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TRENDS IN RESIDENTIAL CONSTRUCTION
TOWARDS ENERGY EFFICIENCY IN THE
LANSING, MICHIGAN AREA
1972 - 1979

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Kenneth Steven Moss

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TRENDS IN RESIDENTIAL CONSTRUCTION

TOWARDS ENERGY EFFICIENCY IN THE

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By

Kenneth Steven Moss

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ABSTRACT

TRENDS IN RESIDENTIAL CONSTRUCTION
TOWARDS ENERGY EFFICIENCY IN THE
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This study examines the effect energy price increases have had on increasing the amount of energy efficiency in single family homes in the Lansing, Michigan, area. A number of market factors in the construction industry are examined as well as their effect on builders and home buyers. Data on builders' reactions and trends toward energy efficiency were collected through a self-administered questionnaire. The results indicated that there were a number of factors besides cost that determine whether energy efficient products or designs will be used by home builders.

Generally, the needs and desires of the buyer are as important to the builder as first cost and the builder will change his product as long as there is an existing market. Builders strongly tend toward achieving energy efficiency through existing channels and modes of construction rather than accept new innovations and products from outside them. Government regulation will probably be the major force in determining the guidelines and course of energy efficiency in housing.

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CHAPTER I

INTRODUCTION

It has become evident that our narrowing energy resources will result in increasing costs for energy in all forms. The energy problem has many facets and implications and there is an immediate need for effective conservation methods. One area where costs have become of major importance is residential energy consumption.

The American preference is for single family homes which is also the most energy intensive type of housing. The single family home has become more common, rising from two-thirds of all American households in 1940 to over three-quarters at present (Newman, 1975, p. 39). The main reason why the single family home is such a voracious energy consumer is straight-forward. Schoen states:

> An important principle of energy conservation is that the more a dwelling is protected from the weather, the less energy it needs for heating. Thus--all other factors being equal--an apartment uses less energy than a row house (town house) of the same size, row house less than a semi-detached house and a semi-detached house less than a free standing single family home (Newman, 1975, p. 34).

An increasing concern of builder and homebuyers is how energy efficient the new single family home should be. Builders are in essence the final major determinant in what direction energy efficiency in residential homes will take. Since the majority of homes in the U.S. are speculatively built, it is the builder who generally determines the architectural design, type of heating,* materials, equipment and other factors. These factors, determined at the time of construction, once built, may be impossible or difficult and expensive to change. Furthermore, houses built now will be standing for forty years or more, saving or wasting energy for that lifetime.

A continuing opportunity to conserve our available energy is presented in current and future residential construction, which usually adds an average of 2 million units each year to our heating and cooling load (Oviatt, 1975, p. 2). Increased efficiency of energy use would help to slow energy growth rates and help to relieve pressure on scarce energy resources.

Objectives

This study is aimed at examining some general trends builders in the Lansing vicinity have taken to increase energy efficiency in single family homes. Research in the construction industry is minimal. While there is a plethora of research and ongoing projects in the area of energy efficiency, there is a void between the research and what is actually done as a matter of practice in the construction industry. In addition to examining the builder's viewpoint, this study also explores the reasons why certain products and innovations fail to gain acceptance while others succeed.

The approach to the problem is twofold. First, the market factors affecting the demand and response toward energy efficiency

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*Largely determined by availability and price of various fuel types.

are assessed. Second, data from a survey of local home builders is analyzed to determine their viewpoint and how they have responded to the problem.

There are a large number of housing components that could be improved to increase energy efficiency in the home. This study looks at some of the most prominent ones, where significant changes would most likely produce cost effective benefits.

Scope and Limitations of Study

Conservation measures can be broken into two basic types. The first involves voluntary lifestyle changes that do not cost money. The second involves technical fixes or the use of energy efficient equipment which usually costs money. This study focuses on the latter.

This study directly addresses the status of energy efficiency in new single family homes. By its nature, only a small segment of the housing market is being examined since new construction adds only 2 percent per year to the total housing stock. Existing housing is not considered as well as multiple housing. Since this study is centered in the Lansing area, the information cannot be generalized to other areas of the country because of climatic variations, availability of fuel types and differences in local building practices.

Appliances were not considered in the study for three reasons. First, they constitute only 15 percent of total home energy consumption (Table 2). Secondly, appliance usage varies from household to household. Third, many appliances are installed by the homeowner after occupancy.

The purpose of the questionnaire is to examine trends in construction. Because of the nature of the questions and small size of respondents, the results do not lend themselves to statistical analysis. The results are only used as possible indicators of certain trends. The quetionnaire is based on two assumptions.

1. Respondents will accurately record construction methods and materials they have used since 1972.

2. The survey research design, using questionnaires, is an appropriate method for collecting data on builders' activities.

Definitions

Space heating system--The main source of heat supply for a dwelling unit.

Appliances--Equipment designed for a particular use in the household which is not operated by a fossil fuel. Included in those items commonly thought of as appliances--cooking ranges, lighting, kitchen appliances, television and small portable appliances.

First cost--The initial investment in a building or product.

Life cycle cost--The discounted present worth of total costs of using a building or product over its expected useful life.

Custom builder--Builders who build homes to the specifications of a homebuyer.

Speculative builder--Builders who build homes in advance of their sale, anticipating a market for them.

East North central region--Geographic sector of the U.S. including Michigan, Ohio, Indiana, Illinois and Wisconsin.

R value (thermal resistance)--The thermal resistance to heat flow and the reciprocal of the thermal transmittance. (R = 1/U).

Thermal transmittance--The overall value of heat transmittance (air to air) expressed in units of BTU per hour, per square foot, per degree Fahrenheit. It is the time rate of heat flow.

Passive solar system--A system that uses gravity, heat flows, evaporation or other acts of nature to operate without mechanical devices to collect and transfer energy. It usually makes use of design and materials from which the house is constructed to directly capture, store and distribute solar heat to its occupants.

Active solar system--Any system that needs mechanical means such as motors, valves, pumps, solar collector plates and related devices to collect and transfer solar energy.

Heating Degree Day--Unit used to predict seasonal fuel consumption for heating. For one day, the number of degree-days is equal to the number of degress that the mean temperature for that day is below 65 F. For the heating season, the number of degree days is the sum of degrees for all days that the mean temperature falls below 65 F.

Cost Effective--For the purposes of this study, measures are considered cost effective is investment costs, including costs of money (under several hundred dollars) are recovered in five years or less, or for larger expenses, measures are considered cost effective if the homeowner can recover costs within the time he/she expects to live there.

CHAPTER II

ENERGY CONSUMPTION IN MICHIGAN

There have been significant shifts in fuel use for space heating in the North Central region since 1950. At that time the most predominant fuel was coal. By 1960 fuel oil was the major heating fuel for most of Michigan. Since 1970 natural gas has become the most predominant fuel. The following table shows the percentage breakdown of fuel type usage in Michigan.

TABLE 1.--Average Single Family Home Heating Fuel Usage in Michigan

Fuel	Fraction of Homes Using Each Fuel
Fuel Oil	22.13%
Natural Gas	70.47%
Electricity	2.54%
Propane	2.62%
Coal	2.24%
	100.00%

Source: Bureau of Mines, 1970 Census of Housing, Michigan Department of Energy.

In 1975 residential energy use accounted for about 21 percent of total energy consumption (Newman, 1975, p. 21). Residential energy use grew at 4 percent per year from 1950 to 1972, double the rate of increase in the number of households and population growth rate (Office of Science and Technology, 1972, p. 33). This growth in energy consumption per household partially reflects and contributes to increases in our standard of living.

TABLE 2.--End Use Consumption in Residential Subjector

Space Heating	63.5%
Water Heating	18.4
Air Conditioning	2.7
Lighting	5.9
Other Appliances	9.3
	100.0%

Source: Institute for Ecological Policies, County Energy Plan Guidebook, 1979, pp. 4-3.

The East North Central region uses more energy for residential space heating than any other region in the country, both absolutely and on a per household basis. As seen from the table above, space heating is by far the most important energy consumer. Space heating, water heating and air conditioning compromise almost 85 percent of home energy use and are also the factors that the builder has control over in new home construction.

Energy Conservation Factors--Consumer Aspects

Some basic factors affect the consumer's degree of interest in an energy efficient home.

Income

Generally, the more money a consumer has, the more energy they will use at home. The Energy Policy Project of the Ford Foundation showed that upper income households with an annual income of $16,000 or more consumed about twice as much energy as poorer households (Berman, 1974, p. 17). Paradoxically, the higher income grups are more likely to have equipment in the home that saves energy as well as a house and equipment that uses a great deal of energy.

Cost of Energy

The major factor that promotes energy conservation is the high price of energy. The inflation rate for energy sources in Michigan has been very close to 23 percent per year since 1970 (Energy Administration, State of Michigan, 1978, p. 1). This present rate means that energy costs will double every three to four years.

Unfortunately, no one knows how much energy costs may increase in the next five years, much less for the forty-year life of a new home. Recent estimates of our energy resources strongly suggest that increases in energy costs in the future will exceed other inflationary factors. Additionally, energy costs cannot increase in any such magnitude without affecting the cots of all manufactured goods, services, labor and money. General inflation accompanies increased energy costs, and both contribute to the overall increase in the cost of housing.

TABLE 3.--Average Selling Price of Home Heating Fuels--North Central Region

Year	Electricity (¢/kWh)	Gas (¢/100^3)	Oil (¢/gal.)
1973	2.54	NA	NA
1974	3.1	NA	34.7
1975	3.51	153.7	37.7
1976	3.73	185.8	40.6
1977	4.05	225.5	47.0
1978	4.31	260.2	49.4
1979	4.62	330.9	71.7
1980 (April)	4.9	348.6	96.0

Source: U.S. Department of Energy, Monthly Energy Review (March 1980).

Cost of Housing and Extra Initial Cost

Since 1972 the median selling price of new homes in the U.S. has been rising at about double the percentage increase of median family income. According to the Harvard M.I.T. Joint Center Urban Studies, the number of American families able to afford new homes has dropped from seven out of ten in 1950 to four out of ten in 1975 to barely 25 percent in 1977 (Fortune, 1976, p. 84). In view of rapidly rising prices for new homes in the past three years, it is reasonable to assume the present figure is even less.

The price of new homes, even without energy efficient innovations, is at a point where many buyers are already borrowing at the upper limits of their ability to obtain mortgage funds. Many marginal buyers may not be able to consider the extra 5 to 10 percent (or more) in additional cost, for example, a solar hot water heater typically entails (Jordan, 1977, p. II-5). While most potential homebuyers have some interest in energy efficiency of a new home, the total overall cost of the house will obviously be a more important consideration.

Mortgage (interest) Rates

Mortgage rates are obviously intertwined with the total cost of a new home. Mortgage rates have risen dramatically over the past five years.

When expenditures are made for energy efficient equipment in a new home, it usually becomes part of the mortgage, at interest. This hidden cost is large; and if calculated at a conservative 10 percent for thirty years has the effect of tripling the original cost. Interest rates depend on the general inflation rate and rises proportionately (Oviatt, 1975, p. 14).

Inflation Rate

Closely tied to interest rates and the cost of energy is the inflation rate. Expected price increases are imporant to homebuyers in determining what the future benefits of an investment will be.

Cost Effectiveness of Innovation

Whether the innovation is perceived by the homebuyer as cost effective will influence the desire for inclusion of the product in the home. While no studies have been done to determine exactly how this is accomplished, it can be assumed to be intuitively determined by the buyer. Prospective buyers are acutely aware of the increasing burden of energy bills and are becoming more sophisticated in this area.

Since the cost of energy has been rising faster than new home prices, inflation, interest rates, and income, it is reasonable to assume that the desire to obtain an energy efficient home is becoming an important concern of homebuyers. "Professional Builder" found that 80 percent of homebuyers are willing to pay $600 extra to save $100 per year on utility bills (Georgia Institute of Technology, 1978, p. 21). However, initial overall cost of the new home, the major factor will far outweigh this.

Barriers to Incorporation of Energy Efficient Innovations in Residential Construction

The character of the building market is a key element in understanding the present state of practices and standards which influence energy conservation in residential construction.

> Taken as a whole, the industry can be characterized as an activity which is highly fragmented, involving many small operators and consumers; undercapitalized and therefore a captive of national economic cycles; operating in a very powerful, somewhat unique and frequenty difficult labor environment; carrying on basically little research & development in comparison to other industries of its size; largely reinventing the specific team of participant actors to carry out each specific construction project; and due to all of these attributes, compromising an extremely risky sector in the U.S. Economy (Schoen, 1975, p. 51).

First Cost

The great majority of residential construction starts are speculative. Because of the generally speculative nature of residential construction, first costs are given high priority in all planning, building, financing and marketing of homes. The residential construction industry, with its associated financial institutions, is attuned to the market demands where first costs are of overriding importance and responds to the needs for construction of homes with techniques designed to reduce first costs.

This is an extremely important point because there are many technical options available to make more effective use of energy in supplying the requirements of residential services. However, in most instances, the implementation of these techniques requires some additional initial investment which is to be justified by savings in operating costs, particulaly savings of costs for fuel and electrical power.

Being in a risk averse business, builders are generally unaccustomed to using life cycle costing as a basis for purchasing decisions. Usually decisions (especially in the case of speculative builders) are made on the basis of lowest initial cost, therefore some new technologies may fail to reach their full potential because of their high first cost.

Specialization

Usually, the various trades involved in homebuilding have little to do with each other. It is rare that there any of the specialized functions has either the resources or interest to alone move a major innovative technique or piece of hardward from its initial innovation to its hoped for widespread commercial use. A non-aggregated market is slower to diffuse technology than an aggregated market which often means marketing problems for new energy technologies (Schoen, 1975, p. 52).

Tradition Orientation

The residential construction industry is craft based rather than science based. It operates through a series of craft based unions each applying separate skills to the construction process. As a result of this craft orientation, there is a heavy reliance upon using previous methods. This tends to make the industry tradition oriented (Schoen, 1975, p. 53).

Technological Uncertainties

Potential users may be unsure whether technologies still in their infancy will perform as advertised. The problem is accentuated where these technologies have not been sufficiently demonstrated. Builders do not find "ideal homes" or "dream homes" and similar demonstrations of new technology adequate to satisfy their questions. The new innovations must work with a high degree of reliability and should be of sufficient scale that they are perceived by builders as realistic possibilities.

Personal Tastes

Personal tastes and values are often wedded to existing technologies. For example, architectural design changes in home appearance caused by the incorporation of solar space heating may be an important deterrent to some homebuyers since the designs are different from the traditional ones consumers have accepted over the years. In general, the industry is motivated to change only when the needs and desires of the client have changed. These changes have evolved slowly due to changes in living standards, shifts in population, changing employment and recreational needs.

Economic Uncertainties

Economic factors such as the general economic climate, inflation and interest rates will affect builders' decisions.

> . . . depending on the supply and costs of capital within the national economy, the added financial charges can make the difference between success and failure for the builder. In addition, the cost of construction is rising at the rate of 18-24 percent per year of 1 1/2 - 2 percent per month, a rate not expected to be stemmed in the near future. If new energy technologies for buildings require installation techniques that increase construction time (construction costs), it is unlikely they will be accepted rapidly by the industry even if they have other economic advantages. These characteristics tend to make the industry very first cost sensitive, since an easy wasy to reduce the risk introduced by high finance charges is to reduce initial capital requirements. New energy devices which have lower operating costs but higher first costs than do other energy systems may meet resistances (Schoen, 1975, p. 51).

Economic barriers may diminish soon for new energy technologies as fuel prices continue to rise and more economical conservation-oriented techniques become available.

Finally, there is always a measure of normal builder/consumer resistence to the acceptance of new products. All innovations no matter how significant require time to become accepted and widely used.

CHAPTER III

METHODOLOGY

This section of the study focuses on the extent of progress builders in the Lansing area have made toward achieving energy efficiency in new single family homes. Within this chapter the discussion will center on the following points:

1. Description of Sampled Community
2. Sample Design and Selection
3. Survey Research Method
4. Analysis of Data

The Sampled Community

The sample of new home builders was selected from the greater metropolitan area of Lansing, Michigan, and surrounding communities up to a radius of 18 miles. The Lansing area is a well-defined community containing a diversity of functions, and strong economic base. The area is the seat of state government, contains light and heavy industry (primarily related to the automobile industry) and a major university. The surrounding area is a productive diversified agricultural sector. The Lansing area was considered to be a viable geographical unit containing a representative sample consisting of urban, suburban, and rural builders.

Selection of the Sample

New home builders were identified and selected from the listings in the Yellow Pages of the Lansing area phone book and the membership list of the Greater Lansing Home Builders Association. All builders were contacted by phone in advance to determine how many homes they had build (on the average) per year. Those buildings less than three homes per year were not included in the analysis of the data, since this was indicative that the individual or company might not be involved in new home construction as a full time business. Questionnaires were sent to a total of fifty-nine builders within the defined area.

Survey Research Method

The use of a self-administered questionnaire is an efficient way to collect data on a large number of variables. The questionnaire was designed by the investigator and mailed to respondents with a cover letter explaining the purpose of the survey. The data was collected in March and April, 1980. The questionnaire requested:

1. General characteristics of the builder or company including size, type (custom or speculative), average selling price of homes, size of homes built and extent of housing built through government financing
2. Types of equipment and materials incorporated into new homes including windows, fireplaces, space heating systems, and associated energy efficient devices, insulation and sheathing

3. Design characteristics of the builder's homes
4. The builder's interpretation of what factors were important in determining energy efficiency and general opinions on the subject.

A number of questions asked for responses to the same question for three different time periods--1972, 1975, and 1979--to determine whether there had been any significant changes in the response over this time period. Completed questionnaires were returned to the investigator in self-addressed stamped envelopes.

The majority of responses were coded and keypunched onto computer cards by the investigator. The cards were processed at the computer center at Michigan State University using an SPSS (Statistical Packages for Social Sciences) format. The program was designed to:

1. Generate frequency tables and statistics to 23 of the 38 questions.
2. Provide cross-tabulations and breakdowns of builders by size and type and correlate these variables with responses

Some questions not coded into the program were tabulated and analyzed by the investigator due to the complexity of developing a program to analyze certain questions. Also, the number of respondents was small so it was relatively simple to tabulate and analyze the information.

Analysis of Data

The major emphasis on the data is the builders' responses as a group. The analysis of responses by size and type did not produce any significant results and were not considered valid since the number of respondents when broken into subgroups was too small. Data from the questions that had responses for the three separate time periods were assembled into tables in order to easily discern any distinct trends.

The data does not lend itself to statistical analysis for several reasons. First, there are few distinct numbers to work with due to the nature of the questionnaire. Questions were designed for rather general responses rather than exact numbers which the builder would probably not have at hand nor be interested in figuring out. Second, the total number of respondents was too small to lend itself to statistical analysis.

CHAPTER IV

FINDINGS AND INTERPRETATION

Analysis of Data

Description of Sample Population

The data in this investigation is presented in percentages or whole numbers in reference to the total number of respondents for a specific year or the entire survey.

A total of thirty-one of the fifty-nine questionnaires were returned by mail to the investigator (approximately 51 percent response). It was found that fourteen of the respondents built homes primarily in the Lansing/East Lansing area, thirteen in the surrounding communities, and four in rural areas. Of the total thirty-one respondents, nineteen had been in business before 1972 and had collectively built 281 homes for that year. A sum total of twenty-three respondents were in business by 1975 and collectively built 389 homes for that year. In 1970 thirty respondents were in business and built 902 homes in that year.

Tables 4 and 5 are illustrative of an imbalance of the respondents. The number of respondents building custom homes is greater than those building speculative for all three years. However, the speculative builders built more homes on the average, per builder. Small custom builders made up a third of the respondents for each year but

TABLE 4.--Number of Homes Built by Size of Builder by Year

Year	Small 1-10 Homes		Medium 11-75 Homes		Large 75+ Homes		Totals	
1972	38	(9)*	243	(10)	--		281	(19)
1975	47	(10)	342	(13)	--		389	(23)
1979	71	(11)	621	(17)	210	(2)	902	(30)
	156	10%	1206	77%	210	13%	1572	

*Numbers in parentheses refer to the total number of builders in that size group for each year.

TABLE 5.--Type of Builder by Year

Year	Speculative	Custom	Total No. Respondents
1972	7 (151)*	12 (130)	19
1975	7 (166)	16 (223)	23
1979	9 (448)	21 (454)	30

*Numbers in parentheses refer to the total number of homes built by each type for each year.

TABLE 6.--Type by Size by Number of Homes Built by Year

Year	Size	Speculative		Custom		Total No. Homes
1972	Small	2	(5)*	7	(33)	(281)
	Medium	5	(146)	5	(97)	
1975	Small	2	(6)	8	(41)	(389)
	Medium	5	(160)	8	(182)	
1979	Small	1	(2)	10	(69)	(902)
	Medium	7	(346)	10	(275)	
	Large	1	(100)	1	(110)	

*Numbers in parentheses refers to the total number of homes built by each size/type category.

only built about 9 percent of the total number of homes and are over-represented. Medium size builders built 80 percent of the homes although much fewer in number.

Estimates obtained from the questionnaires indicated that 20-30 percent of the 1572 homes built during 1972-1979 were financed through government programs. The FHA and MSHDA programs were cited as the two most frequently used. This is consistent with the current national average for government insured housing.

About three quarters of the homes financed through government programs are done so through speculative builders.

It is interesting to note that in 1972, government programs accounted for 18 percent of all new homes. With the rapidly increasing rise in interest rates at the end of the 1970's, the figure is up to 33 percent. Government financed housing to date usually has tighter requirements for making new homes energy efficient as

TABLE 7.--National Averages--Methods of New Home Financing 1979

Type of Financing	Percentages
Conventional	69
FHA	13
VA	10
FmHA	2
Other (State Programs) or (ASH)	6
	100%

Source: NAHB, Statistical Department, Washington, D.C., 1980.

opposed to the requirements of a conventional loan obtained through most banks. Government involvement in new home construction will probably be a key factor in increasing energy efficient requirements. This will be discussed further in Chapter V.

TABLE 8.--Frequency of Average Number of Bedrooms per House

Year	No. Bedrooms/House				Respondents
	2	3	4	5 or more	
1972	-	10	8	1	19
1975	-	14	8	1	23
1979	1	22	6	1	30

The number of bedrooms is usually indicative of the size of the house. The strong preference for building three bedroom homes remained stable for all three years.

TABLE 9.--Frequency of Predominant Floor Area by Year

	1972	1975	1979
Less than 1,000 sq. ft.	--	--	--
1,000 - 1,200 sq. ft.	2	3	6
1,200 - 1,400 sq. ft.	3	3	5
1,400 - 1,600 sq. ft.	1	3	4
1,601 - 1,800 sq. ft.	4	2	3
1,800 - 2,000 sq. ft.	3	4	1
2,001 - 2,200 sq. ft.	2	5	3
2,201+	4	3	8
	19	23	30

There was no distinct pattern in the distribution of floor area. In 1979 there did appear a small tendency toward either small or very large homes. The use of a basement as the predominant type of foundation was indicated by all the respondents.

Analysis of Trends Toward Energy Efficiency

A vast array of housing characteristics affect energy efficiency although some are more important than others. The investigator choose some of the more important factors where there is a moderate to high potential for improvement. The following data and discussions are an analysis of the extent various selected products and design factors are being employed by respondents of the questionnaire.

Space Heating

Because residential space heating accounts for such a large share of energy use, improvements in new space heating systems could have significant long-term conservation effects.

Percentages calculated by the investigator showed that gas was the overwhelming choice of heating fuel for all three years. In 1972 it accounted for the heat source in approximately 90 percent of the homes built by the respondents. By 1979 this figure had risen to over 95 percent. Oil made up almost all of the remaining 5 percent. Additionally, this 5 percent was comprised mainly of the respondents building in rural areas where gas is usually not available except in liquified form. Some builders indicated that they had installed a few heat pumps or electric resistance heating or wood stoves, but collectively this totalled less than fifteen homes of the total 1572 for all three years.

The main reason for selecting gas as a heat source is its lower price when compared to other forms of energy. However, there is also general agreement that natural gas is also the most limited of fossil fuels (U.S. Department of Commerce, 1977, p. 9). Reserves in the U.S. have been decreasing stadily over the past ten years and natural gas shortages have already been experienced in some areas of the country.

The use of electric resistance for space heating was not an economical form of heating for the North Central region and is much more suited to the West and southern regions of the country. Homes using electrical resistanace for heating in Michigan would require an additional 5 to 6 inches of insulation in the attic and an extra 2 inches in the sidewalls as compared to a conventional gas heated home (Table 17). Also, electric heating is inherently more wasteful than direct combustion heating. All other things being equal, and electrically heated home requires about twice as much fuel per unit of heat as a gas or oil heated home (Newman, 1975, p. 25).

Heat pumps have generally not found acceptance as of yet in this area since at present they are only marginally competitive with gas heat. They also have a significantly higher initial installation cost than gas or oil systems. Finally, the efficiency of heat pumps drops off rapidly at temperatures under 20°F.

Electronic Ignitions

Electronic ignitions (device which replaced pilot light in gas furnaces) did not make any headway with the respondents until sometime after 1975. By 1979 it had gained a fairly solid acceptance with almost two thirds of the builders installing it in most of all of their homes.

TABLE 10.--Frequency of Electronic Ignition Usage in Gas Furnaces

Year	Degree of Usage					
	None	Some homes	About half	Most	All Homes	
1972	19	--	--	--	--	(19)
1975	19	3	--	--	1	(23)
1979	2	6	3	12	7	(30)

A study by the Rand Corporation showed that the installation of electronic ignitions on gas furnaces would save 6 percent on the annual amount of gas used (Dole, 1975, p. 98). State law as of October 1979 now requires use of electronic ignitions in gas furnaces.

Automatic Flue Damper

It is estimated that as much as 75 percent of the heat presently lost in the exhaust air of conventional heating systems could be saved through the application of an automatic flue damper. The automatic flue damper has been found to reduce fuel consumption by 23 percent on gas heating systems (Subcommittee on Energy and Power, 1977, p. 7). The addition of the device adds approximately $125 to $150 to the cost of a gas system. The device has gained slow acceptance with the respondents.

TABLE 11.--Frequency of Automatic Flue Damper Installation

Year	Degree of Usage				
	None	Some homes	About half	Most	All homes
1972	18	1	--	--	--
1975	21	2	--	--	--
1979	13	7	3	4	3

Air Conditioning

New residences and commercial structures account for most of the growing demand of electricity in the form of air conditioning, heating and appliances. Residential homes now consume 32 percent of all electricity generated (Roberts, 1973, p. 21). In the fifteen year period between 1960 and 1975, the number of households with some form of air conditioning increased at the rate of about 6,000 a day (U.S. Department of Commerce, 1977, p. 4). Unfortunately, no data is available on the rate of installation in new homes or by region. Also, the South and Western portions of the country has probably accounted for a large portion of this.

The frequency of installation of air conditioning by the respondents was stable throughout all three years. It is possible that this is one area where builders in the Michigan area have cut back to reduce the total cost of the home since an average system can run $1,000 to $2,000. The greater usage of insulation also reduces the need for air conditioning.

TABLE 12.--Frequency of Air Conditioning Installation

Year	Degree of Usage					
	None	Some homes	About half	Most	All homes	
1972	4	9	4	2	--	(19)
1975	4	11	6	2	--	(23)
1979	6	13	6	2	3	(30)

Fireplaces

Traditional masonry fireplaces are very inefficient, delivering little more than 10 percent of the energy generated to a room while pouring the larger portion of the heat up the chimney. Used in a home heated by other means, they draw much of the heated air from other parts of the house, reducing the effectiveness of the principal heater.

Between 1975 and 1979 respondents made a major shift from masonry fireplaces to prefabricated or "zero clearance fireplaces." In this instance it was highly advantageous for the respondents to change since prefabricted fireplaces can be installed for about one-third to half the cost of a masonry unit. Additionally, tests witnessed by the Pittsburgh Testing Laboratory have shown prefabricated fireplaces to be approximately 22 percent more energy efficient than masonry units. Blower systems, which enhance heat circulated from prefabricated units, have received a much slower acceptance rate.

TABLE 13.--Frequency of Prefabricated Fireplace Installation

Year	Masonry	Prefabricated	Respondents
1972	17	2	19
1975	17	6	23
1979	9	21	30

While zero clearance fireplaces are highly energy efficient, the fireplace is today primarily an item of decor and rarely used as a primary heat source.

TABLE 14.--Frequency of Fan Installation with Prefab Fireplaces

Year	None	Some homes	Half	Most	All homes	
1972	18	--	1	--	--	(19)
1975	17	4	2	--	--	(23)
1979	8	12	4	3	3	(30)

Wall Construction

A definite constraint on insulation thickness is imposed by the standard stud depth of 3 1/2 inches. While 5 1/2 inch studs would allow for an additional 2 inches of insulation in the sidewalls, increased costs for framing lumber and an increase in the depth of all window and door frames (plus added cost of insulation) would probably offset the benefits in energy savings. Respondents overwhelmingly indicated the use of the 2 x 4 for sidewall construction. A few builders indicated they had built several homes incorporating 2 x 6's in the walls in 1979.

Windows

Windows account for a significant percentage of heat loss in a typical residence due to their high thermal transmittance. On a per square foot basis, they generally lose five to ten times more heat than do the ceilings or walls of a home (Eccli, 1976, p. 124). Although wood is far superior to aluminum in insulative value, aluminum has gained wide acceptance due to a lower initial cost and ease of maintenance. According to the NAHB, in 1978 aluminum windows accounted for 53 percent of all windows installed in new homes while wood accounted for 36 percent and 11 percent were steel, plastic clad or other types.

TABLE 15.--Frequency of Window Type Usage by Respondents

Year	Wood	Aluminum	Respondents
1972	18	1	19
1975	18	5	23
1979	23	7	30

TABLE 16.--Frequency of Glazing Type Usage by Respondents

Year	Storm Units	Double Glazed	Insulated Glass	Respondents
1972	3	5	11	19
1975	3	3	17	23
1979	5	4	21	30

As seen from the data, the use of wood windows and insulated glass were strong preferences by respondents for all three years. (This consistent preference for wood is much higher than the national average.) It is interesting to note that wood windows cost an average of two to three times as much as aluminum and would add $1,200 to $1,500 to the cost of a home. The strong preference for wood is weighted by the custom builders, who accounted for 2/3 of the questionnaires. Aluminum windows are more widely used by speculative builders. A breakdown of Table 14 by the investigator into types, custom or speculative, showed that custom builders strongly preferred wood windows, while speculative builders accounted for the majority of those using aluminum.

The Small Homes Council has stated that triple glazed windows are cost efficient in areas with an average winter temperature colder than 30°F or more than 4,500 heating degree days. The Lansing area averaged 6,909 heating degree days (Daverman Associates, 1977, p. 25). None of the respondents indicated using triple glazing on any scale. The extra cost for triple glazing would increase the cost of an average home (12 - 14 windows) by approximately $1,000.

Apparently, respondents were willing to invest the extra money in wood frames but not the triple glazing.

Insulation

A very significant reduction in energy use can be accomplished by increasing the amount of insulation in a home. Thermal insulation was not widely used in residential buildings until 1930. Houses since that period were frequently nominally insulated, either because good standards were not generally known or because "first cost" was the controlling factor to the builder. In the 1960's, when energy costs were still low, it was economical to have an R value of 19 in the ceiling. Now it is economical to have an R value of 38 or more.

There are basically three different kinds of insulation in use.

1. Loose Cellulose - R value (per inch) = 3.7
2. Batt or Blanket - R value (per inch) = 2.9 - 3.4
3. Blown Fiberglass (or rockwool) - R value (per inch) = 2.2 - 2.9.

TABLE 17.--Attic Insulation for Winter Heating

Gas (Therm)	Oil (Gallon)	Electric (kWh)	Electric Heat Pump. (kWh)	Respondents
18¢	25¢	1¢	2¢	30
24¢	34¢	1.3¢	2.6¢	33
33¢ 34¢*	42¢	1.6¢	3.3¢	33
36¢	50¢	2¢	4¢ 4.7¢*	38
54¢	75¢ 96¢*	3¢	6¢	49
72¢	100¢	4¢ 4.7¢	8¢	49
90¢	125¢	5¢	10¢	57

*Prices are as of April 1980.

Note: Figures based on economic analysis by the National Bureau of Standards and Federal Energy Administration. The previous table indicates the optimum insulation thickness that will give the largest long-term savings on heating and cooling for the money invested in insulation.

The R values vary according to the qualify of the work and whether the insulation completely fills the cavity to be insulated. Ideally cellulose is the best insulation material for ceilings because of its high R value and ability to completely fill cavities.

TABLE 18.--Frequency of Insulation Type Usage by Respondents

Year	Loose Cellulose	Batt or Blanket	Blown Rckwl. or Fiberglass	Respondents
1972	4	7	8	19
1975	9	7	7	23
1979	15	6	9	30

Table 18 shows that loose cellulose gained increasing popularity and that by 1979 half of the respondents were using it. Examination of the data by the investigator also revealed that those using blown rockwool or fiberglass were generally those who were placing 12 inches of insultation (as opposed to 10 inches used by most of those using cellulose) to compensate for the smaller R value. The R values from respondents with three exceptions ranged from thirty-seven to forty in 1979.

As seen from Table 17, respondents as of 1979 were generally installing insulation to an R value adequate for gas heated homes. At present prices for fuel oil and electric resistance heat an R value of 49 and 55 is needed to heat the home economically. The additional cost to both the builder and homebuyers has made these two methods of home heating uneconomical.

TABLE 19.--Frequency of Ceiling Insulation Thickness use by Respondents

Year	Thickness in Inches						Respondents
	4	6	8	10	12	13+	
1972	1	13	2	2	1	-	19
1975	-	6	8	7	2	-	23
1979	-	1	1	14	13	1	30

Foundation Insulation

Insulation of the foundation has received slow acceptance from the respondents. Usually the basement is not part of the living space of the house and probably considered to be an unnecessary additional cost by the respondents. All respondents were using 3 1/2 inch batt insulation in the sidewalls with an approximate R value of 13.

TABLE 20.--Frequency of Foundation Insulation Installation by Respondents

Year	None	Some homes	About half	Most	All homes	Respondents
1972	14	4	--	--	1	19
1975	14	6	1	--	2	23
1970	7	13	3	1	6	30

Sheathing

Due to the increasingly high prices for lunber, plywood sheathing was only being used by two of the respondents in 1972.

Fiberboard (Celotex), which is also a slightly better insulator and more workable, was the overwhelming preference for 1972 and 1975. By 1979 there was a major shift to extruded polystyrene (Styrofoam) sheathing with 24 of the 30 respondents using it. In addition to having a high R value, it is lightweight and easier to work with than plywood or fiberboard.

TABLE 21.--Frequency of Sheathing Type Usage by Respondents

Year	Plywood	Fiberboard	Extruded Polystyrene	Respondent
1972	2	17	--	19
1975	2	18	33	23
1979	2	4	24	30

TABLE 22.--R Values for Various Sheathing Types

Plywood (1/2 inch)	R = .68
Insulating Sheathing (1/2 inch)	R = 1.32
Fiberboard (low density 1/2 inch)	R = 2.00
Extruded Polystyrene (1/2 inch)	R = 4
Extruden Polystyrene (1 inch)	R = 5.26

Source: ASHRAE Handbook of Fundamentals, 1972.

A survey of several local lumber yards revealed that polystyrene sheathing was over twice as expensive as fiberboard or insulating sheathing, yet the majority of respondents were now using it. For most, it is probably used to meet increasingly stringent FHA-MPS requirements which now require an R value of 19 in the sidewalls. It is also probable that it is an excellent selling point to the home-buyer becuase of its insulative value.

Passive Solar Design Usage

Amounts of energy required for heating, cooling, and ventilation are greatly affected by the configuration and layout of spaces within a building. Respondents were asked the extent they had incorporated six of the more common passive design innovations into their house plans. None of these concepts had made any significant headway with the respondents.

TABLE 23.--Frequency of House Orientation to the South by Respondents

Year	None	Some homes	Many homes	Respondents
1972	17	1	1	19
1975	19	3	1	23
1979	18	11	1	30

TABLE 24.--Frequency of Window Placement to the South Side

Year	None	Some homes	Many homes	Respondents
1972	15	2	2	19
1975	16	5	2	23
1979	14	3	3	30

TABLE 25.--Frequency Use of Topography/Vegetation for Heating or Cooling

Year	None	Some homes	Many homes	Respondents
1972	13	6	--	19
1975	16	6	1	23
1979	13	14	3	30

TABLE 26.--Frequency of Orientation of Living Spaces to South

Year	None	Some homes	Many homes	Respondents
1972	15	4	--	19
1975	16	7	--	23
1979	11	18	1	30

TABLE 27.--Frequency of Blank Wall/Bathroom/Storage Space to North

Year	None	Some homes	Many homes	Respondents
1972	13	5	1	19
1975	15	8	--	23
1979	10	18	2	30

TABLE 28.--Frequency Usage of Building Mass for Heat Storage

Year	None	Some homes	Many homes	Respondents
1972	19	--	--	19
1975	23	--	--	23
1979	24	6	--	30

With the exception of the question concerning placement of a significant amount of window/glass area to the south side, none of the concepts by themselves could add a significant amount of heat to a home. Examination of the data by the investigator showed that only three of the respondents in 1979 were using all of the concepts together on some frequency to develop a passive solar heated home. However, respondents felt that passive solar housing was feasible by a 4:1 margin, even though most of them had not included passive design in their homes.

Respondents were asked to rank the factors that most determined why they would not use passive solar design concepts. The most important factor was that most potential home buyers already had a certain architectural style in mind. Passive solar design usually calls for major exterior design changes that conflict with or are hard to match to traditional designs. Respondents felt that these contemporary designs were not yet marketable to the public on a large scale.

Passive design not being worth the added expense (cost effective) was rated as the second most important factor. The third most important factor was that other problems and design factors were more important when building in a subdivision. For example, most homeowners would like to have their house oriented toward the street rather than south (if the two directions conflict). Also installation of solar systems at ideal orientations for optimal performance might lead to rows of structures with similar or identical roof configurations. A diversity of roof slopes and orientations is an important part of contemporary housing developments (Schoen, 1975, p. 98). Solar energy systems would have to be adapted to blend in with these environments,not an easy task. The reliability of passive solar heating was not seen as a major deterrent by most builders.

Passive Design--Discussion

The initial costs for passive solar heating are not fixed by the costs of any equipment, but are determined largely by the design and materials which the builder selects. To date, the majority of passive homes are built by unorthodox designers, owner builders and architects, not concerned with wide scale marketability of their final products. These custom designer/builders are generally sheltered from the risks of the marketplace. A drawback to speculative houses is that capital risks are assumed by the builder.

Although passive solar design systems are generally agreed to be more cost effective than active solar systems, the barrier of increased initial costs is still there. However, this need not always be the case. Passive solar homes can be built for an additional cost of less than 3 percent as well as up to an additional 25 percent. The main question is to what degree the design is expected to decrease energy consumption in the home.

The acceptance of passive solar design by builders will be difficult for a number of reasons:

1. There is little confidence in passive design because of a lack of hard data for proven performance. According to a national survey of architects, a lack of data indicating proven performance

is one of the most formidable barriers to adopting solar technology as elements in architectural design (Schoen, 1975, p. 89). This is aggravated by the number of variables such as local climatic factors, floor plan layout, window location, and selection of floor and wall materials, which will affect how well a passive design will work.

2. Lack of finely detailed passive designs aside from custom plans. This factor is changing rapidly though with the increasing publication of passive oriented design books.

3. Present tax incentives do not offset the increased costs enough.

4. Climatic conditions in the Central Michigan area are highly unfavorable toward solar energy designs. The Lansing area has twice as many cloudy days as clear ones. Most of these cloudy days occur during winter when the solar energy is needed the most. Although diffuse sunlight radiation is available during cloudy days, it does not provide nearly enough energy that can be utilized on a clear day.

5. Requirements for a back-up system (needed in most of the North Central region).

Passive design does offer some advantages. The principles of passive design are generally simple and there is little need for additional research except in developing reliable methods for determining performance of various designs in different locations. There are relatively small negative consequences should the system not perform as required.

Active Solar Systems

The thirty respondents were split evenly when asked whether active solar systems were feasible in the Lansing area. Respondents were then asked to rank factors (in order of importance) why active systems were not feasible to them. As a group, the most important factor was the unreliability of active systems as a stable heat source. Ranked second was the added expense. Third, it was not considered cost effective yet.

Active Solar Systems--Discussion

In addition to the above factors, there are others that also prevent acceptance of active solar hot water and space heating systems:

1. The durability of collector systems is still uncertain since the industry is still young. There are numerous collectors on the market today which cannot be expected to operate satisfactorily even for ten years.

2. There is a lack of system performance standards that are uniformly applicable to all manufacturers products.

3. Climatic factors and low insolation values make the Lansing area an unfavorable location for active systems.

4. Some architectural design changes are needed to incorporate active collectors which might hurt the marketability of the home. Also, each home has unique heat characteristics which would require a careful assessment when sizing the collector system.

Since 1978 active systems have been competitive with electricity and marginally competitive with fuel oil in most areas of the country (Bedzedk, 1978, p. 5). In the Lansing area (as seen from the sections on space heating and insulation), solar systems will probably have to become at least marginally competitive with gas prices to become a serious possible alternative to builders. Ideally, active solar systems should be available in simple packages which can easily be installed by existing HVAC contractors. At present, this trend is just coming into being.

Builders' View of Home Buyer Concerns

As seen from Table 29, builders found homebuyers to be primarily concerned about insulation in a new home. Windows ranked

TABLE 29.--Frequency/Ranking of Home Buyer Concerns by Respondents

Importance	Aspect of Energy Efficiency		
	Type of Heating System	Insulation	Type of Windows Resistant to Heat Loss
1st	6	23	4
2nd	9	15	17
3rd	16	2	9

second and the type of heating system was third. There is a significant correlation between these results and data in Table 19. Respondents indicating installing high R values (more than banks or most federal financing programs would require), in the ceilings. Extra insulation has become a major selling point in new homes mostly because consumer's desire it.

Builders' Comments

A number of builders added comments mainly on the subject of active and passive solar systems. The following quotes are representative of the majority of responses.

> I would build solar homes if the credits (tax) offset the costs. Buyers would be there if there was no additional expense. There is not much market for "guinea pigs" who might pay for an inferior system now when a better system may exist in two to five years (a medium-size speculative builder).
>
> In a very short time the energy costs are going to be of utmost importance. Passive solar with active solar assist is going to be most marketable. In the future the house that is not energy efficient will be like owning a '72 Cadillac today (a medium size speculative builder).
>
> There are so many new gimmicks on the market for solar heating. If some method was proven effective like traditional gal force air heat etc., which people knew would work and what they could save, they would make a decision on whether it was worth it. I would like to build a solar home if I would sell them (a medium size custom builder).
>
> We priced a passive solar house in November 1979. The added cost was over $20,000 more. With today's interest costs (10-16%), it would more than erase the fuel savings even with tax credits. We could only justify this expenditure if we had the money and could expect a substantial increase in fuel costs (a small custom builder).
>
> With current technology, it is much better to spend the money on brick 6 or 8 inch walls, better window and doors, etc. We will let other perfect new solar ideas--we will be happy to change after there is conclusive proof and market acceptance. We think that after the gimmicks have been tossed (out) and the field tests are complete, someone will come up with an economically feasible and marketable solar system (a medium size custom builder).

> We build a passive solar house in 1978. The system itself was not totally efficient, but a hydro hearth in the fireplace used in conjunction with a gas furnace added to efficiency (a small custom builder)

None of the respondents had plans for installing active solar systems in 1980 although two answered there was a possibility.

CHAPTER V

GOVERNMENT INVOLVEMENT IN ENERGY CONSERVATION

Federal Government Goals

Federal legislative action can be broken down into two categories:

1. Voluntary--including educational, informal and tax incentives.
2. Mandatory--including construction standards, efficiency standards for appliances, fuel taxes and energy prices (energy rate structures)

The federal government's response to the energy situation has generally been oriented to making do with less energy and developing new resources (domestically), rather than importing more oil and natural gas. To date, emphasis has been primarily toward educational and voluntary measures. However, within the next few years it is apparent that mandatory measures will come into effect. This will include deregulation of fuels, uniform building standards, and fuel taxes in order to stimulate conservation and new technologies.

Three of the six key points of the National Plan for Energy Research, Development and Demonstration (ERDA-48) are

1. Promoting the role of the private sector in the development and commercialization of new energy technologies.

2. Conservation technologies are to be singled out for increased attention and are to be ranked with several supply technologies as being the highest priority for national action (especially conservation in buildings).

3. Federal programs to assist industry in accelerating the market penetration of energy technologies with near term potential (Engery Research and Development Administration, 1976, p. 1).

During the 1970's government involvement to increase energy efficiency in residential homes has largely been limited to promoting voluntary conservation, education and distribution of information and providing tax incentives. Of these three, the educational activities have probably been the most effective. The effects of voluntary conservation are not readily measurable and tax incentives have not been large enough to offset the initial costs of certain innovations, primarily solar. As the energy problem continued to grow, the government can be expected to broaden its activities increasingly into mandatory measures exemplified by natural gas deregulation and the probable implementation of the Building Energy Performance Standards.

Federal Programs

A major area where the federal government has been able to infuence energy efficiency in housing has been through insurance programs such as FHA, FnMA, and VA loans. These programs currently have a direct effect on 27 percent of all new home construction in the U.S. This figure is likely to rise further as long as interest rates remain high, since loans can be obtained at a slightly lower rate through these programs.

Currently, the nearest approach to a national standard for thermal insulation in residential construction is the FHA-Minimum Property Standards for One and Two Family Units. Until early 1970 FHA-MPS requirements for insulation were nominal. As of 1977 FHA had requirements of R-19 in the ceiling and R-11 in the sidewalls. It was not until 1972 that specific insulation standards were called for. Current FHA standards require R-33 in the ceiling and R-13 in the walls. FHA requirements are important since they are often used as a guideline for banks when making conventional loans. The enforcement of these rules are not nearly as stringent since the bank is usually concerned about the overall value of the house structure rather than any specific aspects. The VA loan program uses FHA standards for its guidelines.

FnMA has even more stringent standards for thermal insulation although the number of houses affected by this program is small. Current requirements call for R-38 in the ceilings and R-19 in the sidewalls. In Michigan, MSHDA guidelines are R13W in the R-30 in ceilings.

Future Government Involvement

The Department of Energy has developed a set of energy consumption "budget levels" which a particular type of building must meet. The building would be designed to use no more than a prescribed amount of energy each year for heating, cooling and hot water. The regulations are performance oriented and adapt to regional conditions and building fuctions. The building energy performance standards (BEPS) do not require certain construction techniques and are supposed to allow the private sector a great deal of flexibility. Buildings which meet the proposed energy budgets will consume 35-40 percent less energy than recently constructed buildings (Federal Register, 1979, Vol. 44, p. 68218).

At present prices a typical 1640 sq. ft. home would cost an extra $1,200 or approximately 75 cents extra per square foot. However, under the proposed rules, the Department of Energy claims the energy savings will more than offset the increased construction costs (based on life cycle costing). The BEPS are generally more stringent than existing energy requirements by other agencies. For example, in Michigan triple glazing, R-38 in the ceilings and R-19 in the walls would be required (Professional Builder, 1980, p. 80). If approved by Congress this year, the standards will go into effect sometime during 1981 and become the new construction standards for all federal agencies such as the FHA, VA, etc. It is probable that these guidelines will become the standards for those homes obtained through conventional loans. The BEPS may also be incorporated into model building codes such as BOCA and the Uniform Building Code which will almost guarantee widespread enforcement of BEPS.

The most important effect of government policies such as BEPS is the possibility of 100 percent market penetration of these standards. Local and state regulations have a much smaller effect. The costs of implementation and administration of BEPS is expected to be small since the method of enforcement (in the form of inspections) already exists through the present building inspection system.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary of Findings

This study was a determination of trends toward energy efficiency in new single family homes in the Lansing area. An analysis of this type is useful in showing what problems forestall further acceptance and incorporation of energy efficient products and innovations in new homes as well as what progress has been made. A self-administered questionnaire was used to gather data from home builders in the Lansing area. Of the thirty-one respondents, two-thirds were custom builders, most of them of smaller size. Although there were fewer speculative builders involved in the survey, they were of much larger size, produced more homes, and are underrepresented.

Builders have concentrated on improving energy efficiency in homes primarily by increasing the insulation of the building envelope. In addition to increasingly larger amounts of insulation being used in the ceilings, extruded polystyrene sheathing is becoming widely used and there was a strong preference for wood, insulated glass windows.

Gas heating has been the overwhelming preference for new home builders except in areas where it is not available. Gas is presently the cheapest present source of heating fuel and a highly favorable choice from both the builders and home buyers point of view. The use of electronic ignitions for gas furnaces has received favorable acceptance but this point is now moot in Michigan since is is now required by state law. However, highly cost effective gas furnace accessories such as the automatic flue damper has received a much slower acceptance presumably because of initial cost.

Prefabricated (zero clearance) fireplaces have achieved rapid acceptance since their initial cost is far below that of a masonry fireplace. Although secondary compared to the savings to the builder, they are also more energy efficient and a useful selling point to the homebuyer. Another highly cost effective accessory to the fireplace, the fan system, has received slow market acceptance, presumably because of first cost again.

Air conditioning was not being installed with as great a frequency as expected by the investigator. However, increased insulation lessens the need for air conditioning, and the Michigan summer temperatures are not that severe. This is probably one area where builders have cut back to reduce initial costs of the home.

Major energy efficient innovations such as passive and active solar heating have received no acceptance in the Lansing area for a number of reasons. In the case of passive design, builders felt that the main barrier was the buyer preference for more traditional designs. There were also other problems with passive design when developing a subdivision, and these factors were considered more important. Interestingly, the cost factor was ranked third. However, it is probable that all three of these factors are highly important, since a ranking of factors was rather subjective and shows no indication of degree. Respondents were more receptive to passive design rather than active ones.

It is highly likely that government intervention from the federal level is going to determine the future of energy efficiency in housing. The present HUD-FHA Minimum Property Standards will probably become much more stringent within a year or two. The increased standards may raise the price of a home by an additional .75 to $1.00 per square foot. These standards will probably be adopted by banks and affect homes purchased through conventional loans, although enforcement might not be as rigid as government financed or insured housing. The use of federal standards for housing is at present the only way to achieve 100 percent market penetration of energy conservation policies in new housing.

A variety of factors affect both the builder and consumer in making choices in the area of energy efficiency. For the buyer, the rising cost of energy, cost of housing, mortgage rates, inflation, cost effectiveness, and personal tastes will affect the decision to buy an energy efficient house. Energy costs have been rising faster than all other factors and are rapidly becoming an important consideration. For the builder, first costs, economic factors such as the cost of borrowing money, internal market characteristics of the building industry and the builders perception of buyer desires are factors. In general, most of these barriers will diminish in the near future, once again because of the energy problem. Builders are most concerned with the needs and desires of the buyer and will tend toward further improvements in energy efficiency if the buyer desires it. At present the major emphasis has been primarily on constructing a weathertight, well insulated building envelope.

Conclusions

Continuing changes in energy prices will continue to influence decisions concerning life cycle and capital costs and this will affect the use of energy conserving technologies. Economic barriers will probably diminish as fuel prices rise and more economical conservation technologies become available. One major factor will be the deregulation of natural gas, scheduled to occur in stages over the next few years. It is likely builders will be faced with (or forced into) accepting new directions in energy efficiency.

In general, innovations at the individual building component or subsystem level has fared somewhat better than full building systems. While some of the components and materials had achieved wide or moderate acceptance, active and passive solar systems, which required some modification of house design were not acceptable. Builders attempt to "fit" energy efficient products to the traditional house and construction methods. Innovations that require significant changes in standard construction are much less likely to succeed. Builders rarely introduce radical departures in design, materials, or hardward/subsystems in their developments without extensive proven performance and market acceptance first. Incorporation of energy efficient innovations in new homes also faces significant barriers due to the nature of the construction industry and its sensitivity to first costs.

Builders are highly response to shifts in market demand. Homebuyers have primarily been concerned with increased insulation and weathertightness of the home. This has been the primary area of improvement in efficiency by builders.

While first cost is usually the most important factor to a builder, this approach is usually not conducive to the best interests of a typical home buyer since the few hundred dollars saved by minimizing costs might cost the owner a few thousand dollars over the life of the home. However, many potential buyers still cannot afford some technologies since the additional expense places the total price of the home beyond their means.

An additional factor is the rate at which the American family has been moving. One builder reported to the investigator that the time an average family will own a house had dropped to under seven years. This is hardly enough time to recoup costs invested in energy efficient equipment or designs.

The owner of a custom house faces a different situation. They are likely to remain there for a much longer time than the owner of a speculative house. The owner is much more likely to be interested in getting the most energy efficient house for the money. Jordan states:

> About 20% of the custom houses (approximately 100,000 units/yr.) are designed by an architect, in consultation with the owner, and constructed by a well-established, high-quality

> builder. People having houses designed and built for them will by and large not be extremely sensitive to capital costs if they are attracted to solar or other energy technologies. If the buyer has the necessary capital and the architects and builders have the necessary expertise to incorporate them into buildings, this could be the most attractive market for solar installation or an energy efficient products (p. II-5).

It is likely that new innovations will be tested and developed in the custom home first before entering the larger speculative market.

Suggestions for Future Study

Due to the diversity of building materials, products, and number and types of builders, it is difficult to assess accurately (numerically) progress toward energy efficiency in housing. On the whole the instrument used in this study covered most of the major points, but it might be revised and streamlined to gain more factual information.

First, the list of energy efficient products could be extended to include a number of other items such as coefficient of performance on air conditioners, caulking, door types (door core materials) and other furnace accessories such as flue restrictors, flue heat exchangers and thermostat types. Also, a higher response rate and specific hard data could be obtained by shortening the questionnaire so that only the previous construction year is covered rather than three separate ones going back seven years.

If possible, a future study should attempt to cover a larger region or several population sectors within the same geographic area and obtain a larger sample. Ideally, at least fifty responses should be obtained. While 50 might not appear to be a large sample, the total number of units that fifty builders might construct would likely approach 2,000 units. Also, a large sampling would permit cross analysis of builders by type (custom or speculative) and relative size. This might show some interesting trends.

The coding of information using SPSS (Statistical Packages for Social Science) format was an excellent method for analyzing coded data as opposed to FORTRAN programming. However, questions in which the respondent was asked to rank answers in some order are difficult to program. This type of question might be dropped from the program or given a different approach.

APPENDICES

APPENDIX A

QUESTIONNAIRE

GENERAL QUESTIONS

1. In what year did your company begin building homes? ___________

2. Where have you built the majority of your homes?
   ☐ Lansing/East Lansing ☐ surrounding communities ☐ rural ☐ other areas

3. Approximately how many homes did you build for each of the following years? ______ 1972
   ______ 1975
   ______ 1979

4. Were these homes speculative or completely custom built for the following years?

   1972
   ☐ generally speculative
   ☐ custom

   1975
   ☐ generally speculative
   ☐ custom

   1979
   ☐ generally speculative
   ☐ custom

5. During the following years, did you build predominantly on scattered sites or subdivisions?

   1972
   ☐ scattered sites
   ☐ subdivisions

   1975
   ☐ scattered sites
   ☐ subdivisions

   1979
   ☐ scattered sites
   ☐ subdivisions

6. What was the predominant floor area for your homes for the following years?

   1972
   ☐ less than 1000 sf.
   ☐ 1,000 - 1,200 sf.
   ☐ 1,200 - 1,400 sf.
   ☐ 1,400 - 1,600 sf.
   ☐ 1,600 - 1,800 sf.
   ☐ 1,800 - 2,000 sf.
   ☐ 2,000 - 2,200 sf.
   ☐ 2,200 +

   1975
   ☐ less than 1000 sf.
   ☐ 1,000 - 1,200 sf.
   ☐ 1,200 - 1,400 sf.
   ☐ 1,400 - 1,600 sf.
   ☐ 1,600 - 1,800 sf.
   ☐ 1,800 - 2,000 sf.
   ☐ 2,000 - 2,200 sf.
   ☐ 2,200 +

   1979
   ☐ less than 1000 sf.
   ☐ 1,000 - 1,200 sf.
   ☐ 1,200 - 1,400 sf.
   ☐ 1,400 - 1,600 sf.
   ☐ 1,600 - 1,800 sf.
   ☐ 1,800 - 2,000 sf.
   ☐ 2,000 - 2,200 sf.
   ☐ 2,200 +

7. How would you characterize the selling price of the majority of the homes you have built?
   ☐ low ☐ moderately priced (average) ☐ higher priced ☐ relatively expensive

8. What was the pedominant number of bedrooms built in your homes during the following years?

   1972
   ☐ 2
   ☐ 3
   ☐ 4
   ☐ 5 or more

   1975
   ☐ 2
   ☐ 3
   ☐ 4
   ☐ 5 or more

   1979
   ☐ 2
   ☐ 3
   ☐ 4
   ☐ 5 or more

9. Have you built homes between 1972 - 1979 through any government programs or financing?
   ☐ yes ☐ no

10. If you answered <u>yes</u> in question 9, what percentage of your homes were through government programs or financing? Also rank the following government agencies starting with the ones most frequently used. 1 = most frequent 2 = less frequent etc. for as many as you need.

    ☐ 1 - 10%
    ☐ 10 - 20%
    ☐ 20 - 35%
    ☐ 35 - 50%
    ☐ 50 - 75%
    ☐ 75% +

    ______FHA
    ______Farmers Home Adm.
    ______VA
    ______MSHDA
    ______Other ____________

STRUCTURAL DESIGN

11. What was the most predominant type of window used in your homes for the following years?

1972	1975	1979
☐ double hung	☐ double hung	☐ double hung
☐ sliding	☐ sliding	☐ sliding
☐ casement	☐ casement	☐ casement
wood or aluminum?	wood or aluminum?	wood or aluminum?
☐ wood	☐ wood	☐ wood
☐ aluminum	☐ aluminum	☐ aluminum

12. How many layers of glazing were on these windows? Select one or the appropriate combination which best describes the number and type you used for the following years.

1972	1975	1979
☐ 1	☐ 1	☐ 1
☐ 2	☐ 2	☐ 2
☐ 3	☐ 3	☐ 3
☐ with storm unit	☐ with storm unit	☐ with storm unit
☐ thermopane window	☐ thermopane window	☐ thermopane window

13. What was the predominant type of foundation used in your homes for the following years? B = basement C = crawl space S = slab

1972 ______

1975 ______

1979 ______

14. Have you used stud sizes other than 2x4's in the house walls for the following years?

1972	1975	1979
☐ yes	☐ yes	☐ yes
☐ no	☐ no	☐ no

15. If you checked yes for any year in question 14, what size was the stud and on what frequency did you use it?

☐ 2x6	☐ for one home
☐ other ________	☐ for a few homes
	☐ for about half
	☐ for many homes
	☐ for all homes

16. What was the predominant style of home you built for the following years?

1972	1975	1979
☐ ranch	☐ ranch	☐ ranch
☐ 2 story	☐ 2 story	☐ 2 story

UTILITIES AND FIREPLACES

17. What was the approximate percentage of distribution for the types of central heating systems you may have installed in homes for the following years?

	1972	1975	1979
Gas	_____%	_____%	_____%
Oil	_____%	_____%	_____%
Electric	_____%	_____%	_____%
Heat pump	_____%	_____%	_____%
Other____________	_____%	_____%	_____%

18. On what frequency were the following features installed along with the central heating system?

	1972	1975	1979
electronic ignition	☐ none	☐ none	☐ none
	☐ a few systems	☐ a few systems	☐ a few systems
	☐ about half	☐ about half	☐ about half
	☐ most	☐ most	☐ most
	☐ on all systems	☐ on all systems	☐ on all systems
automatic flue damper	☐ none	☐ none	☐ none
	☐ a few systems	☐ a few systems	☐ a few systems
	☐ about half	☐ about half	☐ about half
	☐ on most	☐ on most	☐ on most
	☐ on all systems	☐ on all systems	☐ on all systems
humidifiers	☐ none	☐ none	☐ none
	☐ a few	☐ a few	☐ a few
	☐ about half	☐ about half	☐ about half
	☐ on most	☐ on most	☐ on most
	☐ with all systems	☐ with all systems	☐ with all systems
central air conditioning	☐ none	☐ none	☐ none
	☐ a few	☐ a few	☐ a few
	☐ about half	☐ about half	☐ about half
	☐ on most	☐ on most	☐ on most
	☐ with all systems	☐ with all systems	☐ with all systems

19. On what frequency have you installed the following types of water heaters in homes for the following years?

	1972	1975	1979
Gas	____%	____%	____%
Electric	____%	____%	____%
Other ____________	____%	____%	____%

20. What was the predominant type of fireplace installed in the homes you have built for the following years? prefabricated = zero clearance fireplace

1972	1975	1979
☐ masonry	☐ masonry	☐ masonry
☐ prefabricated	☐ prefabricated	☐ prefabricated

21. If you installed any zero clearance fireplaces, how many of these had fans or blower systems installed with them?

1972	1975	1979
☐ none	☐ none	☐ none
☐ some	☐ some	☐ some
☐ about half	☐ about half	☐ about half
☐ most	☐ most	☐ most
☐ all	☐ all	☐ all

INSULATION

22. What is the predominant type of insulation you have used in <u>ceilings</u> for your homes for the following years? Also, what was the approximate depth in inches and/or R value achieved?

1972	1975	1979
☐ loose cellulose	☐ loose cellulose	☐ loose cellulose
☐ batt	☐ batt	☐ batt
☐ other ________	☐ other ________	☐ other ________
_____inches	_____inches	_____inches
_____R value	_____R value	_____R value

23. What is the predominant type of insulation you have used in <u>walls</u> for your homes for the following years? Also, what was the approximate depth in inches and/or R value achieved?

1972	1975	1979
☐ loose cellulose	☐ loose cellulose	☐ loose cellulose
☐ batt	☐ batt	☐ batt
☐ other________	☐ other________	☐ other ________
_____inches	_____inches	_____inches
_____R value	_____R value	_____R value

24. What type of sheathing did you use on your homes for the following years?

1972	1975	1979
☐ wood sheathing	☐ wood sheathing	☐ wood sheathing
☐ fiberboard sheathing	☐ fiberboard sheathing	☐ fiberboard sheathing
☐ styrofoam	☐ styrofoam	☐ styrofoam

25. On what frequency did you insulate around the foundations of the homes you built for the following years?

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some	☐ some
☐ about half	☐ about half	☐ about half
☐ most	☐ most	☐ most
☐ all	☐ all	☐ all

DESIGN CHANGES

28. This question concerns some possible design changes you may have made in your homes over the past years. To what extent have you made the following changes:

A) Intentionally oriented the house to within 25° of due south (along and east-west axis) to take advantage of the sun

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some homes	☐ some homes
☐ many homes	☐ many homes	☐ many homes

B) Intentionally placed the majority of the windows to the south side of the house and less on the north and west sides

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some homes	☐ some homes
☐ many	☐ many	☐ many

C) Utilized vegetation (trees for windbreaks or shade) or topography specifically to aid or protect the home in heating or cooling

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some homes	☐ some homes
☐ many	☐ many	☐ many

D) Intentionally oriented the major living spaces (living room, den, bedrooms) to the south side of the house or where they would receive the most sun exposure

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some homes	☐ some homes
☐ many	☐ many	☐ many

E) Intentionally arranged blank walls, garages, bathrooms and storage areas to the north or west sides of the house

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some homes	☐ some homes
☐ many	☐ many	☐ many

F) Intentionally made use of brick or masonry floors or walls or other forms to retain heat from solar energy inside the house

1972	1975	1979
☐ none	☐ none	☐ none
☐ some homes	☐ some homes	☐ some homes
☐ many	☐ many	☐ many

G) If you marked <u>some</u> or <u>many</u> in part F, briefly specify the methods for storing heat that you used

____

____

29. How do you feel about the feasibility of "passive" solar heating methods (such as in question 28, A-F)

☐ generally feasible ☐ not worthile

30. Of the following factors, rank four in order of importance as to why you <u>would not</u> want to use passive solar heating methods (such as A-F, question 28) in order to take advantage of solar heat? 1 = most important reason 4 = least important

☐ most home buyers have a certain architectural style in mind / conflicts with what most homebuyers would like

☐ not worth the added expense

☐ not feasible, especially in a subdivision, because of other more important considerations

☐ not worth any real economic savings in energy yet

☐ not a reliable method of heating in this area

SUMMARY QUESTIONS

31. How important did you feel "energy efficient housing" was to new home buyers for the following years?

1972	1975	1979
☐ not really important	☐ not really important	☐ not really important
☐ some showed concern	☐ some showed concern	☐ some showed concern
☐ practically all were	☐ practically all were	☐ practically all were

32. Rank the following in order of importance. What particular aspects in the area of energy efficiency concern new home buyers the most? 1 = most important 3 = least important

______type of heating system in house

______insulation

______type of windows / resistance to heat loss

______other (specify) ____________________

33. Rank the following in order of frequency. Where do you get most of the house plans you use for building homes? 1 = most frequent 2 = less frequent etc. for as many as you need.

_____developed by my company

_____brought in by home buyer

_____from plan books

_____designed by architect or other company

_____other (specify) ____________________

34. Do you plan on installing any kind of solar space heating or water heating equipment on any of your homes this year? (1980)

☐ yes ☐ no ☐ possibly

35. If you marked yes in question 34, on how many homes and what type of system?

☐ one home ☐ hot water heating systems mostly

☐ a few homes ☐ space heating systems

☐ many homes ☐ both

36. How do you feel about the possibilities of using solar panels for hot water heating or space heating in this area (around Ingham county) at present?

☐ generally feasible ☐ not feasible

37. If you answered not feasible in question 36, rank the following in order of importance as to why you would not want to install solar panels on homes. 1 = most important 4 = least important rank only 4

______not a reliable method of heating

______still too expensive even with tax credits

______not marketable to the public yet

______not cost effective in this area

______not esthetic or would require other design changes in the house that would not be worth the expense

______other reasons (specify) ____________________

____

38. If you have any additional comments or suggestions, please write them in the space below.

Thank you for your time, patience and cooperation!

APPENDIX B

SPSS COMPUTER PROGRAM

APPENDIX B

SPSS COMPUTER PROGRAM

```
MOSS,RG2
PW=MOSS
HAL,SPSS
*EOR
RUN NAME                DEFINE,FREQUENCY,BREAKDOWN AND CROSSTABULATE
VARIALBE LIST           CASENO,YEAR, TYPE,SIZE, STARTS,AREA,PRICE
                        ROOMS,WTYPE,CLZNG,EIGHTN,FLUDAMP,AIRCOND,
                        HEARTH,FAN,CINSUL,CINCH,SHEATH, FINSUL,
                        ORIENT,GLASPAC,VEG,LIVSPAC,BLNKWL,MASS,
                        PASFEAS,ASOLAR
INPUT FORMAT            FIXED (F2,S,F1.0,1X,2F1.0,1X,F3.0,3FI.0,1X,
                        2F2.0,1X,3F1.o.1X,2F1.0.1X,F1.0,1X,F2.0,1X,
                        2F1.0,1X,6F1.o.1X,F1.0.1X,F1.0)
N OF CASES              UNKNWON
CROSSTABS               TABLES=STARTS BY TYPE OF YEAR
CROSSTABS               TABLES=STARTS BY SIZE BY YEAR
CROSSTABS               TABLES=SIZE BY TYPE BY YEAR
READ INPUT DATA
011 11     48 5 2122 000 10 2  8 20 001000
012 11     38 5 3122 000 10 2 10 31 001000
013 12  15645 3122 440 11 2 12 32 111000 1 0
023 21   6434 1111 221 00 2 12 12 001110 1 1
.........
.........
.........
*EOR
CROSSTABS               TABLES=SIZE BY WTYPE,EIGNTH,FLUDAMP, AIRCOND,
                        HEARTH,FAN, CINSUL, CINCH, SHEATH,FINSUL,ORIENT,
                        GLASPAC,VEG,LIVSPAC,BLNKWL BY YEAR
CROSSTABS               TABLES=TYPE BY WTYPE,EIGNTH, FLUDAMP,AIRCOND,
                        HEARTH,FAN, CINSUL,CINCH, SHEATH, FINSUL,ORIENT,
                        GLASPAC,VEG,LIVSPAC,BLNKWL BY YEAR
*SELECT IF              (YEAR EQ 1)
FREQUENCIES             GENERAL=ALL
OPTIONS                 7,8
STATISTICS              ALL
*SELECT IF              (YEAR EQ 2)
FREQUENCIES             GENERAL=ALL
OPTIONS                 7,8
STATISTICS              ALL
```

```
*SELECT IF          (YEAR EQ 3)
FREQUENCIES         GENERAL=ALL
OPTIONS             7,8
STATISTICS          ALL
FINISH
*EOF
```

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REFERENCES CITED

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