HOME BUILDERS ENERGY AWARENESS AS RELATED TO CONSTRUCTION AND DESIGN FEATURES OF HOUSING

By

JANE DAVIDSON REAGOR

Bachelor of Science

Memphis State University

Memphis, Tennessee

1964

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements of
the Degree of
MASTER OF SCIENCE
July, 1978

HOME BUILDERS ENERGY AWARENESS AS RELATED
TO CONSTRUCTION AND DESIGN FEATURES
OF HOUSING

Thesis Approved:

K. Kay Stewart
Thesis Adviser

Margaret Weber

Christine F. Salmon

Sue Williams

Norman N Durham
Dean of the Graduate College

PREFACE

Energy efficiency in the design and construction of new housing is a subject that has been of little concern to builders and homebuyers alike until the past few years. The need for energy efficiency in new housing is evident as the supplies of energy diminish and the prices continue to rise. Builders have begun to take the initiative and build houses with measures that will cut back on energy consumption. This study is primarily concerned with home builders and their level of energy awareness in relation to energy efficient construction and design features and techniques in new construction.

The writer wishes to express her sincere gratitude to her major adviser, Dr. Kay Stewart, Associate Professor, Housing, Design, and Consumer Resources, for her guidance, encouragement, support, and time spent in helping me to complete this study. Dr. Stewart's enthusiasm is a great inspiration to those who study under her.

Appreciation is also expressed to the other committee members, Dr. Margaret Weber, Christine Salmon, and Sue Williams for their concern, guidance, friendship, and assistance in the completion of this study.

An expression of gratitude is expressed to Leo Cravens, Executive Vice President of Oklahoma Home Builders Association, for his assistance with this project. The writer also expresses gratitude to Ken Jones, Energy Specialist at Oklahoma State University, for his help in preparing the questionnaire and the coding scale used in this study.

Special thanks is expressed to Dr. Carl Hall, Head of Housing, Design, and Consumer Resources Department, for his support and guidance throughout the year. Appreciation is given to Oklahoma State University for the privilege of being granted a graduate teaching assistantship which allowed me to pursue an interest in housing and design.

The writer wishes to express appreciation to special friends Alta Lane and Debra Ray, who are partly responsible for my being able to pursue this study. I am most indebted to my family for their continual support. My mother, Mrs. Gladys Etheridge, is a perfect example of what a mother should be. She has always been there when I have needed her. My brother, Jerry Davidson, and his family have encouraged me greatly in this interest. A special thanks to my mother-in-law, Mrs. Dorothy Reagor, who sacrificed her time to care for one of my children who was not able to move here with me.

And lastly, I thank my children, Wayne, Caroline, and Howard, for their patience and help and understanding throughout this study.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

Statement of the Problem

Until the Arab oil embargo in 1973, most builders and homebuyers were not concerned with energy conservation in housing. The cost of heating or cooling a home was so low that few builders did more than meet minimum insulation standards. Energy was plentiful and inexpensive until 1973. The situation has reversed itself since that time. Fuel supplies are not only uncertain but very costly. Many home-owner's utility rates are as high as their monthly mortgage payments (Professional Builder, 1977, p. 49). Energy conservation is becoming increasingly important to homeowners in addition to those in the building industry.

In an energy message delivered April 20, 1977, President Carter said:

> The second major area where we can reduce waste is in our homes and buildings. Some buildings waste half the energy used for heating and cooling. From now on, we must make sure that new buildings are efficient as possible and that old buildings are equipped, or retrofitted with insulation and heating systems that dramatically reduce the cost of fuel (p. 568).

Carter further proposed tax incentives for those who weatherize their homes; direct federal help for low-income residents; and grants for those who will use solar heating. A number of specific goals were set for the year 1985. These include plans to reduce the annual growth rate in the United States' energy demand to less than two percent. The specific goals involving the homes of Americans called for the insulation of 90 percent of homes and new buildings and to use solar energy in more than two and a half million houses. Plans were announced to remove barriers by opening a secondary market for residential energy conservation loans through the Federal Home Loan Mortgage Corporation and the Federal National Mortgage Association. If the plans announced by President Carter prove to be insufficient in achieving widespread residential conservation, then mandatory measures will be considered and proposed to go into effect by 1980 (Carter, 1977, pp. 561-572).

Carter's plan did not catch the home building industry off guard. Since the time of the oil embargo and even before, many builders had voluntarily opted to upgrade the energy efficiency of new homes. Now the nation's homebuilders will be called upon to build houses that require even less energy for operation.

A variety of design and construction features can be incorporated into new houses to reduce the use of energy. There are also heating and cooling systems as well as appliances that are more efficient than others. The value of energy efficient design and construction features must be measured against their cost. According to Ralph J.

Johnson (1977) President of the National Association of Home Builders Research Foundation:

> Their marketability varies depending on location, climate, price class of the home, the type and cost of fuel or energy, type of heating and cooling system and other factors (p. 1).

Building energy conserving homes will add to the selling price of new construction. Most of the design and construction features are thought to be economically feasible over a period of time. However, not all energy conserving features will add to first cost; some, like less glass area, will lower first cost. Also, energy conserving homes will be more comfortable and will have lower fuel costs. Marketability must remain a matter of judgment of each builder for each type of house he builds (Johnson, 1977, pp. 1-2).

The rising cost of energy in addition to the uncertainty of the future supplies of fossil fuels for energy challenges the homebuilding industry to build energy conserving homes which will help to reduce the national energy demand.

Purpose of the Study

The purpose of this study was to conduct a survey among Oklahoma Home Builders to measure their awareness of energy efficient design and construction features of new housing. Guidelines published by the National Association of Home Builders (NAHB) were used as a guide for this measurement.

Objectives

The specific objectives of this study were:

1. To identify characteristics of the builders.
2. To determine builders' attitudes about the energy shortage, the government's position on energy, and the lending institution's attitudes on energy.
3. To measure the level of energy awareness of builders regarding energy efficient techniques and features in housing design and construction.
4. To examine differences in energy awareness levels for builders with different characteristics; size of firm, age of builder, education of builder, length of time in business, size of city in which he is now building, price and size of houses built last year.
5. To determine if builders are evaluating the effectiveness of energy saving features they are incorporating into new construction and, if so, what type of evaluation they are doing.
6. To determine which energy efficiency guideline(s) for construction practices are being used by builders.

Hypotheses

Seven specific null hypotheses were examined in this study. There is no significant difference in the builders' scores on the Energy Awareness Scale and the following:

a) the number of houses he constructed last year

b) the age of the builder

c) the level of education

d) the length of time in business

e) the size of city in which he is building

f) price range of the homes he built last year

g) average square footage of houses he constructed last year

Procedure

The sample for this survey was obtained from the membership list of the Oklahoma Home Builders Association. The total membership of the Oklahoma Home Builders Association totaled 2,762 and was a combination of both active and associate members. Associate members are those who are suppliers, lending institutions, and others who are in related fields to home building. Active members are the ones who are actually building housing. The membership list was reviewed and associate members were removed from the potential sample. A random sample of 300 was drawn from the 1,045 active building members.

A questionnaire was developed using the six specific objectives as a guide (see Appendix A). The questionnaire was pretested by administering it to builders in Stillwater, Oklahoma, and these builders were eliminated from the membership list before the sample was drawn. Following the pretest, the questionnaire was revised for clarity and completeness. An Energy Specialist at Oklahoma State University assisted with the development of questions and the scoring for the Energy Awareness Scale.

On May 3, 1978, the questionnaire accompanied by a cover letter (Appendix A), was mailed to the 300 builders in the sample. By the cut-off date of May 15, 1978, 60 questionnaires had been returned. Of the 60 questionnaires received, six were eliminated because respondents were primarily commercial builders. The data were checked, coded and punched into computer data cards in preparation for analysis.

Analysis of Data

Preliminary analysis was conducted by means of frequencies and percentages. Chi-Square tests were used to test the seven null hypotheses. The Statistical Analysis System (SAS)--a computer library program--was used for the analysis. Significant findings were identified, conclusions were drawn and recommendations were made based on these findings and conclusions.

Definition of Special Terms

The term "energy efficiency in the design and construction of housing" describes those features and techniques, when used in the construction of housing, that reduce the energy consumption of a house.

British Thermal Unit (BTU) is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

A kilowatt hour (kwhr) is the energy transferred or expanded in one hour by one kilowatt of power. One kilowatt is equivalent of about one and one-third horsepower.

The efficiency of an energy conversion is the ratio of the useful work or energy output to the total work or energy input.

Energy is the capacity of a body or substance to perform work. It is a quantity having the dimensions of a force times a distance. Energy exists in many forms and can be converted from one form to another.

Fossil fuels such as coal, crude oil, or natural gas are formed from the fossil remains or organic materials.

A heat pump is a refrigeration machine that can also work in a reverse cycle.

Heat is a form of kinetic energy that flows from one body to another because of a temperature difference between them.

HVAC refers to heating, ventilating, and air conditioning systems.

Heat gain is that amount of heat gained by a space from all sources. The total heat gain represents the amount of heat that must be removed from a space to maintain desired indoor conditions.

Heat loss is the sum cooling effect of the building structure when the outdoor temperature is lower than the desired indoor temperature. It represents the amount of heat that must be provided to a space to maintain indoor comfort conditions.

R-value is the measure of the ability of a material to retard heat flow in a building element.

U-value is the total heat transmission rate of a building element.

A vapor barrier restricts the passage of moisture through building elements.

Insulation is any material that reduces the passage of heat through building elements.

Infiltration refers to outdoor air leakage into a building.

Life cycle cost is the total cost of an item, including initial purchase price as well as cost of operations and maintenance over the life of the item.

CHAPTER II

REVIEW OF LITERATURE

National Energy Crisis

The United States is facing an energy shortage of unknown duration which is forcing consumers as well as industry and business to take a serious look at conservation in every area of life. The explanation for the energy crisis is simple, natural sources of energy are decreasing while the demand for energy is increasing at an alarming rate. While only six percent of the world's population lives in the United States, this six percent consumes 33 percent of the world's energy (Montgomery, 1973, p. 17). The United States accounts for 31 percent of the gross national product of the world. If the United States did not use much of the world's total energy, then it could not produce the large proportion of the world's goods and services. So the use of energy and the gross national product are closely associated because business and industry require energy.

Weber and Feder (1977) stated that America's need for energy has been growing since the industrial revolution:

> Expanding population accounts for some of that growth--more people, more use of energy; the

> larger factor, however, has been increasing energy use per person. While U.S. population grew by 34 percent from 1950 to 1970, per capita energy consumption grew by 46 percent. The combined effect gave us a 1970 level of energy use almost double that of 1950. If this curve had continued, by 1990 annual use would have almost doubled again. At that rate, we would have used in those 20 years as much energy as we had used in all the years from 1607 to 1970. The curve has been flattened by the oil embargo, hiked energy prices and the recession that followed, but it is too early to tell if this change will be a major deflection of the curve or only a minor kink in it (p. 5).

According to Udall, Conconi and Osterhout, "historians will look back on 1973 as the year the era of cheap energy ended" (1974, p. 22). The United States has taken cheap energy for granted in the past. The American people revel in the exceptional and grand in all areas of life from automobiles to housing. It was computed that energy use in the United States was so significant that it was equal to each citizen having 200 personal servants. Most Americans believed that there was nothing that could not be solved in this great technological country. When warned of the impending energy crisis, most people did not heed the counsel. Lines at gas stations all over the nation in 1973 and 1974 convinced many people that the energy crisis was indeed true (Udall, Conconi and Osterhout, 1974, pp. 22-27).

Energy Demand and Sources of Fuel

Before the embargo, United States' petroleum consumption had reached 18 million barrels a day. After the embargo, a higher price resulted with the cost spiraling from $1.80 a barrel to somewhere around $13.00 a barrel. This great price increase caused a decline in the consumption of energy in 1974 and 1975. In 1976 energy consumption began to rise but at a slower rate (Weber and Feder, 1977, p. 7).

Even the energy experts were astonished at the rapid change in the petroleum picture in the early seventies because as recently as 1954, the United States had pumped half the world's oil from its own wells and had consumed about half of that oil. The impact of the Organization of Petroleum Exporting Countries (OPEC) embargo taught the United States that its consumption had far outrun its capacity for production (Udall, Conconi and Osterhout, 1974, pp. 89-94).

Today, four years after the oil embargo, the United States is more dependent than ever on foreign sources for oil. The volume of imports climbed from 23 percent in 1970 to more than 40 percent in 1977. The Federal Energy Administration has estimated that oil imports will exceed 50 percent of United States consumption by 1985 (American Petroleum Institute, 1977, p. 5). Significantly, the report on energy (1974) by the Ford Foundation warned:

> Even if there were no further annual growth in energy use after the 1980's, the nation would still need to find enough supplies every year to meet an energy demand one-third larger than than of 1973 (p. 108).

There has been little argument over the fact that the United States must have dependable access to energy sources if present standards of living are maintained, jobs provided and a position of continued leadership in world affairs. There are differences of opinions about how much energy will be needed and particularly over what the alternate or promising energy sources are (American Petroleum Institute, 1977, p. 16).

Fossil fuels have been the mainstay of American's energy system, accounting for 95 percent of the United States' energy consumption in 1973. Even with the unveiling of alternate sources such as nuclear power, fossil fuels will dominate energy supply at least until the turn of the century. While oil is the most versatile, natural gas is the cleanest major energy source (Ford Foundation, 1977, p. 181). Most authorities agree that of the fossil fuels in the United States, natural gas is in the shortest supply. The bitter winter of 1976-77 brought to light the fact of the domestic shortage of natural gas. The Federal Energy Administration (FEA) and many states have set priorities for energy use with first usage being designated for space heating for residences. Today natural gas is being used at nearly twice the rate which new reserves are being discovered (Weber and Feder, 1977, p. 8). Regulation of gas prices has been one of the biggest sources of dispute between Congress and the President. Presently, natural gas that remains inside the state where it is produced is free from price controls, but gas that is shipped across state lines has a government price ceiling (Time, 1977, pp. 85-86).

Coal resources are more abundant than either gas or oil and could meet energy needs for several centuries if ways could be found to extract it cheaply and safely without harming the environment. The several centuries that are agreed to be the outside limit for fossil fuels as energy sources are a short period in history (Weber and Feder, 1977, p. 11).

Residential use of electricity has increased 129 percent in the last decade. In 1961, 4,016 kilowatts per household were consumed and ten years later, 7,379 kilowatts per household were consumed. This represented one-third of the total electrical use in the United States (Montgomery, 1973, pp. 18-19). The net efficiency for electricity is a little more than 30 percent, with the remaining 70 percent being incurred through generation and waste heat. "The consumption of electricity is a key index to the rate at which the nation uses energy" (Udall, Conconi and Osterhout, 1974, p. 29).

Steadman presented a system by which the losses inherent in the central generation of electricity can be cut. The "total energy" system in practice is to bring onto the site of a subdivision a miniature generating plant which supplies the needs of that development alone. The

The losses in power transmission are avoided and the heat waste can be used to supply water heating needs. The "total energy" system can best be used in mixed developments where the heating and electrical demands can be spread more evenly over the entire twenty-four hour period. Systems presently in operation are Rocheale Village in New York and at the HUD Jersey City "Operation Breakthrough" site, among other places (Steadman, 1975, pp. 23-25).

The engineering consulting firm Hittman Associates studied the use of energy in a "typical" house for a family of four in the Baltimore-Washington area. The study was conducted for the Department of Housing and Urban Development (HUD) and the typical house was defined as having 1,500 square feet, two story construction with wood framing and storm doors and windows and good insulation. The study compared two houses, one all-electric and the other which used natural gas instead of electricity for major heating, cooking and clothes drying purposes. Electricity was specified for all other purposes. The home using natural gas used about half the energy that would be required if it were all electric. The major cut in energy use was in the central heating system. According to Clark (1974) all electric homes are being encouraged:

> Notwithstanding this potential savings in energy, the Federal Power Commission (FPC) continues to advocate the development of all-electric homes, and predicts that construction of electric homes will surge from the 1970 total of just over four million homes to twenty-four million in 1990.

> At the same time, natural gas has been increasingly allocated, not for direct home energy purposes, but for burning at electric power plants. The FPC prediction that 40 percent of new dwellings in the 1970's and higher percentages thereafter will be all-electric spells energy disaster, as the already overtaxed energy resources of this country are diverted into the production of wasteful electric power (p. 187).

According to projections of the National Energy Plan, if energy requirements could be reduced, then the United States will have the time it needs to develop alternate supplies of energy. Promising alternate sources include solar technology, use of geothermal, nuclear breeder, and nuclear fusion. The long term future for energy sources in America is uncertain; a variety of technologies are needed not only for the present but for the future (National Energy Plan, 1977, p. X). The energy crisis is interwoven into the economy as well as the environment. The production of energy and its consumption is a complex blend which accounts for a significant share of the United States' economic activity and touches every part of American life (Udall, Conconi and Osterhout, 1975, pp. 136-137).

The recognition of environment damage directly related to energy consumption is a fairly new phenomenon. Each energy supply option is usually associated with certain factors that are harmful to the environment. Competent controls to protect the environment are not without costs or controls. The question is then, what does a high energy civilization do to continue to enjoy benefits from energy and at the same time protect its people and planet (Ford Foundation, 1975, p. 179).

Political and Economic Implications of the Energy Dilemma

The energy crisis has been felt in every area of life during the past few years. According to Barry Commoner (1977):

> . . . energy supply problems have disrupted daily life; they have triggered an economic depression; they have led to a bitter confrontation between the industrialized countries and the developing ones; they have generated lightly disguised threats by the President and the Secretary of State to invade oil-producing countries (p. 4).

During the early days of the oil embargo, President Nixon introduced the idea of "Project Independence" as the answer to the U.S. energy crisis. In a national television address he stated that by 1980, America should be able to meet its energy needs from America's own resources. The solving of the energy crisis was such a complex problem that involved many areas of society that such a goal was impossible to reach (Udall, Conconi and Osterhout, 1975, p. 128).

Energy prices were a central issue which provoked a strong policy debate between the Ford Administration and Congress in 1975. The administration wanted the government out of the pricing business, therefore letting prices rise to cut the energy demand. Congress believed that economic recovery should take priority over energy conservation and that higher prices would begin another period of inflation and slow down economic recovery (Weber and Feder, 1977, pp. 12-13).

According to Commoner, all the sources of energy now used require a large investment of capital and if the U.S. continues to rely on these sources and the same economic theory, then energy will demand increasingly larger capital investment and higher selling prices. The present energy system, Commoner says, has a "built-in propensity toward inflation."

Commoner further stated that the government, in offering tax incentives and facilitating financing for adding insulation and solar, would be very advantageous. Insulation and solar heating are job creating programs involving many sectors of the contruction industry. These jobs would be a valuable aid in reducing the unemployed and increasing the Gross National Product (Commoner, 1977, pp. 13-15).

National Energy Plan

Energy conservation currently implemented is fully in agreement with economic growth. Adjustments made in energy consumption now can prevent disasters in the future according to the proponents of the National Energy Plan of President Carter.

Conservation and fuel efficiency are the basics of the proposed National Energy Plan. Conservation is cheaper than the production of new supplies and can be a benefit to international stability by easing the pressure of the world's fuel supplies. According to Carter's Plan:

> Conservation and improved efficiency can lead to quick results. A significant percentage of poorly insulated homes in the United States could be brought up to strict fuel efficiency standards in less time than it now takes to design, license and build one nuclear power-plant (National Energy Plan, 1977, p. 29).

Although conservation methods are relatively inexpensive, they do call for sacrifice on the part of the American people. According to basic theory behind the Energy Plan, if the American people are led to believe that they can obtain energy at a cheap rate, then they will continue to consume energy at a rate that the United States cannot afford to maintain (National Energy Plan, 1977, p. XI).

In the residential sector the greatest potential for the conservation of energy lies in space conditioning and water heating. Space conditioning accounts for 60 percent of the residential energy use. About 11 percent of the total energy consumption is used for residential space heating. After the automobile, heating a home is the largest single energy consuming expense in the overall family energy budget. In the 1960's air conditioning energy consumption increased by 81 percent. In 1972 nearly half the houses in the United States had room air conditioners (Ford Foundation, 1974, pp. 49-51).

> Currently, there are approximately 74 million residential units in the United States, and 1.5 million nonresidential buildings with 29

> billion square feet of floor space. Almost 20 percent of U.S. energy is used to heat and cool buildings. Some of these buildings needlessly waste as much as half of that energy. The hermetically sealed glass and steel skyscraper is the analogue of the gas-guzzling automobile. The energy efficiency of American buildings is a direct result of the cheap energy era in which most of these structures were built (National Energy Plan, 1977, pp. 40-41).

One form of conservation, not using energy in the first place, depends solely on voluntary choice by consumers. A second form of conservation refers to governmentally mandated levels of energy conservation. The law setting the speed limit at 55 miles per hour as a national speed limit is an example of this. In the building industry, codes requiring insulation and other energy saving techniques in construction would be an example of this.

The matter of energy conservation is not so convenient when it requires an initial investment as in the case of when a homeowner adds insulation to an existing home (Weber and Feder, 1970, pp. 29-30). A recent study by Hirst noted that the combined effects of rising prices, the Energy Policy and Conservation Act (higher efficiencies in appliances) energy conservation technology, and the Energy Conservation and Production Act (energy performance standards in buildings) all together will have a positive effect in lowering rates of growth in residential energy demand (Hirst, 1976, p. 1248).

For many decades energy has been priced at levels that have encouraged consumption. There have been rate structures that have given lower rates to larger users. This has been one of the reasons why conservation measures have been delayed so long. In the past the American people have adopted ways of doing things that are energy intensive.

Over 50 percent of energy consumed in the United States is discarded as waste. Energy can no longer be wasted. Conservation methods are needed to preserve current dwindling supplies.

> Conservation can be encouraged or enforced in many ways: (1) higher prices, changed pricing structures, and/or taxes on energy to discourage use; (2) education of users on the why and how of energy conservation; (3) tax incentives and subsidies to promote installation of energy-saving equipment; (4) direct allocation of energy to users (rationing); and (5) technological change to minimize energy use accompanied or not by mandated standards for energy use of selected goods (Rudd and Longstreth, 1978, p. 40).

While potential for energy saving is great, there seems to have been little progress made in this area. In a recent rederally sponsored study, Milstein (1977) concluded that most Americans were aware of the energy crisis in America and were knowledgeable about the situation. However, there was a gap between what people said and what they did. "While 76 percent of those surveyed said they favored sharing rides to and from work, only 10 percent did so" (Weber and Feder, 1977, p. 31). From the study it would appear that large fractions of those surveyed did not know the basic facts concerning the energy dilemma. Also, the term "energy use" was equated with the American dream of material possessions. Many were cynical about the problem and blamed politicians and big business. In brief, they were not convinced that a crisis existed (Weber and Feder, 1977, pp. 31-32). It is a serious mistake to regard energy conservation as an end in itself. Conservation is worthwhile as a way of alleviating the present shortages. Energy growth is desirable according to the Ford study because it gives us more goods and services and upgrades our standard of living (Ford Foundation, 1974, p. 11).

Energy Bills

Bill HR 8650 (Energy Conservation Building Act of 1975) directed the Secretary of HUD to develop energy conservation performance standards for building construction. In justification for the law Congress found that:

> Large amounts of fuels and energy are consumed unnecessarily each year in heating, cooling, and ventilating residential and commercial buildings because such buildings lack adequate energy conservation features. . . . (Hearing, August 7, 1975, p. 11).

The bill would encourage states and local government to adopt and enforce such standards through their existing building codes and other construction control mechanisms (Congressional Quarterly, 1975, p. 1662).

The bill was strongly opposed by the National Association of Home Builders (NAHB) as well as the American Institute of Architects (AIA). Speaking against the bill in a hearing was John C. Hart, 1975 First Vice-President of

NAHB and William Marshall, Jr., President of AIA. Mr. Hart said that at that time the building industry had been co-operating with the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) to develop a model set of energy conservation standards for new buildings and that the enactment of the Energy Conservation Act would disrupt the national voluntary effort (Congressional Hearing, 1975, pp. 52-55). Marshall, in his opposition to the bill, said:

> Mandatory energy standards are the result of an attitude that says we cannot trust professionals and building owners and the normal workings of the marketplace to produce satisfactory solution (Congressional Hearing, 1975, p. 56).

Marshall further proposed a program which would provide tax incentives that would stimulate greater innovation on the part of the industry.

As passed by the House HR 8650 only encouraged and did not mandate development of the energy efficiency standards for new buildings. Many of those opposing its passage argued that even this bill threatened to impose a federal building code upon the nation. The bill was subsequently dropped in conference (Congressional Quarterly, 1975, p. 1944.

In Oklahoma, Senate Bill No. 523, entitled Oklahoma Building Energy Conservation Act, was introduced into the second session of the 36th Oklahoma Legislature in January by Senator Bob Murphy of Stillwater. The bill would create the Oklahoma Building Energy Conservation Commission which would consist of six members representing different areas of the building industry. The act would be administered and enforced by the State Fire Marshall. New buildings or proposed construction or alterations would have to be planned in accordance with the provisions of the Building Officials Code of America (BOCA) International, Incorporated. A permit would have to be issued for construction. A political subdivision could, if it desired, enact rules and regulations which would have higher requirements. However, no municipality or subdivision would be able to enforce any ordinances that are less than the standards set by BOCA (Bill 523, 1978, pp. 3-9).

The process of making energy decisions takes a considerable amount of time. Many decisions require cooperative effort by private enterprise and government and lack of coordination often produces delay. Research in the energy field is relatively new and even when new supplies or sources are found, the development time is long. For example, there was a gap of twenty-five years between the founding of atomic power and the beginning of the first commercial nuclear plant (Ford Foundation, 1974, p. 5).

Energy Conservation in Building

According to the Ford Energy Policy Project, three basic approaches can be taken to save energy in space conditioning; improved building design; more efficient systems for heating and cooling; and after 1985, the increased use of solar (Ford Foundation, 1975, p. 49).

The greatest share of residential construction in any given year is the direct result of increases in the number of households. Between 1970 and 1975 the number of households, 7.5 million, accounted for 68 percent of the 11.4 million units built during the same time period. The Harvard-MIT study of 1977 has estimated that approximately 11.9 households will come into existence between 1975 and 1985. This will call for new construction to accommodate this growing need for additional housing units. To meet this need the housing industry will have to build 2.0 to 2.3 million units per year during this ten year span (Frieden and Solomon, 1977, p. 140).

Buildings that are designed today in the middle 70's may be expected to have a useful life at least up to 2010 and after. Steadman argues that perhaps buildings should be designed for longer life spans. Buildings are not like other products such as cars, where the technology can be rapidly changed (Steadman, 1975, p. 26).

Regardless of the source of energy that the house uses, the actual shell of the house is very important in determining how much energy the home will require to heat or cool. A well-constructed house will require less energy because of less heat and cooling losses. The effects are more evident with air-conditioning, because heat gain will require more energy to operate the air-conditioning system (Clark, 1974, p. 182).

Technology after World War II, along with a period of cheap energy, allowed architects and builders to disregard the environment and build structures that overcame climatic conditions by using larger mechanical conditioning systems (Architectural Forum, 1973, p. 62). Energy conservation in the residential and commercial sectors is primarily a function of building design. Because of the structure of the industry, many builders, in trying to keep first costs low, have bypassed investments in insulation and other features that would be economical over the life of the building (Ford Foundation, 1975, p. 53).

Building costs have risen 70 percent since 1966 and continue to rise at about one percent per month. A builder's preoccupation with the initial investment is of prime concern.

> First costs, however, are not an accurate indication of the cost of a building because they are merged into a series of monthly payments, along with operating, interest and maintenance costs. Life-cycle costs, on the other hand, reflect the cost of a building to an owner over its entire lifetime and allow an architect and owner, among others, to evaluate the trade-offs between a system or building that is inexpensive to build versus one that is inexpensive to operate (AIA, 1976, p. 10).

Life-cycle costs consider the total costs of constructing, owning and operating a building over tis entire estimated lifetime. The rising cost of energy plus the shortage is provoking builders to look at various tradeoffs. But the tendency to keep first costs low has been reinforced by the enormous rate of inflation in the cost of building.

For builders there is the real difficulty or raising the extra capital to pay for initial energy conserving investments (Steadman, 1975, p. 44).

Calculations must be made that analyze the cost against the benefits. If benefits exceed costs, then the extra money in energy saving features is justified. Time to recoup capital investment calculates the time required to gain back an investment through annual operating and maintenance costs, which are then used to pay the interest required to amortize a loan for the initial investment. If this time is less than the estimated life of the building, then the investment is justified. Much of residential building is speculative in which the primary motive is to keep first costs low. According to American Institute of Architects, "energy conservation has very few buyers right now" (1976, p. 13). The Institute also stated that unless the homebuying public begins to demand housing units that have energy saving features or unless there is some form of regulation imposed upon builders, then there is little desire for the homebuilder to reduce energy consumption through design changes (AIA, 1976, pp. 11-13).

In energy conservation, one of the problems is that many consumers are not aware of the energy saving opportunities, many of which do not even add to first costs. The report by the Ford Foundation suggested that adequate information made available to the consumer would have an impact on the energy use in building design. The building construction industry is a fragmented industry and as a result the technical ability is not coordinated to develop and implement improvements in methods and techniques. Because of the building industry's problem in gaining access to capital, it has emphasized keeping first costs as low as possible. In few instances does the average builder have the capital to implement new systems or take a chance on installing energy features at his own risk (Ford Foundation, 1975, pp. 53-54).

The nature of high energy American society, in particular the economic system, encourages waste through incentives for first cost purchase as opposed to life-cycle costing. The initial cost of a home with energy saving features will be higher but over the lifetime of the home, less money will be spent to heat and cool the home (Clark, 1974, p. 183). No factor in energy conservation is more important than comprehensive planning before a structure is erected. Buildings today can be built with measures that reduce energy consumption by as much as 50 percent (Architectural Forum, 1973, p. 64).

Buildings should have an energy budget so that the various energy conserving features of a structure integrate and complement each other. Many older buildings were planned without taking into consideration the environment. Builders and architects today need to learn to take advantage of the natural environment that will save in energy consumption by suiting the structure to the local conditions (Udall, Conconi, and Osterhout, p. 214).

Construction Practices

Insulation

Insulation is any material that reduces the passage of heat through building elements. It does not heat or cool, but it does restrict the flow of heat out of areas that one is trying to keep warm or into spaces one is trying to keep cool. Insulation is a one time investment which shows up in dividends in the form of lowered utility bills.

The R-value designates the ability to retard heat flow in a building element. The higher the R-value, the more effective the insulating material. Insulation should be purchased according to the R-value and not the thickness (Cooperative Extension Serivce, OSU, n.d., p. 99).

Two primary benefits of insulation are: economy of operation and comfort. The cost of space conditioning is directly related to the total heat loss and heat gain of the dwelling. U-value is used to designate the total heat transmission rate of a building element. The lower the U-value, the higher the insulating value.

> The rate of heat flow U through the wall without insulation is 0.25 British Thermal Units per hour per square foot of wall for each degree of temperature. For the insulated wall the heat transfer rate is 0.07 BTU--a reduction of more than two-thirds in the amount of heat loss or gain due to the wall (NAHB, 1971, p. 8).

Insulation helps to make a home more comfortable because the temperature differences of room to room and floor to ceiling will be more uniform than they would be without insulation. Insulation also heps reduce drafts that are produced by convection currents generated by interior surface air temperature differences. Insulation reduces the cold wall effect. Interior surfaces of uninsulated frame or masonry exterior walls can be 8°F to 14°F or more than insulated walls in winter. Proper insulation in building elements increases the interior surface temperature in winter and lowers it in summer. In winter people feel more comfortable because the human body loses less of the heat it produces to maintain a constant temperature. If heat is lost too rapidly by radiation to a cold wall, ceiling or floor, a person will feel cold. In the summer the reverse works because insulation lowers the mean radiant temperature. When wall, ceiling or floor surfaces are relatively cold, most people will raise the thermostat higher in order to be more comfortable. Insulation enables one to be equally comfortable at lower air temperatures. At an outside design temperature of plus 10°F, a 3-degree lower thermostat setting will save more than 5 percent of the yearly heating cost. The same principle works in reverse in summer (NAHB, 1971, pp. 8-9).

Of all the designs for reducing energy consumption in buildings, thermal insulation is the most effective and the most generally applicable. According to Griffin, it probably yields the greatest long term economy of any capital investment made in a building. Fast rising energy costs are constantly raising the economic levels of thermal insulation. The other benefits of thermal insulation besides comfort and economy of operation are prevention of condensation on interior surfaces and reduced heating, ventilating, and air-conditioning capacity (Griffin, 1974, p. 47).

Insulators are compared to each other by the term resistance. A material with a resistance of "5" per inch of thickness would retain heat five times better than a material with a resistance of "1" per inch of thickness (Eccli, 1976, p. 204). Three laws concerning heat and cold play important roles in insulation. Conduction is the flow of heat through a solid material. It is generally the prime mechanism for transmitting heat through the building system. Conduction depends primarily on "direct contact between vibrating molecules transmitting kinetic energy directly through the material" (Griffin, 1974, p. 52). The primary function of thermal insulation is to resist heat transmission by conduction. Convection requires air to move heat energy from one place to another. Warm rises; therefore, insulation in the ceiling will minimize loss of heat. Caulking and sealants protect against convective heat loss. Radiation is the process by which heat is transmitted across air spaces. In the winter, a house radiates heat to the cold outside. In the summer, the process works in reverse so insulation can protect the inside of a house from the effects of radiation (Griffin, 1974, pp. 49-52).

There are four types of insulation normally used in residential building. These types include: batt or blanket; fill type; rigid board; and blow insulation. Batt or blanket is produced in various thicknesses and in widths from 16 to 24 inches to fit between wall studs or ceiling and floor joints. They may be purchased with or without a vapor barrier. The fill type insulation is available in glass fiber, mineral wool, vermiculite and cellulose. It is primarily used in existing wall construction and ceilings. The fill type tends to settle in time and this factor might make it a poor choice for new construction (Cooperative Extension Service, Oklahoma State University, n.d., pp. 143-144). A new type of fill insulation recently introduced into the market is "foamed in place Urea-formaldehyde." Presently, it is expensive but is an excellent material for insulating the walls of older homes. Some of the foams are not fire resistant and may be likely to give off toxic fumes in a fire (Cooperative Extension Service, OSU, n.d., p. 144).

Fiberglass is probably the most common of all the insulating material today. It is fire proof and moderate in cost and has all the properties of glass.

> Glass fibers are made by drawing molten glass through hundreds of small orifices that shape the glass into filaments smaller than human hairs (Owen-Corning, 1975, p. 1).

Cellulose is fire and moisture resistant, but its effectiveness as insulation over a long term is not known. Cellulose has about 20 percent higher resistance to heat and conduction than mineral wool or fiberglass. If space for insulation is limited, this may be an important consideration (Cooperative Extension Service, OSU, n.d., p. 100).

Rigid insulation is of a board type construction and may be wood, vegetable, glass or formed plastics. It has structural strength and can be used also as sun-siding. It varies from other types of insulation in that it is more dense and has a lower R-value. It is primarily used along the perimeter edge of slab floors and roof deck insulation. Polystyrene is available in thickness up to eight inches. Because it is plastic, its R-value is higher per unit of thickness than fiberglass, rock wool or cellulose. Most building codes require that polystyrene must not be left exposed. If used on exterior walls, the siding must cover it. For perimeter slab where moisture may be a problem, high density polystyrene is most often used (Hudson, 1977, pp. 75-76).

Blown-on insulation has been most popular in commercial building but it can be used in homes to insulate concrete walls, basements and wall sections. It comes in many forms from wood to foams. Building codes should be checked before use of blown-on insulation is used (Cooperative Extension Service, OSU, n.d., p. 144).

The amount of insulation to use depends on a variety of factors which may vary from location to location. The justification of the use of more insulation may be based on the desire for a higher reduction in heat in space conditioning costs and the desire for a higher degree of comfort. Higher fuel and energy rates, lower first cost of insulation, severe heating or cooling seasons, lower interest rates and longer mortgage terms are variables that figure in the use of more insulation. However, on the other hand, mild heating and cooling seasons, lower energy rates, higher first cost of insulation, higher interest rates and shorter mortgage terms tend to indicate the use of less insulation. The amount of insulation also depends upon the design features of the house plus marketing considerations and consumer preference. While the ceiling is the most important place in which to put insulation, insulation in the walls makes a significant amount of difference in heat loss and heat gain. In preparing the manual on energy efficient housing construction and design, the Research Foundation of NAHB made calculations of energy savings based on a 1,600 square foot house, one story, single detached.

Calculations were figured on a zero design temperature of 70 degrees and savings stated are based on this figure. An R-19 insulation instead of R-11 in walls with 2 x 6's, 24 inches on center, would reduce energy consumption by 1950 Btuh (NAHB, 1971, p. 11).

Energy conservation must be evaluated by both the initial cost and the life-cycle cost. Failure to quantify the life cycle impacts of energy designs in building can lead to false energy economies (Bernstein, Reed and Aleriza, 1976, p. 440). The installation of insulation must be measured strongly against the climate conditions. There is a point of no return of the investment in insulation. Upgrading insulation can reach a point of diminishing returns. Many think that more is better but this is true only up to a point or specified R-value for various building elements. The optimal recommended R-values for Oklahoma are: ceiling --R-30, exterior walls--R-19 and perimeter slab--R-7.5 (NAHB, 1977, pp. 4-6). Any additional construction costs for energy conserving options must be judged accordingly.

The Federal Housing Administration guidelines for insulation in 1965 permitted heat losses as high as 50 Btu's per square foot of floor space per hour. Revised FHA standards in 1971 reduced this loss somewhat, but according to one official, almost none of the buildings in use today meet the new standards. Many older buildings have little or no insulation.

> Even the revised guidelines do not require the economically optimum amount of insulation, according to a study by John Moyers of Oak Ridge National Laboratory. From calculations for model houses in three different regions of the country--Atlanta, New York and Minneapolis--Moyers finds that additional insulation in walls and ceilings, weather stripping, foil insulation in floors, and in some regions, storm windows can be economically justified. These improvements, in addition to saving the homeowner money, could save an average of 42 percent of the energy used for space heating alone, compared to that used in houses meeting the pre-1971 FHA guidelines (Hammond, 1976, pp. 61-62).

Most homes built before 1965 have about 1-1/2 inches insulating materials in the ceiling, none in the walls and floors, and single glass windows. Attic insulation which many homeowners could do themselves would cost about $200 in an average home (1,600 square feet of floor space) and would pay for itself in two to five years, depending upon the climate (Fowler, n.d., p. 2).

According to a recent House and Home survey, 91 percent of all the builders reported that they are upgrading the insulation in their own homes or the homes they are building. In the first half of 1977 nearly three million homeowners added attic insulation, compared with 750,000 in the same period of 1976 (Hudson, 1977, p. 70).

Vapor Barrier

A vapor barrier is used in conjunction with insulation to decrease the chance of moisture condensing inside a building section in the winter. The importance of vapor barrier increases as the outside temperature becomes lower (NAHB, 1971, p. 12). Vapor barrier restricts the passage of moisture through walls and ceilings which would break down insulation. It protects against mildew and rot as well as protecting the insulation. In order to be effective, the vapor barrier must be continuous and cannot have tears or holes. It must always be placed next to the living area or the warm side of a wall, ceiling or floor (Cooperative Extension Service, OSU, n.d., pp. 139-142).

Ventilation

Energy efficiency in attic design requires one square foot ventilation for each 300 square feet of ceiling. According to the NAHB, sufficient data are not available to determine the contribution of attic ventilation to reducing the heating load. Actual reduction of the heating load is affected to a great extent by the amount of attic insulation used (Johnson, 1977, p. 14).

Heat from the sun can increase attic temperatures up to 40 degrees Fahrenheit hotter than the outside air. With an attic fan, the heat flow downward into the house can be reduced by more than one-half. Since moisture can condense in the attic and reduce the effectiveness of insulation, it is very important that ventilators beneath the roof overhead are free from obstruction (U.S. Department of Commerce, 1971, pp. 9-10). An attic fan can cut down the number of hours needed for air conditioning when the outside air cools. Attic ventilation also serves to allow moisture vapor to escape, thereby minimizing the need for winter-time condensation (Owens-Corning, n.d., p. 2).

Space Conditioning

Space heating, ventilating and air-conditioning (HVAC) account for more than 20 percent of the nation's total energy consumption. This is a prime target for energy conservation because space conditioning uses ten times as much energy as is consumed by lighting (Griffin, 1974, p. 21). The energy consumption for heating and cooling is approximately equal to the amount of fuel that a medium size automobile uses in a year (1,000 gallon of gasoline). On a national basis the energy for home heating exceeds that for cooling by 11 to 1 (Eccli, 1976, p. 223).

Oversized equipment operating below capacity operates less efficiently than properly sized equipment at rated capacity. The more often the system cycles, the greater loss of heat up the chimney. For an average house, an oversized system can waste up to 10 percent of the annual heating fuel bill. According to Eccli, it is often difficult to find a furnace that is not too large for a small insulated house (Eccli, 1976, p. 225). The NAHB Research Foundation has stated that one of the most frequent mistakes that builders and consumers make in the field of space conditioning equipment is to think that bigger is better.

> One of the most important energy conservation measures that can be taken is to carefully determine the heat loss and heat gain requirements of the dwelling and install equipment no larger than that required. Oversized equipment results in short periods of operation, poor comfort conditions, lower seasonal efficiency and more energy consumption (Johnson, 1977, p. 16).

Electric resistance heating uses much more raw energy than oil or gas systems. Electric heat is much more expensive also. If using electricity for space conditioning, a heat pump is more economical. The heat pump is basically a refrigeration system for heating and cooling. Overall consumption of raw energy is about one-half to one-third as much as with electric resistance heating (Eccli, 1976, p. 227).

The sizing of heat pumps should be based on analysis of both the heating and cooling load. In determining the size, more consideration is given to the dominant load but attention is also given to the "heating load output of the heat pump at average outdoor temperatures for the local climate, depending on manufacturer's performance curves" (Johnson, 1977, p. 18).

An air conditioner's Energy Efficiency Ratio (EER) indicates a unit's cooling capacity divided by the number of watts required to operate it. The higher the EER, the less the unit costs to run and the greater the energy savings. For energy efficiency the model with the highest EER for the size of space to cool should be used. An oversized unit goes on and off frequently. It lowers the temperature quickly, but does not remove the humidity. An undersized unit runs constantly but does not properly cool. The air conditioner condenser should be protected from the direct sunlight; usually the north side of the house is considered the best location (Cooperative Extension Service, OSU, n.d., p. 130).

Ducts should not be run though non-conditioned spaces, but if necessary, ducts should be well insulated. The undersizing of duct work reduces the efficiency of the overall system (Johnson, 1977, p. 15).

The furnace location should be installed in a place where it will be easily accessible so that filters can be changed regularly. Clogged filters reduce the energy efficiency for space conditioning (Johnson, 1977, p. 17).

The location of the hot water heater should be in the area of the greatest use of hot water in the home. Hot water pipes placed in unheated areas will reduce energy efficiency. If pipes must be placed in unheated spaces, then the pipes should be insulated (Johnson, 1977, p. 19).

Framing Practices

In framing practices many builders have begun to use 2 x 6 on 24" centers instead of the traditional 2 x 4 on 16" centers. More initial insulation can be used with 2 x 6 studs but the same R-values can be obtained with 2 x 4 framing practices. According to the NAHB Thermal Performance Guidelines, the eliminating of unnecessary framing members in construction will help to reduce heat loss and heat gain. Some framing practices recommended are 2-stud corners, drywall back-up clips at partition intersections and the use of plywood box headers filled with insulation (NAHB, 1977, p. 10). In conventional framing 3-stud corners did not permit use of insulation in the corners resulting in a cold corner effect. With 2-stud corners insulation can be placed in hard to reach places such as corners. Drywall back-up clips are used to hold the sheetrock in 2-stud corner intersections. Plywood box headers are used above windows and filled with insulation.

There is another factor to be considered in using 2 x 6 studs. Wood studs conduct more heat than the insulation which is placed in the space between them, so the entire walls will lose less heat than it would with 2 x 4 on 16 inch centers. The extra two inches of space that the 2 x 6 provides for insulation reduces the heat loss on the order of 35 percent (Eccli, 1976, p. 211).

Design Features

House Design

The consumption of energy can be reduced by lowering the ratio of exterior walls to the floor area. Unusual shapes such as T, H or L shaped houses use more energy than rectangular houses with the same amount of floor space (NAHB, 1977, p. 10).

> Theoretically, a two-story, square house has the least heat loss, but with R-11 and R-19 insulation use in the walls and ceilings respectively, a one-story home, relatively deep front to back, has essentially the same heat loss as a two-story home (Johnson, 1977, p. 4).

Reducing the ceiling height in houses will conserve energy. NAHB suggests reducing the wall height from 8 feet to 7'6" (NAHB, 1977, p. 10).

Windows and Doors

Air leakage through glass walls chiefly concerns the problem of window desing--operable versus fixed windows. Double hung windows allow for less air leakage than other types. Sliding glass doors are not very energy efficient. Operable windows should be limited to a minimum number that is necessary for natural ventilation (Griffin, 1974, pp. 71-72). A window that is poorly fit and not weatherstripped will allow five and a half times as much air infiltration as a well fit window which is weatherstripped. Storm windows reduce heat loss plus air infiltration. Storm doors will reduce the BTU's requirements by 1100 in the average size house of 1,600 square feet (Johnson, 1977, p. 9).

Air leakage through loosely fitted doors and window frames increases energy use daily. Weatherstripping and caulking can cut heat loss by 15 to 30 percent (Griffin, 1974, p. 116).

Storm windows and storm doors cut heat loss by creating dead air space between exterior and interior windows and doors. This air space (at least 3-4 inches) is the actual energy saver. Windows and doors cover 20 percent of the sidewalls in an average home and heat losses from these two may be responsible for as much as 50 percent of the utility bill. It is estimated that storm windows and doors will pay for themselves in seven to ten years or less, depending on energy cost. After that they will return a dividend of 13 to 18 percent (Cooperative Extension Service, OSU, n.d., pp. 93, 94).

Shading southern exposed glass with an overhang is an important way of reducing heat gain in the summer without losing heat gain in the winter.

> At the 35-degree latitude (North Carolina, Oklahoma, Las Vegas) a 28-inch overhang will completely shade, in the summer, floor to ceiling glass have a southern exposure and reduce heat gain 50 percent on that glass (Johnson, 1977, p. 8).

Plain glass windows provide little thermal protection for a home. Insulating glass reduces the transfer of heat between the inside of a dwelling and the outside, which will result in lower utility bills (Lewis, 1978, p. 196). The window area of the typical house is probably equal to about 15 percent of the floor area and could be reduced to around 10 percent under most codes. When reducing window area, the sill height should be raised. This is advantageous because it retains the upper part of the window, which provides better natural light and it helps reduce heat gain in the summer because the upper part of the window can be shaded by an overhang (Johnson, 1977, p. 5).

Glass should be minimized on the east and west walls. A large amount of glass on the south side provides some solar heating (NAHB, 1977, p. 10). Glazing represents the largest single factor affecting building heat loss and gain and glazing has the greatest potential for conservation (AIA, 1974, p. 37).

Insulating glass formed by double pane enclosing an air space, doubles the thermal resistance of glass (Griffin, 1974, p. 66). Double or triple-pane glass can reduce thermal transmission by as much as 80 percent over conventional single pane glass (AIA, 1974, p. 39). Windows on a per square foot basis, lose five to ten times more heat than do the walls or ceiling of a home. Adding storm doors or double panes to windows would be as efficient as adding two inches of insulation to walls and ceiling (Eccli, 1975, p. 125).

Garages and Carports

Garages and carports can help reduce the energy demand. In cold climates the garage should be placed on the north, northeast or northwest. In hot climates it should be placed on the east or west side (Johnson, 1977, p. 10).

Site Orientation

New housing can be planned to fit the environment. Large glass areas should be avoided on a side exposed to a cold north wind (Wyatt, 1976, p. 300). A minimum of glass on the north wall in a colder climate should be considered in the design of housing because building suffers greatest heat loss there (AIA, 1974, p. 32). According to the NAHB, homes should be oriented with the ridges running east to west rather than north to south (NAHB, 1977, p. 10).

Building design that ignores the natural environment will have to use more energy to compensate. "The sun is perhaps the single most important natural element to consider in building design (AIA, 1974, p. 25). The sun strikes the east and west walls longer and more fiercely than a south wall. Skillful planning of building, topography, trees, shrubbery and other natural features in residential construction will save a considerable amount of energy (Griffin, 1974, p. 38). Overhangs when properly designed can take advantage of the sun in the winter for heating and block out the sun in the summer (Whatt, 1976, p. 300). Overhangs are 70 to 80 percent effective in reducing heat gain through the glass (Department of Commerce, 1971, p. 7).

Fireplaces

D. G. Harvey of Hittman Associates, in a study for the Department of Housing and Urban Development and the National Science Foundation, found that unused fireplaces were a major source of energy loss. Harvey stated that heat recovery devices could reduce flue losses in the heating system and improve the overall gas furnace efficiency by as much as 12 percent (Hammond, 1976, pp. 62-63).

Improperly designed and made fireplaces result in significant heat losses. Devices for heat recovery and recirculation of air will aid in efficiency. Outside air supplied to the firebox will reduce heat loss. When the fireplace is not in use, light fitting dampers and glass doors should be installed for reduction of heat loss (NAHB, 1977, p. 10).

Restraints

Building code restrictions have an impact on the implementation of new technology in the construction industry. While most major cities have their own building code, smaller cities or communities may utilize one form or another of one of the four major regional "model" codes in use all over the country. Most codes are specification rather than performance in their operation. Most codes tend to favor existing products and techniques over the newer ones. Builders are reluctant to try out anything new if it requires approval before it can be used. Building codes can be a deterrent to the implementation of new techniques which might save energy in the design and construction of building.

> Finally, we conclude that there is a need to establish energy performance criteria which would limit the amount of energy a building would require over the course of a year. This

> can be in the form of maximum usable watts/square foot or BTUs/cubic foot of building space. It seems unlikely that any other form of constraint would be able to have as immediate an energy-conserving effect upon new construction (Schoen et al., 1975, p. 98).

Economic issues have inhibited wider use of energy designs and features in the past. The economic risks are probably the greatest for builders. The higher first costs associated with the use of energy conserving features may be absorbed by the builder if the buyers are not willing to pay extra for these features. There is also the risk facing the builder that there will not be enough raw energy to operate equipment within the housing (Schoen et al., 1975, pp. 107-109).

Builders of energy efficient housing often complain that lenders or mortgage bankers underestimate the importance of energy saving homes when evaluating buyers' qualifications. A survey on energy lending programs revealed that builders may be complaining less about lenders' practices. The survey of 656 savings and loan associations and mutual savings banks showed that almost 40 percent of the institutions now encourage mortgage loans on energy efficient homes. The survey was conducted by the Savings Institutions Marketing Society of America (SIMSA). The company's research director said that two key factors have convinced lenders that this is a good policy.

> First, lenders believe energy-efficient homes will increase in value more rapidly than homes without energy-saving features. Second, they

> see ever increasing utility bills affecting adversely the ability of borrowers to meet monthly mortgage payments (Professional Builder, 1978, p. 69).

Some lending institutions are distributing information on energy conservation construction which is mostly supplied to them by utility companies and the government. One lending institution has been offering loans for insulation retrofit at an annual percentage rate of nine and a half. Some 13 percent of the lenders surveyed have assigned personnel to work with borrowers and builders interested in energy conservation (Professional Builder, 1978, p. 69).

Energy Guidelines

The first comprehensive and nationally applicable design standard for energy conservation in buildings was ASHRAE 90-75 (American Society of Heating, Refrigerating and Air-Conditioning Engineers) entitled "Energy Conservation in New Building Design." The guide was finalized in 1975 and was directed toward the design of building systems with adequate thermal resistance and the design and selection of space conditioning and illumination systems which would use energy more efficiently. The standards are voluntary. ASHRAE has sponsored several seminars to acquaint professionals and code enforcement officials with the provisions in the Standard 90-75. Standards set forth in the guide are performance oriented rather than prescriptive (Heldenbrand, 1977, pp. 9-11).

The Code of Energy Conservation in New Building Construction is a code for energy efficiency in building put together by the National Conference of States on Building Codes and Standards, Inc., (NCSBS) and the United States Department of Energy (DOE). The code is very similar to ASHRAE and is a performance oriented code. The code is intended to provide flexibility in permitting the use of innovative approaches to achieve energy conservation (BOCA, 1977, p. 2).

The 1976 Minimum Property Standards (MPS) issued by the Department of Housing and Urban Development (HUD) were devised to limit heat transmission through exterior walls, floors, and ceilings. A current research study found the MPS to be most effective in reducing annual energy consumption, particularly in the area of space heating (Heldenbrnad, 1977, p. 16).

The most comprehensive program of code development, according to Heldenbrand, is that sponsored by the Energy Research Development Agency (ERDA). It involves the National Conference of States on Building Codes and Standards (NCSBCS) as the prime contractor with a model code (BOCA, ICBO, SBCC and the National Academy of Code Administrators (NACA) as subcontractors). ERDA is reported to be developing and testing energy conservation educational programs for state and local building officials (Heldenbrand, 1977, p. 16).

The NAHB has developed voluntary energy conservation guidelines for new home construction. The guidelines called Thermal Performance Guidelines of One and Two Family Dwellings provide builders with a design procedure that can be used to develop a balanced package of energy conserving techniques (NAHB Guidelines, 1977, p. 1). The guidelines were introduced at NAHB's 1977 fall board of directors meeting in San Antonio, where acceptance was unanimous.

> Here is a simple and systematic approach (to energy conservation) based upon performance engineering, that can be applied to all residential construction. It eliminates the guesswork for both builders and buyers (NAHB, 1977, p. 49).

The guidelines are based on an energy index, and the energy index is based on local climate (expressed in heating degree days and cooling annual hours), local fuel costs and the efficiency of the space conditioning system. The booklet form guideline includes a worksheet for calculating the energy index which will vary from city to city. After a builder has figures the local energy index, he can use the graphs to determine which R-values of insulation to use. Using the worksheet, the builder can figure whether or not the practice saves enough money to justify the increased cost for construction.

An energy conservation technique is considered cost effective if the homebuyer can recoup the add-on construction costs through energy savings in less than seven years. By using the guidelines a builder can evaluate the cost effectiveness of 19 energy conservation insulation practices.

According to the NAHB, the guidelines generally meet or exceed local energy requirements, as well as ASHRAE 90-75 (Professional Builder, 1977, p. 49).

Besides the nineteen items covered in the bar graphs, there are pointers on other techniques that will help builders increase the energy efficiency of their new construction. According to the NAHB, the guidelines, based on performance engineering, can be used in any area of the country and permit freedom of choice in selecting the make-up of the total energy package. In the development of the guidelines, NAHB discovered that from a cost-effective standpoint many builders may have been going too far with energy saving (Housing, 1977, pp. 8-20).

In order to better aid their members in building more energy efficient housing, NAHB prepared a book on Designing, Building and Selling Energy Conserving Homes for use all over the country in seminars designed to give builders enough information about energy conservation so they will be able to make sound decisions on what to incorporate into new construction. For builders who do not have time or will not take the time to figure energy conserving features, Johnson (president of the NAHB Research Foundation) provided a check list of features that would be cost effective in most typical homes (Scope, 1977, p. 46).

The NAHB Research Foundation has instituted a program of checking insulation and then labeling it according to a performance test. If it meets specifications, then it will be stamped with a label assuring the buyer of thermal value. R-value of samples are independently and randomly selected and tested for thermal properties in the research laboratory (Builder, 1978, p. 102).

Oklahoma Gas and Electric, in attempts to cut back on energy consumption, has certain features called "minimum design features," which, if a home has these features, qualifies it for the designation by Oklahoma Gas and Electric of "Energy Savings Home." Minimum design features that a builder or owner must include are: (1) properly installed electric heat pump and duct system, (2) double pane or storm windows, (3) storm doors or foam-filled metal door with R-value of R-10, (4) ceiling insulation with R-value of R-30, (5) raised floor or floors under uninsulated area with insulation of an R-value of R-19, (6) wall insulation properly installed with an R-value of R-19 and (7) perimeter insulation for slab floor construction with R-value of R-7. If the homes do not fulfill the requirements of items 6 and 7, the ceiling insulation should be increased. Insulation in the wall cannot be less than R-15 and the total R-value of the wall and the ceiling must be equal to or exceed R-49.

Besides these features regarding insulation, space conditioning doors and windows, Oklahoma Gas and Electric recommends other design features to increase energy savings. Some of the itmes are glass area equal to eight percent or less of floor space, vapor barrier, fireplaces with glass doors and an outside air supply and a power attic ventilator. Oklahoma Gas and Electric has conducted surveys on houses with these features by checking utility bills and has figures to document the savings (Oklahoma Gas and Electric, personal correspondence, January, 1978).

Energy Studies

In a study by Peterson, the thermal design of new single family housing in relation to climatic and economic variables was studied. The optimal design of energy conserving housing varies significantly with variations in climate and energy prices. While optimal use of energy conservation techniques will increase the purchase price of a house, informed homebuyers will realize that the increase in monthly mortgage payments will be more than offset by reductions in monthly utility costs and by the likely increase in the resale value of the house (Peterson, 1976, pp. 446-452).

Energy conservation evaluation of building components must include both engineering analysis of in structure performance and life cycle analysis of all energy related factors. The failure to quantify the life cycle impacts of conservation designs can lead to false energy economics (Bernstein et al., 1976, p. 440).

Multiplex Home Corporation in Michigan offers not one but six optional energy saving packages. The company's director of marketing and sales, Lawrence R. Rospierski, said that more and more homebuyers are becoming sophisticated about energy conservation. He said that consumers realize that an energy efficient home will maintain its resale value. However, most buyers are sticking with the lower cost energy options. According to this company, the most important features in the energy packages are increased sidewall and ceiling insulation (Professional Builder, 1977, p. 60).

The Scarborough Corporation building in New Jersey began offering an optional energy saving package in March of 1977. The added cost for the conservation features was quite substantial: from $1500 to $1800 per unit. Nonetheless, 95 percent of the buyers of this company's homes are opting for the energy package. Many of the buyers bought a smaller house so that they could afford the energy package. The building company claimed that the Energy Plus Pak will reduce heating and cooling costs by about 40 percent. If this is true, the energy package will pay for itself in four years (Professional Builder, 1977, p. 63).

In a survey conducted by Professional Builder in January of 1977, nine out of ten buyers surveyed said they would be willing to spend $600 or more for energy saving features that would cut heating and cooling bills by $100 a year. This survey indicated that homebuyers, although saying they would only spend a certain amount for energy features, are doing quite another, according to builders surveyed. One builder reported a marketing program that is ideal for small volume, small town builders. He drops off pamphlets that explain the energy features in the homes and documents the low utility bills of previous buyers of his energy saving homes (*Professional Builder*, 1977, p. 57).

Energy Houses

Energy Efficient Houses

The Energy Efficient Residence (EER) Research and Demonstration Program was developed by the NAHB Research Foundation under contract to the Department of Housing and Urban Development. The purpose is to establish guidelines for cost effective design and construction of energy conserving homes. The program will seek to address optimum levels of energy conserving features from the home purchaser's viewpoint. A wide range of energy conserving options were investigated and the most cost effective of these were selected for the construction of the demonstration house. The demonstration house and a typical conventional house will be monitored for one year. The Energy Efficient Residence is expected to use approximately one-half the energy required in the conventional house (Energy Efficient Residence, n.d., pp. 1-7).

Arkansas Story

Over 200 homes in Arkansas as of early 1978 have been built to new standards of energy conservation. Two of these houses (approximately 1,200 square feet) in Benton, Arkansas were heated and cooled throughout 1975 for an average of $10.77 per month. The structures were built with 2 x 6 studs 24" on center. The roof is supported by a modified truss using post and beam construction. Insulation (fiber glass) is an R-19 in the walls. The slab is insulated with one and a half inches of urethane at the perimeter, R-19 between joists in crawl spaces and R-38 in the attic. The energy economy is dependent upon much more than the insulation, however. The window area is reduced to eight percent of the total living area. Vapor barriers are built into walls, ceiling and floor. Caulking and weatherstripping are used to combat infiltration. Cost savings in framing are enhanced by the use of back-up clips to install the dry wall, thus eliminating the need for T's. According to proponents of this energy saving home, it takes the whole system to derive the benefits (Breniff, 1978, pp. 1-2).

NAHB's Evaluation of the Arkansas Story

The technical services department of the NAHB have received a number of inquiries from builders all over the nation concerning the report prepared by Owens-Corning

Fiberglass called the "Arkansas Story" in which a number of construction and design details for reducing energy costs are given. The NAHB suggests that it is not necessary that all of the suggestions be used in their entirety to achieve a significant savings. NAHB suggested that each construction detail must be evaluated on its own basis individually.

> The argument used in the Arkansas Report that a 2 x 6 stud wall 24" on center is cost competitive with a 2 x 4 stud wall 16" is meaningless since all nationally recognized model building codes and the HUD Minimum Property Standards recognize 2 x 4 stud walls 24" on center for single story houses and for the second story of two story houses (NAHB, 1977, pp. 1-5).

NAHB says that all the framing techniques can be used with 2 x 4 stud walls. The use of floor insulation over crawl spaces and around slab perimeters appears to have a favorable cost-benefit ratio (NAHB, 1977, pp. 1-5).

Summary

There is no one way to reduce by a large amount the energy demand of the average home today. What is required, however, is a coordinated series of energy saving techniques which, used together, will have a significant impact on energy demand.

The saving of energy in the home is worthwhile since the home consumes such a large portion of total energy. Homes can be built with many design and construction features to cut back on consumption.

The National Association of Home Builders, with recent publications on energy, are showing their concern to their members by making these available.

CHAPTER III

ANALYSIS OF DATA

Introduction

The major purpose of this study was to conduct a survey among home builders to measure their energy awareness related to efficient design and construction features and techniques in new housing. This chapter presents the findings related to the six specific objectives stated in Chapter I.

Data were analyzed by means of frequency counts and percentages which were tabulated for all items in the questionnaire. Objectives 1, 2, 3, 5, and 6 were accomplished by the use of these descriptive statistics. Objective 4 was met by using the Chi-Square test to examine the null hypotheses. The Chi-Square is a statistical technique used for summarizing differences in distribution found between two or more sample groups in a counting experiment.

Characteristics of the Sample

The first objective of the study was to identify specific characteristics of the builders. Items 1-9 in the questionnaire were used for these measures (Appendix A).

The characteristics of the 54 builders who returned the questionnaires are shown in Table I. For some items on the questionnaire, categories were combined because of an insufficient number of cases for a particular response. Age categories were reduced from five to four, while education and number of houses built were reduced to three categories each. Because so few builders were building in towns of less than 10,000, this category was combined with cities of population size 10,000-40,999.

Forty-four percent of the home builders had been in the building field for ten years or longer. The smallest percentage (15) had been building two years or less. The home builders were fairly evenly distributed throughout the age categories. The highest percent (36) were in the range of 31-40 years of age. Over one-half of the builders (57%) had a college education or more. Thirty percent of the respondents had some college while only thirteen percent had high school diplomas or less. Over 75 percent of the builders last year built under 50 homes, so it can be said that the majority of the sample represented either small or medium sized operations. The highest percentage (42%) were building in cities of 40,999 or under in population.

Item 6 in the questionnaire (Appendix A) asked the builder to indicate the percent of the building he did last year in each category (single detached and semi-detached; condominium, apartment and townhouse; commercial

TABLE I

CHARACTERISTICS OF SAMPLE

Characteristics	Frequency	Percent
Number of years in home building		
0-2 years	8	15
3-5	9	17
6-10	13	24
10+	24	44
Age of home builder		
20-30 years	11	20
31-40	19	36
41-50	13	24
51+	11	20
Level of education		
High school or less	7	13
Some college	16	30
College graduate or more	31	57
Size of city		
Under 40,999	22	42
41,000 to 100,999	14	26
Over 101,000	17	32
Number of houses built last year		
25 or under	26	49
26 to 50	14	26
Over 51	13	25
Type of construction		
10-60% single family	8	15
61-97% single family	8	15
100% single family	36	70
Average square footage of houses built last year		
Under 1,600	14	28
1,601 to 2,500	28	56
Over 2,500	8	16
Of the houses he built last year, 50% or more were		
Under $40,000	8	16
$40,000-$59,999	24	48
$60,000 or more	18	36

or other). This information was used to develop a code to show percent of single family housing built by each builder. All of the builders who were building in a commercial category and did no residential building were removed from the sample. Some builders were building in more than one category but if at least 10 percent of the builders' production was in the category of single family housing, he was kept in the sample. Seventy percent of the builders were building only single family housing.

Item 8 was used to develop a code for the average size home being built by each builder. Over half of the builders were constructing homes of 1,601 to 2,500 square feet.

Item 9 was used to develop a code for the typical price range of homes being built by each builder. If a builder reported that over 50 percent of the houses he built last year were in a given price range, that price range was considered to be typical for that builder. Table I shows that 48 percent of the builders were typically building in the $40,000-$59,999 price range. Five builders reported that 100 percent of the homes they built last year were under $40,000. Twelve builders were building exclusively in the $40,000 to $59,000 range and another eleven were only building in the price range of $60,000 and over. Eight of these building in the highest price range stated that they were building homes of $110,000 up to $250,000.

Energy and Government Controls

The second objective of this study was to determine builders' attitudes about (1) the energy shortage, (2) the government's energy position, (3) the lending institution's interest in energy saving housing design. Items 10-15 were the measures of these attitudes (Appendix A). Table II shows frequencies and percentages for six attitudinal questions.

In the study it was important to first determine whether home builders felt that there was a real energy crisis or not. Sixty-five percent felt that there was a real shortage of energy. Many claims have been made that the energy shortage has been blown out of proportion by the government and oil companies and that the shortage is a contrived situation. Forty-three percent of the builders reported believing that the government and oil companies are deliberately falsifying reports of the current situation.

Government intervention in business has always been held in controversy. Most industry and businesses believe that they should be able to control themselves from within. In response to whether the government should set up energy efficiency standards in the home building industry, over two-thirds of the builders indicated that no requirements should be set up. Only five percent said that they thought the government should set up detailed requirements. A

TABLE II

ATTITUDES OF HOME BUILDERS RELATED TO ENERGY SHORTAGE AND GOVERNMENT CONTROLS

Attitudes	Frequency	Percent
Real energy problem		
Yes	35	65
No	10	19
Undecided	9	16
Situation blown out of proportion		
Yes	22	40
No	29	55
No response	3	5
Lending institution's interest		
5 Much interest	12	21
4	14	26
3	20	36
2	5	10
1 No interest	1	2
No response	2	4
Government requirements for construction		
1 No requirements	36	67
2	6	11
3	8	15
4	1	2
5 Detailed requirements	3	5
Proposal to give tax credit for insulation		
5 Agree strongly	12	22
4	9	17
3	18	33
2	0	0
1 Disagree strongly	15	28
Oklahoma Building Energy Conservation Act		
Some effect and raise prices	14	26
Little or no effect	13	24
Do not know	10	18
Will be a problem	2	4
No response	15	28

federal bill (HR8650) to regulate the construction industry with regard to energy efficiency standards in 1975 met with strong opposition and was never made into law (Congressional Quarterly, 1975, p. 1944). Similar opposition was expressed by the builders in this sample. If Carter's proposed energy plan does not achieve considerable residential conservation, then his administration will propose mandatory measurements to go into effect by 1980 (National Energy Plan, 1977, p. 42).

In the National Energy Plan now before Congress, President Carter has advocated giving a tax credit to those who install insulation in existing homes. Only 22 percent of the builders in this study reported that they agreed strongly with the proposed measure, while twenty-eight percent disagreed strongly. Thirty-three percent checked response "3" indicating neither strong approval nor strong disapproval. Heinly previously reported, in a 1977 survey of American home builders, that the majority disagreed with the tax credit plan as stated in the bill. The National Association of Home Builders (NAHB) felt that this bill would increase the shortage of insulation in the future needed for new construction. NAHB appealed to Congress in the fall of 1977 to revise this part of the Energy Plan (Heinly, 1977, p. 27).

The state of Oklahoma, in its concern for energy conservation, has created a Department of Energy. In January of 1978, a bill (Oklahoma Building Conservation Act) was introduced into the state legislature. The bill would create some controls regarding energy efficiency in construction. The builders in the sample were asked their opinion of this bill. Nearly half did not answer this question, or responded that they did not know anything about it. Twenty-four percent said they felt that the bill would have little or no effect on new construction.

Many builders in the past have complained of a failure of lending institutions to adequately allow extra money to cover the initial cost of energy saving features in new construction. On a scale of 5 (much interest) to 1 (no interest), 23 percent of the builders in this study indicated that they thought lending institutions had a great deal of interest in lending money for energy features. A large percentage (38%) marked response "3", indicating that they felt lenders were neither greatly interested nor totally disinterested.

Energy Awareness of Builders

The third objective of this study was to determine the energy awareness level of builders by asking questions related to specific energy efficient techniques and features in housing design and construction. Items 16 through 33 (Appendix A) were used for the Energy Awareness Scale. These items were developed from information published by the National Association Home Builders. The point value for each item and the correct response is indicated in Appendix A. Scores ranged from 49 to 93 with a mean score of 78.02.

The score on the Energy Awareness Scale was used in the analysis of the fourth objective but responses to a few of the more important items are discussed here. Sixty-one percent of the builders checked either eight or ten percent as the recommended energy efficient percentage of glass to square footage of the house. Twenty-nine percent of the builders stated that the energy efficient percentage of glass area in relation to square footage of the house would be either 15 or 20 percent. Some builders stated that a percentage of glass could not be figured for a house, as many factors such as site location and design would determine the glass area needed. The National Association of Home Builders recommends ten percent while the Arkansas Story and Oklahoma Gas and Electric recommends eight percent. The NAHB Thermal Performance Guidelines and manual on energy efficiency homes only came out in the fall of 1977 and many builders may not be acquainted with all the current recommendations. One builder noted that the reduction in window size only requires more usage of electric lights. He felt that more artificial light cost more in energy than the energy lost through windows.

Recommendations by the NAHB suggest lowering the ceiling height to 7'6" for thermal efficiency. Twenty-three percent of the builders in this sample checked 7'6" as the correct ceiling height for energy efficiency while 33%

checked 7' or less as the most energy efficient. One builder stated that anything less than 8' would be efficient, but he also said that home buyers are not attuned to these energy saving features, such as less glass area and lower ceiling height in the design of new homes.

According to the NAHB, the heat pump is more economical to use than electric resistance heating. Most of the builders (98%) indicated that the heat pump was more efficient than electrical resistance heating. Ninety-one percent stated that in Oklahoma it was cheaper to use natural gas than the heat pump.

National Association of Home Builders Research Foundation recommends lowering the ratio of exterior walls to the floor area for energy efficiency. The Foundation states that square or rectangular floor plans are more energy efficient than those that have many angles or unusual shapes. Eighty percent of the builders in this study concurred with this building technique.

All of the builders agreed that the value of energy designs must be measured against their cost. According to the NAHB, not all energy conserving features add to first cost. The use of less glass is one energy saving feature which does not add to first cost, while increasing the insulation does increase first cost. However, 54 percent of the builders surveyed were not aware that not all energy conserving features add to first cost.

Eighty-five percent agreed with NAHB recommendations that the ceiling is the most important place to use insulation. Builders were asked to give the recommended R-values in Oklahoma for ceiling, perimeter slab, and exterior walls. Many did not answer, particularly for the perimeter slab, perhaps indicating that they did not know. Thirty-four of the builders answered correctly the recommended R-value for the ceiling (R-30). Twelve did not answer this question. Of the 30 builders who answered the question about correct R-value for perimeter slab, only one was incorrect. A total of 24 did not answer the question about the R-value for perimeter slab. However, when asked if it was a good practice to insulate slab floors for energy efficiency, 87% said "yes." Sixty-four percent stated that polystyrene would be the best type of insulation to use for slab floors while 28% said that foam insulation would be best. Twelve builders answered incorrectly regarding R-values for exterior walls. The recommended R-values, according to Thermal Performance Guidelines, are: ceiling--R-30, perimeter slab--R-7.5, exterior walls--R-19.

Twelve features were listed and builders were asked to rate their value in relation to energy efficiency on a scale of 1 (no value) to 5 (very valuable). Vapor barrier was rated as valuable or very valuable by 52% of the builders. Duct insulation was rated as very valuable by 67 percent of the builders. Forty-two percent rated window overhangs as very valuable in energy efficiency. Fifty-eight percent regarded attic ventilation as very valuable while sixty-seven rated duct insulation as very valuable. Well fitting doors and windows and weatherstripping and caulking were rated very valuable by the highest percentage (87%) of the builders.

Differences in Levels of Energy Awareness

The fourth objective was to examine differences in energy awareness levels according to specific characteristics of the builders. The characteristics of the builders were coded as shown in Table I. Energy Awareness Scores were divided into quartiles and recoded as follows:

Scores 49 to 73 = 1 Low
74 to 81 = 2
82 to 87 = 3
88 to 93 = 4 High

Seven null hypotheses were examined by Chi-Square analysis. There is no difference in the energy awareness score and the following characteristics of the builders:

(a) number of houses he built last year,

(b) age of the builder,

(c) education of the builder,

(d) length of time in business,

(e) the size of city in which the builder is building,

(f) price range of homes he built last year, and

(g) average square footage of homes constructed last year.

Table III shows the Chi-Square values and the significance levels for the seven tests. No significant differences were found in total Energy Awareness Scores for builders with different characteristics. Thus, none of the null hypotheses were rejected.

TABLE III

CHI-SQUARE VALUES AND SIGNIFICANCE LEVELS FOR THE RELATIONSHIP BETWEEN ENERGY AWARENESS SCORE AND SELECTED CHARACTERISTICS OF HOME BUILDERS

Characteristics	Chi-Square	Sig. Level
Time in Business	9.1	.43
Age	4.4	.88
Education	1.0	.98
Size of City	5.1	.53
Number of Houses Built	8.9	.18
Percent of Construction of Single Family Homes	6.0	.42
Average Square Footage of Homes	1.2	.76

Since no significant differences in the total Energy Awareness Score were found to exist between the builder with different characteristics, some additional analysis was conducted with certain questions considered to be key items in energy awareness. Questions (16, 20, 22, 23, 24, 25, 27, and 29) were selected for this analysis. Each of these questions was cross-tabulated with each builder characteristic. Table IV shows the significant levels for these.

Although the overall Energy Awareness Score was not found to differ significantly with respect to characteristics of the builders, selected items from the scale were associated with builder characteristics. Responses to the question about the recommended percent of glass in relation to square footage of house was significantly associated with the age of the builder ($P < .01$), his time in business ($p < .01$), and the average size of housing constructed last year ($p < .04$). Over 60 percent of the builders who had been in business a short period of time said that the ratio of glass area to total square footage should be 10 percent and none of them recommended that the ratio go as high as 15 percent. Builders who had been in business for 3-10 years were more likely to recommend a ratio of 15 percent. Of those in business for 10 years or more, 48 percent recommended a ratio of 10 percent and 35 percent recommended a ratio of 8 percent (Appendix B Table VII). NAHB recommends 10 percent of glass area in relation to total square footage, while Oklahoma Gas and Electric and the Arkansas Story recommend using only 8 percent of glass area.

Fifty-three percent of the builders in the age category 31-40 reported 8 percent was an energy efficient percentage of glass area (Appendix B, Table VIII). None of

TABLE IV

CHI-SQUARE SIGNIFICANCE LEVELS FOR SELECTED CHARACTERISTICS OF HOME BUILDERS AND SELECTED ITEMS FROM ENERGY AWARENESS TEST

Key Items	Characteristics of Home Builders: Education	Time in Business	Age	Average Sq. Ft. of Houses Built Last Year
Percent of Glass Area Related to Square Footage	NS	.01	.01	.04
Number of Exterior Walls	NS	NS	.04	.05
Energy Saving Features Adding to First Cost	.03	NS	NS	NS

the builders in the 51+ age bracket said that 15 percent was the most efficient glass area for the reduction of energy use. Twelve builders who were building houses of 1,601-2,500 square feet reported that 15 percent was an energy efficient percentage of glass area. Of the builders whose houses averaged less than 1,600 square feet, 50 percent recommended a ratio of 8 percent glass area and 43 percent of the builders recommended a ratio of 10 percent. In larger homes glass may be considered essential to the design of the house. Homebuyers may consider larger glass areas more important than lower utility bills.

Lowering the ratio of exterior walls to total square footage reduces energy consumption. Every time a corner is added to a house there is additional construction cost as well as a house that will use more energy. Responses to this question were not significantly associated with the time in business or the education of the builder but were associated with the age of the builder ($p < .04$) and the total square footage of houses built last year ($p < .05$) (Appendix B, Tables X and XI). Ninety-five percent of the builders in the 31-40 age bracket answered that lowering the ratio of exterior walls would have some effect on energy consumption while only 50 percent of the builders in the 41-50 age group responded that way. Over 80 percent of the builders of homes under 2,500 square feet indicated that lowering the ratio of exterior walls would affect energy use while only 43 percent of the builders of larger homes gave that response.

Question 26 "Do all energy conserving features add to first cost?" was significantly related to the education of the builder ($p < .03$). Sixty-one percent of the builders who were college graduates said that the incorporating of energy saving features and techniques into new construction does not always add to first cost (Appendix B, Table XII). Builders with less education were more likely to say that energy saving features always add to first cost. This finding is related to NAHB findings that many builders may be spending too much on energy saving features. Many think that in order to incorporate energy saving features into housing, considerable money must be spent on the front end but this is not true.

Energy Design Practices of Builders

Although not an objective of the study, three questions were asked about the builders' current energy practices related to insulation (Items 34-36). Based on Thermal Performance Guidelines by the National Association Home Builders the most efficient R-value for ceilings in Oklahoma would be R-30. However, only 27 percent of the builders reported using R-30 in ceilings last year. Thirteen percent reported using only R-19 for ceilings. The recommended R-value for walls in Oklahoma is R-19. Forty-one percent of the builders reported using R-19 in the walls of houses they built last year. Forty-four percent used less than R-19.

Fifty-seven percent stated that they used polystyrene or styrofoam on exterior walls. According to Johnson, NAHB Research Foundation President, "if 1 inch foam polystrene board is substituted for 1/2 inch insulation board, the heat loss would be reduced an additional 1500 Btuh in the conventional 2 x 4 wall with studs 16 inches on center" (1977, p. 14).

Builders were asked how they rated foam as an insulating material in relation to other types of insulation such as cellulose or fiberglass. The percentage of builders responding to this question were almost equally distrubuted among the three responses, "better"--31 percent, "about the same"--28 percent, "not so good"--33 percent. Foam is a relatively new type of insulation, quite expensive but with some distinct disadvantages. It has not been tested enough to know its effectiveness as an insulating material (see Table V).

Use and Evaluation of Energy Saving Features

The fifth objective of this study was to determine if builders are evaluating the effectiveness of energy saving features which they are incorporating into housing and if so, what type of evaluation they are doing. Questions 37-42 were designed to meet this objective. Table

TABLE V

ENERGY DESIGN PRACTICES OF
HOME BUILDERS

Energy Design Practices	Frequency	Percent
Average R-value for Ceiling		
11 R-value	1	2
19	16	30
20-25	8	15
26-29	7	13
30	13	24
33-38	4	7
No Response	5	9
Average R-value for Walls		
11	5	9
13	11	20
14-18	8	15
19	22	41
22-30	2	4
No Response	6	11
Use of Polystyrene or Styrofoam in Exterior Walls		
Yes	31	57
No	23	43
Quality of Foam Insulation in Relation to Other Types		
Better	17	31
About the Same	15	28
Not as Good	18	33
No Response	4	8

VI shows the percent of builders who were using energy efficiency techniques and doing some type of evaluation. A majority (87%) stated that they did use energy saving features in the houses they built last year. This supports the statement by NAHB Research Foundation President that more and more builders are taking the initiative and using energy saving features according to the 1975-1976 data on home building construction practices.

Question 38 asked the builders if there were features they would like to have used but were unable to because of cost or other reasons. One builder stated that the cost is too great to build houses for the low priced market. He further stated that he thought energy homes were good but that his market did not require them. A few builders stated that they would like to use solar but the cost is prohibitive. Another builder stated that many people are going overboard on insulation and not paying enough attention to features such as ventilation, infiltration, the design of the home (overhang, trees, direction, etc.), and proper insulation in proper places. Other features listed by builders as not being economically feasible include: triple glazing, styrofoam on exterior walls, storm windows, cantilevered trusses, and overhead soffit down ducts.

Seventy-nine percent of the builders who are using energy efficiency techniques responded that they did some type of evaluation to determine the effectiveness of these

TABLE VI

USE AND EVALUATION OF ENERGY EFFICIENCY TECHNIQUES

Evaluation Practices	Frequency	Percent
Use of Energy Efficiency Techniques in Design and Construction of New Housing		
No	7	13
Yes	47	87
Features Builders Would Have Liked to Have Used but Could Not		
Yes	31	57
No	21	39
No Response	2	4
Any Type of Evaluation of Energy Practices Last Year in Building		
Yes	37	79
No	10	21
Type of Evaluation		
Check Utility Bills	8	21
Customer's Comments	3	11
Both of the Above	21	55
Other:		
Check Against Guidelines	5	13
Are Energy Saving Features Worth Additional Cost and Time		
1 Not at All	2	4
2	2	4
3	11	20
4	15	28
5 Very Much So	24	44
Builders' Perception of Consumer's Interest in Energy Efficient Housing		
1 No Interest		
2	5	9
3	26	48
4	9	17
5 Great Deal of Interest	14	26

techniques. Types of evaluation included checking utility rates, comments of customers as to their increased comfort and economic benefits, and building houses against certain guidelines established for energy efficiency. Fifty-five percent reported that they used both utility costs and homebuyer's comments to measure the value of energy efficiency. Thirteen percent checked the response "other" and specified that they used guidelines to check their construction practices against such as the NAHB and the Arkansas Story.

On a scale from one to five, forty-four percent of the sample checked response "5" indicating that they thought the extra money and labor involved in building energy efficiency housing was very much worth it. Only four percent said that energy saving features were not worth the cost and time.

Often what buyers do and say are two different things. They may express a desire for energy efficiency in housing but may not be interested enough to invest the extra capital required. Question 42 was designed to ask builders how interested they think homebuyers are in energy efficient housing. On a scale from 1 (no interest) to 5 (great deal of interest), only twenty-six percent of the builders rated consumer's interest as "5" or a great deal of interest. Almost half of the builders (48%) checked response "2" indicating that they thought homebuyers interest in energy efficient housing design was low.

Guidelines for Energy Efficiency

The sixth objective of the study was to determine which guidelines builders are using for energy efficiency in construction practices. Nine home builders used three or more guidelines in the design and construction of energy efficient houses in 1977. Twenty-two used two guidelines as reference material. Two of the builders reported that they used all of the current guidelines for energy efficiency. Fifty-seven percent used guidelines and information published by the National Association Home Builders. Sixty percent stated that they used guidelines recommended by Oklahoma Gas and Electric. Twenty-four percent specified "Other" and the guide most often named was the "Arkansas Story."

Recently there have been many guides and information written on energy efficiency in housing design. Twenty-eight percent of the builders responded that it was good that so many guides were being written. However, fifty-seven percent responded that there were too many guides being written and that it was very confusing. One builder said that regulations would fill a book and that those concerned should be professional and realistic and not dictatorial. Many stated that those issuing the guides have not considered the cost standpoint and practicality of such features. One respondent stated that all the energy guides were based on ASHRAE standards and were all about 10 years behind and therefore obsolete. Another builder stated that the guides were not issued by builder authors who would know more about energy efficiency in construction.

Question 45 asked builders the major source from which they received information about energy saving features and techniques. Eighty percent stated they received the most helpful information from trade magazines. Utility companies were the second source from which builders received the most helpful information.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of the study was to conduct a survey among home builders in Oklahoma to measure their awareness of energy efficient design and construction features for new housing. Information published by the National Association of Home Builders was used as a basis for this measurement.

The specific objectives of the study were: (1) to identify characteristics of builders; (2) to determine builders' attitudes about the energy shortage, the government's energy position, and the lending institution's attitudes on energy; (3) to measure the level of energy awareness of builders related to energy efficient techniques and features in housing design and construction; (4) to examine differences in energy awareness levels for builders with different characteristics (size of firm, age of builder, education of builder, length of time in business, size of city in which he is building, price and size of houses built last year); (5) to determine if builders are evaluating the effectiveness of energy saving features they are incorporating into new construction and if so, what type of evaluation they are doing; and (6) to determine which guideline(s) builders are using for energy efficiency in construction practices.

The sample was drawn from the membership list of the Oklahoma Home Builders Association, excluding members who were not actually building. A random sample of 300 builder members were selected for the study. Questionnaires were mailed to these 300 and only sixty questionnaires were returned by the cut-off date. Six of these were dropped because they were doing only commercial building. Data were analyzed by means of frequency counts, percentages, and Chi-Square tests.

The study was limited to home builders in the state of Oklahoma who were members of National Association Home Builders. The sample was not random since only 54 of the 300 questionnaires were returned and usable. Because of the low percentage of returns, inferences cannot be made of this sample to the population.

Seven null hypotheses were analyzed to achieve Objective 3. It was hypothesized that there would be no difference in the level of energy awareness of the builder and (a) the number of houses built last year; (b) the age of the builder; (c) level of education of the builder; (d) length of time in business; (e) size of city builder is working in; (f) various price range of houses; and (g) average square footage of houses.

None of the null hypotheses were rejected since no significant differences were found between specific characteristics of builders and their energy awareness score. However, builder characteristics were found to be associated with responses to three specific energy awareness questions. The most energy efficient percentage of glass area to use in relation to square footage of a house was associated with the time he had been in business, the age of the builder and the size of houses he built last year. Reduction in energy use related to number of exterior walls was associated with the age of the builder and the size of houses built last year. Responses to whether energy saving features always add to first cost were associated with the education of the builder.

Forty-four percent of the home builders had been in the building industry for ten years or longer. Over one half of the surveyed builders had a college education or more. Over three-fourths of the builders built under 50 homes last year. The highest percentage of builders were in the 31-40 age bracket.

An important part of the study was to determine if builders actually thought there was an energy shortage. Sixty-five percent of surveyed builders felt that there was a real energy crisis. Forty-three percent of the builders felt that the situation has been blown out of proportion. A majority (67%) stated that the government should not make any requirements concerning construction practices. Nearly half the sample did not answer the question about the effect of the proposed "Oklahoma Building Conservation Act" indicating that they did not know anything about it. A large percentage (38%) indicated neither strong interest or disinterest on the part of lending institutions to lend money for energy features in housing.

Most builders had some awareness of energy efficient techniques. However, only 19 percent scored high (88-93) on the overall measure. Builders seemed generally to know more about construction practices than design features. Some of the material concerning energy efficiency in the design and construction of housing is relatively new and publications dealing exclusively with energy efficiency by the NAHB only came out in 1977.

Eight-seven percent said that they were using some type of energy efficient techniques in the construction of new housing. A significant majority of these builders stated that they are doing some type of evaluation for cost effectiveness. Evaluations include customer's comments, checking utility bills, and checking construction against a published guide for energy efficiency.

There seem to be many guidelines for builders to use in building energy efficient homes. The ones used most often were NAHB, Oklahoma Gas and Electric, and the Arkansas Story. Many builders are using more than one guide. One builder said that there are too many guides being written on energy and that there should be some agreement and consolidation among the guides.

There are presently 74 million residential units in the U.S. that require a substantial amount of energy. Utility bills have risen greatly in the past few years. If vigorous conservation measures are not undertaken and the present trend continues, energy demand is projected to increase by more than 30 percent between now and 1985. Conservation is not only the cheapest source of a new energy supply but also the cleanest. Conservation offers opportunities for creativity and ingenuity on the part of the builder as well as the consumer.

In the past, because of the structure of the building industry, builders have been concerned with keeping first costs low for economic purposes and also because the consumer was interested in a low first cost. Habits and values are slow to change and this will be no exception concerning energy. It will take time to change from patterns of wasteful energy use to patterns that stress conservation.

Builders are capable of building energy efficient homes and do have available resources from which to work. This study indicates that many builders are reading and taking advantage of the available material. It was concluded that builders who were interested in energy efficiency in housing were perhaps more inclined to fill out and return the questionnaire. There does seem to be considerable confusion about the "most efficient" energy practices. The prohibitive cost has kept many builders from using some features. Several builders pointed out that the buying public does not demand energy efficient homes. One said that most buyers are still buying homes on the basis of the conventional things such as schools, price, bedroom size, etc. Another said that energy efficient homes are not being sought by consumers because the average family does not stay in the same house for more than five years. For the energy efficiency house build in Maryland by the NAHB, it was estimated that the cost of the energy package was around $3,000, and that it would take a period of seven years to recoup that cost in direct fuel savings. Builders are like other businesses in that they must be able to sell their products. One builder summed it well:

> Any builder can build a home with energy saving features but the real challenge is to build an energy efficient home. Energy efficient homes require constant supervision and extra cost. About $1.000 per square foot over conventionally built homes is required, plus the extra supervision required. Energy efficient homes start on the drawing board and are only as efficient as the people who occupy them.

One builder said, "we prefer tested and proven methods such as the Arkansas Story." Another builder said that he liked the NAHB Thermal Performance Guidelines because they consider cost effectiveness. That higher minimum standards for energy efficiency are needed was the concern of one builder. He further stated that it takes time for the public and builders to accept new programs and approaches.

Conclusions

The rising cost of energy in addition to the uncertainty of future supplies makes energy conservation a much needed project. The home is the logical place to cut back on energy consumption since residential energy accounts for a significant percent of overall energy use in the United States. One specific design feature of construction technique will not significantly save a great deal of energy but these features and techniques taken together can save a large amount. There is no way to greatly reduce the amount of energy used in the average home today. What is required, however, is a coordinated series of energy saving features and techniques which, when used together, will have a significant impact on energy demand.

Implementation of conservation methods in new housing will require initiative on the part of builders mainly, but also on consumers who buy the builders' products. Our generation is discovering that it is facing a challenge that is great in scope--the energy dilemma. To meet this challenge will require a changing of values that regards energy efficiency as worthwhile and declares energy waste as wrong. There is no quick or easy solution to the energy problem. We in America are used to having all our problems solved or at least having the knowledge that problems can be solved. It is somewhat startling to recognize that the nation which can send man to the moon cannot solve its energy problem simply and quickly.

Recommendations

The writer makes the following recommendations relative to energy efficiency in the design and construction of new housing:

1. That some effort be made at consolidating guideline(s) for energy efficiency for consistency which will aid in reducing confusion.
2. That a statement of energy ethics be engaged in by builders in various cities which would be endorsed by others in related fields to construction.
3. That an educational program which would educate consumers, builders, lending institution's architectects, designers, public officials, and other interested parties in energy efficiency in housing.
4. That more intensive research be undertaken with regards to energy practices in the construction industry.
5. That building codes be updated to make energy efficiency in housing more viable.
6. That some type of incentives in the form of tax

credit be given to builders who use or build energy efficiency houses.

7. That as much attention be given to design features relating to energy efficiency as to construction practices such as insulation. So much attention is given to insulation that many think it is the only energy saving feature in connection with housing.
8. That intensive studies be done to find out exactly how much energy is used in the residential sector by different income groups and where energy could be saved.
9. That a decrease in price and time costs for new energy technologies be accomplished to implement the use of these techniques.
10. That low-cost construction loans be given to builders building energy-efficient housing.
11. That the case study approach be used to study in depth energy practices of builders.
12. That studies be done to determine what features homebuyers want in the way of energy conservation in housing and how much investment in energy features they are willing to spend so that builders could have up-to-date information of what the market wants.

A SELECTED BIBLIOGRAPHY

"A Home Builder's Guide to Energy." NAHB Journal-Scope, January 3, 1977, pp. 44-48.

American Institute of Architects. Energy Conservation in Building Design. Washington, D.C., 1974.

American Petroleum Institute. The Need for Energy. Washington, D.C., 1977.

ASHRAE Standard 90-75. American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc., 1975.

Bernstein, Harvey M., James E. Reed, and Taghi Aleriza. "Energy Budget Parametic and Life Cycle Selection of Single Family Residential Structure." ASHRAE. Vol. 82, 1976, pp. 435-444.

Breniff, R. G. Personal correspondence. Toledo, Ohio, February 2, 1978.

"Building Energy Standards." Congressional Quarterly. August 2, 1975, p. 1662.

"Buyers Can Choose From Six Energy Packages." Professional Builder. July, 1977, p. 49.

Carter, Jimmy. "National Message on Energy." Presidential Documents. Vol. 13, No. 17, April 20, 1977, pp. 560-573.

Caudill, William Wayne, Frank D. Lawyer, and Thomas A. Bullock. A Bucket of Oil. Boston: Cahners Publishing Co., Inc., 1974.

Clark, Wilson. Energy for Survival. New York: Anchor Books, 1974.

Code for Energy Conservation in New Building Construction. Building Officials and Code Administrators International, Inc., (BOCA), International Conference of Building Officials (ICBO), National Conference of States on Building Codes and Standards, Inc. (NCSBCS). 1977.

Cooperative Extension Service. Fact Sheets on Energy Conservation. Oklahoma State University, n.d.

Congressional Hearing. "Energy Conservation in Buildings Act of 1975." Banking, Currency and Housing Committee. August 7, 1975, pp. 53-57.

Commoner, Barry. "The Link Between Energy Policy and Unemployment." Nation's Cities. February, 1977, pp. 13-15.

Commoner, Barry. The Poverty of Power. New York: Alfred A. Knopf, 1976.

"Consumer Builder Survey." Professional Builder. December, 1977, pp. 57-84.

Eccli, Eugene. Low-Cost Energy-Efficient Shelter. Emmaus, Pa.: Rodale, Press, Inc., 1976.

"Energy." Professional Builder. December, 1977, p. 49.

"Energy." Time. November 28, 1977, p. 86.

"Energy and the Builder." Professional Builder . April, 1978, p. 69.

"Energy Efficient Residence." U.S. Department of Housing and Urban Development and NAHB Research Foundation, Inc., n.d., pp. 1-8.

"Energy's Impact on Architectural Forum." Architecture Forum. July-August, 1973, pp. 59-74.

Ford Foundation. A Time to Choose. Cambridge: Ballinger Publishing Co., 1974.

Fowler, John M. "Energy Conservation Homes and Buildings." Oak Ridge: National Science Teachers Association, n.d., pp. 1-4.

Fowler, John M. and King C. Kryger. "Alternate Energy Sources." Oak Ridge: National Science Teachers Association, n.d., pp. 1-8.

Frieden, Bernard J. and Arthur P. Solomon. The Nation's Housing: 1975-1985. Cambridge: Joint Center for Urban Studies of the Massachusetts Institute and Harvard University, 1977.

"From NAHB: Energy-Saving Guidelines." Housing. November, 1977, pp. 18-20.

Griffin, C. W. Energy Conservation in Buildings: Techniques for Economical Design. Washington: The Construction Specifications Institute, Inc., 1974.

Hammond, Allen L. "Conservation of Energy: The Potential for More Efficient Use." In Carol S. Wedin and L. Gertrude Nygren, Housing Perspectives. Minneapolis: Burgess Publishing Co., 1976.

Hayes, Denis. "The Transition to a Post-Petroleum World." Journal of Home Economics. May, 1978, pp. 22-25.

Heinly, David. "Insulation Shortage this Past Winter." Builder. Vol. 1, No. 1, May, 1978, p. 27.

Heldenbrand, Jim L. "Development and Application of Design Performance Standards for Energy Conservation in Buildings." Industrialization Forum. Vol. 8, No. 3, 1977, pp. 9-16.

Hirst, Eric. "Residential Energy Use Alternatives, 1976-2000." Science Magazine. December 17, 1976, pp. 1247-1252.

Hudson, Elaine. "Insulation." Housing. Vol. 52, No. 5, November, 1977, pp. 70-77.

Jones, Jerold W. and Burkley J Hendrix. "Residential Energy Requirements and Opportunities for Energy Conservation." ASHRAE. Vol. 82, 1976, pp. 417-423.

Jones, Rudard A. "Technological Aspects: Time for a New Direction." AIA Journal. December, 1971, pp. 28-31.

Johnson, Ralph J. Designing and Building and Selling Energy Conserving Homes. Rockville: NAHB, 1977.

Lewis, Evelyn L. Housing Decisions. South Holland: The Goodheart-Wilcox Co., Inc., 1978.

Montgomery, James E. "Housing Technology: How Does it Affect the Energy Crisis?" Journal of Home Economics. December, 1973, pp. 7-8.

Murphy, Bob. Bill No. 523. Oklahoma Building Conservation Act, State of Oklahoma, 2nd Session of the 36th Legislature, January, 1978.

National Association Home Builders. Thermal Performance Guidelines for One and Two Family Dwellings. Washington, D.C., 1977.

National Association Home Builders. Insulation Manual. Rockville: NAHB, 1971.

National Association Home Builders. "NAHB's Technical Services Department Analysis of 'The Arkansas Story.' Rockville: NAHB, n.d., pp. 1-5.

Newark, Norma L. and Patricia J. Thompson. Self, Space and Shelter. San Francisco: Canfield Press, 1977.

Oklahoma Gas and Electric Company. Personal interview. Drumwright, Oklahoma. January, 1978.

Owens-Corning. 44 Ways to Build Energy Conservation Into Your Homes. Toledo, 1975.

Page, Clint. "Looking for a National Energy Policy." Nation's Cities. Vol. 15, No. 22, February, 1977, pp. 3-6.

Peterson, Stephen. "Economic Optimization in the Energy Conservation Design of Single Family Housing." ASHRAE, Fol. 82, 1976, pp. 446-453.

Rudd, Nancy M. and Molly Longstreth. "Strategies for Energy Conservation." Journal of Home Economics. May, 1978, pp. 40-43.

Schoen, Richard, Alan Hirshberg, and Jerome Weingart. New Energy Technologies for Buildings. Cambridge: Ballinger Publishing Co., 1975.

Steadman, Philip. Energy, Environment and Building. Cambridge: Cambridge University Press, 1975.

The National Energy Plan. Executive Office of the President. Washington, D.C., 1977.

Thirring, Hans. Energy for Man. New York: Harper and Row, 1976.

Udall, Stewart, Charles Conconi, and David Osterhout. The Energy Balloon. New York: Penquin Books, Inc., 1975.

U.S. Department of Commerce. 11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling. Washington, D.C.: Government Printing Office, 1971, pp. 9-10.

Weber, Isabelle P. and Stanley A. Feder. Energy Dilemmas. Washington, D.C.: League of Women Voters, 1977.

Weber, Isabelle P. and Stanley A. Feder. Energy Options. Washington, D.C.: League of Women Voters, 1977.

Wyatt, William E. General Architectural Drafting. Peoria: Charles A. Bennett Co., Inc., 1976.

APPENDIXES

APPENDIX A

COVER LETTER AND QUESTIONNAIRE

May 3, 1978

I am a graduate student at Oklahoma State University in the Department of Housing, Design, and Consumer Resources. I want to know what Oklahoma Homebuilders think about the energy situation and what makes an energy efficient house. I have talked with Leo Cravens, your Executive Vice-President, who encouraged me to ask for your opinions.

I have worked as a partner with my husband in the home-building industry for 18 years. I know your time is very limited and that you often have a dozen things to do at once, but I need your help.

Would you please take 15 minutes right away to fill out this questionnaire and return it in the enclosed envelope by May 15th? All responses should be anonymous so do not put your name on it.

I very much appreciate your help.

Sincerely,

Jane Reagor
Graduate Student

K. Kay Stewart
Graduate Adviser

QUESTIONNAIRE

Questions:

1. How long have you been in the homebuilding business?

    ____ 1. 0-2 years
    ____ 2. 3-5 years
    ____ 3. 6-10 years
    ____ 4. 10 or longer (if longer, how long?__________)

2. Which of the following age categories describes you?

    ____ 1. 20-30
    ____ 2. 31-40
    ____ 3. 41-50
    ____ 4. 41-60
    ____ 5. 60 or over

3. Which education level applies to you?

    ____ 1. 8th grade or less
    ____ 2. grades 9 through 11
    ____ 3. high school graduate
    ____ 4. some college
    ____ 5. college graduate or more

4. What size city are you building in? Check all that apply.

    ____ 1. under 10,000 population
    ____ 2. 10,000 to 40,999
    ____ 3. 41,000 to 100,999
    ____ 4. over 101,000

5. How many houses did you build last year?

    ____ 1. under 10
    ____ 2. 10 to 25
    ____ 3. 26 to 50
    ____ 4. 51 to 100
    ____ 5. over 100

6. What percentage of your building is in each of the following categories? (Write the appropriate percentage by each type.)

    ____ 1. single detached
    ____ 2. semi-detached
    ____ 3. condominium
    ____ 4. apartment
    ____ 5. townhouse
    ____ 6. commercial
    ____ 7. other (specify)

7. What is the average square footage of the single family homes which you constructed last year?

____

8. Of the houses you built last year, what percent was in each of the following categories of total square footage?

_____ 1. under 1,200
_____ 2. 1,201 - 1,600
_____ 3. 1,601 - 2,000
_____ 4. 2,001 - 2,500
_____ 5. 2,501 - 3,000
_____ 6. over 3,000

9. What percent of the single family homes which you built last year were in the following price ranges? (Give percentages.)

_____ 1. $20,000 - $29,999
_____ 2. $30,000 - $39,999
_____ 3. $40,000 - $49,999
_____ 4. $50,000 - $59,999
_____ 5. $60,000 - $69,999
_____ 6. $70,000 and up (Specify $__________)

10. Do you feel that there is a real energy problem in America?

_____ 1. yes
_____ 2. no
_____ 3. undecided

11. Do you feel that the oil companies and government are blowing energy shortage out of proportion?

_____ 1. yes
_____ 2. no

12. What has been the lending institution's attitudes about allowing extra mortgage money for energy saving features?

Much interest				No interest
5	4	3	2	1

13. Should the government set up requirements as to energy efficiency in the homebuilding industry?

No requirements				Detailed Requirements
1	2	3	4	5

14. To what extent do you agree or disagree with Carter's proposal to give tax credit to those who properly install insulation?

Agree Strongly				Disagree Strongly
5	4	3	2	1

15. If passed, what effect do you think that the "Oklahoma Building Energy Conservation Act" will have on new construction?

____

____

____

16. What would you recommend as an energy efficient percentage of glass area in relation to square footage of the house?

POINTS

______ 1. 20 percent — 5
______ 2. 15 percent
__X__ 3. 10 percent
__X__ 4. 8 percent
______ 5. other (please specify____________)

17. Do you consider storm windows to be a good investment for energy conservation?

__X__ 1. yes — 4
______ 2. no

18. For energy efficiency and economics, do you feel that triple glazed windows should be installed instead of storm windows?

______ 1. yes — 5
__X__ 2. no

19. Which ceiling height is the most thermal energy efficient?

______ 1. less than 7' — 5
__X__ 2. 7'6"
______ 3. 7'10"
______ 4. 8'
______ 5. more than 8'

20. For energy efficiency which direction should the ridge of the house be parallel to?

__X__ 1. east-west — 5
______ 2. north-south
______ 3. no difference

21. (a) If using electric heating, which unit uses less energy?

__X__ 1. heat pump — 5
______ 2. electric resistance

(b) Is it more economical to use natural gas heating or the heat pump?

__________________ — 5

POINTS

22. Lowering the ratio of exterior walls to floor area has no effect on energy use.

____	1.	true	5
X	2.	false	

23. Oversized air conditioning equipment wastes energy and lowers comfort level.

X	1.	true	5
____	2.	false	

24. The value of energy designs must be measured against their cost.

X	1.	true	5
____	2.	false	

25. All energy conserving features add to first cost.

____	1.	true	5
X	2.	false	

26. How much do the energy saving features add to the overall cost of a home?

____

27. Thickness of insulation is a more accurate comparison than the R-value.

____	1.	true	5
X	2.	false	

28. Is it possible to use a 2 x 4 sall construction and obtain an R-value of 19?

X	1.	yes	5
____	2.	no	

(If yes, how: ______________________________)

29. If you had only one place to put insulation in a house, where would be the most important place to put it for energy efficiency?

X	1.	ceiling	10
____	2.	wall	
____	3.	attic	
____	4.	floor	

30. What R-value should each of the following have in order to be energy efficient?

30	ceiling	6
7.5	perimeter slab	
19	exterior walls	

31. Is it a good practice to insulate slab floors for energy efficiency?

X	1.	yes	5
____	2.	no	

POINTS

32. What kind of insulation would best be used under the edges of a slab floor for energy efficiency?

__X__ 1. polystyrene — 3
_____ 2. fiberglass
_____ 3. foam

33. How valuable are these features in energy efficiency? Circle the number whihc expresses your opinion. — 12

	No Value				Very Valuable
Vapor barrier	1	2	3	4	5
Attic ventilation	1	2	3	4	5
Overhang to shade windows	1	2	3	4	5
Framing practices	1	2	3	4	5
Addition of carport or garage	1	2	3	4	5
Location of air conditioner condensers	1	2	3	4	5
Duct insulation	1	2	3	4	5
Furnace location	1	2	3	4	5
Location of hot water heater	1	2	3	4	5
Properly installed fireplaces	1	2	3	4	5
Weatherstripping and caulking	1	2	3	4	5
Doors and windows that fit properly	1	2	3	4	5

34. Of all the homes that you constructed last year, what has been the average R-value for:

_______ ceiling area
_______ exterior wall area

35. Do you use polystyrene or styrofoam as insulation on exterior walls?

_____ 1. yes
_____ 2. no

36. How do you rate the quality of foam insulation in relation to other types such as cellulose or fiberglass?

_____ 1. better
_____ 2. about the same
_____ 3. not as good

37. Did you use energy efficiency techniques in the design and construction of new housing last year?

    _____ 1. no
    _____ 2. yes

38. Were there certain energy saving features that you would have liked to have used but were unable to because of cost or other reasons?

    _____ 1. yes
    _____ 2. no

    If yes, briefly explain: ____________________________

39. Did you do any type of evaluation to determine the effectiveness of energy efficiency techniques which you used?

    _____ 1. yes
    _____ 2. no

40. What type evaluation did you use? (If more than one, check.)

    _____ 1. check utility costs
    _____ 2. customer's comments (comfort)
    _____ 3. other (please specify_____________
    _________________________________)

41. Are energy saving features worth the additional labor and material costs?

Not at all				Very much so
1	2	3	4	5

42. How would you rank today's consumer interest in energy efficient housing design?

No interest				Great deal of interest
1	2	3	4	5

43. If you used energy efficiency features and techniques in your construction last year which guideline(s) did you use?

    _____NAHB (Nat'l. Assoc. Home Builders)
    _____OG&E (Oklahoma Gas & Electric)
    _____ASHRAE (American Society of Heating, Refrigeration & Air Cond. Engrs.)
    _____HUD (Housing & Urban Development)
    _____FHA (Federal Housing Administration)
    _____BOCA (Building Officials Code of America)
    _____National Conference of States on Building Codes & Standards
    _____Other (please specify__________________)

44. There seems to be many guides being written on energy. What do you think of this?

____

____

____

45. What are the major sources from which you get information about energy saving techniques and features?

_____ 1. trade magazines
_____ 2. other contractors
_____ 3. sales persons
_____ 4. business meetings
_____ 5. advertisements
_____ 6. course work (college or other)
_____ 7. utility companies
_____ 8. other (please specify______________)

46. From which of the above have you received the most useful information?

____

I would welcome any additional comments.

APPENDIX B

CHI-SQUARE TABLES

TABLE VII

CHI-SQUARE FOR RECOMMENDED RATIO OF GLASS AREA AND TIME IN BUSINESS

Percentage of Glass Area to Total Sq. Ft.	Time in Business							
	0-2 years		3-5 years		6-10 years		10+	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
15	0	0	5	56	6	55	4	17
10	5	63	0	0	1	9	11	48
8	3	37	4	44	4	36	8	35
Total	8	100	9	100	11	100	23	100

Chi-Square 16.5 Sig. Level P = .01

TABLE VIII

CHI-SQUARE FOR RECOMMENDED RATIO OF GLASS AREA AND AGE OF BUILDER

Percentage of Glass Area to Total Sq. Ft.	Age of Builder							
	20-30		31-40		41-50		51+	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
15	4	40	7	37	4	33	0	0
10	2	20	2	10	7	58	6	60
8	4	40	10	53	1	9	4	40
Total	10	100	19	100	12	100	10	100

Chi-Square 15.564 Sig. Level P = .01

TABLE IX

CHI-SQUARE FOR RECOMMENDED RATIO OF GLASS AREA AND SIZE OF HOUSES BUILT

Percentage of Glass Area of Total Sq. Ft.	Size of Houses: Under 1,600 Freq.	%	1,601 to 2,500 Freq.	%	Over 2,500 Freq.	%
15	1	7	9	35	3	43
10	6	43	5	19	4	57
8	7	50	12	46	0	0
Total	14	100	26	100	7	100

Chi-Square 9.76 Sig. Level P = .04

TABLE X

CHI-SQUARE FOR RATIO OF EXTERIOR WALLS TO FLOOR AREA AND AGE OF BUILDER

Lowering the Ratio of Exterior Walls to Floor Area Will Not Affect Energy Use	Age of Builder: 20-30 Freq.	%	31-40 Freq.	%	41-50 Freq.	%	51+ Freq.	%
True	2	22	1	5	5	50	2	18
False	7	78	18	95	5	50	9	82
Total	9	100	19	100	10	100	11	100

Chi-Square 8.1 Sig. Level P = .04

TABLE XI

CHI-SQUARE FOR RATIO OF EXTERIOR WALLS TO FLOOR AREA AND SIZE OF HOUSES BUILT

Lowering the Ration of Exterior Walls to Floor Area Will Not Affect Energy Use	Size of Houses: Under 1,600 Freq.	%	1,600 to 2,500 Freq.	%	Over 2,500 Freq.	%
True	2	17	4	15	4	57
False	10	83	23	85	3	43
Total	12	100	27	100	7	100

Chi-Square 6.1 Sig. Level P = .04

TABLE XII

CHI-SQUARE FOR FIRST COST OF ENERGY SAVING FEATURES AND EDUCATION OF THE BUILDER

Do Energy Saving Features Always Add to First Cost?	Education of Builder: High School Grad or Less Freq.	%	Some College Freq.	%	College Grad or More Freq.	%
True	6	86	11	69	12	39
False	1	14	5	31	19	61
Total	7	100	16	100	31	100

Chi-Square 7.1 Sig. Level P = .03

VITA 2

JANE DAVIDSON REAGOR

Candidate for the Degree of

Master of Science

Thesis: HOME BUILDERS ENERGY AWARENESS AS RELATED TO CONSTRUCTION AND DESIGN FEATURES OF HOUSING

Major Field: Housing, Design, and Consumer Resources

Biographical:

Personal Data: Born in Dyer, Tennessee, August 12, 1939, the daughter of Mrs. Gladys Etheridge and the late Thomas Davidson.

Education: Graduated from Dyer High School, Dyer, Tennessee in May, 1957; received Bachelor of Science degree in Journalism from Memphis State University in February, 1964; completed requirements for the Master of Science degree at Oklahoma State University in July, 1978.

Professional Experience: Graduate Teaching Assistant, O.S.U., 1977-1978; Home Economics Teacher, Frayser Baptist School, Memphis, Tennessee, 1976-1977; Interior Design and Consultant, Terry Reagor Building Corporation, Memphis, Tennessee, 1970-1976.

Professional Organizations: American Home Economics Association, Kappa Omicron Phi, American Society Interior Designers, American Association Housing Educators.