A COMPUTERIZED ANALYSIS OF HOME ENERGY REDUCTION ALTERNATIVES USED IN A STATEWIDE EXTENSION PROGRAM

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ABSTRACT

A computer program has been developed which can provide homeowners with an evaluation of the economics of adding insulation to the ceiling, walls and floors of their homes along with the addition of storm windows and doors. This evaluation is done from data collected on a simplified input form. The basic calculation procedure used in the program is discussed in detail including the assumptions made. The program input form and typical output are also presented.

INTRODUCTION

Long-range forecasts have indicated for a number of years that energy prices would be rising and there could be spot shortages of fuel. Then, with the severe winter of 1977, homeowners suddenly became aware of the problems associated with fuel shortages. The combination of increasing cost and the fear of recurring shortages has provided the incentive for homeowners to look at ways of conserving energy. However, it is possible they would like to conserve energy without having any effect on their present life style. This has led many of them to look into adding insulation and storm windows or doors to their homes.

Increased levels of insulation in residential houses can save homeowners money and also reduce the national energy consumption. On a gross energy basis it has been estimated that in 1973 about 20 percent of the energy used in this country was used by the household and commercial sector, with an annual rate of increase close to 3 percent per year (9). The portion of this percentage which should be allocated to the residential sector is estimated to range between 60 and 70 percent (3,4). Of the gross energy utilized by the residential sector, approximately 61 percent of this has been estimated to be used for space heating and air conditioning (8). It is this percentage which the program described in this paper helps to encourage individuals to reduce.

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According to Project Independence (4), "Universal application of technology which is currently available, at reasonable cost, would reduce the growth rate in the combined resident-commercial sectors to under one percent per year. Such a reduction would imply a savings in the year of 1990 of nearly three million barrels of oil per day." Of this amount, more than 1.5 million barrels of oil per day could be saved in single-family detached houses.

One difficulty the homeowner faces in reinsulating is the concept of marginal returns with added insulation. Several programs, such as studied by National Bureau of Standards and the Oak Ridge Laboratory (5,6), have been developed that do a detailed analysis of the marginal returns with added insulation. These studies provided highly detailed accounts of energy savings and of marginal returns for investing in added insulation. However, these reports are very detailed and must be read by someone who understands the processes of marginal returns and, therefore are not useful to the majority of homeowners. They also require a very good understanding of construction methods and the R-value of current insulation in individual homes. Other less detailed programs have also been developed for use by the homeowner. These programs includes those developed by Virginia Polytechnic Institute and that developed for the Federal Energy Administrations Project Conserve (10,7). The Project Conserve program was developed for FEA as a standard program, which could be used by state agencies to aid homeowners in determining the value of added insulation. It is designed for an input form which is filled out by the consumer and mailed in. The computer is then run on the individual's home and the results returned. Some basic problems exist with this program; one is that it does not look at the concept of marginal returns as it adds insulation. The VPI model was developed for use on its terminal system, this allows anyone with access to a terminal to use its program for evaluating added insulation. The difficulty with the VPI program lies in the availability of the terminal system to the average homeowner.

Because of the limitations in existing programs a new computer program was developed at the University of Kentucky, which would allow the homeowner to fill out a simple input form and get back a computerized analysis of his home showing the marginal cost of return for adding additional insulation to the existing house. Previous programs, to a large extent, have relied on information published by the American Society of Heating and Refrigerating and Air Conditioning Engineers in their 1972 edition of Handbook of Fundamentals (1). This design information is still considered among the best available. Because of the use of a common source of information, the above-mentioned programs are similar in calculating procedure. ASHRA data are also used extensively in the construction of the model described in this paper.

PROGRAM DESIGN

The objective of the developed computer program was to provide a homeowner with as much detailed information as possible while still requiring him to fill out only a relatively simple input form. The assumption is that the individual must be able to understand the output that is returned to him. Also, this program was developed to be used in conjunction with the statewide Cooperative Extension Service, which has a staff of county agents trained to understand the output of the model. The program is a steady-state type program which does not allow for transient effects of various building types. This approach was chosen over a more complicated program because the objective was not to evaluate different types of construction per se, but rather to look in general at the feasibility of reinsulating. In this paper, reinsulating includes the addition of storm windows and storm doors.

The model input form, shown in Appendix I, was developed requiring only limited information from the homeowner. An input form to be filled out by the consumer and returned was chosen rather than a terminal input-output approach in order to provide the service to more people. However, the program does exist on a terminal system.

The questions on the input form basically include the essential characteristics of the home such as dimensions, number of windows, present insulation thickness, heating and cooling degree days for use in calculations, air conditioning, fuel type and interest rates. Other questions are also included, but this gives a basic concept of the questions asked. The answers to these questions are necessary to provide a reasonable evaluation of the current energy used in their home and the dollars that could be saved by adding insulation.

Because a concept of the model was to provide information that would be useful and also understood by the consumer, the output (as shown in Appendix II) was designed to provide information that would allow the homeowner to evaluate an investment in insulation and determine for himself whether the investment is feasible. The program was designed to be used over long periods of time without updating and revision as the cost of materials change. Therefore, the program does not include any cost data, with the exception of the cost of electricity. This cost is specified by the program if the homeowner indicates he has air conditioning and uses a type of fuel for heating other than electricity.

To simplify calculations within the model, heating system and fuel costs (question 20) are converted into a fuel cost per 100,000 Btu's allowing for the furnace efficiency. Table 1 lists the furnace efficiencies now used in the model. The heat content of the fuel is similarly adjusted to reflect proper fuel usages with reduced furnace efficiencies. In the case of heat pumps, equation 1 is used to relate efficiency to climatic areas.

$$Y - 2.643 - .000143*X \tag{1}$$

where
Y = Average seasonal heat pump coefficient of performance
X = Heating degree days

This equation was developed from manufacturers' literature on heat pump performance (2). This approach was taken so the program could be used without revision in other areas of the country.

TABLE 1

Assumed Furnace Efficiencies

Natural Gas Furnace --------	75%
L.P. Gas Furnace ----------	75%
Electric Ceiling Pannels --	100%
Electric Baseboard --------	100%
Electric Furnace ----------	90%
Oil Furnace ---------------	65%
Coal Furnace --------------	50%
Wood Furnace --------------	15%

The model calculates fuel savings with the addition of insulation for both heating and cooling. An assumption is made that the entire house is heated. If the entire house is not cooled (question 19) the fuel savings for the portion cooled are a percentage of the savings for the entire house. For cooling this results in the savings being spread uniformly throughout the house instead of providing increased savings in specific areas. These simplifying assumptions were required to reduce the complexity of the model and, more importantly, to simplify the input questionnaire and the output.

The ceiling insulations initial U-value is calculated using equations 2 and 3, depending on the thickness of ceiling insulation read.

$$UCL = .90/(1.67+CLINS*ROLD)+.10/8.55 \tag{2}$$

$$UCL = .90/(1.67+CLINS*ROLD)+.10/(8.55+(CLINS-5.5)*ROLD) \tag{3}$$

where
UCL = U-value of the entire ceiling
CLINS= Initial ceiling insulation thickness
ROLD = R value of existing insulation
.90 = Percent ceiling area not covered by joists
.10 = Percent ceiling area covered by joists
1.67 = R value of ceiling material and air surface

8.55 = R value of ceiling material, air surfaces and joist material
5.5 = Joist thickness

The two equations are required to make an adjustment for the thermal resistance of the ceiling joists. Figure 1 shows the three possible initial conditions for ceiling insulation depth, with the crosshatched area above the joist in (c) indicating the need for equation 3. The initial U-value for ceiling insulation is multiplied by the ceiling area to allow summing with similar values for the walls, floors, windows and doors to determine an annual heating and cooling loss factors for an existing home.

When determining the cooling cost for an existing home, the calculated ceiling "U times area" value is multiplied by an additional value to represent the increased heat load caused by increased attic temperatures. The use of a single value was chosen over the alternative method of calculating a temperature which varied with insulation thickness when trial calculations showed that attic temperature was more dependent on the attic ventilation rate than on insulation thickness. Because attic ventilation rates would be difficult values to obtain with a questionnaire, a single value was developed to reflect common natural attic ventilation rates.

The procedure used for calculating the value of additional of ceiling insulation allows for the change from equation 2 to 3. An approximation of the thickness of existing and added insulation, DEPFC, was necessary to determine when the thickness of insulation exceeded the thickness of the joists. The model assumes that 2 x 6 joists are used. Figure 2 illustrates the need for changing equations after the ceiling insulation covers the joists. The inflection in the curve occurs after the added insulation begins to add its thermal resistance to that of the joist (Figure 1c).

The fuel cost savings for adding ceiling insulation are calculated as total savings for the entire amount of insulation added, DOLSV, and the saving for the last layer of insulation added, DOLSVI. The total savings, DOLSV, are included in the output along with the savings for the last layer, DOLSVI, to help demonstrate to the user the concept for marginal returns, Appendix II. The savings for the last layer of insulation added are used in equations 4 and 5 to determine the investment that could be made in that layer of insulation and paid for with the corresponding fuel savings in 5, 10 or 20 years.

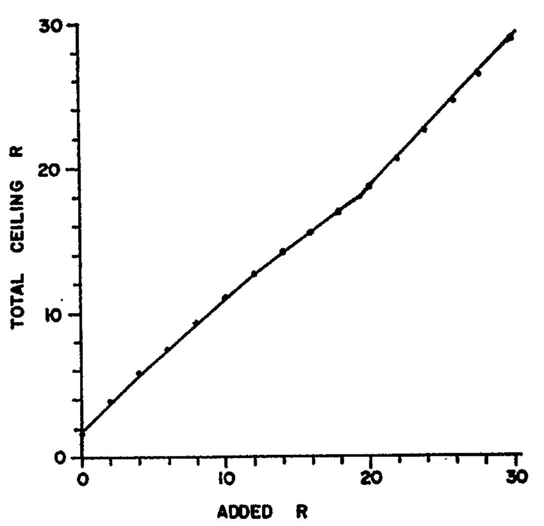


FIG. 2 ADDED R VERSUS TOTAL CEILING R

$$PVUS = \frac{(1 + i)^n - 1}{i\ (1+i)^n} * S \qquad (4)$$

$$PVGS = \frac{1}{i}\ \left[\frac{(1+i)^n - 1}{i(1+i)^n} - \frac{n}{(1+i)^n}\right] * (S*G) \qquad (5)$$

where
PVUS = Present value of a uniform series
i = Interest rate
n = Number of years
S = Savings per year
PVGS = Present value of a gradient series
G = Percent increase in savings per year

Equation 5 was added to allow for increasing fuel costs with time. Use of a uniform gradient series assumes that the fuel cost increases are linear over time, which was felt to be a reasonable assumption for this program. The model utilizes a variable name, ENEYR, to describe the percent increase in fuel savings to allow easy adjustment of this value if desired. This procedure is also used for adding floor and wall insulation and in the window and door analysis.

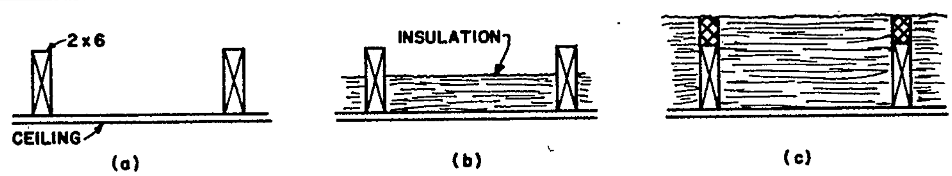


FIG. 1 INITIAL CEILING INSULATION THICKNESS CONDITIONS

The calculation procedure used for the floor insulation analysis is similar to the ceiling insulation procedure. In determining the R-value of house floors, the model defines the floor being considered as the first story floor for homes with crawl spaces or unheated basements, the basement floor for homes with heated basements and the concrete floor on slab foundations. For mobile home floors, two types are considered: a concrete slab floor or the first story floor on a home supported above grade. Equations 6 and 7 are used to determine the U-values for first story floors and are based on 2 x 10 floor joists 16 inches o.c., with equation 8 being used for concrete floors.

UFLR = .90/(2.62+FLINS*ROLD+RCRP) + .10/(14.18+RCRP) (6)

UFLR = .90/(2.62+FLINS*ROLD+RCRP) + .10/(14.18+(FLINS-9.25)*ROLD+RCRP) (7)

UFLR = 1./(10.+FLINS*ROLD+RCRP) (8)

where
UFLR = U-value of the entire floor
FLINS = Initial floor insulation thickness
ROLD = R-value of existing insulation
RCRP = R-value for carpeting
.90 = Percent floor area not covered by joists
.10 = Percent floor area covered by joists
2.62 = R-value of floor material and air surface
14.18 = R-value of floor material, air surface and joist material
9.25 = Joist thickness
10. = R-value of concrete floor, air surface and soil surface

These U-values are multiplied by the factors given in Table 2 to reflect different heat loss rates for different foundation types. The concrete floor U-value multipliers include an allowance for changes in ground temperature with climatic region under the assumption that ground temperature is linearly related to heating degree day levels.

TABLE 2

Floor Heat Loss Reduction Factors

HOUSE FOUNDATION	
Crawl Space	.5
Unheated Basement	.5
Heated Basement	1.1-HOGDY*.00005
Slab on Ground	(1.1-HOGDY*.00005)*2.
MOBILE HOME FOUNDATION	
Slab on Ground	(1.-HOGDY*.00005)*2.
Supported with Skirts	.8
Supported without Skirts	1.

Because the temperature under most floors will become only slightly higher than the inside temperature during the summer (even in extreme situations) no cooling load is calculated for the floor. There may be a possible increase in cooling load due to floor insulation because of the reduction heat transfer through the floor; however, determining the magnitude of this effect would be difficult.

Wall insulation analysis is divided into two wall types: upperwall sections with wood frame construction and in homes with heated basements, lower wall sections with concrete construction are considered. Because some new homes are being constructed with 2 x 6's, 24" o.c. two equations 9, 10 are used to determine the initial U-value of the wall. In actual construction 2 x 4 walls are only 3.5 inches thick but because a large number of users indicated their initial insulation thickness as 4 inches the program uses equation 10 for a 2 x 4 wall until the insulation thickness specified is greater than 4.1 inches.

UUWL = .90/(2.6 + RWLIN + RSDG) + .10/7 (9)

UUWL = .933/(2.6 + RWLIN + RSDG) + .067/9.5 (10)

where
UUWL = U-value of the entire wall
RWLIN = R-value of the initial wall insulation
RSDG = R-value for siding
.90 = Percent wall area not covered by studs-16 inches O.c.
.10 = Percent wall area covered by studs - 16 inches o.c.
2.6 = R-value of wall material and air surface
7. = R-value of wall material, air surface and stud material - 2 x 4
.933 = Percent wall area not covered by studs - 24 inches o.c.
.067 = Percent wall area covered by studs - 24 inches o.c.
9.5 = R-value of wall material, air surfaces and stud material - 2 x 6

Inspection of the above-mentioned equations will show the change in framing percentage factors, .10 to .067, for the wider stud spacing used with 2 x 6's. Basement walls **utilize** an equation similar to Equation 8 with a multiplication factor of 2 times the factor for a heated basement floor, Table 2.

Because the program adds the same amount of insulation to the walls as to the ceiling and floor, a third wall section must be considered in which it would be feasible to add high levels of insulation (e.g., R>25). Figure 3 shows the 3 types of wall sections considered where (c) can be expanded to any width. Equation 11 is used to calculate the U-value for insulation levels above R = 20.

UUWL = .866/(2.6+RWLIN+RSDG+RTLN) + .134/(7.+(WLINS-3.5)*ROLD+RTLN) (11)

where
RTLN = Total amount of R added
.866 = Percent wall area not covered by studs - 12 inches o.c.
.134 = Percent wall area covered by studs - 12 inches o.c.
3.5 = Stud thickness

For the storm window analysis section of the program, a window size of 12 ft.^{2} is assumed for regular windows rather than making the user calculate their window area. For picture windows an area of 20 ft.^{2} is used. An infiltration rate of 14 cfh is assigned to regular windows and a rate of 12 cfh is used for picture windows. The infiltration rates represent those for the entire window and frame areas. With storm windows, the rate for the window area is reduced 50%, while the rate for the frame area is unchanged. This results in an infiltration rate with storm windows of 9 cfh for regular windows and 8.4 cfh for picture windows.

The calculation for windows differs from the ceiling analysis because adding additional insulation to windows is impractical. In the window analysis section two levels of improvement are possible. If the user has indicated that he does not have storm windows, then storm windows are added and the infiltration rate is reduced as indicated in the preceding paragraph, this increases the R-value from .89 to 1.79. A third layer of glass is also added in the program which increases the R from 1.79 to 2.84 but does not reduce the infiltration rate further.

The storm door analysis section of the program assumes a door area of 21 ft.^{2} with an infiltration rate of 48 cfh. Because it is impractical to add a third layer of material to doors the addition of a storm door is the only alternative considered. If the user does not currently have storm doors the program adds them and reduces the infiltration rate to 26.4 cfh and increases the R from 2.08 to 3.08. If the user does have storm doors, nothing additional is done.

The program may tend to underestimate the annual heating and cooling energy requirements for users who operate their heating and cooling system most of the year because the program does not include two higher variable components: infiltration through other areas and the humidity load on the cooling system. But the operation of heating and cooling systems varies widely between individuals, and this can cause differences in annual fuel costs which may improve the relative accuracy of the program. It should be noted, however, that this program's primary purpose is to evaluate the economics of adding insulation as accurately as possible.

MODEL OUTPUT

The model output is shown in Appendix II. It can be seen from Appendix II that 10 layers of insulation were added in layers of R = 5. The model determines the R-value per layer from a variable named RNEW so that the total R added, 10 times RNEW, can be adjusted as economic conditions change. No indication of the inches of insulation required to achieve a R-value is included because of the variability in insulation types available.

The amounts that can be invested in insulation and paid for with fuel savings are also shown in Appendix II. These figures provide the user with a reasonable guide to use when investing in insulation. The model makes no attempt at recommending any level of insulation, but it provides a basis for making a judgement. Best use of the output is made by obtaining estimates of fuel savings for adding insulation in layers and then determining the added cost of each additional layer. This allows the homeowner to make a judgement as to how many layers of insulation to add.

SUMMARY

This model has been found to produce results which agree with local energy suppliers' determinations of recommended R values. It should be noted that this program does not make recommendations but does the heat loss and gain calculations and economic analysis which would be difficult for the majority of users to do properly. With the consideration given to increasing fuel costs, the information provided by the program should not become rapidly outdated. Responses from users as to the usefulness of the output have been favorable.

More than 300 homeowners have utilized this model. The input forms have been distributed by the county Cooperative Extension Service staff, and the model has also been advertised by some energy suppliers throughout the state. Future plans for this model include a statewide promotion campaign to further encourage its use.

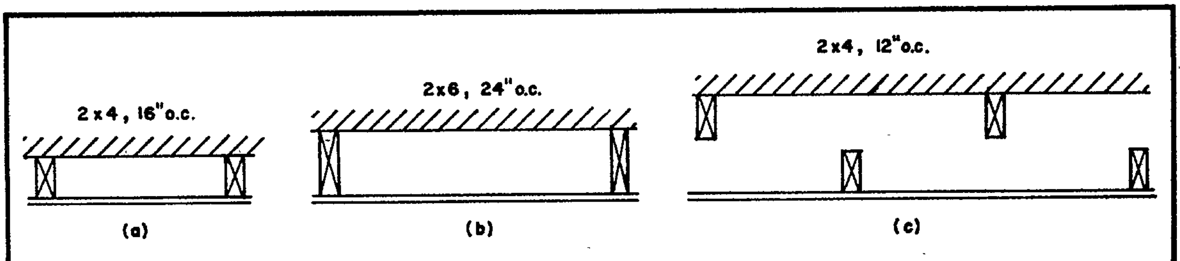


FIG. 3 WALL SECTIONS UTILIZED

APPENDIX I - INPUT FORM

COMPUTERIZED
HOME HEATING AND COOLING SURVEY SHEET

Agricultural Engineering Department
University of Kentucky

INSTRUCTIONS

Since there are so many variables in houses it is impractical to make a general analysis fit all of them. When you answer the questions do your best to give the answers that best fit your house.

For the questions that are to be answered by a yes or no or by numbers, be sure to write your answer in the blank space following the question.

For the questions requiring a check mark, check only one blank space. As an example, number 20 has several choices. You may have more than one system because of remodeling or additions to your home, but check only one blank, indicating the dominant one.

For question 20 be sure to include the cost of your fuel.

If you have questions about how to fill out this survey sheet you can get help from your County Extension Office or your energy supplier.

Send Survey Sheet along with $1.00 to: Home Analysis
Cooperative Extension Service
Agricultural Engineering Building
University of Kentucky
Lexington, KY 40506

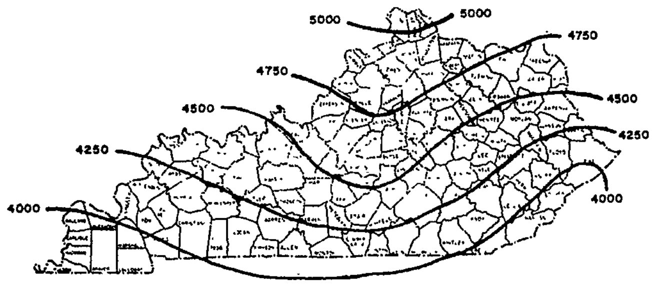
Make check payable to: University of Kentucky Research Foundation

UNIVERSITY OF KENTUCKY · COLLEGE OF AGRICULTURE · COOPERATIVE EXTENSION SERVICE
AGRICULTURE · HOME ECONOMICS · 4-H · DEVELOPMENT

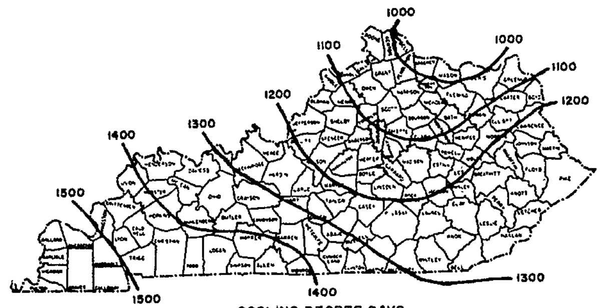
INSTRUCTIONS FOR DETERMINING DEGREE DAYS

First, locate your home on the map for Heating Degree Days. Then estimate the value by the relative distance to the numbered lines on the map. Record this 4 digit number by question 16.

Second, locate your home on the map for Cooling Degree Days. Then estimate the value as before, and record this 4 digit number by question 16.



HEATING DEGREE DAYS



COOLING DEGREE DAYS

COOPERATIVE EXTENSION SERVICE
· UNIVERSITY OF KENTUCKY
AGRICULTURAL ENGINEERING DEPARTMENT

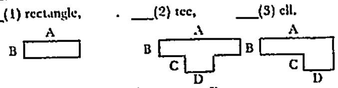
SURVEY SHEET

Computer Analysis of Home Heating and Cooling
(See Instructions Attached)

This analysis for the home of: Mailing Address if not home address.

NAME:______________________ ______________________
STREET:______________________ ______________________
CITY:______________________ ______________________
ZIP CODE:______________________ ______________________
COUNTY:______________________ ______________________

1. Check the type of dwelling: ___(1) mobile home, ___(2) single story ___(3) split level, ___(4) two story.
2. Check the type of floor plan: ___(1) rectangle, ___(2) tee, ___(3) ell.



3. Dimensions (feet) of above: A = _____, B = _____, C = _____, D = _____.
4. Number of regular windows = _____.
5. Number of picture windows (count each sliding glass door as 2 picture windows) = _____.
6. Number of doors which open to outside = _____.
7. Do you have storm or thermopane windows? (Yes or No) _____.
8. Do you have storm or thermopane doors? (Yes or No) _____.
9. Present insulation thickness (inches): Ceiling = _____, walls = _____, floor = _____.
10. Do you have carpeting in a majority of the house? (Yes or No) _____.
11. Check the type of siding on the house: ___(1) brick, ___(2) wood, ___(3) aluminum ___(4) asbestos shingles, ___(5) stone.
12. If you don't live in a mobile home check the type house foundation: _____(1) crawl space, _____(2) basement, _____(3) slab on ground.
13. If you have a basement, is it heated? (Yes or No) _____.
14. If you have a basement, are the walls insulated? (Yes or No) _____.
15. If you live in a mobile home check the type foundation: _____(1) slab on ground, _____(2) pillars, no wind protection skirts, _____(3) pillars with wind protection skirts.
16. Degree days, heating = _____, Degree days, cooling = _____ (see maps, pg. 4).
17. Do you have air conditioning? (Yes or No) _____.
18. If you have air conditioning check the type: _____(1) central, _____(2) room.
19. Check portion of house cooled: ___(1) 1/4, ___(2) 1/2, ___(3) 3/4, ___(4) all.
20. Check the type heating system and fuel cost:
    - ___(1) Natural gas, forced air circulation, with gas cost @ $_______ per M cu. ft.
    - ___(2) L.P. Gas, forced air @ _____¢ per gallon.
    - ___(3) Electric ceiling panels @ _____¢ per KWH.
    - ___(4) Electric baseboard @ _____¢ per KWH.
    - ___(5) Electric heat pump @ _____¢ per KWH.
    - ___(6) Electric furnace, forced air @ _____¢ per KWH.
    - ___(7) Hot water, electric @ _____¢ per KWH.
    - ___(8) Hot water, natural gas @ $_____ per M cu. ft.
    - ___(9) Hot water, L.P. gas @ _____¢ per gallon.
    - ___(10) Coal furnace, forced air, hot water or steam with coal @ $_____ per ton.
    - ___(11) Oil furnace, forced air, hot water or steam with fuel oil @ _____¢ per gallon.
    - ___(12) Oil space heater @ _____¢ per gallon.
    - ___(13) Coal space heater @ $_____ per ton.
    - ___(14) Wood space heater @ $_____ per cord.
    - ___(15) L.P. gas space heater @ _____¢ per gallon.
21. Do you have a fireplace? (Yes or No) _____.
22. Hours per year the fireplace is used = _____.
23. Interest rate on the money used for improvement = _____%.

APPENDIX II - COMPUTER OUTPUT

COMPUTERIZED HOME HEATING AND COOLING ANALYSIS
BY
COOPERATIVE EXTENSION SERVICE
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF KENTUCKY

FOR THE HOME OF:
EXAMPLE

INPUT DATA

1. TYPE OF DWELLING: (2) SINGLE STORY OR SPLIT FOYER
2. TYPE OF FLOOR PLAN: (1) RECTANGLE
3. DIMENSIONS (FEET):
   - LENGTH A= 24.0
   - LENGTH B= 41.7
   - LENGTH C= 0.0
   - LENGTH D= 0.0
4. REGULAR WINDOWS= 7.
5. PICTURE WINDOWS= 1.
6. OUTSIDE DOORS= 2.
7. STORM OR THERMOPANE WINDOWS? NO
8. STORM OR THERMOPANE DOORS? NO
9. PRESENT INSULATION THICKNESS (INCHES):
   - CEILING= 0.00
   - WALLS= 0.00
   - FLOOR= 0.00
10. CARPETING IN A MAJORITY OF THE HOUSE? YES
11. TYPE OF SIDING: (1) BRICK
12. TYPE OF HOUSE FOUNDATION: (2) BASEMENT
13. BASEMENT HEATED? YES
14. BASEMENT WALLS INSULATED? NO
15. TYPE OF MOBILE HOME FOUNDATION: N/A
16. HEATING DEGREE DAYS= 4700.
    COOLING DEGREE DAYS= 1100.
17. AIR CONDITIONING? YES
19. PORTION OF HOUSE COOLED: (1) 1/4
19. PORTION OF HOUSE COOLED: (4) ALL
20. TYPE OF HEATING SYSTEM AND FUEL COST:
    (6) ELECTRIC FURNACE, FORCED AIR
    ELECTRIC @ 3.50 PER KWH
21. FIREPLACE? YES
22. HOURS FIREPLACE IS USED= 500.
23. INTEREST RATE = 8.00%

1. HEATING COST ANALYSIS:

ANNUAL HEATING COST ESTIMATED TO BE: $1612.
ANNUAL AMOUNT OF FUEL USED=46067.KWH
BASED ON ELECTRIC AT 3.50 PER KWH
ANNUAL FIREPLACE CONSUMPTION ESTIMATED TO BE:
1.6 CORDS OF WOOD PER YR.
WHICH REDUCES YOUR ABOVE HEATING REQUIREMENT BY $138.

COOLING COST ANALYSIS:

ANNUAL COOLING COST ESTIMATED TO BE: $ 192.
ANNUAL AMOUNT OF FUEL USED= 5479. KWH
BASED ON ELECTRIC AT 3.50 PER KWH

TOTAL ANNUAL ENERGY COST ESTIMATED TO BE: $1804.

2. CEILING INSULATION ANALYSIS:

CEILING AREA= 1000. SQ. FT.
PRESENT R= 1.3

ANNUAL CEILING HEAT COST= $ 637.
PERCENT OF TOTAL HEAT COST = 40.%
ANNUAL AMOUNT OF FUEL USED=19199.KWH

ANNUAL CEILING COOLING COST= $ 127.
PERCENT OF TOTAL COOLING COST= 66.%
ANNUAL AMOUNT OF FUEL USED= 3634. KWH

R VALUE OF LAST LAYER OF INSUL-ATION ADDED	TOTAL ADDED R	TOTAL FUEL $ SAVED $/YR	FUEL $ SAVED BY LAST LAYER OF INSULATION ADDED $/YR	DOLLARS THAT CAN BE INVESTED IN THE LAST LAYER OF INSULATION ADDED AND BE PAYED FOR WITH THE FUEL SAVINGS FOR THAT LAYER IN 5, 10, OR 20 YEARS AT: PRESENT FUEL PRICE			10.%/YR INCREASE		
				5 YRS	10 YRS	20 YRS	5 YRS	10 YRS	20 YRS
5.0	5.0	561.	561.	2239.	3762.	5505.	2652.	5219.	9379.
5.0	10.0	641.	80.	320.	538.	788.	380.	747.	1342.
5.0	15.0	673.	32.	129.	215.	315.	152.	299.	537.
5.0	20.0	692.	19.	74.	125.	183.	88.	173.	311.
5.0	25.0	708.	16.	64.	108.	157.	76.	149.	268.
5.0	30.0	718.	10.	40.	66.	97.	47.	92.	166.
5.0	35.0	724.	7.	27.	46.	67.	32.	64.	115.
5.0	40.0	729.	5.	20.	34.	50.	24.	47.	85.
5.0	45.0	733.	4.	16.	26.	39.	18.	36.	65.
5.0	50.0	736.	3.	12.	21.	30.	15.	29.	52.

3. WALL INSULATION ANALYSIS:

WALL AREA= 905. SQ. FT.
PRESENT R= 4.2

ANNUAL WALL HEAT COST= $ 250.
PERCENT OF TOTAL HEAT COST = 15.%
ANNUAL AMOUNT OF FUEL USED= 7138.KWH

ANNUAL WALL COOLING COST =$ 25.
PERCENT OF TOTAL COOLING COST= 13.%
ANNUAL AMOUNT OF FUEL USED= 713. KWH

R VALUE OF LAST LAYER OF INSUL-ATION ADDED	TOTAL ADDED R	TOTAL FUEL $ SAVED $/YR	FUEL $ SAVED BY LAST LAYER OF INSULATION ADDED $/YR	DOLLARS THAT CAN BE INVESTED IN THE LAST LAYER OF INSULATION ADDED AND BE PAYED FOR WITH THE FUEL SAVINGS FOR THAT LAYER IN 5, 10, OR 20 YEARS AT: PRESENT FUEL PRICE			10.%/YR INCREASE		
				5 YRS	10 YRS	20 YRS	5 YRS	10 YRS	20 YRS
5.0	5.0	129.	129.	517.	869.	1271.	612.	1205.	2166.
5.0	10.0	179.	49.	197.	331.	485.	234.	460.	826.
5.0	15.0	207.	28.	113.	189.	277.	134.	263.	472.
5.0	20.0	221.	14.	56.	93.	137.	66.	130.	233.
5.0	25.0	231.	10.	41.	70.	102.	49.	96.	173.
5.0	30.0	238.	7.	28.	47.	68.	33.	65.	116.
5.0	35.0	243.	5.	20.	34.	49.	24.	47.	84.
5.0	40.0	247.	4.	15.	25.	37.	18.	35.	63.
5.0	45.0	250.	3.	12.	20.	29.	14.	28.	50.
5.0	50.0	253.	2.	10.	16.	23.	11.	22.	40.

INSULATING BASEMENT WALLS

WALL AREA= 1051. SQ. FT.
PRESENT R= 10.0

ANNUAL BASEMENT HEAT COST=$ 236.
PERCENT OF TOTAL HEAT COST = 15.%
ANNUAL AMOUNT OF FUEL USED= 6737.KWH

R VALUE OF LAST LAYER OF INSUL-ATION ADDED	TOTAL ADDED R	TOTAL FUEL $ SAVED $/YR	FUEL $ SAVED BY LAST LAYER OF INSULATION ADDED $/YR	DOLLARS THAT CAN BE INVESTED IN THE LAST LAYER OF INSULATION ADDED AND BE PAYED FOR WITH THE FUEL SAVINGS FOR THAT LAYER IN 5, 10, OR 20 YEARS AT: PRESENT FUEL PRICE			10.%/YR INCREASE		
				5 YRS	10 YRS	20 YRS	5 YRS	10 YRS	20 YRS
5.0	5.0	75.	75.	301.	506.	741.	357.	702.	1262.
5.0	10.0	114.	39.	156.	262.	383.	185.	363.	653.
5.0	15.0	139.	25.	100.	167.	245.	118.	232.	417.
5.0	20.0	156.	16.	65.	110.	161.	78.	153.	274.
5.0	25.0	167.	12.	46.	78.	114.	55.	108.	194.
5.0	30.0	176.	9.	35.	58.	85.	41.	81.	145.
5.0	35.0	183.	7.	27.	45.	66.	32.	63.	112.
5.0	40.0	189.	5.	21.	36.	53.	25.	50.	90.
5.0	45.0	193.	4.	17.	29.	43.	21.	41.	73.
5.0	50.0	196.	4.	15.	24.	36.	17.	34.	61.

APPENDIX II - COMPUTER OUTPUT CONTINUED

4. STORM WINDOW ANALYSIS:

WINDOW AREA FIGURED AS 104. SQ.FT.

ANNUAL WINDOW HEAT COST = $262.
PERCENT OF TOTAL HEAT COST = 16.%
ANNUAL AMOUNT OF FUEL USED= 7499.KWH

ANNUAL WINDOW COOLING COST =$ 26.
PERCENT OF TOTAL COOLING COST= 14.%
ANNUAL AMOUNT OF FUEL USED= 749. KWH

FUEL SAVINGS WITH STORM WINDOWS =$ 118.

DOLLARS THAT CAN BE INVESTED IN STORM WINDOWS AND BE PAYED FOR WITH FUEL SAVINGS IN 5, 10,OR 20 YEARS AT:

PRESENT FUEL PRICE			10.%/YR INCREASE		
5 YRS	10 YRS	20 YRS	5 YRS	10 YRS	20 YRS
470.	790.	1155.	557.	1095.	1968.

FUEL SAVINGS WITH A THIRD LAYER OF GLASS =$ 27.
(I.E.,THERMOPANE+STORM)

DOLLARS THAT CAN BE INVESTED IN A THIRD LAYER OF GLASS AND BE PAYED FOR WITH FUEL SAVINGS IN 5, 10,OR 20 YEARS AT:

PRESENT FUEL PRICE			10.%/YR INCREASE		
5 YRS	10 YRS	20 YRS	5 YRS	10 YRS	20 YRS
109.	183.	268.	129.	254.	457.

6. FLOOR INSULATION ANALYSIS:

BASEMENT FLOOR
FLOOR AREA= 1000.1 SQ. FT.
PRESENT R= 12.1

ANNUAL FLOOR HEAT COST =$ 93.
PERCENT OF TOTAL HEAT COST = 6.%
ANNUAL AMOUNT OF FUEL USED= 2654.KWH

R VALUE OF LAST LAYER OF INSULATION ADDED	TOTAL ADDED R	TOTAL FUEL $ SAVED $/YR	FUEL $ SAVED BY LAST LAYER OF INSULATION ADDED $/YR	DOLLARS THAT CAN BE INVESTED IN THE LAST LAYER OF INSULATION ADDED AND BE PAYED FOR WITH THE FUEL SAVINGS FOR THAT LAYER IN 5, 10,OR 20 YEARS AT: PRESENT FUEL PRICE 5 YRS	PRESENT FUEL PRICE 10 YRS	PRESENT FUEL PRICE 20 YRS	10.%/YR INCREASE 5 YRS	10.%/YR INCREASE 10 YRS	10.%/YR INCREASE 20 YRS
5.0	5.0	27.	27.	109.	182.	267.	129.	253.	455.
5.0	10.0	42.	15.	59.	100.	146.	70.	138.	249.
5.0	15.0	51.	9.	37.	63.	92.	44.	87.	157.
5.0	20.0	58.	6.	26.	43.	63.	31.	60.	108.
5.0	25.0	63.	5.	19.	32.	46.	22.	44.	79.
5.0	30.0	66.	4.	14.	24.	35.	17.	33.	60.
5.0	35.0	69.	3.	11.	19.	28.	13.	26.	47.
5.0	40.0	71.	2.	9.	15.	22.	11.	21.	39.
5.0	45.0	73.	2.	8.	13.	19.	9.	18.	32.
5.0	50.0	75.	2.	6.	11.	16.	7.	15.	26.

WHEN INSULATING THE FLOOR, CHECK WATER PIPE LOCATION AND PROTECTION FROM COLD TEMPERATURES TO PREVENT FREEZING.

THIS COMPLETES YOUR HOUSE INSULATION AND ENERGY ANALYSIS.
THANK Y FOR PARTICIPATING.
WE HOPE YOU WILL PRACTICE WAYS TO CONSERVE ENERGY
IF YOU HAVE ANY QUESTIONS CONTACT YOUR COUNTY EXTENSION SERVICE OFFICE
OR CONTACT SOMEONE IN THE AGRICULTURAL ENGINEERING DEPT.
UNIV. OF KY.
LEXINGTON,KY. 40506

5. STORM DOOR ANALYSIS:

OUTSIDE DOOR AREA FIGURED AS 42.0 SQ.FT.

ANNUAL DOOR HEAT COST=$134.
PERCENT OF TOTAL HEAT COST = 8.%
ANNUAL AMOUNT OF FUEL USED= 3840.KWH

ANNUAL DOOR COOLING COST =$ 13.
PERCENT OF TOTAL COOLING COST= 7.%
ANNUAL AMOUNT OF FUEL USED= 383. KWH

FUEL SAVINGS WITH STORM DOORS =$ 63.

DOLLARS THAT CAN BE INVESTED IN STORM DOORS AND BE PAYED FOR WITH FUEL SAVINGS IN 5, 10,OR 20 YEARS AT:

PRESENT FUEL PRICE			10.%/YR INCREASE		
5 YRS	10 YRS	20 YRS	5 YRS	10 YRS	20 YRS
253.	425.	622.	299.	589.	1059.

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