13 Oct 1977

Energy Conservation in Buildings -- The Missouri Plan

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ENERGY CONSERVATION IN BUILDINGS - THE MISSOURI PLAN

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A. The Residential Sector

In 1974, approximately 23 percent (256.5 trillion Btu's) of Missouri energy was consumed in the residential sector. In 1980, this figure is projected to be 246.6 trillion Btu's (21 percent) (ref. 1). The reduction reflects already implemented conservation activities and the increased use of electric heating at higher end point efficiency. Estimates suggest that energy savings of nearly 50 percent could be achieved in this sector, primarily by upgrading the thermal efficiency of building structures and changing user behavior patterns. This given potential, the reduction of energy consumption in this sector has become a major target of the Missouri Energy Conservation Plan.

The intent of the residential portion of the conservation plan is to establish a variety of programs ranging from mandatory practices, through incentive and assistance programs, to persuasive voluntary programs. These programs are to be reinforced by a strong set of public awareness and energy conservation education programs. Many of the public awareness and educational programs should also achieve conservation in other end use sectors.

Selection of the Energy Conservation Measures

The National Energy Policy and Conservation Act (PL 94-163) mandates the establishment of a thermal efficiency standard for new and renovated structures. However, energy savings from new and renovated buildings are small when compared to the potential savings in the retrofit of existing residential buildings. This paper distinguishes between renovated buildings and retrofitted buildings. The definition of new and renovated buildings can be found on Page 2 The retrofit of existing structures is addressed in the section, Residential Retrofit Program (pages 5-8.)

A further note is that the energy savings for the Weatherization Program for low-income, elderly, and handicapped citizens are accounted for in pages 5-8. Special consideration has been addressed to this program, and it is noted as an implementation strategy in the Missouri Department of Natural Resources Energy Conservation Plan. Section 14.

I. Mandatory Thermal Efficiency Standards for New and Renovated Buildings

Section 420.35 subpart (c) of the state guidelines under the National Energy Policy and Conservation Act requires that the thermal efficiency standards:

1. be in place and ready for implementation with respect to all buildings other than exempted buildings throughout all political subdivisions of the State by January 1, 1978, unless an extension of time has been granted by FEA under 420.41 (b);

2. take into account the exterior envelope physical characteristics, HVAC system selection and configuration, HVAC equipment performance and service water heating design and equipment selection;

3. for all new non-residential structures, be no less stringent than a standard consistent with provisions of Sections 4-9 of ASHRAE 90-75 (American Society of Heating, Refrigeration, and Air-conditioning Engineers);

4. for all new residential buildings, be no less stringent than either the HUD minimum property standards or a standard consistent with the provisions of Sections 4-9 ASHRAE 90-75; and

5. for renovated buildings, (i) apply to those buildings determined by the State to be renovated buildings; and (ii) contain the elements deemed appropriate by the State regarding thermal efficiency standards for renovated buildings (ref. 2).

Description of the Problem

The residential sector consumes more energy than actually needed, primarily because construction practices have not taken into consideration the need for thermally efficient structures. This problem is a result of many closely knit, but separate phenomena. Traditionally, builders are first-cost sensitive. They are unlikely to add "invisible" (e.g., insulation) features which do not enhance the aesthetic appeal of a building, but do raise the price. Until recently, the buyer was also first-cost sensitive. Rarely did he consider annual operating or life cycle costs. Even if the buyer was sensitive to life-cycle costs, he seldom had the information to calculate the long-range operating cost of his dwelling unit.

The building market is competitive within regions and therefore cost is an important consideration. Energy conserving measures that increase first costs will not be undertaken unless they are required by code or perceived by the purchaser to be an economic advantage.

Calculation of Energy Savings

1. New Residential Buildings

New residential buildings are defined as any buildings of the classes listed below which will be constructed in the State of Missouri after October 1, 1978. This date has been used in this calculation because the legislature will not convene until January, 1978. Missouri law stipulates that any law passed in legislative session becomes effective ninety days after adjournment, unless specified. Therefore, for this analysis, the ninety-day period was used and it was assumed that a law will be enacted in the 1978 session. In addition, it was assumed that a six-month period would pass before any significant construction is completed. Thus, energy savings are computed from the first quarter of 1979.

Class	Building Type
1	Single Family Dwelling
2	Low Density Apartment
3	Low Rise Apartment
4	High Rise Apartment

The plan proposed the above buildings be designed and constructed in accordance with the requirements of ASHRAE Standard 90-75 or other equivalent nationally recognized consensus standard or building code. In no case shall the requirements be less stringent than the ASHRAE 90-75 standard and anticipated subsequent amendments.

2. Renovated Residential Buildings

Renovated residential buildings are a subgroup of the class of existing residential buildings. An existing residential building is defined as any and all buildings or building types of the foregoing described classes which are currently consuming any amount of energy which is obtained by conversion of depletable resources, and for which construction commenced prior to October 1, 1978. A renovated building is defined as a building which meets the criteria established by the BOCA code in section 106.0. The language in this section is as follows:

> BOCA CODE, SECTION 106.0- EXISTING STRUCTURES
>
> 106.1 Application: Except as provided in this section, existing structures, when altered or repaired as herein specified, shall be made to conform to the full requirements of this code for new structures.
>
> 106.2 Alterations exceeding 50 percent: If

alterations or repairs are made within any period of twelve (12) months, costing in excess of fifty (50) percent of the physical value of the structure, this code's requirements for new structures shall apply.

106.3 Damages exceeding 50 percent: If the structure is damaged by fire or any other cause to an extent in excess of fifty (50) percent of the physical value of the structure before the damage was incurred, this code's requirements for new structures shall apply.

106.4 Alterations under 50 percent: If the cost of alterations or repairs described herein is between twenty-five (25) and fifty (50) percent of the physical value of the structure, the building official shall determine to what degree the portions so altered or repaired shall be made to conform to the requirements for new structures.

106.5 Alterations under 25 percent: If the cost of alterations or repairs described herein is twenty-five percent or less of the physical value of the structure, the building official shall permit the restoration of the structure to its condition previous to damage or deterioration with the same kind of materials as those of which the structure was constructed; provided that such construction does not endanger the general safety and public welfare and complies with the provisions of Section 926.2 in respect to existing roofs.

106.6 Increase in size: If the structure is increased in floor area or number of stories, the entire structure shall be made to conform with the requirements of this code in respect to means of egress, fire safety, light, and ventilation.

106.7 Part change in use: If a portion of the structure is changed in occupancy or to a new use group, and that portion is separated from the remainder of the structure with the required vertical and horizontal fire divisions complying with the fire grading in Table 902, then the construction involved in the change shall be made to conform to the requirements for the new use and occupancy, and the existing portion shall be made to comply with the exitway requirements of this code.

106.8 Physical Value: In applying the provisions of this section, the physical value of the structure shall be determined by the building official and be based on current replacement costs. Calculations in this report have assumed that any building undergoing these modifications will be upgraded to the ASHRAE 90-75 Standard or its equivalent.

3. Energy Savings

The Missouri Department of Natural Resources has used a methodology for estimating the energy savings which was developed by the Stanford Research Institute and provided by the Federal Energy Administration. Table I below depicts the potential energy savings in Missouri from incorporation of thermal efficiency standards on October 1, 1978, for new construction. The Appendix contains the data base which was used in determining energy savings. It should be noted that the data used in calculations for this paper do not differ substantially from the data base provided by the FEA.

TABLE I

POTENTIAL ENERGY SAVINGS FROM MANDATORY RESIDENTIAL THERMAL EFFICIENCY STANDARDS

SECTOR	TOTAL ENERGY SAVINGS 10^{12} BTU'S	% OF PROJECTED CONSUMPTION 1980
SINGLE-FAMILY DWELLING	1.42	
LOW-DENSITY DWELLING	.41	
LOW-RISE DWELLING	.18	
HIGH-RISE DWELLING	.09	
TOTAL	2.10	.13%

The total savings of 2.10 trillion Btu's is based on the assumption that the Missouri legislature will enact thermal efficiency standards for the state in 1978. This means that new construction and renovations will have been under these standards for nine calendar quarters at the end of 1980.

4. Calculations for Environmental Considerations

Improvements in the thermal efficiency of new and renovated residential buildings will reduce environmental impacts. The reduction in emissions will be modest because the total stock of new and renovated buildings by 1980 is a small fraction of the total stock.

Considerations for Obtaining Compliance

A common objection to thermal efficiency standards is that they increase the first cost of a building. This has been found to be true with ASHRAE 90-75. In 1975, an Arthur D. Little study determined that this standard would increase the initial cost of the structure while lowering the construction costs and operating costs. (ref.3) The primary reason for the increase in the initial cost was that buildings would require design changes. The lower construction costs and the reduced operating costs permit the increase in initial cost to be recaptured within a short time, generally four months to three years.

The initial construction costs of those buildings modified under the standard prescriptive/performance approach in ASHRAE 90-75 were shown to be less than those of conventional buildings. Unit savings range from $0.04 to $0.94 per square foot, with the greatest savings experienced in high-rise buildings.

ASHRAE 90-75 generally increases the cost of the exterior wall, floors, roof, and domestic hot water system. Glazing costs may be higher or lower depending upon building type. Unit costs for lighting, and particularly HVAC equipment and distribution systems, were significantly lower and tended to offset the increase in other costs.

Average changes in unit costs are as follows:

	Dollars per Square Foot
Single-family residence	$ -0.02
Multi-family residence	$ -0.41

For the prototypical buildings investigated in the Authur D. Little study the cost of additional design effort was found to be between $0.09 and $0.36 per square foot of floor area. With the exception of the single-family residence, the straight payback of design services due to energy cost savings was found to be less than one year, and less than six months in most cases. Average additional design costs and payback periods are as follows:

Dollars Per Square Foot

	Annual Energy Savings
Single-family detached residence	$0.07
Low-rise apartment	$0.31
	Additional first-cost Design Services
Single-family detached residence	$0.24
Low-rise apartment	$0.09
	Straight Payback
Single-family detached residence	2.9 years
Low-rise apartment	3.4 months

Other Considerations in Obtaining Compliance

Economic, Social

It is anticipated that there will be a substantial increase in the opportunities for suppliers of building insulation and efficient HVAC systems. The current situation of the insulation market reveals national shortages of insulation material. This can be expected to last through 1978. Instances of price gouging in areas where demand is particularly high and supplies constrained can be expected. Beyond raising initial costs, this may restrict the building market. To what extent, has not been examined. This condition may also stimulate a situation in which low quality insulation material is marketed by "fast-buck" firms. There have been several reported fraud cases and this practice will continue.

II. Residential Retrofit Program

Selection of the Energy Conservation Measures

Residential energy use has been discussed on the first page of this report. The Governor's Commission on Energy Conservation, Residential Measures Committee, has determined that there exists a large potential for energy savings by retrofitting existing buildings. This could amount to as much as 70 percent of the energy presently being used in building operations.

Description of Measure

The measure fall into 8 categories:

1. Reduction in room temperature. The comfort level depends not only on the room air temperature, but also on the floor and wall temperatures. If by better insulation and by better distribution of the warm air flow, floor and wall temperatures can be raised, the room air temperature can be lowered without deterioration of the comfort level. It is assumed that a 2^{0}F reduction (from the normal 72^{0} thermostat setting) in room air temperature could be accomplished without any modifications in the structure. Furthermore, bedrooms and other rooms not continuously used need not be heated to 72^{0}F as they usually are. A 10^{0}F reduction in the room temperature of bedrooms and other parts of the building used infrequently (assumed to comprise 1/3 of the living area) is also considered an acceptable first step conservation measure.

2. Pilot lights turned off during non-heating periods. Most gas furnaces have large pilot lights that consume appreciable amounts of energy during the non-heating periods when they are not needed. It is estimated that 4 million Btu's per dwelling unit can be conserved each year by turning off the furnace pilot light for 5 months of the year.

3. Solar heating through uncovered windows. While most people know that rooms stay cooler in summer when windows are covered by curtains or shades, very few make use of the solar heating potential through properly oriented uncovered windows in winter. In this estimate, it is assumed that one-third of the windows receive sunlight for at least half of the day during the heating season.

4. Weatherstripping. It is assumed that careful weatherstripping and caulking of windows and doors can reduce infiltration losses by one-half.

5. Ceiling and Wall Insulation. Ceiling insulation to R-30 is cost effective in most cases. The walls of frame buildings can be insulated simply by blowing insulation material into the space between studs. For brick walls or brick and block walls, insulation is difficult. Insulation is most effective when applied to the outside, but then the structure requires a new outside surface of stucco or siding.

6. Removable Window Insulation. Substantial savings are possible with removable window insulation. The insulating material can easily increase the window heat resistance from R-1 to R-7 or more, and furthermore reduce infiltration losses. The absence of cold glass surfaces increases the comfort level and allows one to reduce the room temperature. Commercial removable window insulating shutters or panels are not as yet available, but will appear with greater consumer demand for energy conserving devices.

7. Improved Heating Furnace. Retrofitting furnaces with outside combustion air, electronic ignition, automatically controlled damper, means for flue gas recovery, etc., is normally not a cost-effective conservation measure. However, the total replacement of inefficient furnaces with more efficient units can be highly cost effective. Mobile home furnaces with a sealed combustion chamber and a double walled flue, where the combustion air is entrained through the flue, have much greater efficiencies than coventional furnaces. This is true because no warm air from the home is entrained through the flue at any time, and because the flow of

combustion air stops as soon as the burning ceases. It is estimated that the use of sealed furnaces in all types of homes would increase the average furnace efficiency from the present 60 percent to 80 percent, in addition to reducing infiltration losses.

8. Water heating conservation measures. Two measures are recommended: Insulating hot water tank walls to R-11, and replacing the conventional 5-gallon per minute shower heads with flow restrictors allowing only 3 gallons per minute. Both of these measures are very cost-effective.

All of these foregoing measures are to be implemented through programs conducted in the Missouri Energy Conservation Program.

Calculations of Energy Savings

Since data on the energy efficiency of Missouri residential buildings vary widely, it was decided to establish a model of an "average" Missouri home and then look into the energy savings possible for such a home. The average home is detailed in the Appendix. The house is assumed to be a single-family dwelling with 30 X 40 sq. ft. gross floor area, consisting of one floor with an 8-foot ceiling and a basement with a 7-foot ceiling. The window area is 12 percent of the floor area, or 144 sq. ft. The home consumes 148 million Btu's/Yr. for space and water heating at 60 percent furnace efficiency. Additionally, the furnace pilot light consumes 4 million Btu's for 5 months during the summer. Thus, the total consumption is 162 million Btu's/Yr.

Energy Cost

For the purpose of analysis it is assumed that all space and water heating is provided only by gas or oil, and that the heaters have an average efficiency of 60 percent. A weighted average price for natural gas, gas liquids and oil of $2.40/million Btu's is also assumed. This is slightly more than the present price for natural gas, but less than the price for gas liquids or fuel oil. The cost for fuel including heater efficiency then is $2.40/.60 = $4.00/ million Btu's retained in the building.*

Potential Space and Water Heating Savings

Table 2 gives the results of the computed savings for space and water heating for each of the measures. The first six columns are for each measure applied separately. The number of years for payback does not include interest costs, since one can assume that the price increase of the saved fuel will more than pay for the interest. The last two columns give usage and savings when the measures are applied in the sequence of the table.

TABLE 2

POTENTIAL SAVINGS FOR "AVERAGE" MISSOURI HOME

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Fuel Saved		Implementation Cost	Years Payback	Cumulative Usage/Saving	
No.	Sub-Measure	Million Btu's/Yr	$/Yr	$		%	%
0	Before	0	0			100	0
1	-2°F total	6	28			94	6
	-10°F, (1/3) of total	10	40			83	17
2	Pilot light off 5 months	4	10			79	21
3	Uncover windows in sun, (1/3) of total	5	20			74	26
4	Weatherstrip (1/2) infiltration	11	44	50.-	.9	64	36
5	Ceiling insulation to R-30	14	56	480.-	8.6	52	48
6	Removable window insulation R-7 for 16 hours/day	8	32	260.-	.8	45	55
7	Sealed combustion furnace	31	75	500.-	6.6	34	66
8	Watertank insulation to R-11	3	12	30.-	2.5	31	69
9	Water conserving shower head	4	16	12.-	.8	27	73
	TOTALS	96	$333	$1332.-	4.0		

*With a price of electric heating of 1.7¢/kwh, electric resistance heating would cost $5.00/ million Btu's. The cost of $4/million Btu's is assumed in the study for all energy calculations.

If the furnace is replaced after the other measures have been applied, its size will be reduced but so will the savings and the cost, so that the payback time remains the same. The energy savings, if all listed measures are applied, are 73 percent.

Further fuel savings could be obtained by wall insulation and by solar assisted space and water heating. It should be kept in mind that the savings listed in the table are for the "average" Missouri residential building. Actual buildings will have different energy conservation potentials. For example, reasonably well-insulated walls and a low ceiling insulation have been assumed. Many brick or brick and block buildings have substantially lower R-factors for the walls, so that wall insulation, omitted in the listed measures, becomes more important, though quite difficult to achieve. In many homes with less than adequate ceiling insulation an effective measure to reduce ceiling heat losses is to partially close the attic vents in winter, though sufficient cool outside air must be admitted to prevent moisture condensation on the inside of the roof. About 1/3 of the savings from a R-30 ceiling insulation can be expected from this measure. While weather-stripping and ceiling and wall insulation are widely recommended, the large energy conservation potential of modifying furnaces is little known and deserves wider recognition.

It would be unrealistic to assume that the 1.3 million homes in Missouri achieve savings of 73 percent per building. Results from the FEA program Project Conserve (a somewhat similar program to that advanced in this report) suggest that compliance levels range between 8 - 21 percent with savings of 15-25 percent per building. The Department of Natural Resources Energy Program believes that the vigorous implementation of programs will improve upon the historically low compliance levels.

Accordingly, energy savings are estimated at a compliance level of 30 percent and with 20 percent savings per building. Based on 162 million Btu's/Yr. per average home, the total potential is 12.6 trillion Btu's. This is equivalent to .8 percent of the total projected Missouri energy consumption in 1980.

Energy Consumer's Considerations for Obtaining Compliance

Implementation approaches for attaining compliance levels are detailed in the Missouri State Energy Conservation Plan, Section 14. However, a few comments on the necessary steps are included here.

Sub-Measure 1 - reductions in room temperature - will require informing the public of the substantial dollar savings obtainable.

Sub-Measure 2 - turning off the furnace pilot when the furnace is not needed - will require instructions to the homeowners on how to relight the pilot together with information on the dollar savings. Obviously, the measure will save little money if a service call is made each time the pilot must be relit.

Sub-Measure 3 - uncovering windows in the sun - will require instructions on the effectiveness of this measure.

Sub-Measure 4 - weatherstripping - is by now widely recognized as highly cost effective, but needs promotion to be universally adopted.

Sub-Measure 5 - ceiling insulation - needs information to the homeowner as to its cost effectiveness, financing, and tax incentives.

Sub-Measure 6 - removable window insulation - will require both public information and incentives for suitable product development.

Sub-Measure 7 - sealed combustion furnaces - will require promotion and incentives for product development and for homeowner acceptance of product.

Sub-Measure 8 - watertank insulation and water conserving shower heads - will require education of the public as to the cost effectiveness of these measures.

B. ENERGY CONSERVATION MEASURES - COMMERCIAL SECTOR

Introduction to the Commercial Sector

The commercial/institutional sector uses 20 percent of the energy consumed in Missouri (ref. 1). Approximately 75 percent of this is used for lighting and space heating. (Commercial/institutional buildings as defined here means all non-residential buildings, including public buildings.)

Experience and estimates suggest that energy demand in new buildings can be reduced by as much as 60 percent, but the average is 30-40 percent.

Energy consumption in existing buildings can be reduced from 15-20 percent with little, if any, initial costs; and 15-25 percent additional savings through investments that can be recovered in less than 3 years based on 1977 fuel costs. Given this potential, the reduction of energy demand in this sector is a major objective of the Missouri Energy Conservation Plan.

Selection of the Energy Conservation Measures

The Energy Policy and Conservation Act mandates the establishment of lighting efficiency standards for new and existing public buildings, and thermal efficiency standards for new and renovated non-residential buildings.

The Missouri commercial/institutional sector conservation plan proposes to establish:

1. Mandatory thermal efficiency standards for new and renovated commercial/institutional buildings;
2. Mandatory lighting efficiency standards for public buildings;
3. Persuasive voluntary programs for the retrofit of existing buildings.

The Building Standards Review Committee of the Governor's Commission on Energy Conservation was convened in February, 1977, to select and recommend standards for new construction in the state of Missouri. After considerable and careful deliberation, the committee unanimously agreed to recommend state-wide adoption, for all new residential and non-residential buildings, ASHRAE 90-75 (American Society of Heating, Refrigeration, and Air-conditioning Engineers) "Energy Conservation in New Buildings Design", and subsequent amendments.

Energy savings from the incorporation of thermal efficiency standards for new and renovated commercial buildings are addressed below. Lighting efficiency energy savings in public buildings is covered later in this paper, as well as the savings potential for the retrofit of existing commercial/institutional buildings. The distinction between renovation and retrofit is the same as the one developed in the residential sector.

I. Thermal Efficiency Standards, New and Renovated Commercial/Institutional Buildings

Description of the Problem

The consumption of energy by commercial/institutional buildings is not being managed to the degree that energy costs would economically justify. In new buildings this is largely a result of building practices which do not reflect the need for thermally efficient structures. Factors which contribute to this condition are either ignorance of energy conserving practices on the part of building contractors or unwillingness to raise the initial selling price.

Description of the Measure

The Commercial/Institutional Buildings Committee of the Governor's Commission on Energy Conservation believed that a standard more stringent than ASHRAE 90-75 was both desirable and realizable. However, the Committee also recognized that the time required to develop, evaluate, and incorporate the amendments would probably preclude adoption by 1980 (or, at best, preclude any savings before 1980).

Calculations of Energy Savings

The basic data on energy use in the commercial sector has been published in Missouri Energy Profiles. Data required for the calculation of estimated energy savings is summarized in Tables 3 & 4. Detailed data and actual calculation of energy savings are given in the Appendix.

Table 3 shows, by fuel type and year, the total energy use in the commercial sector of the state. Some items are presented in the table which cannot be included in estimated energy savings in thermal and lighting systems. Motor gasoline, asphalt, and motor oils are not used in thermal or lighting operations of buildings.

The passage of legislation or the adoption of a statewide building energy code may not be possible for some time because of the absence of a statewide building code. For the purpose of calculating energy savings, it is again assumed that the standards and enforcement mechanisms will be in place in October, 1978. In addition, the time lag between the effective date of the standards and completion of any significant new construction is assumed to be six months. Consequently, the starting date for counting energy savings is the first quarter of 1979.

The last factor required in calculating energy savings is the degree of compliance anticipated. Assuming that the standards will be enforced through existing building code authorities those buildings outside these jurisdictions might not conform. Data indicates that 95 percent of all buildings in the state are in areas covered by building codes. Assuming that this trend continues, at least 95 percent of new buildings will be required to conform to a statewide efficiency standard. It is also assumed that 50 percent of all the buildings built outside code jurisdictions will also conform, due to economic pressures and the direct technology transfer programs of the state energy conservation program.

The estimated energy savings, summarized in Table 4, were calculated using the FEA supplied methodology and data base.

Calculations for Environmental Considerations

There are no harmful effects on environmental quality from application of thermal and lighting standards. The environmental effects are beneficial in the form of reduced requirements for electrical generating capacity and decreased pollution resulting from reduced combustion of fuels in the building.

Energy Consumer's Considerations for Obtaining Compliance

According to the impact study by A. D. Little, building owners and operators should experience, for most building types, a slight decrease in costs for renovation or new construction compliance to ASHRAE 90-75, with trade off's between increased costs for design fees, shell materials, insulation and decreased costs for HVAC and lighting systems. Some resistance to compliance, therefore, is anticipated initially, until these patterns of cost trade off's become common knowledge.

TABLE 3

COMMERCIAL SECTOR ENERGY USAGE (BTU X 10^{12})

ENERGY CONSUMPTION AT BUILDING BOUNDARY		1968	1974	1980 (PROJ)*	
NATURAL GAS		82.4	93.2	64.2	
L.P. GAS		4.0	4.3	4.6	
TOTAL GAS		86.4	97.5	68.8	
RESIDUAL OILS		12.8	7.2	5.7	
DISTILLATE		20.3	18.3	21.2	
MOTOR GAS		0.8	0.8	0.9	
ASPHALT & READ OILS		35.7	48.6	32.2	
TOTAL PETROLEUM PRODUCTS		69.6	74.9	60.0	
ELECTRICITY		19.9	26.9	31.7	
OTHER		1.3	1.3	.0	
TOTAL, OTHER		21.2	28.2	31.7	
GRAND TOTAL (AT BUILDING BOUNDARY)		177.2	200.6	160.5	
ENERGY CONSUMPTION INCLUDING 3.4 ELECTRICAL GENERATION INEFFICIENCY FACTOR					
GAS, OIL & OTHERS		157.3	173.7	128.8	
ELEC	(19.9 X 3.4)	67.7	91.5 (26.9 x 3.4)	104.6	(31.7 x 3.3)
TOTAL ENERGY USED		255.0	275.2	233.4	
% OF MISSOURI TOTAL		19.2	20.2	15.2	
MISSOURI TOTAL		1174.7	1363.5	1536.5	

*1980 PROJECTION ASSUMED NO ENERGY CONSERVATION MEASURES IMPLEMENTED

TABLE 4

PROJECTED ENERGY SAVINGS

NEW & RENOVATED COMMERCIAL BUILDINGS, THERMAL EFFICIENCY STANDARDS

BUILDING TYPE	ENERGY SAVINGS ON 100% COMPLIANCE BTU x 10^{12}		% COMPLIANCE		1980 ANNUAL ENERGY SAVINGS BTU x 10^{12}	
	NEW	RENOVATED	NEW	RENOVATED	NEW	RENOVATED
OFFICE	.780	.054	95	50	.741	.027
RETAIL	.610	.038	95	30	.580	.011
SCHOOLS	.543	.066	100	90	.543	.059
HOSPITALS	.231	.025	100	90	.231	.022
OTHER	.527	.057	95	40	.500	.023
SUBTOTAL	2.691	.240			2.595	0.142
TOTAL	2.931				2.737	
% OF MISSOURI 1980 TOTAL (1536.47)					.18%	

Cost-Effectiveness

Energy conservation standards applied to building thermal systems are cost-effective in all types of buildings. Estimates of initial cost impacts and energy savings resulting from application of ASHRAE 90-75 on selected buildings (as tabulated below) show initial costs are actually less in most cases. (The tabulated initial costs include the estimated change in construction costs as well as the estimated increase for architectural and engineering design. In cases where initial costs are increased, such as retail buildings, the savings in energy quickly recover the added capital outlay. On a straight payback, the aditional capital outlay is recovered in 2.3 months. Other studies and experiences have shown the same cost-effectiveness for other types of buildings.)

	Change in Initial Cost ($/Sq-Ft.)
Office Buildings	-0.13
Retail	+0.13
Schools	-0.24

	Annual Energy Savings ($/Sq-Ft)
Office Buildings	0.349
Retail	0.673
Schools	0.143

Economic Impact

The application of thermal standards has widespread economic impacts. In terms of the building itself, they affect initial cost (including equipment, construction, and design investments and operating costs - energy and maintenance). As indicated above, these effects are beneficial to the building owner/occupant.

The industries affected by the application of thermal standards include the suppliers of HVAC equipment, insulation, siding materials, window and window glass, lamp and fixture suppliers, construction contractors and architect and engineering design firms, and of course, energy supply industries. A total quantitive analysis of the impacts has not been completed for Missouri businesses.

Social Impact

No social impacts, other than the economic and environmental effects, are envisioned.

Health and Safety

To date, the only aspect of ASHRAE 90-75 considered to have any impact on health, safety, and welfare is the reduced ventilation and infiltration rates and the changes in lighting.

Reduced ventilation and infiltration is expected to increase the exposure of non-smokers to particulates of and odor from tobaccos and possibly increase the indoor pollutant levels from pollutant sources within the building. The smoking problem can be resolved by restricting smoking to specified smoking areas in public buildings. The pollutant levels have not been quantitatively evaluated and require further review and evaluation to determine the impact and potential solutions.

Other Considerations in Obtaining Compliance

Regulatory, Legislative

As with any regulatory or legislative attempt, implementation will certainly meet with some opposition, particularly those areas where the impact is unknown. A strong informational/ promotional program is advocated to help overcome some of these objections. This program must, however, run concurrently with efforts to implement the regulations since time will not permit doing it sequentially.

The probability of legislated thermal and lighting standards before 1980 is low. However, the likelihood of incorporation of energy standards by existing building code authorities is high.

II. Lighting Efficiency Standards for Public Buildings Description of the Problem

Commercial and institutional buildings were designed and constructed with little or no thought given to energy efficiency because energy was both cheap and plentiful. Not only are the structures and their mechanical and electrical systems not designed to optimize the use of energy, they also are not designed to be efficiently operated. Each year these facilities consume more and more energy as the structure and systems deteriorate and maintenance and replacement become more costly and are neglected.

Eventually, energy prices and the scarcity of fuels will force improvements in these systems. However, because of current public attitude and governmental policy concerning the control and pricing of energy supplies, it is doubtful that the desired 5 percent reduction in consumption can be realized without specific regulatory controls.

Description of the Measure

This measure requires the enforcement of mandatory lighting efficiency standards for public buildings. The criteria established in this measure conform to the minimum criteria in the federal Energy Policy & Conservation Act. These include:

1. For all new public buildings the standard will be no less stringent than a standard consistent with the provisions of ASHRAE 90-75, Section 9;

2. For an existing public building, the element deemed appropriate by Missouri is that a building of 40,000 square feet or more will be required to retrofit its lighting levels to a standard that is no less stringent than the provisions of Section 9 of ASHRAE 90-75;

3. A public building is defined according to the definitions in Section 420.11, Federal Register, Volume 41, No. 213 - Wednesday, November 8, 1976

"...any building which is open to the public during normal business hours, except exempted buildings. Each of the following is included within the definition of 'public building', unless it is an exempted building:

---any building which provides facilities or shelter for public assembly, or which is used for educational, office, or institutional purposes;

---any inn, hotel, motel, sports arena, supermarket, transportation terminal, retail store, restaurant, or other commercial establishment which provides services or retails merchandise;

---any portion of an industrial plant building used primarily as office space;

---any building owned by a State or political subdivision thereof, including libraries, museums, schools, hospitals, auditoriums, sports arenas, and university buildings".

Calculations of Energy Savings

It is anticipated that acceptance of a statewide building energy code will not be possible for some time. Therefore, for these calculations it is again assumed that the required standards and enforcement mechanisms would be in place and take effect in October, 1978. In addition, the time lag between the effective date of the standards and completion of any significant renovation was assumed to be six months. Therefore, the starting date for counting energy savings is the first quarter of 1979.

Despite the fact that lighting standards will be mandatory there are a number of reasons why 100 percent compliance will not be achieved. First, some buildings are not under any jurisdictional boundary and it will be extremely difficult to enforce any statewide standard in those areas. Further, the degree of compliance will vary among the different types of buildings and occupances. Buildings such as schools, hospitals, nursing homes, and others under control of some regulatory agency would probably show a higher degree of compliance than other types. The compliances assumed and the energy savings are shown in Table 5.

COST EFFECTIVENESS

The cost effectiveness of applying thermal and lighting energy standards to existing buildings is potentially high. Nonetheless, it needs to be carefully calculated for each building and each modification considered. The possible energy savings of such standards and the cost of implementing some techniques are a function of building design (such as exterior wall construction, quantity of fenestration, existing insulation, type of HVAC system, lighting types, etc.). Consequently, a universal statement cannot be made about the cost effectiveness of any given technique. Each case must be evaluated on an individual basis. Therefore, standards for renovated buildings will have to take this variability into account and be flexible enough to make them practical.

TABLE 5

PROJECTED ENERGY SAVINGS, LIGHTING STANDARDS FOR PUBLIC BUILDINGS

BUILDING TYPE	ENERGY SAVINGS BASED ON 100% COMPLIANCE BTU X 10^{12}		% COMPLIANCE		1980 ANNUAL ENERGY SAVINGS BTU X 10^{12}	
	NEW	EXISTING	NEW	EXISTING	NEW	EXISTING
OFFICE	.227	.006	95	50	.216	.003
RETAIL	.389	.013	95	30	.370	.004
SCHOOLS	.204	.008	100	90	.204	.007
HOSPITALS	.132	.006	100	90	.132	.006
OTHER	.381	.015	95	40	.362	.006
SUBTOTAL	1.333	.048			1.284	.026
TOTAL					1.31 X 10^{12}	
% OF MISSOURI 1980 TOTAL (1536.47 X 10^{12})				.08%		

Source: Missouri Energy Profiles

The estimated energy savings were calculated using the FEA supplied methodology and data base. The detailed calculations and data are given in the Appendix.

Energy Consumer's Considerations for Obtaining Compliance

Essentially the same as Page 10, "Economic Impact"

Regulatory, Legislative

As with any regulatory or legislative attempt, implementation will certainly meet with some opposition, particularly those areas where the impact is unknown. A strong informational/promotional program is advocated to help overcome some of these objections. This program must, however, run concurrently with efforts to implement the regulations since time will not permit doing it sequentially.

III. Commercial - Institutional Energy Management Selection of the Energy Conservation Measures

The energy savings reflected in pages 5-12 of this paper, are solely for new and renovated structures. A large potential exists for additional savings in the retrofit of existing commercial/institutional buildings. As noted previously, there is a fine difference between renovation and retrofit. This distinction has been addressed in previous pages.

The objective of measures chosen for energy conservation in commercial/institutional and state buildings is to reduce energy consumption by increasing the thermal and lighting energy consumption efficiencies of the buildings.

The measures used to increase building efficiencies include: changing thermostat settings, reducing lighting levels, relamping, reducing hot water temperature, adjusting boilers, etc.

Information on each of these individual steps can be delivered to the end-user in three identifiable packages:

1. the energy audit,
2. literature or handbook distribution,
3. education/information seminars.

These techniques for delivering information vary greatly in effectiveness but are all considered important in reaching the building owner/operator.

DNR-Missouri Energy Program staff has concluded from their work with schools, hospitals, municipalities, and industry that programs to reduce energy consumption in existing commercial, industrial, and institutional buildings can achieve major energy savings per work hour and dollar investment.

It is estimated that through effective programs of energy management assistance to existing facilities that energy consumption can be reduced in affected buildings by at least 20 percent by 1980. Programs and measures described here are estimated to save a total of 2.43 trillion Btu's annually, or .16 percent of the projected gross energy consumption.

Calculations of Energy Savings

Measure 1, The Energy Audit

The potential savings that can be derived from basic "walk through" audits are based upon previous experience of the Missouri Department of Natural Resources Energy Program. Savings on the order of 20 percent per building have been achieved with regularity. The DNR-MEP Energy Management Assistance Program (EMAP) expects to audit 1000 buildings (400 in 1978 and 600 in 1979). Of these 1000 buildings, 75 percent are expected to achieve savings of 20 percent or more.

Additional buildings can be audited by the computer program provided by the Public School Energy Conservation Service. It is estimated that 20 percent of the 3600 school buildings will be audited from 1978 to 1980. Savings are estimated at 50 percent response to the results with 20 percent savings per building.

Energy savings in this category amount to 1.63 trillion Btu's. (See Appendix I for calculations.)

Measure 2, Literature or Handbook Distribution

Distribution of literature is expected to reach 4,000 building owner/operators per year beyond those affected by Measure 1. Of the owner/operators, 10 percent of them are expected to achieve 10 percent energy savings per building in response to this literature. Therefore, assuming a building size of 40,000 square feet with an energy consumption of 200,000 Btu's/sq ft/yr., energy savings of .3 trillion Btu's are possible (see note below). This amounts to .02 percent of the projected 1980 gross energy consumption.

Measure 3, Education/Information Seminars

A series of technical seminars is expected to reach approximately 6,000 building owners and operators. Previous experience suggests that 10 percent (600) will attempt serious conservation efforts. Assuming the same building characteristics and potential savings as in Measure 2, potential savings will be .5 trillion BTU or .03 percent of the projected energy consumption. Energy savings from the Program Measures are summarized in Table 6.

TABLE 6

POTENTIAL ENERGY SAVINGS, RETROFIT OF EXISTING COMMERCIAL/INSTITUTIONAL BUILDINGS

MEASURE	ENERGY SAVINGS TRILLION BTU'S
1	1.63
2	.3
3	.5
TOTAL	2.43
% OF PROJECTED CONSUMPTION	.16

Note: 40,000 square feet represents an average size building as determined by a telephone survey of county assessors in Kansas City and St. Louis. It is only estimated that there are this many buildings of that size.

To meet the mandatory FEA requirements, we have drafted legislation which would give the State the authority to develop mandatory thermal and lighting efficiency regulations which would then be enforced by the local building code authorities in Missouri. Unincorporated areas would not be covered by this legislation since they lack building code authorities. However, we believe 95 percent of all construction in the state falls under the jurisdiction of a building code authority.

The legislation we have drafted will be sponsored by Representative Ed Sweeney. Since Missouri does not have a statewide building code, the passage of a statewide energy efficiency code may be difficult to enact. Two alternate strategies are being promoted by DNR.

First, we will be promoting the adoption of the NCSBSC/ERDA model energy conservation code by Missouri municipalities. Missouri building code authorities are currently using either the BOCA code or the Unifrom Building Code. The NCSBSC/ERDA model code is designed as a supplement to either of these codes and can be adopted in the normal course of building code authorities annual revision to its current codes. For this reason, we believe that a modest education program on the merits of the NCSBSC/ERDA code and training programs for the building code officials and inspectors who will use it, will bring about significant adoption of this code by Missouri local code authorities. Current energy efficiency supplements to the BOCA code and the Uniform Code are also consistent with the NCSBSC/ERDA model and are already being adopted, or are under consideration by several Missouri municipalities.

The second strategy is to use the Public Service Commission's powers to promote energy conservation in buildings. The State Energy Conservation Plan recommends that the PSC require "condition of service" criteria for all new buildings. In other words, energy efficiency standards would have to be met for a new residential/commercial building before that building could be hooked up for service by a private utility.

As a result of this recommendation, the Missouri PSC staff, at the request of the Governor, have drafted a model "condition of service criteria" order based on ASHRAE 90-75. This draft order is now before the Commission members and the public for review and comment. The question of enforcement is particularly important. It is not yet clear whether responsibility will fall on the utility owner, the builder, or the local building code authority.

In conclusion, the potential for energy conservation in buildings is very high, even though the savings between now and 1980 appear low; .31 percent for new residential/commercial buildings, and .95 percent for efforts in existing residential/commercial buildings.

It should be remembered that almost 40 percent of all the energy we use in Missouri goes into heating, cooling, ventilating, and lighting homes and buildings. Energy efficiency standards for new construction can reduce future energy use in new buildings by 40-50 percent and, as more and more existing buildings receive either major renovations or are replaced by new structures, we can expect to see major energy conservation savings, particularly in the late 1980's. More immediate and even larger savings are possible by focusing on the existing housing stock and commercial/institutional buildings. The potential energy savings for existing buildings outlined above are probably far too low when one considers the actions people are taking on their own to make their homes, offices, schools, small businesses, stores, and public facilities more efficient.

The current shortage of insulation is a clear indication that Missouri citizens are now responding quickly to rising energy costs and the need for conservation.

REFERENCES

1. Missouri Energy Profiles, Department of Natural Resources, Jefferson City, Missouri 65101
2. Federal Register, Volume 41, No. 213, Wednesday, November 8, 1976.
3. Energy Conservation in New Building Design, An Impact Assessment of ASHRAE Standard 90-75. Conservation Paper #43B, Federal Energy Administration, 1975.

APPENDIX

I. Residential Calculations

Methodology and Data Used in Estimating Energy Savings from Mandatory Thermal Efficiency Standards for New and Renovated Residential Buildings

TABLE 1.A

ANNUAL NEW CONSTRUCTION, MISSOURI

(MILLIONS OF SQUARE FEET)

BUILDING TYPE	
SINGLE-FAMILY	45.4
LOW-DENSITY	11.6
LOW-RISE	3.7
HIGH-RISE	2.4

The methodology used was taken from the State Energy Conservation Plan Handbook, Volume 2 of the Sourcebook, page 42, update 2/3/77. All data is from the same source, pages 44-48, Federal Energy Administration.

TABLE 1.B

ANNUAL RENOVATIONS
(MILLIONS OF SQUARE FEET)

BUILDING TYPE	
SINGLE-FAMILY	11.2
LOW-DENSITY	3.6
LOW-RISE	2.0
HIGH-RISE	.5

TABLE 1.C

ANNUAL SPACE HEATING NEEDS IN CONVENTIONAL AND ASHRAE 90-75 BUILDINGS (1,000 BTU/FT^2/YR.)*

BUILDING TYPE	CONVENTIONAL	ASHRAE 90-75
SINGLE-FAMILY	106.08	91.23
LOW-DENSITY	109.71	94.35
LOW-RISE	77.03	54.31
HIGH-RISE	65.72	46.00

* THE ELECTRIC COMPONENT OF SPACE HEATING HAS BEEN CORRECTED TO ACCOUNT FOR GENERATING AND SPACE HEATING EFFICIENCY.

TABLE 1.D

ANNUAL AIR-CONDITIONING NEEDS IN CONVENTIONAL AND ASHRAE 90-75 BUILDINGS IN BTU/FT^2/YR (1,000's)* **

BUILDING TYPE	CONVENTIONAL	ASHRAE 90-75
SINGLE-FAMILY	16.16	10.00
LOW-DENSITY	13.74	8.51
LOW-RISE	15.43	7.09
HIGH-RISE	14.26	6.57

*ALL AIR-CONDITIONING IS ELECTRIC AND HAS BEEN CORRECTED BACK TO THE GENERATING PLANT ASSUMING A 30% EFFICIENCY.

**ALL DEMANDS HAVE BEEN DECREASED TO ACCOUNT FOR THE FRACTION OF BUILDINGS NOT AIR-CONDITIONED IN 1980.

The methodology assumes the post standards construction or renovation factor to be 1.875. This is based on the 3rd quarter of 1978. In the text it was stated that the first effective date for the standard would be October 1, 1978. If one assumes an average of 1/2 year for construction then 1.375 would be the proper figure.

A source of data inconsistency may arise with renovation considerations. The calculations have assumed that 25 percent of the renovations meet the conditions outlined in the section, "Calculation of Energy Savings", beginning on Page 3. Given that the original assumption was that renovations were equal to one-half of the number of removals (which may or may not be true) and that 25 percent is an outright assumption, there is room for substantial error. The Missouri DNR Energy Program staff acknowledge these difficulties and will attempt to develop a better data base. The calculations, therefore, are considered to be first order estimates subject to change. This appears to be consistent with objectives that have been identified by the FEA.

II. "Average" Missouri Home

The following tables refer to the "average" home model developed by the Governor's Commission on Energy Conservation, Residential Measure Committee, and used in our paper under, "Calculation of Energy Savings".

The house is assumed to be a single-family dwelling with a 30x40 sq. ft. gross floor area, consisting of one floor with an 8-foot ceiling and a basement with a 7-foot ceiling. The window area is 12 percent of the floor area, or 144 sq. ft. The home is moderately insulated with the following heat resistances:

CEILING	R-8
WALLS	R-16
WINDOWS	R-1.24 (BETWEEN SINGLE AND DOUBLE WINDOW)
FLOOR	SPECIAL COMPUTATION
INFILTRATION	35% OF HEAT TRANSFER LOSS
WATER HEATING	25% OF SPACE HEATING
HEATER EFFICIENCY	60%
DEGREE DAYS PER YEAR	5000
HEAT GAIN (APPLIANCES, PERSONS)	9.5% OF HEAT LOSS

With these assumptions one obtains the following heat losses:

TABLE OF HEAT LOSSES FOR MODEL HOME

ITEM	BTU/H°F	BTU/DAY°F	MMBTU/YEAR
CEILING	150	3.600	18
WALLS	171	4.100	20
WINDOWS	116	2,780	14
FLOOR	83	2,000	10
INFILTRATION	182	4,370	22
TOTAL HEAT LOSS	702	16,850	84
HEAT GAIN	67	1,610	8
HEAT LOSS MINUS GAIN	635	15,240	76
WATER HEATING			19
TOTAL SPACE & WATER			95

WITH 60 PERCENT HEATER EFFICIENCY THE TOTAL ENERGY FOR SPACE AND WATER HEATING IS 95/.6 = MBTU/YR. ADDING 4 MMBTU FOR 5-MONTH SUMMER BURNING OF THE FURNACE PILOT LIGHT, ONE OBTAINS 162 MMBTU/YR.

III. Commercial Calculations

Methodology and Data Used in Estimating Energy Savings from Mandatory Thermal Efficiency Standards for New & Renovated Commercial Building

The methodology was taken from the State Energy Conservation Handbook, Volume 2 of the Sourcebook, update 2/3/77, Federal Energy Administration.

TABLE II.A
ANNUAL NEW CONSTRUCTION, MISSOURI
(MILLIONS OF SQUARE FEET)

BUILDING TYPE	
OFFICE	5.1
RETAIL	8.2
SCHOOLS	5.3
HOSPITALS	1.8
OTHER	2.4

TABLE II.B
ANNUAL RENOVATIONS
(MILLIONS OF SQUARE FEET)

BUILDING TYPE	
OFFICE	.4
RETAIL	.5
SCHOOLS	.6
HOSPITAL	.2
OTHER	.9

TABLE II.C

ANNUAL SPACE HEATING NEEDS IN CONVENTIONAL AND ASHRAE 90-75 BUILDINGS (1,000 BTU/FT^2/YR.)*

BUILDING TYPE	CONVENTIONAL	ASHRAE 90-75
OFFICE	114.04	30.79
RETAIL	58.91	21.21
SCHOOL	97.35	44.78
HOSPITAL	119.85	57.53
OTHER	60.25	28.92

TABLE II.D

ANNUAL AIR-CONDITIONING NEEDS IN CONVENTIONAL AND ASHRAE 90-75 BUILDINGS (1,000 BTU/FT^2/YR.)**

BUILDING TYPE	CONVENTIONAL	ASHRAE 90-75
OFFICE	70.72	42.45
RETAIL	77.71	61.42
SCHOOL	41.69	19.62
HOSPITAL	93.63	65.53
OTHER	77.71	61.42

*ALL AIR-CONDITIONING IS ELECTRIC AND HAS BEEN CORRECTED BACK TO THE GENERATING PLANT, ASSUMING A 30 PERCENT EFFICIENCY.

**ALL DEMANDS HAVE BEEN DECREASED TO ACCOUNT FOR THE FRACTION OF BUILDINGS NOT AIR-CONDITIONED IN 1980.