION | 3.970 | 9.83** | 3 | 3.970 | 3.135** |
| LOCATION | 177.359 | 8.15** | 4 | 177.359 | 2.855** |
| PLAN*LOCATION | -200.718 | 6.57* | 5 | -200.718 | 2.563* |
| PLAN | 321.851 | 7.15** | 6 | 321.851 | 2.674** |
| SIZE | 0.045 | 8.67** | 6 | 0.045 | 2.945** |
| PLAN*CONDITION | -2.875 | 3.29* | 7 | -2.875 | -1.814* |
| Intercept | -26.966 | | | -26.966 | -0.303 |
| $R^2$ | 0.3304 | | | 0.3304 | |
| df | 7 | | | 7 | |
| F-ratio | 13.61*** | | | 13.61*** | |
| MSE | 30,739.935 | | | 30,739.935 | |

***p<0.001
**p<0.01
*p<0.01

households. These results were consistent with the findings about summer electricity consumption. Similarly, direction of effect for residential location was inconclusive for non-AMP households due to a factor of intercorrelation. Although this predictor significantly impacted summer cost, the sign of the regression coefficient did not allow these results to be generalized.

The effect of the AMP plan participation was twofold. The constant level of cost or intercept was greater for AMP consumers compared to that of non-AMP consumers. Additionally, the rates of cost as significantly affected by physical condition of the home and location of residence were different for AMP households compared to those of non-AMP households. Equation 11 which was devised from the regression model was as follows:

$$\begin{aligned} \text{Summer Cost} = {} & 294.884 + 0.001\ (\text{INCOME}) \\ & + 1.095\ (\text{CONDITION}) \\ & - 23.359\ (\text{LOCATION}) + 0.045\ (\text{SIZE}). \end{aligned} \tag{11}$$

The interaction effect with residential location and physical condition reduced the rates of cost for these respective variables. The rate of cost associated with the influence of physical condition was reduced to 1.095 dollars. Additionally, the rate of cost related to the impact of residential location was modified to 23.359 dollars. These findings suggested that a AMP household who had a higher level of income and lived in a large, urban home which was in excellent physical condition was expected to have a greater summer electricity cost compared to those of other AMP consumers.

For AMP and non-AMP households, a one dollar increase in household income increased summer cost by .001 cents. Additionally, a one square foot increase in house size escalated summer cost by 0.045 cents. For non-AMP households, a one percent increase in physical condition of the home escalated summer cost by 3.97 dollars. Conversely, an increase in physical condition of a AMP consumer's home was anticipated to elevate summer cost by approximately 1.10 dollars.

Total Electricity Consumption

The combination of variables which met the least MSE criterion for predicting total electricity consumption was listed in Table XIII. These predictor variables together explained 28.2 percent of the variation in total KWH usage. Two interaction terms, AMP plan participation with residential location and also with house size, were included in this "best" set but were not statistically significant. Therefore, these variables were excluded in the reduced model for OLS regression analysis.

The reduced model yielded an $R^2$ value of 0.2634. In other words, physical condition of the home, residential location, household income, and AMP plan participation

TABLE XIII

MULTIPLE REGRESSION RESULTS FOR TOTAL ELECTRICITY CONSUMPTION

| Predictors | Full Beta | F | Step | Reduced Beta | t |
|---|---|---|---|---|---|
| CONDITION | 154.927 | 15.35*** | 1 | 147.659 | 3.726*** |
| SIZE | 1.026 | 2.53 | 3 | | |
| LOCATION | 6601.045 | 6.56* | 4 | 3737.846 | 2.280* |
| INCOME | 0.063 | 6.20* | 5 | 0.079 | 3.364*** |
| PLAN | 3756.574 | 10.43** | 5 | 3232.412 | 2.939** |
| PLAN*LOCATION | -5023.091 | 2.37 | 6 | | |
| Intercept | -2602.598 | | | -1179.629 | -0.461 |
| $R^2$ | 0.2820 | | | 0.2634 | |
| df | 6 | | | 4 | |
| F-ratio | 12.70*** | | | 17.52*** | |
| MSE | 55,087,030.88 | | | 55,937,524.42 | |

***p<0.001
**p<0.01
*p<0.01

explained 26.34 percent of the variance in total electricity usage. Equation 12 for non-AMP households was derived from the reduced model results:

$$\text{Total KWH} = -1179.629 + 147.659\ (\text{CONDITION}) + 3737.846\ (\text{LOCATION}) + 0.079\ (\text{INCOME}). \quad (12)$$

For AMP households, Equation 13 was deduced from the findings as the following:

$$\text{Total KWH} = 2052.783 + 147.659\ (\text{CONDITION}) + 3737.846\ (\text{LOCATION}) + 0.079\ (\text{INCOME}). \quad (13)$$

The most noticeable difference between Equations 12 and 13 was the constant level of consumption denoted by intercept. With the inclusion of the PLAN variable in the reduced model, this effect suggested that the constant level of consumption for AMP households was significantly higher than that level for non-AMP households.

The other effects were consistent which implied a parallel relationship between the rate of consumption for the two types of households. A one percent increase in the physical condition of the home was expected to escalate total consumption by approximately 148 KWH. Likewise, total consumption would elevate 0.079 KWH with an increase of one dollar in household income. Conclusions about the rate of consumption associated with residential location were restricted because the direction of effect was undetermined due to an intercorrelation factor. This finding limited the generalizations of these results to the AMP household population.

From these findings, one could conclude that a household who had a higher level of income and occupied a home which was in excellent condition consumed a higher quantity of electricity than other households during the total period. Location of residence also significantly impacted total KWH usage. Additionally, these results implied that AMP consumers were expected to have a higher constant level of consumption than non-AMP households which was the most significant influence from participation in the AMP plan.

## Total Electricity Cost

Table XIV presented the set of predictor variables which was selected as the "best" combination in the explanation of total electricity cost for the period under analysis. All variables within the set were statistically significant at the 0.10 level or greater. Thus, these variables were included in the reduced OLS regression model and findings were identical to the results from the stepwise procedure. Effects of physical condition, household income, residential location, house size, participation in the AMP plan, and the interaction between AMP plan participation and residential location explained 31.2 percent of the

TABLE XIV

MULTIPLE REGRESSION RESULTS FOR
TOTAL ELECTRICITY COST

| Predictor | Full Beta | Full F | Step | Reduced Beta | Reduced t |
|---|---|---|---|---|---|
| CONDITION | 8.222 | 16.27*** | 1 | 8.222 | 4.033*** |
| INCOME | 0.003 | 7.54** | 3 | 0.003 | 2.746** |
| LOCATION | 368.610 | 7.70** | 4 | 368.610 | 2.775** |
| PLAN | 207.758 | 12.00*** | 5 | 59.975 | 3.464*** |
| SIZE | 0.065 | 3.80* | 5 | 0.065 | 1.950* |
| PLAN*LOCATION | -324.902 | 3.72* | 6[a] | -324.902 | -1.930* |
| Intercept | 113.28 | | | 113.28 | 0.838 |
| $R^2$ | 0.3120 | | | 0.3120 | |
| df | 6 | | | 6 | |
| F-ratio | 14.66*** | | | 14.66*** | |
| MSE | 146,460.70 | | | 146,460.70 | |

***p<0.001
**p<0.01
*p<0.01

[a]Entered first during step 5.

variance in total electricity cost.

Equation 14 was representative of the model derived for non-AMP households:

$$\text{Total Cost} = 113.28 + 8.222\ (\text{CONDITION}) + 0.003\ (\text{INCOME}) + 368.61\ (\text{LOCATION}) + 0.65\ (\text{SIZE}). \quad (14)$$

Due to the significance of the PLAN variable and the interaction between AMP plan participation and residential location, the AMP households' total cost was significantly impacted by participation in the AMP plan. Equation 15 was constructed from these results for AMP households:

$$\text{Total Cost} = 173.255 + 8.222\ (\text{CONDITION}) + 0.003\ (\text{INCOME}) + 43.708\ (\text{LOCATION}) + 0.65\ (\text{SIZE}). \quad (15)$$

The constant level of cost, otherwise known as the intercept, was significantly altered by participation in the AMP plan. This result was congruent with the findings of total electricity consumption. AMP households' constant level of cost was higher than non-AMP consumers' constant measure. Participation in the AMP plan also impacted the rate of cost associated with the influence of residential location. However, the direction of effect was inconclusive due to intercorrelation influences. Generalization to the

AMP consumer population about the effect of residential location, thus, was limited.

As applied to AMP and non-AMP households, total cost escalated by 8.22 dollars with a one percent increase in physical condition. Additionally, with a one dollar increase in household income, total cost climbed 0.003 cents. Total cost increased 65 cents with each additional square foot added to house size. Thus, a non-AMP or AMP household who had a higher level of household income and resided in a large home which was in excellent physical condition was expected to have greater total electricity costs as compared to those of other households.

## Model Development

The third objective of this study was to develop a model which would represent the interaction of payment plan choice with specific housing characteristics, household income, and residential location. These illustrations which demonstrated the significant influences on winter, summer and total consumption as well as costs were constructed from results of the regression analysis.

As earlier described, participation in the AMP plan could have potentially affected consumption and cost in three ways:

1. An additional predictor variable could be identified as significantly affecting consumption or cost of AMP households.

2. The constant measure of consumption or cost could be altered.

3. Rate of consumption or cost associated with a particular predictor could be influenced.

Thus, the following models will describe the aggregate effect of the AMP plan.

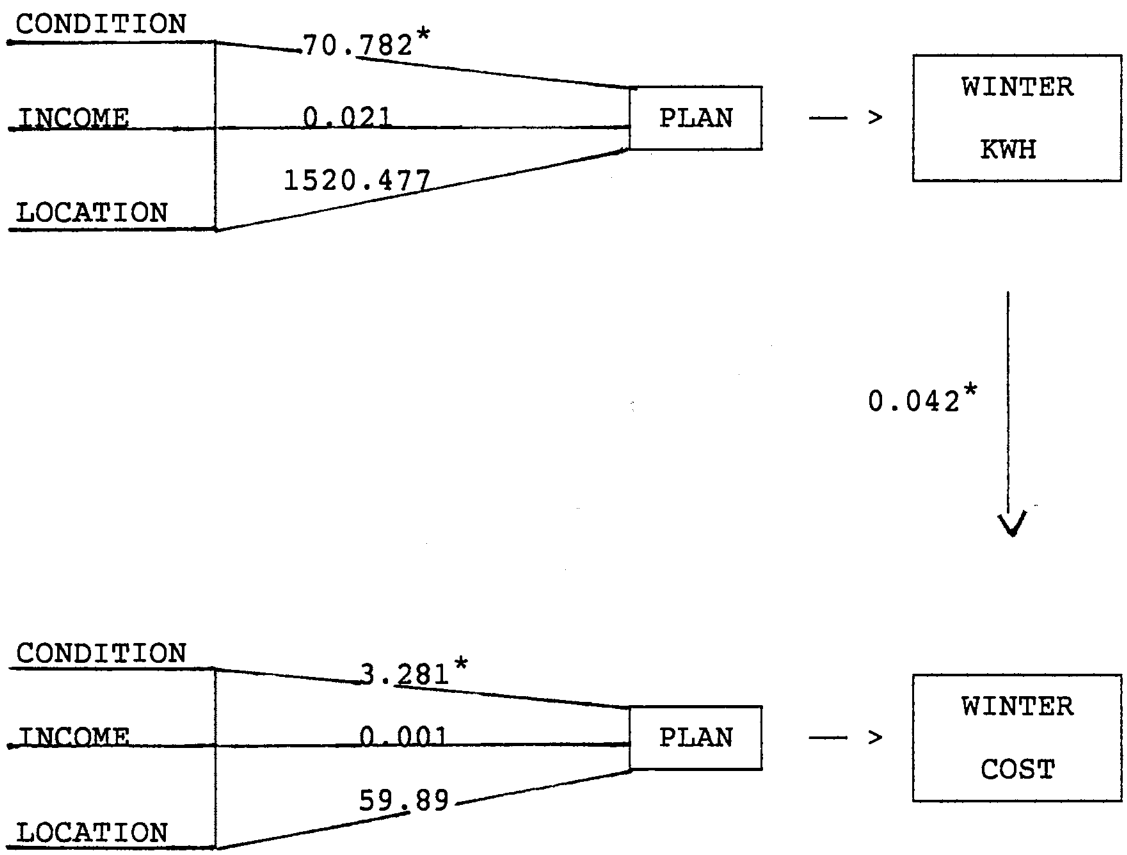
## Winter Consumption and Cost

The statistically significant predictors for winter consumption and cost were identical (see Figure 6). The influence of the AMP plan selection was evident in the addition of another statistically significant variable, household income, in the model for AMP households.

## Summer Consumption and Cost

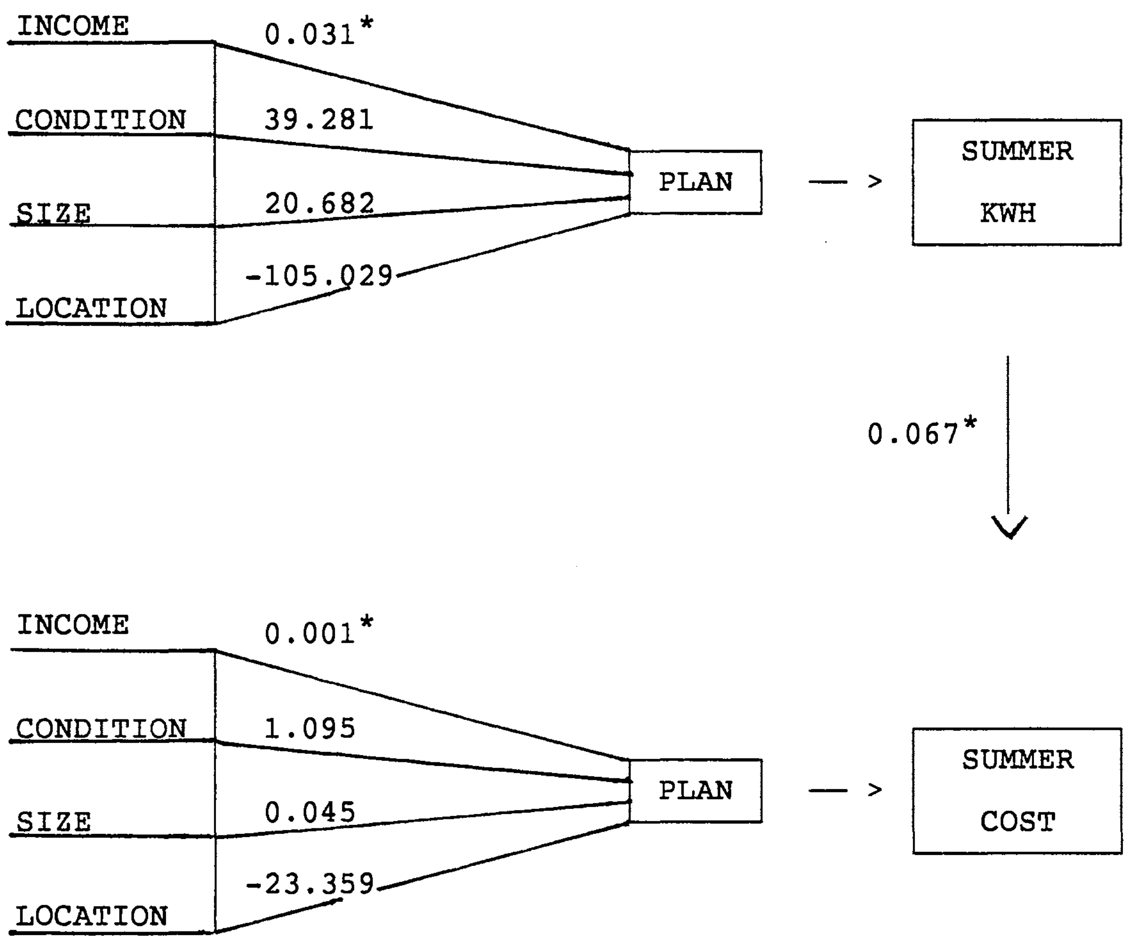
Summer electricity consumption and cost of an AMP household were significantly influenced in two ways. AMP plan participation altered the constant level of consumption and cost and changed the rates of consumption associated with physical condition of the house and residential location (see Figure 7).

Choosing to participate in the AMP adjusted the rate of summer consumption related to residential location. Effect of this choice significantly changed the rate of summer electricity consumption for urban households. In addition, the constant level of summer electricity consumption was significantly affected by the AMP plan. AMP




* $p<0.001$

Figure 6. Model of Winter Electricity Consumption and Cost for AMP Households.




*$p<0.001$

Figure 7. Model of Summer Electricity Consumption and Cost for AMP Households.

households were expected to consume electricity in the summer at a higher constant quantity than that of non-AMP households.

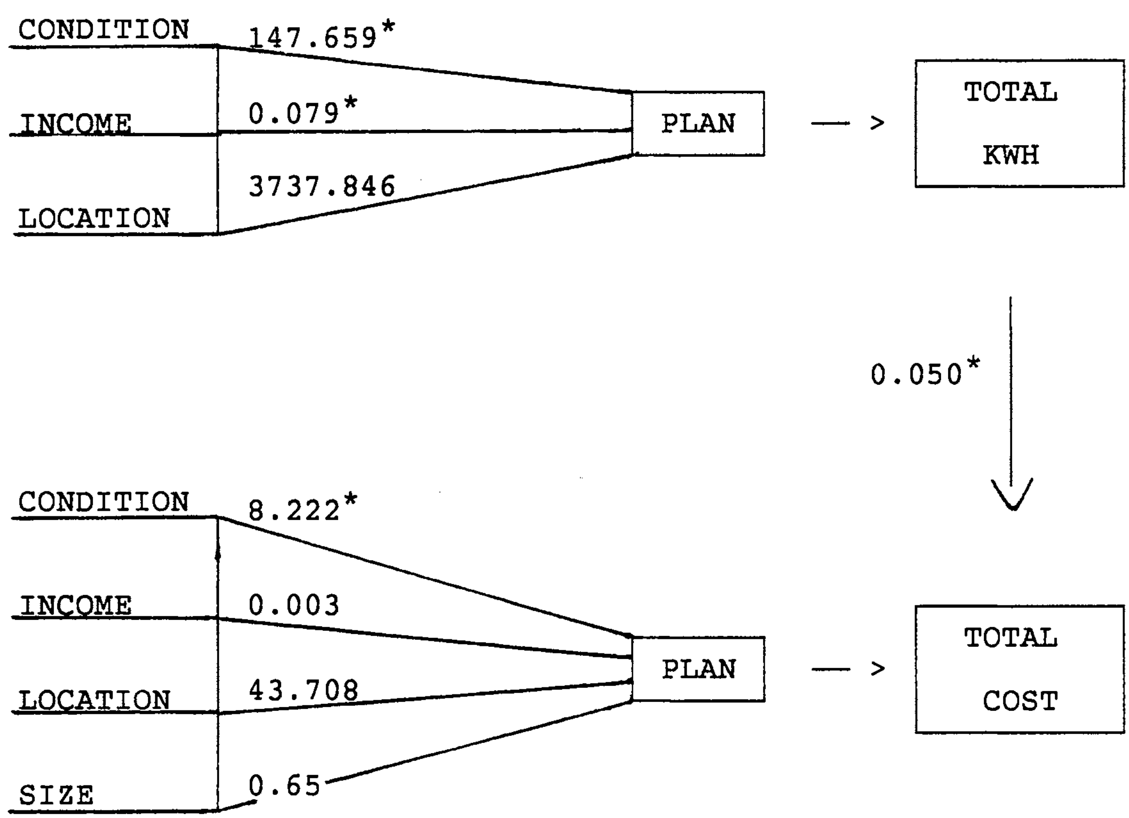
Influence of the AMP plan was similar for summer cost. The AMP plan participation changed the constant measure of summer cost for AMP households. Additionally, this billing choice altered the rates of summer cost related to physical condition of the house and residential location.

## Total Consumption and Cost

The effect of the AMP plan on total consumption and cost was different. Total consumption was influenced by the AMP plan by changing the constant consumption level. Participation in the AMP plan caused the constant measure of total cost to increase and, the rate of consumption associated with residential location to be altered (see Figure 8).

Modification of the constant level of total consumption suggested that AMP consumer utilized electricity at a greater level than did non-AMP consumers. Because rates of consumption were identical for AMP and non-AMP households, the linear relationship between consumption levels was parallel.

The constant level of total cost was also increased for AMP households. Thus, AMP consumers faced a higher constant cost for electricity than did non-AMP consumers. Additionally, the rate of cost associated with location of




* p<0.001

Figure 8. Model of Total Electricity Consumption and Cost for AMP Households.

residence was significantly influenced by the AMP plan.

## Summary

For objectives one, two, and three, OLS regression with stepwise techniques were conducted. The results indicated that participating in the AMP plan significantly influenced electricity consumption and cost for these households. Models were designed to illustrate these effects.

Winter consumption and cost for AMP households were significantly impacted by physical condition and residential location in addition to household income. Summer consumption and cost were affected by the AMP plan through an increased level of constant consumption and cost and changed rates of consumption and cost associated with physical condition of the home and residential location.

The effects on total consumption for AMP and non-AMP households were identical. However, AMP households were expected to consume a higher constant level compared to non-AMP households. Thus, the linear relationship between these two types of households' total consumption was parallel. Total cost was influenced by the AMP plan through an increased level of constant cost and a changed rate of consumption associated with residential location.

# CHAPTER V

# SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

## Introduction

Greater energy demand in addition to increasing energy prices placed American energy consumers, particularly low income and fixed income families, in a financially vulnerable position. One utility billing method option, Average Monthly Payment plan, was introduced to alleviate the burden of fluctuating monthly costs on less affluent households' budgets. The effect of this policy was not explored before implementation, nor had the influence been determined since initiation of AMP plans. Therefore, it was relevant to explore the impact of AMP plans on household energy consumption and cost.

## Objectives of Study

The purpose of this exploratory study was to assess the effect of payment plan choice interacting with specific housing characteristics, household income, and residential location on total and seasonal household electric consumption and cost. Specific objectives of this analysis included: (a) to identify effect of payment plan choice, specific housing characteristics, household income, and residential location on total household electric consumption and cost; (b) to identify effect of payment plan choice, specific housing characteristics, household income, and residential location on seasonal household electric consumption and cost; and (c) to develop a model for the effect of payment plan choice, specific housing characteristics, household income, and residential location on household electric consumption and cost.

## Summary and Conclusions

A sample of 600 households was randomly selected from an Oklahoma electric utility's customer accounts with equal representation of AMP and non-AMP households. Monthly consumption and cost data were provided by the company, while specific housing characteristics and household income information were obtained from county assessment records.

### Sample Characteristics

Non-AMP and AMP households occupied homes which were similar in age and physical condition. On the average, non-AMP consumers lived in larger houses and had higher household incomes than did AMP consumers. A majority of AMP and non-AMP households resided in urban locations, while a smaller proportion of the sample were located in rural areas.

Results consistently implied that AMP households' average usage levels were greater, and these consumers experienced higher average costs during monthly, seasonal, and total periods than did non-AMP households. Considering the conclusions of the literature review which indicated that income and house size were positively associated with elevated energy usage, findings of the present study were considered unusual. With smaller homes and lower household incomes, AMP households were expected to utilize less electricity and, thus, would have had lower average monthly utility costs.

Analysis which established relationships among dependent and independent variables found that total, winter, and summer electricity consumption and costs were significantly associated with each other. House size, age of house, physical condition, and participation in the AMP plan were positively related to total, winter, and summer KWH and costs at significant levels. Location of residence was significantly negatively correlated with summer KWH and cost. This result implied that increased summer electricity consumption and cost were associated with an urban location.

## Effect of AMP Plans

Results from stepwise and ordinary least squares regression analysis indicated that AMP households' seasonal and total consumption and cost were significantly impacted by participation in the AMP plan. However, the effect was different within each analysis. Three models were constructed to explain the impact of AMP plans on winter, summer, and total electricity consumption and cost of AMP households.

For AMP and non-AMP consumers, physical condition of the homes and residential location were significant predictors of winter consumption and cost. The interaction of the AMP plan participation and predictor variables signified that AMP households' winter consumption and cost were positively influenced by an increase in household income. Thus, one could conclude that a AMP household who had a higher level of income and resided in a home in excellent condition would have higher winter consumption and cost compared to other households. Location of residence significantly impacted winter consumption and cost, however, the direction of effect was undefined by this analysis.

Summer electricity consumption and cost analysis produced similar results. Participation in the AMP plan caused a change in the constant level of summer consumption and cost. Additionally, rates of consumption and cost for AMP households were significantly influenced by the selection of the AMP plan.

AMP households who had higher levels of income and lived in large, urban homes which were in excellent physical condition were expected to utilize greater quantities of electricity in the summer season and, thus, have greater costs for this period compared to other AMP households. Contrasted with non-AMP consumers, the rate of summer electricity cost associated with physical condition of the homes was lower for AMP households; however, a positive effect was maintained.

Analysis of total electricity consumption and cost yielded different combinations of significant influences. Comparatively, these results were unusual when given the similar models between consumption and cost for the winter and summer season. Within the total consumption analysis, the identical factors controlled AMP and non-AMP households' consumption. Households which had higher levels of income and resided in homes that were in excellent condition were anticipated to have greater total consumption compared to other households. AMP consumers' consumption was expected to parallel non-AMP consumers' consumption except at a greater constant level.

Total electricity cost was positively impacted by physical condition of the home, household income, house size, and residential location. Thus, from these results, households who had high levels of income and occupied large homes in excellent physical condition would have elevated total electricity costs. AMP consumers faced significantly greater constant total costs than did non-AMP consumers due to their participation in the AMP plan. The rate of cost associated with residential location was also altered due to the AMP plan selection; however, the direction of the effect was inconclusive with this analysis.

Within this study, three variables consistently appeared within the prediction models: household income, physical condition of the home, and residential location. Household income has been advocated by previous research as a significant predictor. Thus, this finding was not surprising given the indications of the literature. However, few studies have addressed the influence of physical condition and residential location. This study inconclusively determined the direction of the effect of residential location, thus additional research would be needed to clarify the role of this significant influence.

Physical condition was representative of several components of maintenance and descriptors of the home. Obviously, this influence comprised an extremely significant effect on electricity consumption and cost within this study. This finding was unusual when given the fact that physical condition had a significant positive effect on consumption and cost. Previous research indicated that poor maintenance or physical condition would increase consumption and cost which was the opposite to the findings of this study. However, physical condition of the home and age of house were highly positively correlated. One could conclude that those houses which were in excellent physical condition were also newer homes which may be a key to interpreting the positive influence of physical condition. One conclusion of the literature review was that residents of newer homes consumed more electricity than residents of other homes. One explanation which was suggested by Jaffee et al. (1982)

was that older homes could be poorly suited for large electricity usage because of inadequate wiring, space limitation, or lack of duct work for central air conditioning. Thus, newer homes were more likely to be "total electric" homes compared to older homes. These homes which were graded in excellent physical condition could consume greater quantities of electricity because they were constructed and wired to handle higher electricity loads. Thus, further analysis would be needed to clarify the role of physical condition.

Participation in the AMP plan significantly affected total and seasonal consumption and cost. Combination of significant predictors with participation in the AMP plan considerably impacted consumption and cost of electricity for AMP consumers. AMP consumers tended to consume and pay for electricity at a significantly greater level than did non-AMP consumers. This effect on level of consumption and cost was indicative that AMP consumers received a different energy cost cue. Because of this false cost signal, these households tended to demand more energy than did non-AMP households, particularly for the summer season and the total period. Greater demand for electricity translated into higher costs for these households. Thus, participation in the AMP plan would tend to cause increased demand for electricity and, thus, would increase household electricity costs.

## Policy Implications

Sweet and Hexter (1987) stated that with the design of the first energy programs, little evidence was available regarding the relationship between energy usage and less affluent households. Even with an extensive collection of energy research, it was evident that policies were formulated without consideration of adverse effects on the elderly, the poor, and families with limited incomes. The potential consequences of the AMP plan policy on these households should also have been investigated prior to initiation.

One of the main objectives of the AMP plan policy was to provide an optional payment method which could assist in budgeting for household monthly utility bills. Utility company representatives, consumer advocates, and policy makers viewed this billing option as a financial outlet for households to cope with erratic monthly energy bills. However, research was not conducted to explore the repercussions of this policy.

Economists have argued that when the cost of consumption was suppressed, demand would be altered to match the "new" or false cost signal. The findings from this study suggested that AMP consumers received a different cost signal compared to that received by non-AMP consumers. Thus, further assessment of this policy would be needed to clarify the degree to which a household's energy consumption could be impacted. Policy makers should confront the possibility that while this policy could be accomplishing the goal of providing a budgetary service for AMP households, energy consumption and costs could be greater for AMP households in the short run and, in turn, long run as indicated by this study. Presently, the benefits of budgeting for monthly bills could be advantageous for these households. Conversely, over a longer period of time, AMP households would pay significantly more for utility services which could be financially detrimental for low and fixed income AMP households.

In the future, energy policy must be more carefully scrutinized as to the potential outcomes before implementation. Specifically, restructuring the AMP plan policy would be warranted when given the preliminary results of this study. AMP consumers should be alerted to the effects of this billing procedure on household consumption and cost. Additionally, regulatory agencies and utility representatives along with consumers should consider the influences of the AMP policy and its potential effect on energy demand and limited future supplies.

## Recommendations

With the prevailing impact of energy costs on limited income households' financial resources in combination with increased reliance on electricity, research which focuses on estimation of household energy demand will continue to be valuable. Recommendations for future research include:

1. A similar study should be conducted with a broader sampling frame to include customers from different utility companies. Variation in price could be explored in a sample from utilities with different price schedules.

2. Development of a thermal efficiency score or a structure efficiency score would be necessary to clarify the role of the structure and the impact of heating/cooling load on household energy consumption and cost interacting with choice of payment plan.

3. The establishment of a relationship between actual income and the proxy variable could provide a secondary measurement of household income for future research when data on actual household income could be unavailable.

4. Further investigation of the relationship between household income and land and improvement values was warranted to substantiate the link between these variables.

5. Data for longitudinal studies would be necessary to analyze households' electricity consumption prior to and proceeding implementation of the AMP plan. Comparison of consumption and cost levels could provide additional insight into the effect of this policy on household energy demand.

6. Research would be essential to examine the sociodemographic and economic characteristics of the households who have been participating in the AMP plan. These results could provide evidence as to who would tend to be a AMP consumer.

BIBLIOGRAPHY

American Petroleum Institute. (1988). Energy security white paper: U.S. decisions and global trends. Washington,DC: Author.

Babbie, E. (1986). The practice of social research (4th ed.). Belmont, CA: Wadsworth.

Barnes, R., Gillingham, R., & Hagemann, R. (1981, November). The short-run residential demand for electricity. Review of Economic Statistics, 63(4), 541-552.

Battalio, R.C., Kagel, J.H., Winkler, R.C., & Winett, R.A. (1979). Residential electricity demand: An experimental study. The Review of Economics and Statistics, 61(2), 180-189.

Bauer, J.W., & Badenhop, S.B. (1984). Residential energy research: Progress and potential. Home Economics Research Journal, 12(4), 550-562.

Baxter, L.W., Feldman, S.L., Schinnar, A.P., & Wirtshafter, R.M. (1986). An efficiency analysis of household energy use. Energy Economics, 8(2), 62-73.

Bieber, S.L. (1988). Multiple regression and its alternatives. The Social Science Journal, 25(1), 1-19.

Blocker, T.J. (1983). Residential energy rates: Conservation, cost, and comfort. The Social Science Journal, 20(4), 79-87.

Brandt, J.A., & Guthrie, L.A. (1984). Elderly Residential Conservation Comparisons in the Pacific Northwest. Paper presented at the W-159 Research-Extension Exchange Conference, Salt lake City, UT.

Brazzel, J.M., & Hunter, L.J. (1979). Trends in energy expenditures by black households. The Review of Black Political Economy, 9, 276-299.

Brown, A.C. (1987). Percentage of income payment plans: Regulation meets social reality. Public Utilities Fortnightly, 119, 9-12.

Brown, F.L., Hoffman, L., & Baxter, J.D. (1975). New ways to measure price elasticity. Electrical World, 184, 52-54.

Bureau of Labor Statistics. (1988). Consumer expenditure survey results from 1986. News (USDL: 88-175). Washington, DC: United States Department of Labor.

Chatelain, L.B. (1981). Residential energy consumption practices, weatherization features in dwellings and electrical energy consumption in rural and urban households in Utah. Unpublished doctoral dissertation, Florida State University, Tallahassee, FL.

Cramer, J.C., Dietz, T.M., Miller, N., Craig, P.P., Hackett, B.M., Kowalcyzk, D., Levine, M., & Vine, E.L. (1984). The determinants of residential energy use: A physical-social causal model of summer electricity use. In B.M. Morrison & W. Kempton (Eds.), Families and energy: Coping with uncertainty (pp. 595-615). Lansing, MI: Michigan State University.

Cullen, B.T., Johnson, J.H., Jr., & Sommers, L.M. (1983). Implications of electric utility rate reform legislation for low-income households in Oakland and Livingston Counties, Michigan. The Social Science Journal, 20(2), 88-97.

Cunningham, W.H. & Joseph, B. (1978). Energy conservation, price increases and payback periods. In H.K. Hunt (Ed.), Advances in Consumer Research, Vol. 5. (pp. 201-205). Association for Consumer Research.

Cunningham, W.H., & Lopreato, S.C. (1977). Energy use and conservation incentives. New York: Praeger.

Danielson, L.E. (1979). An analysis of residential demand for water using micro time-series data. Water Resources Research, 15(4), 763-767.

Energy Information Administration (1986). State energy data report: Consumption estimates 1960 - 1986 (DOE/EIA-0214(86)). Washington, DC: Government Printing Office.

Energy Information Administration. (1987a). Annual energy review 1987 (DOE/EIA-0384(87)). Washington, DC: Government Printing Office.

Energy Information Administration. (1987b). Residential energy consumption survey: Consumption and expenditures (DOE/EIA-0321/2-84). Washington, DC: Government Printing Office.

Energy Information Administration (1988). Energy facts 1987 (DOE/EIA-0469(87)). Washington, DC: Government Printing Office.

Energy Information Administration. (1989). Annual energy outlook: Long-term projections (DOE/EIA-0383(89)). Washington, DC: Government Printing Office.

Fast, J.E. (1989). The effects of consumer information on household energy use, In R. Heck (Ed.). Consumer close-ups, 1988-89:8. Ithaca, NY: Department of Consumer Economics and Housing, Cornell University.

Foster, H.S., & Beattie, B.R. (1981). Urban residential demand for water in the United States: Reply. Land Economics, 57, 257-265.

Garbacz, C. (1983). A model of residential demand for electricity using a national household sample. Energy Economics, 5(2), 124-128.

Gladhart, P.M. (1984). Interactions of prices and household characteristics and residential energy conservation. Housing and Society, 11(3), 149-167.

Gladhart, P.M., Zuiches, J.J., & Morrison, B.M. (1977). Impacts of rising prices upon residential energy consumption, attitudes, and conservation policy acceptance. (Occasional Paper No. 9, Project 3152). East Lansing, MI: Michigan State University.

Grima, A.P.L. (1973). The impact of policy variables on residential water demand and related investment requirements. Water Resource Bulletin, 9(4), 703-710.

Hassoun, V.S., & Hunt, F.E. (1980). Electric energy usage in the home: A predictive model. Home Economics Research Journal, 8(4), 252-260.

Heberlein, T.A., Linz, D., & Ortiz, B.P. (1982). Satisfaction, commitment and knowledge of customers on a mandatory participation time-of-day electricity pricing experiment. Journal of Consumer Research, 9, 106-114.

Henderson, L.J., Jr. (1979). Public utility regulations: The socioeconomic dimensions of reform. Review of Black Political Economy, 9, 260-275.

Henson, S.E. (1984). Electricity demand estimates under increasing block rates. Southern Economic Journal, 51, 147-156.

Heslop, L.A., Moran, L., & Cousineau, A. (1981). "Consciousness" in energy conservation behavior: An exploratory study. Journal of Consumer Research, 8, 299-305.

Howe, C.W., & Linaweaver, F.P., Jr. (1967). The impact of price on residential water demand and its relation to system design and price structure. Water Resources Research, 3(1), 13-32.

Iams, D.R., & Royce, V. (1984). Rising energy costs and their impact on household budgets of older Americans. Journal of Housing for the Elderly, 2(3), 15-23.

Jaffee, B.L., Houston, D.A., & Olshavsky, R.W. (1982). Residential electricity demand in rural areas: The role of conservation actions, engineering factors and economic variables. The Journal of Consumer Affairs, 16(1), 137-151.

Jones, C.V., & Morris, F.R. (1984). Instrumental price estimates and residential water demand. Water Resources Research, 20(2), 197-202.

Junk, V., Jones, J., & Kessel, E. (1988). Home energy costs and the elderly. Housing and Society, 15(1), 15-29.

Junk, V., Junk, W., & Jones, J. (1987). Impact of energy audits on home energy consumption. Journal of Consumer Studies and Home Economics, 11, 21-38.

Kasulis, J.J., Huettner, D.A., & Dikeman, N.J. (1981). The feasibility of changing electricity consumption patterns. Journal of Consumer Research, 8, 279-290.

Kohler, D.F., & MItchell, B.M. (1984). Response to residential time-of-use electricity rates. Journal of Econometrics, 26, 141-177.

Lewis-Beck, M.S. (1980). Applied regression: An introduction. In J.L. Sullivan (Ed.), Sage University Paper series: Quantitative Application in the Social Sciences (SEries No. 07-022). Beverly Hills, CA: Sage Publications.

Maurice, S.C., & Phillips, O.R. (1986). Economic analysis: Theory and applications. Homewood, IL: Irwin.

McDermott, K.A., Guldmann, J.M., Pfister, K.A., & Kumari, K.V. (1980). Budget billing plans for electric and gas utilities: An analysis and some recommendations for change. Columbus, OH: The National Regulatory Research Institute.

McDougall, G.H.G., Claxton, J.D., Ritchie, J.R.B., & Anderson, C.D. (1981). Consumer energy research: A review. Journal of Consumer Research, 8, 343-354.

Morrison, B.M. (1975). Socio-physical factors affecting energy consumption in single family dwellings: An empirical test of a human eco-systems model (Doctoral dissertation, Michigan State University, 1975). Ann Arbor, MI: University Microfilms No. 76-5608.

Morrison, B.M., & Gladhart, P.M. (1976, January). Energy and families: The crisis and response. Journal of Home Economics, 68(1), 15-18.

Morrison, B.M., Gladhart, P.M., Zuiches, J.J., Keith, J.G., Keefe, D., & Long, B.K. (1978). Energy and families: The crisis and the response. Journal of Home Economics, 70(4), 18-21.

National Consumer Law Center. (1989). Energy and the poor -- The forgotten crisis. Washington, DC: Author.

Neter, J., Wasserman, W., & Kutner, M.H. (1983). Applied linear regression models. Homewood, IL: Irwin.

Newman, D.K., & Day, D. (1975). The American energy consumer. Cambridge, MA: Ballinger.

Oklahoma Corporation Commission. (1985). Hearings: January 8, 1985, motions for reconsideration. (OCC Report Cause No. 27759/Order No. 274115) Oklahoma City, OK.

Opaluch, J.J. (1982). Urban residential demand for water in the United States: Further discussion. Land Economics, 58(2), 225-227.

Perlman, R. &, Warren, R. (1977). Families in the energy crisis: Impacts and implications for theory and policy. Cambridge, MA: Ballinger.

Prindle, W.R., & Reid, M.W. (1988). Preparing for the energy challenges of the 1990s. Washington, DC: The Alliance to Save Energy.

Ritchie, J.R.B., McDougall, G.H.G., & Claxton, J.D. (1981). Complexities of household energy consumption and conservation. Journal of Consumer Research, 8, 233-242.

Roth, T.P. (1981). Average and marginal price changes and the demand for electricity: An econometric study. Applied Economics, 13, 377-388.

Routh, S.P., Weber, M.J., & Williams, S.E. (1989). Relationship of payment plan option, residential house size, and energy consumption. Paper presented at the meeting of the Oklahoma Home Economics Association, Tulsa, OK.

Ruffin, M.D., & Weinstein, M.B. (1979). Energy in the farm home. Home Economics Research Journal, 8, 2-15.

Seligman, C., & Darley, J.M. (1977). Feedback as a means of decreasing residential energy consumption. Journal of Applied Psychology, 62(4), 363-368.

Sexton, R.J., & Sexton, T.A. (1987). Theoretical and methodological perspectives on consumer response to electricity information. The Journal of Consumer Affairs, 21(2), 238-257.

Sierra Pacific Power Co. (1979). Home energy survey: electrical and gas analysis: Report No. 4. Reno, NV: Author.

Sinden, F.W. (1978). Wind, temperature, and natural ventilation - Theoretical considerations. In R.H. Socolow (Ed.), Saving energy in the home: Princeton's experiments at Twin Rivers (pp. 131-166. Cambridge, MA: Ballinger.

Socolow, R.H. (1978). The Twin Rivers program on energy conservation in housing: Highlights and conclusions. In R.H. Socolow (Ed.), Saving energy in the home: Princeton's experiments at Twin Rivers (pp. 1-62). Cambridge, MA: Ballinger.

Steel, R.G.D. & Torrie, J.H. (1980). Principles and procedures of statisics: A biometric approach (2nd Ed.). New York, NY: McGraw-Hill.

Stern, P.C., & Gardner, G.T. (1981). Psychological research and energy policy. American Psychologist, 36, 329-342.

Stevens, B.J. (1983). Residential energy consumption in apartments, Tallahassee, Florida, 1982 (Doctoral dissertation: Florida State University 1983). Dissertation Abstracts International, 44, 2127B.

Stevens, J. (1986). Applied multivariate statistics for the social sciences. Hillsdale, NJ: Lawrence Erlbaum Associates.

Sweet, D.C., & Hexter, K.W. (1987). Public utilities and the poor: Rights and responsibilities. New York: Praeger.

Taylor, L.D. (1975). The demand for electricity: A survey. Bell Journal of Economics, 6(1), 74-110.

Tyler, L.L., Lovingood, R.P., Bowen, S.P. & Tyler, R.F. (1982). Energy related characteristics of low income urban tenants. Housing and Society, 9(3), 9-15.

U.S. Bureau of Census. (1980). The 1980 census of the population: Characteristics of the population (Vol. 1). Washington, DC: Government Printing Office.

U.S. Department of Labor, Bureau of Labor Statistics. (1976). Consumer expenditure survey series: Interview survey, 1972 and 1973 (Rep. 455-3). Washington, DC: Government Printing Office.

Warriner, G.K. (1981). Electricity consumption by the elderly: Policy implications. Journal of Consumer Research, 8, 258-264.

Wilder, R.P., & Willenborg, J.F. (1975). Residential demand for electricity: A consumer panel approach. Southern Economic Journal, 42(2), 212-217.

Williams, S.E. (1984). Energy education for limited resource Oklahomans: A policy evaluation. Unpublished doctoral dissertation, Oklahoma State University, Stillwater, OK.

Williams, S.E., Weber, M.J., & Routh, S.P. (1988). Impact of utility averaging on residential users (H.E. Research Project #275). Stillwater, OK: Oklahoma State University, College of Home Economics.

Yergin, D., & Hillenbrand, M. (1982). Global insecurity: A strategy for energy and economic renewal. Boston, MA: Houghton Mifflin.

# APPENDIXES

TABLE XV

COMPARISON OF $R^2$ AND MSE VALUES IN STEPWISE REGRESSION EQUATIONS

| | AGE[a] | | CONDITION[b] | |
|---|---|---|---|---|
| Dependents | $R^2$ | MSE | $R^2$ | MSE |
| Winter KWH | 0.1814 | 11,841,722.33 | 0.1868 | 10,951,292.70 |
| Winter Cost | 0.2158 | 21,986.38 | 0.2360 | 20,161.60 |
| Summer KWH | 0.3286 | 6,814,514.03 | 0.3585 | 6,567,466.94 |
| Summer Cost | 0.2985 | 32,033.45 | 0.3304 | 30,739.93 |
| Total KWH | 0.2526 | 59,745,710.06 | 0.2820 | 55,087,030.88 |
| Total Cost | 0.2853 | 159,052.77 | 0.3120 | 146,460.70 |

[a]CONDITION and interaction term excluded.

[b]AGE and interaction term excluded.

TABLE XVI

MAXIMUM $R^2$ STEPWISE REGRESSION RESULTS FOR WINTER ELECTRICITY CONSUMPTION[a]

| Predictor | Beta | F | Step |
|---|---|---|---|
| AGE | 54.695 | 11.61*** | 1 |
| INCOME | 0.024 | 5.31* | 5 |
| PLAN*AGE | 0.544 | 2.93* | 5 |
| LOCATION | 986.057 | 2.09 | 5 |
| PLAN*SIZE | 0.332 | 1.29 | 5 |
| | | | |
| Intercept | 103,989.73 | | |
| $R^2$ | 0.1814 | | |
| df | 5 | | |
| F-ratio | 9.575*** | | |
| MSE | 11,841,722.33 | | |

*** $p<0.001$

** $p<0.01$

* $p<0.1$

[a]AGE included; CONDITION excluded.

TABLE XVII

MAXIMUM $R^2$ STEPWISE REGRESSION RESULTS
FOR WINTER ELECTRICITY COST[a]

| Predictor | Beta | F | Step |
|---|---|---|---|
| AGE | 2.480 | 13.03*** | 1 |
| SIZE | 0.015 | 2.44 | 3 |
| INCOME | 0.001 | 7.07** | 4 |
| PLAN*AGE | 0.037 | 12.49*** | 4 |
| | | | |
| Intercept | -4,628.54 | | |
| $R^2$ | 0.2158 | | |
| df | 4 | | |
| F-ratio | 14.93*** | | |
| MSE | 21,986.38 | | |

*** $p<0.001$

** $p<0.01$

* $p<0.1$

[a]AGE included; CONDITION excluded.

TABLE XVIII

MAXIMUM $R^2$ STEPWISE REGRESSION RESULTS
FOR SUMMER ELECTRICITY CONSUMPTION[a]

| Predictors | Beta | F | Step |
|---|---|---|---|
| INCOME | 0.050 | 23.68*** | 1 |
| PLAN*SIZE | 0.753 | 10.66** | 2 |
| AGE | 26.742 | 4.81* | 4 |
| PLAN*AGE | 1.102 | 7.69** | 5[b] |
| PLAN*INCOME | -0.025 | 3.21* | 5 |
| Intercept | -49,333.27 | | |
| $R^2$ | 0.3286 | | |
| df | 5 | | |
| F-ratio | 21.14*** | | |
| MSE | 6,814,514.03 | | |

*** $p<0.001$

** $p<0.01$

* $p<0.1$

[a]AGE included; CONDITION excluded.

[b]Entered first time in step 3.

TABLE XIX

MAXIMUM $R^2$ STEPWISE REGRESSION RESULTS FOR SUMMER ELECTRICITY COST[a]

| Predictors | Beta | F | Step |
|---|---|---|---|
| INCOME | 0.003 | 25.14*** | 1 |
| PLAN*SIZE | 0.050 | 9.99** | 2 |
| PLAN*AGE | 0.082 | 9.14** | 3 |
| PLAN*INCOME | -0.002 | 5.22* | 4 |
| AGE | 1.612 | 3.72* | 5 |
| Intercept | -2,908.25 | | |
| $R^2$ | 0.2985 | | |
| df | 5 | | |
| F-ratio | 18.38*** | | |
| MSE | 32,033.45 | | |

*** $p<0.001$

** $p<0.01$

* $p<0.1$

[a]AGE included; CONDITION excluded.

TABLE XX

MAXIMUM $R^2$ STEPWISE REGRESSION RESULTS FOR TOTAL ELECTRICITY CONSUMPTION[a]

| Predictors | Beta | F | Step |
|---|---|---|---|
| AGE | 111.204 | 9.64** | 2 |
| SIZE | 0.960 | 3.54* | 3 |
| INCOME | 0.076 | 11.07** | 4 |
| PLAN*AGE | 2.513 | 21.06*** | 4 |
| | | | |
| Intercept | 209,729.53 | | |
| $R^2$ | 0.2526 | | |
| df | 4 | | |
| F-ratio | 18.33*** | | |
| MSE | 59,745,710.06 | | |

*** p<0.001

** p<0.01

* p<0.1

[a]AGE included; CONDITION excluded.

TABLE XXI

MAXIMUM $R^2$ STEPWISE REGRESSION RESULTS FOR TOTAL ELECTRICITY COST[a]

| Predictors | Beta | F | Step |
|---|---|---|---|
| INCOME | 0.006 | 15.08*** | 1 |
| AGE | 6.160 | 10.80** | 3 |
| PLAN*AGE | 0.145 | 5.72* | 4[b] |
| PLAN*INCOME | -0.003 | 1.76 | 5 |
| PLAN*SIZE | 0.080 | 5.10* | 5 |
| LOCATION | 91.630 | 1.34 | 6 |
| Intercept | -11,394.121 | | |
| $R^2$ | 0.2853 | | |
| df | 6 | | |
| F-ratio | 14.31*** | | |
| MSE | 159,052.77 | | |

*** $p<0.001$

** $p<0.01$

* $p<0.1$

[a]AGE included; CONDITION excluded.

[b]Entered first in step 2.

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