



**NBSIR 79-1789**

# **Economic Analysis of Insulation in Selected Masonry and Wood-Frame Walls**

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Stephen R. Petersen

Building Economics and Regulatory Technology Division  
Center for Building Technology  
National Engineering Laboratory  
National Bureau of Standards

September 1979

Prepared for  
**Office of Policy Development and Research**  
**U.S. Department of Housing and Urban Development**

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**U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, Secretary**

**Luther H. Hodges, Jr., Under Secretary**

**Jordan J. Baruch, Assistant Secretary for Science and Technology**

**NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director**



## Preface

This National Bureau of Standards Interagency Report is the result of a request from U.S. Department of Housing and Urban Development under Interagency Agreement H-24-77 (Quick Response Studies), Tasks 13 and 19. It builds directly on concurrent research in economic analysis of insulation in masonry walls funded by the Department of Energy under Interagency Agreement NO. 77-A-01-6010, Task Order A008, BCS.

## ACKNOWLEDGEMENTS

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## ABSTRACT

This report provides a life-cycle cost-benefit analysis of several alternative methods for insulating 8" (200 mm) concrete masonry walls in new single-family residences. In addition, a cost-benefit analysis for insulation in wood-frame walls is provided, consistent with the assumptions used in the masonry wall analysis. A dynamic load simulation model, NBSLD, was used to calculate the heating and cooling requirements for a 1176 square foot (110 m<sup>2</sup>) house with different levels of thermal resistance for both wall types in eight geographic locations. These data are used to calculate the reduction in annual heating and cooling requirements due to several different types of insulation in the cores and furring spaces of the masonry wall and the cavities of the wood-frame wall.

Economic analysis is applied to determine estimates of life-cycle savings from insulation for different locations and furnace types in order to determine the most cost-effective insulation level. In general it is found that the maximum economically justifiable level of insulation in the masonry wall is considerably lower than for the wood-frame wall because of the significantly higher cost of insulating masonry walls.

Key words: Building economics; energy conservation; insulation; life-cycle cost analysis; masonry construction; space heating and cooling requirements; thermal mass.

## 1.0 INTRODUCTION

The Center for Building Technology at the National Bureau of Standards is currently conducting research on the thermal performance of exterior walls of residential buildings, with emphasis on masonry wall construction, in order to assess the economic benefits and costs of alternative insulation strategies.\* This research has been sponsored by the Department of Energy (DoE). The Department of Housing and Urban Development-Federal Housing Administration (HUD-FHA) has supported one phase of this study to provide information needed in the development of their new Minimum Property Standards (MPS) for residential buildings. This report covers that phase of the study.

This report provides specific information requested by HUD-FHA, along with the basic methodology and data used to generate these results. Further description of the methodology and more extensive data and results will be made available upon the completion of the overall research project and publication of the final research report for DoE.

The major objectives of the NBS research in insulation strategies for exterior walls are to determine the extent to which insulation in alternative wall configurations is cost effective on a life-cycle basis; to develop insulation guidelines based on a life-cycle-cost-minimization objective; and to establish the sensitivity of these guidelines to climate, fuel cost and insulation costs on a local basis. These objectives

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\* Note: Metric (SI) Units have been included in this report for reference purposes, in line with the policy of the National Bureau of Standards. Rounding has been applied to reflect equivalent precision.

are consistent with recent policy decisions of HUD-FHA in updating their MPS for single family residences based on the life-cycle-cost effectiveness of a number of conservation measures for reducing space heating and cooling requirements. Moreover, they are consistent with recent DoE decisions regarding the use of economic analysis in the development of building energy performance standards for buildings.

Cost-effective strategies for increasing the thermal performance of wood-frame and masonry walls in the same climate and for the same cost per Btu of heat delivered to (or removed from) the conditioned space might be expected to differ for two distinct reasons: (1) the reduction in annual heating and cooling requirements due to an equal decrease in U-value for the walls may be different and (2) the cost of reducing the U-value for these two wall types may be different.

The first reason is related to the thermal response, or time-delay properties, of the heavier wall which tends to dampen the effects of climate on space cooling and heating requirements. The extent to which this affects the savings from an equal decrease in U-value will be seen later in this report. The second reason is a result of the 3-1/2" (89 mm) stud space in the wood-frame wall which provides a greater space for low-cost insulation materials than the typical 3/4" (19 mm) furring space, and, in some cases, open cores, of a masonry wall. In order to minimize the reduction of usable floor space due to higher levels of insulation on the inside of the dwelling unit, low conductivity, but relatively expensive (e.g., polystyrene and isocyanurate) insulation materials are often used in masonry walls at a considerable cost difference over typical

insulating materials used in wood-frame construction (e.g., fiberglass blanket). Alternatively, wood framing can be added inside the masonry wall together with more conventional fiberglass insulation materials. However, the increased cost of both the framing and the extension of end walls to maintain an equivalent inside floor area must be incorporated into the cost analysis. Insulation on the outside of the exterior walls, while somewhat superior from a thermal performance is not as cost effective as insulation on the inside, since a protective covering must be installed. Such a covering would also negate the benefit of low exterior maintenance characteristic of masonry materials. (Insulation in the cavity of a brick and block cavity wall is not considered in this report although it will be examined in a subsequent, more comprehensive report to DoE.)

## 2.0 SCOPE

HUD-FHA has requested that NBS examine the cost effectiveness of several alternative insulation strategies for masonry walls. In particular, reflective air spaces, rigid isocyanurate insulation, and rigid polystyrene insulation are to be examined with and without core insulation (perlite) in an 8" (200 mm) block wall with 3/4" (19 mm) furring strips and 1/2" (13 mm) gypsum wallboard on the inside. The exact specifications of the insulation strategies to be examined, as specified by HUD-FHA, are shown in Table 1. There are nine different insulation systems specified, for use with 8" (200 mm) block walls. In addition, the sponsor asked NBS to evaluate the cost effectiveness of R-11, R-13

Table 1. Component and Total Resistance<sup>a</sup> for Wall Components and Walls to be Examined<sup>b</sup>

Construction	Wall-Type Designators								
	B3	B4	C3	C4	D3	D4	F2	F5	EXTRA
100 Pcf CMU <sup>c</sup>	1.75		1.75		1.75		1.75		1.75
Cores filled (Perlite)		4.85		4.85		4.85		4.85	
3/4" Reflective Space	3.48	3.48							
1" Reflective Space									3.51
1/2" Isocyanurate									4.00
3/4" Isocyanurate			6.00	6.00					
3/4" Polystyrene					3.94	3.94			
1-1/2" Polystyrene							7.89	7.89	
1/2" Gypsum board	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Outside Surface Air	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Inside Surface Air	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Total R	6.53	9.63	9.05	12.15	6.99	10.09	10.94	14.04	10.56
1/R = U	0.153	0.104	0.110	0.082	0.143	0.099	0.091	0.071	0.095

<sup>a</sup> Resistance = Btu<sup>-1</sup>·°F·ft<sup>2</sup>·h.

<sup>b</sup> As specified by HUD-FHA.

<sup>c</sup> Concrete masonry unit: 8" hollow block, 100 pcf density concrete

Table 1-M. Component and Total Resistance<sup>a</sup> for Wall Components and Walls to be Examined<sup>b</sup>

Construction	Wall-Type Designators								
	B3	B4	C3	C4	D3	D4	F2	F5	EXTRA
1600 kg/m <sup>3</sup> CMU <sup>3</sup>	0.31		0.31		0.31		0.31		0.31
Cores filled (Perlite)		0.85		0.85		0.85		0.85	
19 mm Reflective Space	0.61	0.61							
25 mm Reflective Space									0.62
13 mm Isocyanurate									0.70
19 mm Isocyanurate			1.06	1.06					
19 mm Polystyrene					0.69	0.69			
38 mm Polystyrene							1.39	1.39	
13 mm Gypsum board	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Outside Surface Air	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Inside Surface Air	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Total R	1.15	0.70	1.60	2.14	1.23	1.78	1.93	2.47	1.86
1/R = U	0.87	0.59	0.63	0.47	0.84	0.56	0.52	0.40	0.54

<sup>a</sup> Resistance =  $m^2 \cdot K/W$

<sup>b</sup> As specified by HUD-FHA.

<sup>c</sup> Concrete masonry unit: 200 mm hollow block, 1600 kg/m<sup>3</sup> density concrete

and R-19 (R-metric: 1.9, 2.3 and 3.3) insulation in wood-frame walls, using the same basic assumptions and modeling procedures. Composite or cavity brick and block walls, which are more common than 8" (200 mm) block walls in most parts of the U.S. other than Florida and the Southwest, are not examined in this report.

Previous NBS analysis of the cost effectiveness of a number of conservation measures in wood-frame housing was used by HUD-FHA in developing its most current revision of the MPS. In order to maintain consistency with this previous work, the sponsor asked that the same basic approach be used. This has been accomplished to the extent that it matched the objectives of the ongoing DoE-sponsored research. The only parameter that was significantly changed from the previous NBS analysis for the sponsor is the design of the floor to simulate thermal mass on the inside of the structure. This will be explained in greater detail in the following section. Because this study is intended to examine the cost effectiveness of wall insulation, the specification of other shell components was held constant in each climatic location. However, ceiling insulation levels and glazing specifications (e.g., single, double, triple) were adjusted in each location to conform as closely as possible to the proposed MPS. The eight locations to be used in examining the sensitivity of insulation cost effectiveness, the number of long term heating and cooling degree days, and the attic insulation and window glazing specifications used in each location are shown in Table 2.



Table 2. Cities, Degree Days, Shell Specifications

	HDD <sub>65F</sub> <sup>a</sup>	CDD <sub>65F</sub> <sup>b</sup>	Window Glazing	Attic Insulation	
				Customary	Metric
Albuquerque	4350	1400	Double	R-30	R-5.3
Atlanta	3100	1600	Single	R-19	R-3.3
Indianapolis	5600	1000	Double	R-30	R-5.3
Jacksonville	1300	2600	Single	R-19	R-3.3
Madison	7750	460	Triple	R-38	R-6.7
Phoenix	1550	3500	Single	R-19	R-3.3
Tampa	700	3350	Single	R-19	R-3.3
Washington, D.C.	4200	1400	Double	R-30	R-5.3

<sup>a</sup> Heating Degree Days computed at base 65°F

<sup>b</sup> Cooling Degree Days computed at base 65°F

Note: The base value for "degree days" in SI units has not yet been established, but is expected to be 18°C (64.4°F) rather than 65°F (18.33°C).

Table 3. Prototypical House Parameters<sup>a</sup>

Floor/Attic Area = 1176 ft<sup>2</sup> (110 m<sup>2</sup>)  
 Glass Area = 127 ft<sup>2</sup> [72 ft<sup>2</sup> south, 55 north] (11.8 m<sup>2</sup> [6.7 m<sup>2</sup>, 5.1 m<sup>2</sup>])  
 Outside Dimensions = 28 ft x 42 ft (8.5 m x 12.8 m)  
 Wall Area - Gross = 1120 ft<sup>2</sup>, Net = 973 ft<sup>2</sup> (104 m<sup>2</sup>, 90 m<sup>2</sup>)  
 Door = 20 ft<sup>2</sup> (1.9 m<sup>2</sup>)  
 Solar Absorptivity of exterior walls<sup>b</sup> = 0.50  
 Floor weight = 20,000 lbs (9070 kg)

<sup>a</sup> Based on ranch house design by S. R. Hastings in [1].

<sup>b</sup> Solar absorptivity varies by color: Very light = .25, Light = .35, Medium = .55, Dark = .75, Very dark = .90. (Plain concrete block = approx. .55.)

### 3.0 MODELING THE WALLS FOR THERMAL ANALYSIS

Table 3 provides the basic measurements of the 1176 square foot (110 m<sup>2</sup>), one-story ranch house used in the simulation of heating and cooling requirements typical of a house of this style. This prototype house is modeled after the "compact" ranch style house proposed by S. R. Hastings [1]\* for use in energy conservation research. The house is modeled as one big room as it has been determined through previous analysis at NBS [2] that this more closely simulates actual thermal performance than modeling uncoupled rooms within the house. (Coupling of rooms has not yet been properly simulated). The floor is modeled as a concrete slab weighing 20,000 lbs (9070 kg) and is essentially adiabatic\*\* (i.e., does not transmit heat into the ground.) This concrete floor is meant to represent the internal mass of the house, including partition walls, fixtures, and furnishings, rather than a more typical slab on grade.

The base house is oriented with the long walls facing north and south. Of the 127 square feet (11.8 m<sup>2</sup>) of glass area, 72 square feet (6.7 m<sup>2</sup>) face south and 55 square feet (5.1 m<sup>2</sup>) face north. (The glass to gross wall area ratio is approximately 11 percent.) In addition, in three locations the masonry house is turned 90°, with the larger glass area facing west, in order to determine the impact of orientation on the energy savings from insulating the walls. All glass area is assumed to be 50 percent shaded between May and September. The direct solar heat gain is modeled

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\* Numbers in brackets pertain to references listed on p. 49.

\*\* This is accomplished by modeling a very high thermal resistance beneath the slab in order to isolate it from the ground temperature.

so that 90 percent is distributed directly to the floor, with the remaining 10 percent evenly distributed to the other interior surfaces. (This solar distribution in effect simulates the solar gain of interior partitions and furniture rather than of the inside of the exterior surfaces of the room.)

Operational assumptions are shown in Table 4. Note that a night setback from 68 to 60°F (20 to 15.5°C) is assumed during the heating season. This night setback, together with the internal mass and south facing windows gives the house some advantage from a "passive" solar aspect.

NBSLD [2,3], the NBS Load Determination program, was used to simulate the heating and cooling loads of the prototype house on an hour-by-hour basis for an entire year. Test reference year tapes were used to provide hourly climate data for the locations considered, consistent with the data requirement of NBSLD. Because NBSLD can calculate the thermal response of the walls to a relatively high degree of accuracy, this program is well suited for the thermal analysis in this report. In addition, it has been successfully validated in a number of studies at NBS and elsewhere [4, 5, 6].

In calculating the thermal performance of the 8" (200 mm) block wall, the core section of the block is modeled separately from the web section. NBS analysis has shown that this approach is superior to modeling the wall as homogeneous in mass and thermal resistance. This latter approach is faster in terms of computational effort but exaggerates the thermal response characteristics of the wall. Similarly, wood-frame walls were modeled with studs considered separately from cavities.

Table 4. Operational Profile of House

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Thermostat settings:<sup>a</sup>

Heating Periods 68°F day (20 °C)

60°F night (11 p.m. - 7 a.m.) (15.5 °C)

Cooling Periods 78°F (25.5 °C)

Relative Humidity:<sup>b</sup>

Lower Bound 20%

Upper Bound 60%

Occupants: 2 adults, 2 children

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<sup>a</sup> No cooling or heating is required when indoor temperature is between heating and cooling thermostat settings.

<sup>b</sup> Humidification is assumed if the relative humidity falls below 20 percent. No dehumidification is assumed if the air conditioner is not operating; thus the 60 percent upper bound only applies during periods when the air conditioner is operating.

NBSLD was used to perform extensive simulations of the effects of insulation in an 8" (200 mm) masonry block wall and a conventional wood-frame wall. Washington, D. C., which has annual heating and cooling requirements that are near average for the U.S., was used in these simulations to demonstrate certain effects of various insulation levels that can be used to simplify the requirements for simulations in other climates. In particular, the validity of using U-values to linearly interpolate between annual heating and cooling requirements, as calculated by NBSLD analysis, in order to estimate the heating and/or cooling requirements of alternative insulation levels in the same wall type, was demonstrated. Because the mass of alternative insulation types is insignificant relative to the mass of the wall itself, the results of the NBSLD analysis can be used, within reason, for estimating the effects of any type of insulating material practical for the basic wall constructions examined.

Tables 5A and B contain the data points developed through NBSLD analysis of thermal insulation in the furring space of 8" (200 mm) block walls, with and without perlite insulation in the cores of the blocks, respectively. In addition, data points from the analysis of fiberglass insulation in a wood-frame wall are shown in Table 5C. Table 5D contains the data points for the 90° rotation of the 8" (200 mm) block house in Madison, Phoenix, and Washington, D.C. It should be noted that the U-values in Tables 5A, B, and D do not correspond exactly to the HUD-FHA values shown in Table 1 because the former are based on more generalized material specifications.

Total cooling requirements (C) in this report have been divided into two parts: cooling requirements for all hours in which the outdoor dry bulb

Table 5 A. Wall U-values and Annual Heating and Cooling Requirements for 1176 ft<sup>2</sup> House. (8" Block Walls - no insulation in cores)<sup>a</sup>

Annual Space Heating And Cooling Requirements (million Btu)

	Wall U-value	Heating	Cooling		
			C+	C-	C
Albuquerque	.2417 <sup>b</sup>	21.89	9.06	3.94	13.00
	.1443 <sup>d</sup>	15.28	8.72	4.69	13.40
	.0693 <sup>f</sup>	10.33	8.55	5.61	14.15
Atlanta	.2417	16.81	9.37	7.43	16.80
	.1443	12.55	9.22	8.48	17.70
	.0693	9.36	9.18	9.49	18.68
Indianapolis	.2417	41.34	6.32	4.34	10.65
	.1443	31.26	6.18	5.10	11.28
	.0693	23.35	6.14	6.04	12.17
Jacksonville	.2417	3.50	21.66	11.05	32.71
	.1443	2.27	21.21	12.01	33.22
	.0693	1.47	20.94	13.03	33.97
Madison	.2417	48.71	3.17	2.20	5.37
	.1443	36.23	3.17	2.95	6.12
	.0693	26.41	3.21	3.97	7.18
Phoenix	.2417	3.93	36.44	5.57	42.01
	.1443	2.56	33.84	6.30	40.14
	.0693	1.68	31.86	7.09	38.96
Tampa	.2417	0.824	24.26	13.91	38.16
	.1443	0.474	23.79	15.15	38.94
	.0693	0.275	23.51	16.29	39.80
Washington, D.C.	.2417	21.53	10.70	4.97	15.67
	.1618 <sup>c</sup>	16.10	10.34	5.53	15.86
	.1443	14.92	10.26	5.68	15.94
	.0936 <sup>e</sup>	11.55	10.06	6.20	16.27
	.0693	9.96	9.98	6.52	16.49

- <sup>a</sup> Wall weight = approximately 38 lbs/ft<sup>2</sup>.
- <sup>b</sup> U = .2417 corresponds to an 8" block wall with 3/4" non-reflective airspace (R-0.96) and 1/2" gypsum board.
- <sup>c</sup> U = .1618, same as above with R-3 insulation in place of non-reflective airspace.
- <sup>d</sup> U = .1443, same as above with R-3.75 insulation.
- <sup>e</sup> U = .0936, same as above with R-7.5 insulation.
- <sup>f</sup> U = .0693, same as above with R-11.25 insulation.

Table 5A-M. Wall U-values and Annual Heating and Cooling Requirements for 110 m<sup>2</sup> House. (200 mm Block Walls - no insulation in cores)<sup>a</sup>

	Wall U-value	Heating	Annual Space Heating And Cooling Requirements (GJ)		
			C+	C-	C
Albuquerque	1.37 <sup>b</sup>	23.10	9.56	4.16	13.72
	0.82 <sup>d</sup>	15.07	9.20	4.95	14.14
	0.39 <sup>f</sup>	10.90	9.02	5.92	14.93
Atlanta	1.37	17.74	9.89	7.84	17.73
	0.82	13.24	9.73	8.95	18.67
	0.39	9.88	8.63	8.96	18.65
Indianapolis	1.37	43.62	6.67	4.58	11.24
	0.82	32.98	6.52	5.38	11.90
	0.39	24.64	6.48	6.37	12.84
Jacksonville	1.37	3.69	22.85	11.66	34.51
	0.82	2.39	22.38	12.67	35.05
	0.39	1.55	22.09	13.75	35.84
Madison	1.37	50.82	3.34	2.32	5.67
	0.82	38.22	3.34	3.11	6.46
	0.39	27.86	3.39	4.19	7.58
Phoenix	1.37	4.15	38.45	5.88	44.32
	0.82	2.70	35.70	6.65	42.35
	0.39	1.77	33.61	7.48	41.11
Tampa	1.37	0.87	25.60	14.68	40.26
	0.82	0.50	25.10	15.98	41.08
	0.39	0.29	24.80	17.19	41.99
Washington D.C.	1.37	22.72	11.29	5.24	16.53
	0.92 <sup>c</sup>	16.99	10.91	5.83	16.73
	0.82	15.74	10.82	5.99	16.82
	0.53 <sup>e</sup>	12.19	10.61	6.54	17.17
	0.39	10.51	10.53	6.88	17.40

<sup>a</sup> Wall weight = approximately 185 kg/m<sup>2</sup>.

<sup>b</sup> U-metric = 1.37 corresponds to a 200 mm block wall with 19 mm non-reflective airspace (R-metric 0.17) and 13 mm gypsum board.

<sup>c</sup> U-metric = 0.92, same as above with R-metric 0.53 insulation in place of non-reflective airspace.

<sup>d</sup> U-metric = 0.82, same as above with R-metric 0.66 insulation.

<sup>e</sup> U-metric = 0.53, same as above with R-metric 1.32 insulation.

<sup>f</sup> U-metric = 0.39, same as above with R-metric 1.98 insulation.

Table 5B. Wall U-values and Annual Heating and Cooling Requirements for 1176 ft<sup>2</sup> House (8" Block Walls - perlite insulation in cores)<sup>a</sup>

	U-value	Heating	Cooling		
			C+	C-	C
Albuquerque	.1116 <sup>b</sup>	12.66	8.18	4.92	13.10
	.0791 <sup>d</sup>	10.62	8.26	5.39	13.65
	.0471 <sup>f</sup>	8.71	8.36	5.96	14.32
Atlanta	.1116	10.77	8.79	8.84	17.63
	.0791	9.45	8.93	9.34	18.27
	.0471	8.24	9.07	9.82	18.89
Indianapolis	.1116	27.66	5.89	5.35	11.24
	.0791	24.22	5.95	5.81	11.76
	.0471	20.88	6.03	6.33	12.36
Jacksonville	.1116	1.60	20.43	12.40	32.83
	.0791	1.35	20.59	12.86	33.45
	.0471	1.15	20.71	13.37	34.08
Madison	.1116	31.72	2.98	3.05	6.03
	.0791	27.48	3.06	3.61	6.67
	.0471	23.37	3.15	4.29	7.44
Phoenix	.1116	1.74	32.13	6.31	38.44
	.0791	1.49	31.60	6.85	38.45
	.0471	1.31	31.05	7.37	38.42
Tampa	.1116	0.295	23.01	15.68	38.69
	.0791	0.233	23.15	16.20	39.35
	.0471	0.193	23.27	16.70	39.97
Washington, D.C.	.1116	12.56	9.81	6.00	15.81
	.0843 <sup>c</sup>	10.82	9.78	6.33	16.11
	.0791	10.41	9.78	6.41	16.18
	.0486 <sup>e</sup>	9.12	9.78	6.69	16.47
	.0471	8.42	9.77	6.87	16.64

<sup>a</sup> Wall Weight = approximately 40 lbs/ft<sup>2</sup>.

<sup>b</sup> U = .1116 corresponds to an 8" block wall with poured perlite in cores and a non-reflective 3/4" airspace (R=0.96) on inside wall and 1/2" gypsum wallboard.

<sup>c</sup> U = .853, same as above with R-3 insulation in place of non-reflective airspace.

<sup>d</sup> U = .0791, same as above with R-3.75 insulation.

<sup>e</sup> U = .0586, same as above with R-7.5 insulation.

<sup>f</sup> U = .0471, same as above with R-11.25 insulation.



Table 5B-M. Wall U-values and Annual Heating and Cooling Requirements for 110 m<sup>2</sup> House (200 mm Block Walls - perlite insulation in cores)<sup>a</sup>

	Wall U-value	Annual Space Heating and Cooling Requirements (GJ)			
		Heating	Cooling		
			C+	C-	C
Albuquerque	0.63 <sup>b</sup>	13.36	8.63	5.19	13.82
	0.45 <sup>d</sup>	11.20	8.71	5.69	14.40
	0.27 <sup>f</sup>	9.19	8.82	6.29	15.11
Atlanta	0.63	11.36	9.27	9.33	18.60
	0.45	9.97	9.42	9.85	19.28
	0.27	8.69	9.57	10.36	19.93
Indianapolis	0.63	29.18	6.21	5.64	11.86
	0.45	25.55	6.28	6.13	12.41
	0.27	22.03	6.36	6.68	13.04
Jacksonville	0.63	1.69	21.55	13.08	34.64
	0.45	1.42	21.72	13.57	35.29
	0.27	1.21	21.85	14.11	35.96
Madison	0.63	33.47	3.14	3.22	6.36
	0.45	28.99	3.23	3.81	7.04
	0.27	24.66	3.32	4.53	7.85
Phoenix	0.63	1.84	33.90	6.66	40.56
	0.45	1.57	33.34	7.23	40.57
	0.27	1.38	32.76	7.78	40.54
Tampa	0.63	0.31	24.28	16.54	40.82
	0.45	0.25	24.42	17.09	41.52
	0.27	0.20	24.55	17.62	42.17
Washington D.C.	0.63	13.25	10.35	6.33	16.68
	0.48 <sup>c</sup>	11.42	10.32	6.68	17.00
	0.45	10.98	10.32	6.76	17.07
	0.33 <sup>e</sup>	9.62	10.32	7.06	17.38
	0.27	8.88	10.31	7.25	17.56

<sup>a</sup> Wall weight = approximately 195 kg/m<sup>2</sup>.

<sup>b</sup> U-metric = 0.63 corresponds to a 200 mm block wall with poured perlite in cores and a non-reflective 19 mm airspace (R-metric 0.17) on inside wall and 13 mm gypsum wallboard.

<sup>c</sup> U-metric = 0.48, same as above with R-metric 0.53 insulation in place of non-reflective airspace.

<sup>d</sup> U-metric = 0.45, same as above with R-metric 0.66 insulation.

<sup>e</sup> U-metric = 0.33, same as above with R-metric 1.32 insulation.

<sup>f</sup> U-metric = 0.27, same as above with R-metric 1.98 insulation.

Table 5 C Wall U-values and Annual Heating and Cooling Requirements for 1176 ft<sup>2</sup> House (Wood-frame Walls)<sup>a</sup>

	Wall U-values	<u>Annual Space Heating and Cooling Requirements (million Btu)</u>			
		Heating	Cooling		
			C+	C-	C
Albuquerque	.2130 <sup>b</sup>	20.52	10.10	4.42	14.52
	.0781 <sup>c</sup>	11.11	9.02	5.45	14.48
	.0543 <sup>d</sup>	9.43	8.79	5.82	14.61
Atlanta	.2130	16.04	10.33	7.56	17.89
	.0781	9.92	9.55	9.15	18.69
	.0543	8.81	9.39	9.57	18.94
Indianapolis	.2130	38.63	6.88	4.57	11.45
	.0781	24.40	6.38	5.82	12.20
	.0543	21.81	6.29	6.20	12.49
Jacksonville	.2130	3.65	23.12	10.72	33.84
	.0781	1.70	21.48	12.62	34.10
	.0543	1.38	21.18	13.07	34.25
Madison	.2130	45.44	3.67	2.71	6.38
	.0781	27.72	3.38	3.88	7.27
	.0543	24.51	3.32	4.25	7.57
Phoenix	.2130	4.39	37.56	6.06	43.62
	.0781	2.01	32.80	6.87	39.67
	.0543	1.61	31.86	7.17	39.03
Tampa	.2130	0.862	25.61	13.42	39.03
	.0781	0.334	24.04	15.79	39.83
Washington, D.C.	.2130	19.82	11.32	4.94	16.27
	.1515 <sup>c</sup>	15.64	10.88	5.37	16.25
	.0781	10.65	10.31	6.26	16.57
	.0710 <sup>e</sup>	10.17	10.25	6.36	16.61
	.0543	9.04	10.10	6.64	16.73

<sup>a</sup> Wall Weight = approximately 6 lbs/ft<sup>2</sup>.

<sup>b</sup> U = .2130 corresponds to a 2" x 4" frame wall with 3-1/2" non-reflective airspace (R-0.96).

<sup>c</sup> U = .1515, same as above with reflective airspace (R-3.0).

<sup>d</sup> U = .0781, same as above with R-11 insulation in airspace.

<sup>e</sup> U = .0710, same as above with R-13 insulation in airspace.

<sup>f</sup> U = .0543 corresponds to a 2" x 6" frame wall with nominal R-19 insulation in airspace.

Table 5C-M. Wall U-values and Annual Heating and Cooling Requirements for 110 m<sup>2</sup> House (Wood-frame Walls)<sup>a</sup>

Annual Space Heating and Cooling Requirements (GJ)

	Wall U-value	Heating	Cooling		
			C+	C-	C
Albuquerque	1.21 <sup>b</sup>	21.65	10.66	4.66	15.32
	0.44 <sup>d</sup>	11.72	9.52	5.75	15.28
	0.31 <sup>f</sup>	9.95	9.27	6.14	15.41
Atlanta	1.21	16.92	10.90	7.98	18.88
	0.44	10.47	10.08	9.65	19.72
	0.31	9.30	9.91	10.10	19.98
Indianapolis	1.21	40.76	7.26	4.82	12.08
	0.44	25.74	6.73	6.14	12.87
	0.31	23.01	6.64	6.54	13.18
Jacksonville	1.21	3.85	24.39	11.31	35.70
	0.44	1.79	22.66	13.31	35.98
	0.31	1.46	22.35	13.79	36.14
Madison	1.21	47.94	3.87	2.86	6.73
	0.44	29.25	3.57	4.09	7.67
	0.31	25.86	3.50	4.48	7.99
Phoenix	1.21	4.63	39.63	6.39	46.02
	0.44	2.12	34.61	7.25	41.85
	0.31	1.70	33.61	7.56	41.18
Tampa	1.21	0.91	27.02	14.16	41.18
	0.44	0.35	25.36	16.66	42.02
Washington, D.C.	1.21	20.91	11.94	5.21	17.17
	0.86 <sup>c</sup>	16.50	11.48	5.67	17.14
	0.44	11.24	10.88	6.60	17.48
	0.40 <sup>e</sup>	10.73	10.81	6.71	17.52
	0.31	9.54	10.66	7.01	17.65

<sup>a</sup> Wall weight = approximately 30 kg/m<sup>2</sup>.

<sup>b</sup> U-metric = 1.21 corresponds to a 38 x 89 mm frame wall with 89 mm non-reflective airspace (R-metric 0.17).

<sup>c</sup> U-metric = 0.86, same as above with reflective airspace (R-metric 0.53).

<sup>d</sup> U-metric = 0.44, same as above with R-metric 1.94 insulation in airspace.

<sup>e</sup> U-metric = 0.40, same as above with R-metric 2.29 insulation in airspace.

<sup>f</sup> U-metric = 0.31, corresponds to a 38 x 140 mm frame wall with nominal R-metric 3.35 insulation in airspace.

Table 5 D. Wall U-values and Annual Heating and Cooling Requirements for 1176 ft<sup>2</sup> House - 90° Rotation (8" Block Walls - no insulation in cores)

Annual Space Heating and Cooling Requirements (million Btu)

	Wall U-values	Heating	Cooling		
			C+	C-	C
Madison	.2417	50.988	3.650	2.863	6.513
	.1443	38.595	3.645	3.751	7.396
	.0693	28.824	3.685	4.863	8.548
Phoenix	.2417	4.647	38.960	6.715	44.675
	.1443	3.107	36.393	6.163	42.556
	.0693	2.046	34.436	6.664	41.100
Washington, D.C.	.2417	23.081	11.793	5.869	17.662
	.1443	16.424	11.363	6.651	18.014
	.0693	11.389	11.094	7.456	18.550

Table 5D-M. Wall U-values and Annual Heating and Cooling Requirements for 110 m<sup>2</sup> House - 90° Rotation (200 mm Block Walls - no insulation in cores)

Annual Space Heating and Cooling Requirements (GJ)

	Wall U-value	Heating	Cooling		
			C+	C-	C
Madison	1.37	53.80	3.85	3.02	6.87
	0.82	40.72	3.85	3.96	7.80
	0.39	30.41	3.89	5.13	9.02
Phoenix	1.37	4.90	41.11	6.03	47.13
	0.82	3.28	38.40	6.50	44.90
	0.39	2.16	36.33	7.03	43.36
Washington, D.C.	1.37	24.35	12.44	6.19	18.63
	0.82	17.33	11.99	7.02	19.01
	0.39	12.02	11.70	7.87	19.57

temperature is 78°F (25.5°C) or greater (C+), and cooling requirements for all hours in which the outdoor dry bulb temperature is below 78°F (25.5°C) (C-). (Note that  $C = C- + C+$ .) If windows are assumed to be closed at all times, C is the best representation of annual cooling requirements. If windows are opened for natural ventilation when the outdoor temperature is below 78° (25.5°C), C+ is the best representation. In fact, actual operating practices are usually somewhere between these two extremes. For example, during spring and fall windows and doors may be left open for natural ventilation more frequently than during the summer months. Noise, humidity, air pollution, and security considerations may encourage leaving windows closed more than they might be otherwise, especially in urban areas.

The data points in Tables 5A, 5B, and 5C are shown graphically in Figures 1-8 for the eight cities examined. Visual examination of these figures shows that a change in wall U-value has a very significant effect on heating requirements while having a minimal effect on cooling requirements. In general, the masonry walls perform slightly better than wood-frame walls for the same U-value in the range of 0.05 to 0.15 (U-metric 0.28 to 0.85), which is the range of major interest. The effects of mass in reducing energy requirements appear to be most noticeable with respect to the cooling requirements in hours when the outdoor temperature exceeds the thermostat setpoint (78°F (25.5°C)). For cooling hours in which the outdoor temperature is lower than the thermostat setpoint, the wood-frame wall generally (although not in every case) outperforms the masonry wall. The summation of C+ and C- data generally shows that the masonry walls have a slight (1-5 percent) advantage over wood-frame walls when both are interpolated to a

Fig. 1. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Albuquerque

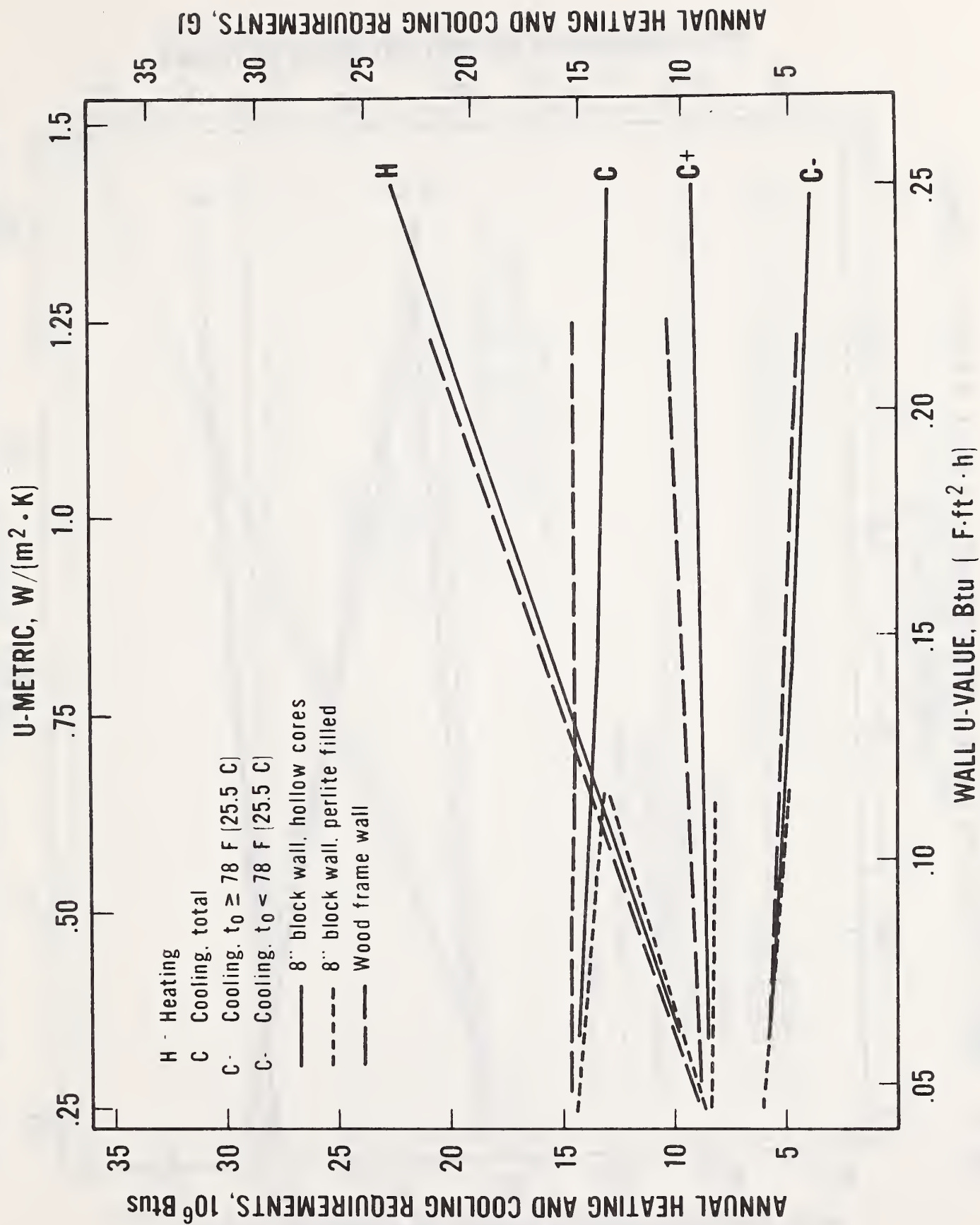


Fig. 2. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Atlanta

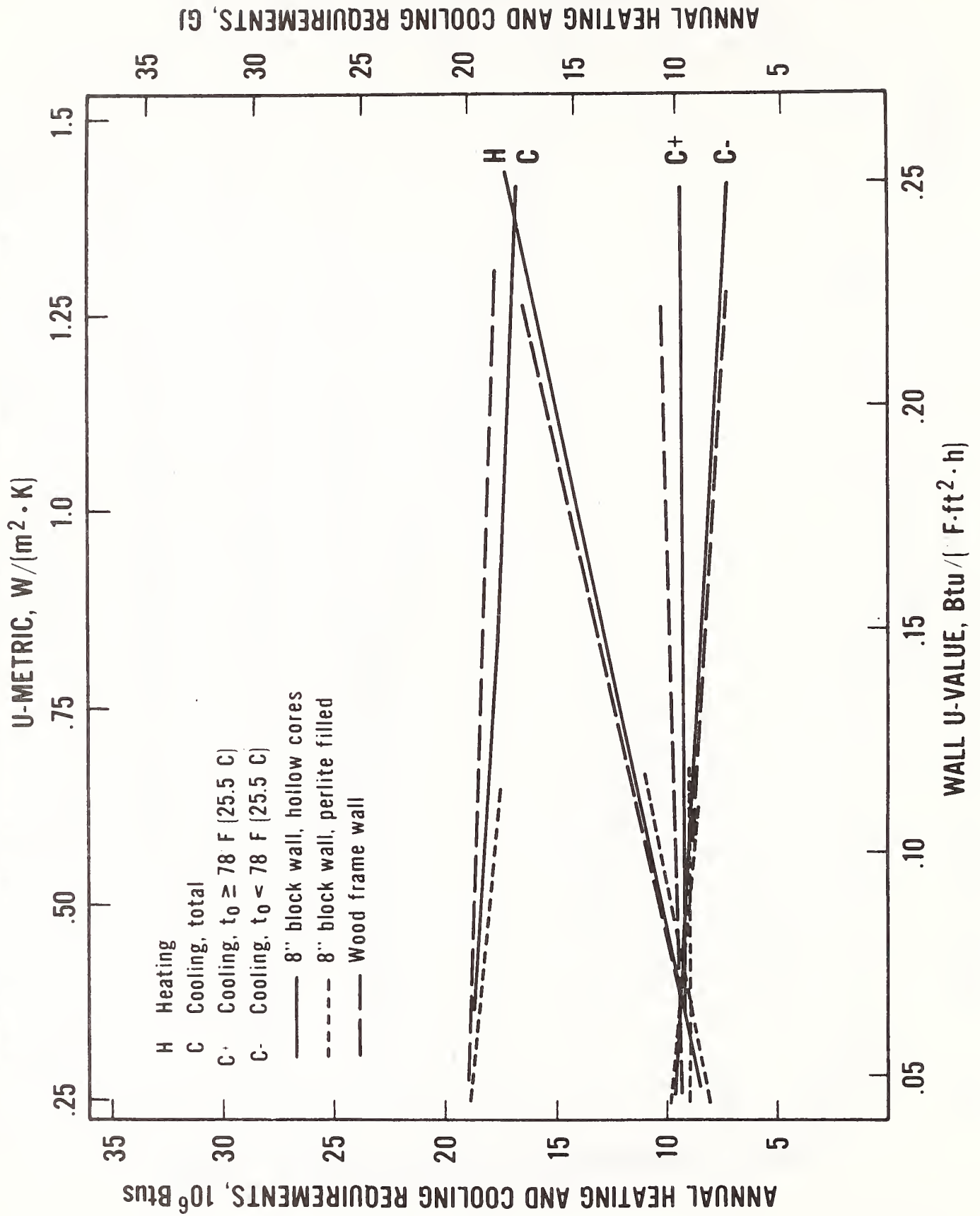




Fig. 3. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Indianapolis

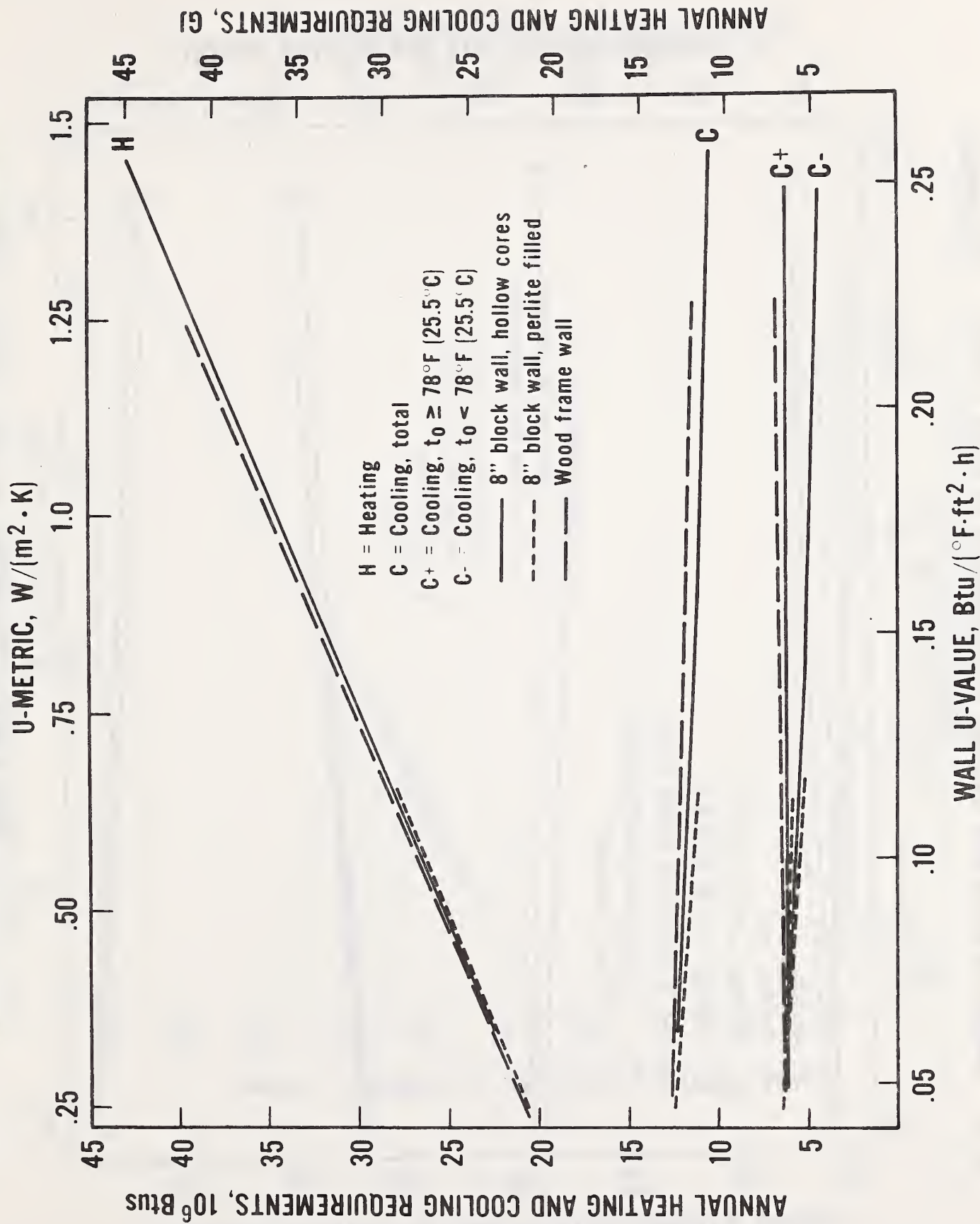


Fig. 4. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Jacksonville

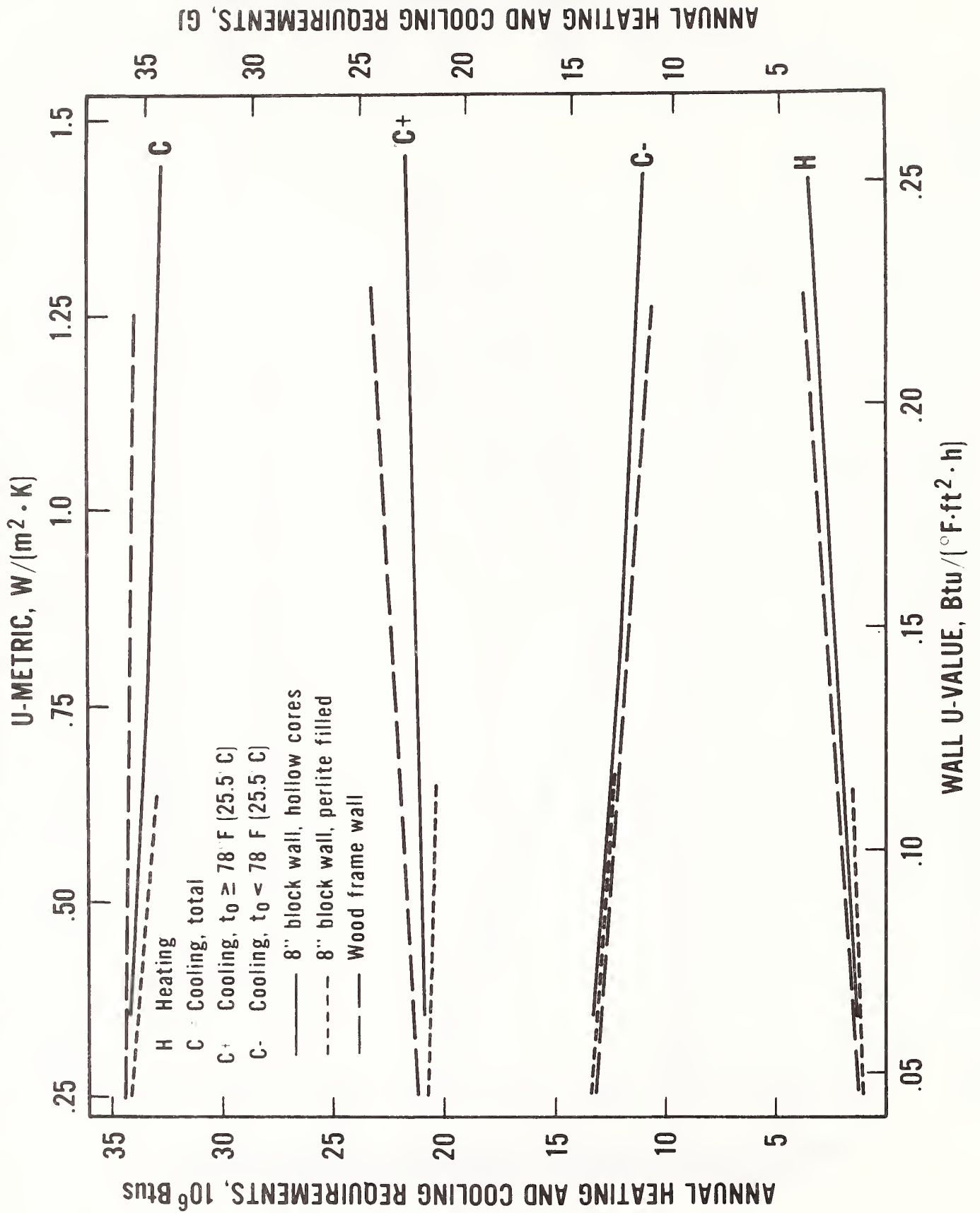


Fig. 5. ANNUAL HEATING COOLING REQUIREMENTS BY WALL U-VALUE : Madison

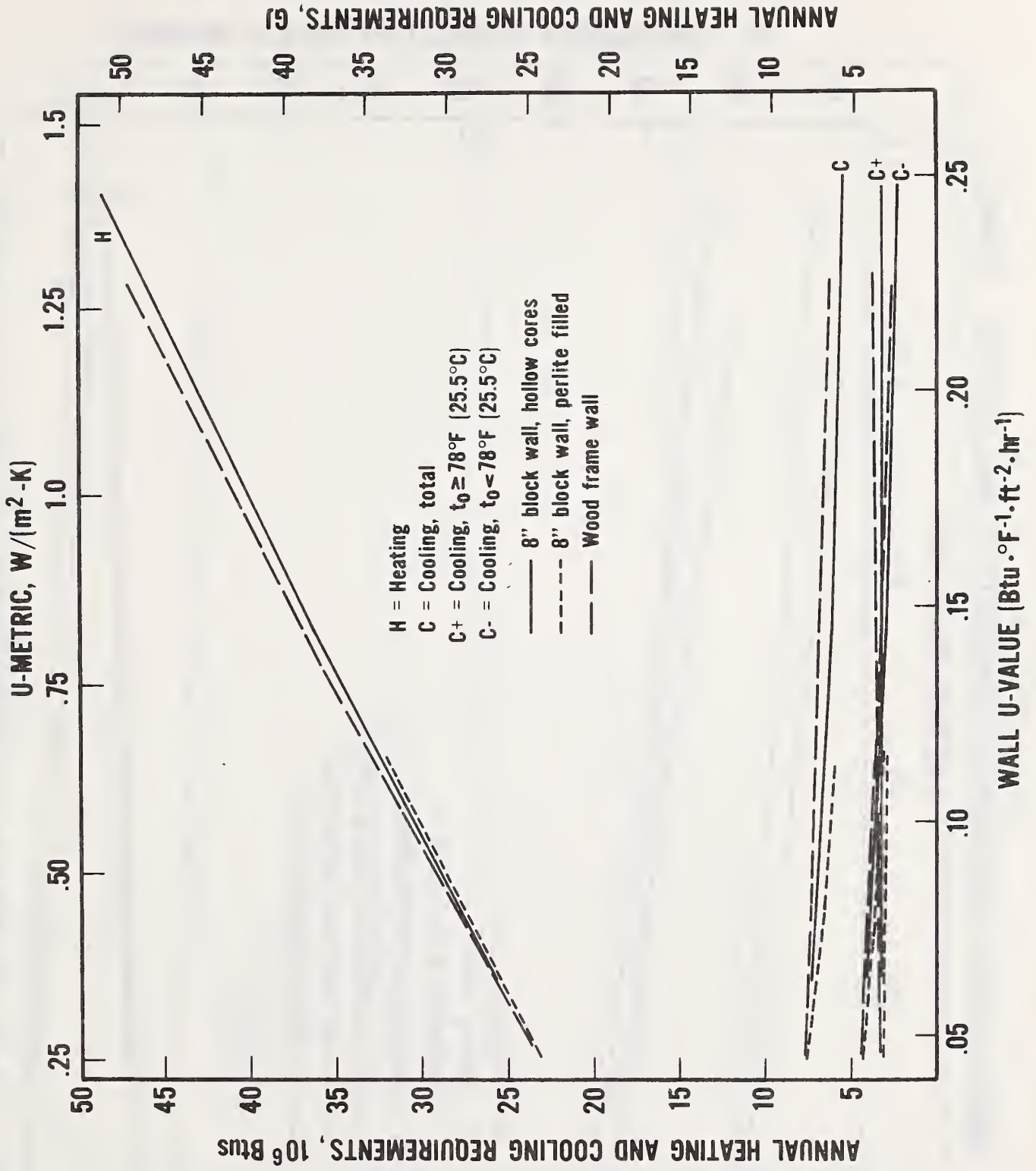


Fig. 6. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Phoenix

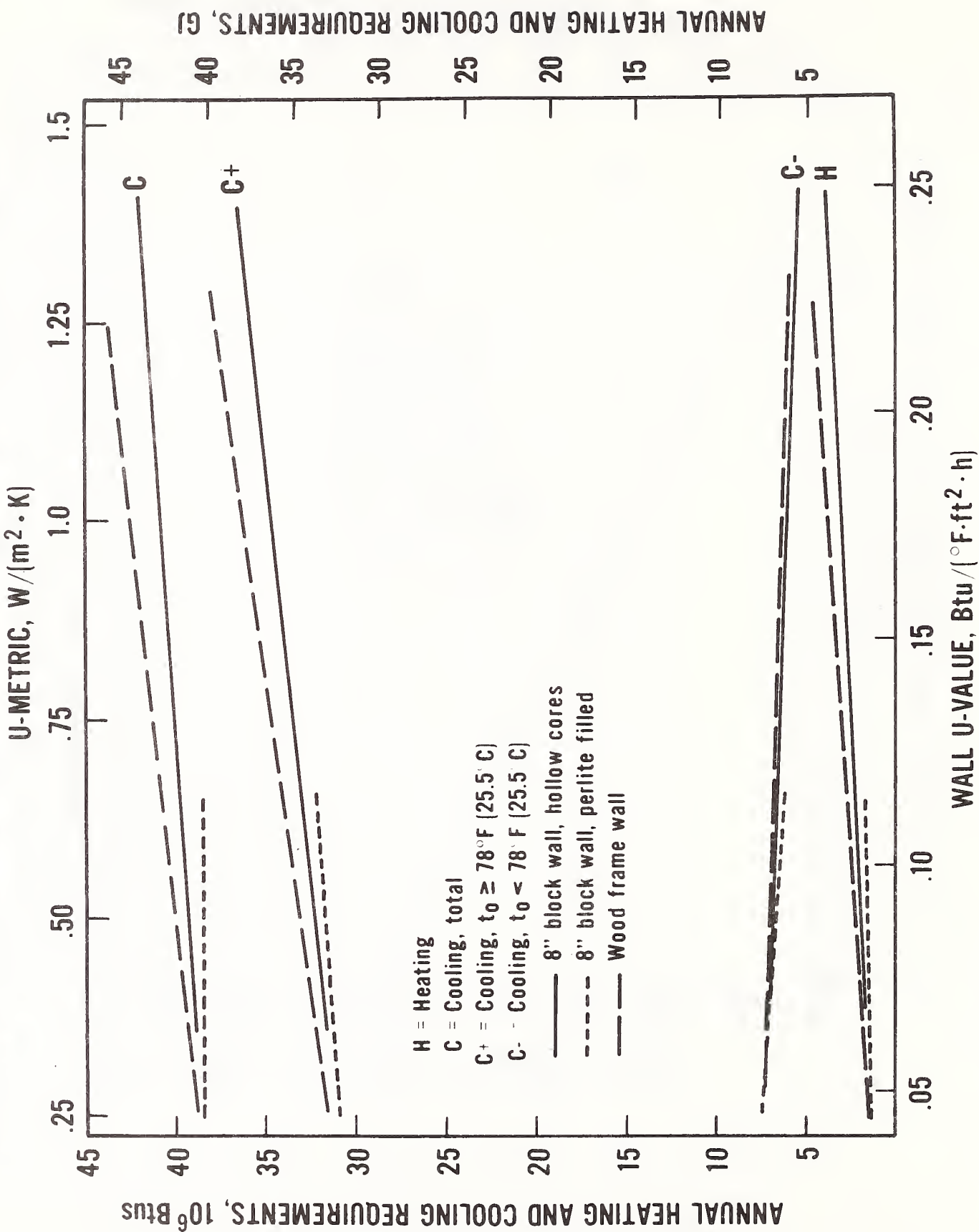


Fig. 7. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Tampa

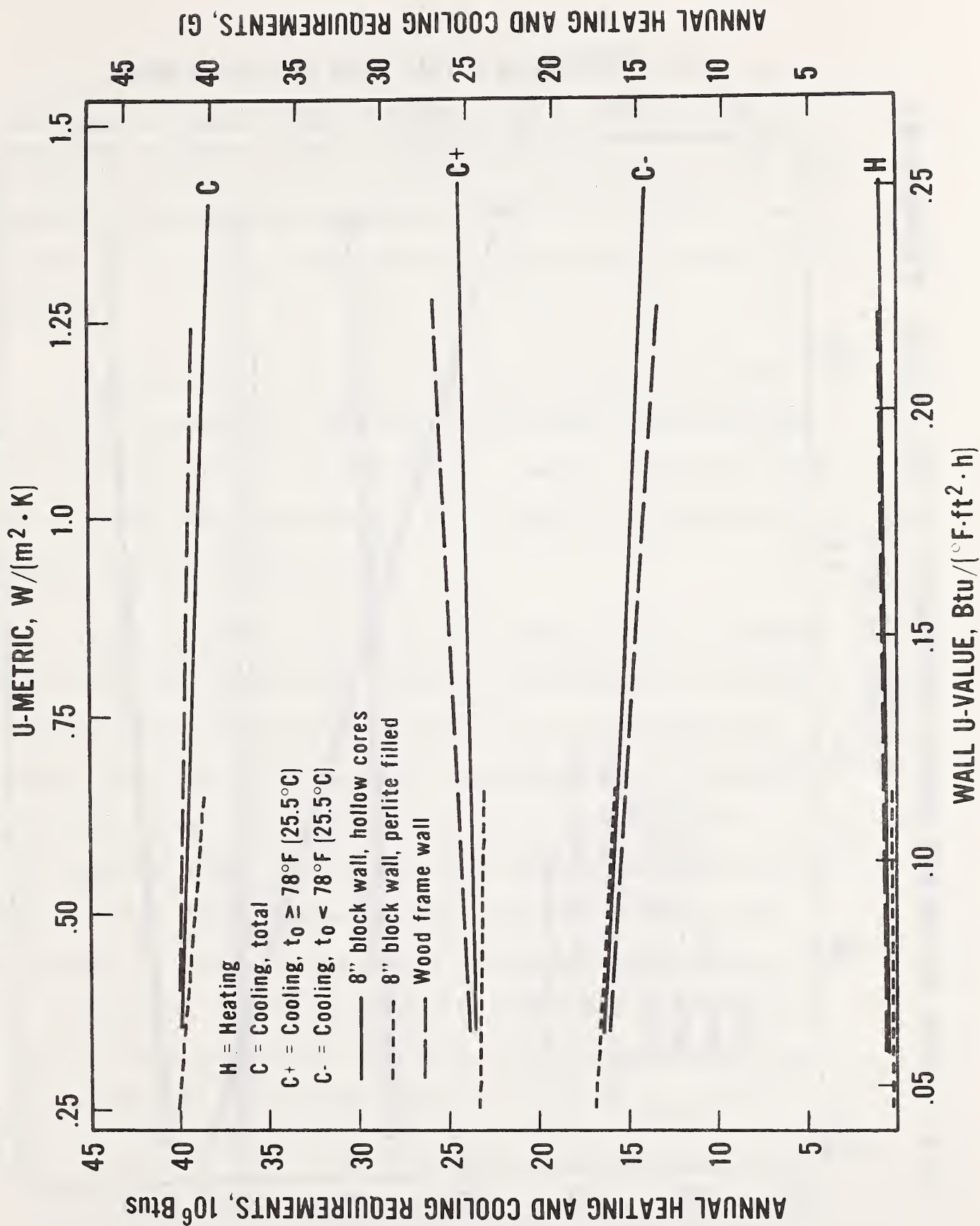
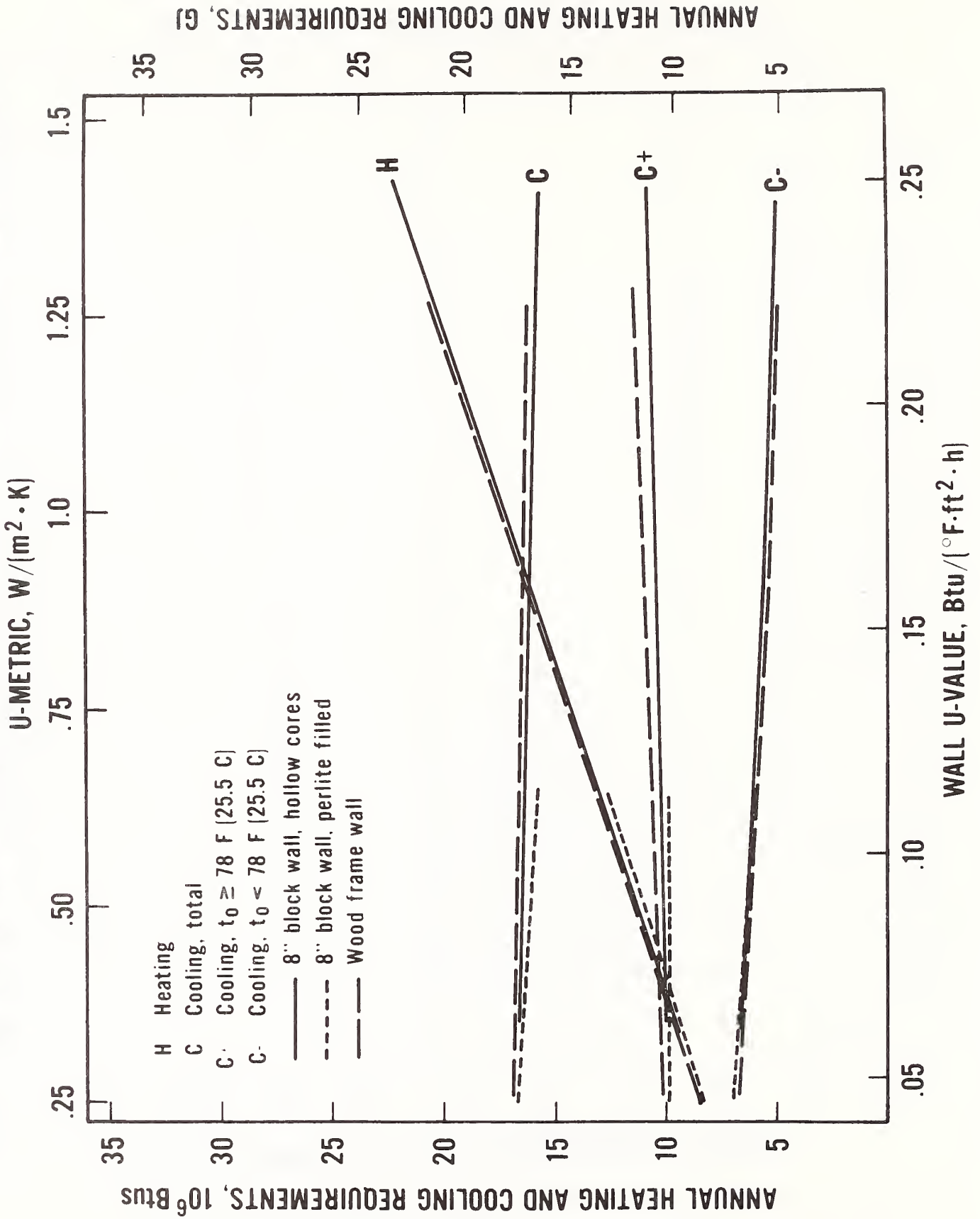


Fig. 8. ANNUAL HEATING AND COOLING REQUIREMENTS BY WALL U-VALUE : Washington, D.C.



U of  $0.1 \text{ Btu hr}^{-1} \text{ ft}^{-2} \text{ }^\circ\text{F}^{-1}$  ( $U \text{ metric} = 0.57 \text{ W/m}^2 \cdot \text{ }^\circ\text{K}$ ). Comparative performance of masonry and wood-frame walls at this U-value is shown in Table 6. However, it must be stressed that the purpose of this report is to determine the cost-effective level of insulation in each system, not to determine the U-value that provides equal thermal performance.

Comparison of Tables 5A and 5D show that the house rotated  $90^\circ$  to the west has somewhat higher heating and cooling requirements than the base houses for the same wall design. However, differences in the energy savings due to reductions in wall U-value are not significant enough to warrant further analysis.

Because the effects of insulation on cooling loads are generally quite small, and because these effects vary from negative to positive depending on the way the house is operated, it is recommended that, except in the case of Phoenix, only the heating saving be considered in the final economic analysis of both masonry and wood-frame walls. Since the insulation in the walls of the house in Phoenix has a distinct beneficial effect even with windows always closed, the benefits of wall insulation in reducing annual cooling requirements should be recognized in that climate. A sensitivity analysis is performed to determine the effect of this recommendation on economic levels of insulation. This will be discussed later in this report.

Table 6. Normalized Annual Heating and Cooling Requirements in million Btu (GJ),  
Wall U = 0.10<sup>a</sup> (U-metric = 0.57)

	<u>Wood Frame</u> 6 lbs/ft <sup>2</sup> (30 kg/m <sup>2</sup> )		<u>8" (200 mm) Block<sup>b</sup></u> 38 lbs/ft <sup>2</sup> (185 kg/m <sup>2</sup> )		<u>Wood Frame</u> 8" Block
Albuquerque					
Heating	12.64	(13.34)	12.36	(13.04)	1.023
Cooling	14.48	(15.28)	13.85	(14.61)	1.045
Atlanta					
Heating	10.91	(11.51)	10.67	(11.26)	1.022
Cooling	18.56	(19.58)	17.69	(18.66)	1.049
Indianapolis					
Heating	26.71	(28.18)	26.55	(28.01)	1.006
Cooling	12.08	(12.75)	11.90	(12.56)	1.015
Jacksonville					
Heating	2.02	(2.13)	1.80	(1.90)	1.122
Cooling	34.06	(35.94)	33.67	(35.52)	1.012
Madison					
Heating	30.60	(32.28)	30.43	(32.11)	1.005
Cooling	7.12	(7.51)	6.75	(7.12)	1.055
Phoenix					
Heating	2.40	(2.53)	2.04	(2.15)	1.176
Cooling	40.31	(42.53)	39.44	(41.61)	1.022
Tampa					
Heating	0.42	(0.44)	0.36	(0.38)	1.167
Cooling	39.70	(41.89)	39.44	(41.61)	1.007
Washington, D.C.					
Heating	12.14	(12.81)	11.98	(12.64)	1.013
Cooling	16.47	(17.38)	16.22	(17.11)	1.015

<sup>a</sup> Interpolated from data in Table 5 A and C using nearest two points to U = 0.10 (U-metric = 0.57).

<sup>b</sup> No insulation in cores, 100 pcf (1600 kg/m<sup>2</sup>) concrete.



Because of the generally linear nature of the performance data for each wall type as a function of its U-value, and because the results of the NBSLD analysis are not sensitive to the type of insulation material examined, but rather only to its thermal conductivity and thickness, interpolation between the data points actually examined and any other U-values within this range can be accomplished with considerable confidence.\* The data points were generated using non-reflective air spaces, reflective air spaces, and several levels of rigid foam insulation. This approach allows extreme flexibility in analyzing different insulation materials at different thicknesses as long as they are considered for the same wall type and same placement within the wall itself. The polystyrene insulation levels examined for the sponsor are for the most part the same as used in establishing the data points with NBSLD, although minor differences in the wall U-values occur due to minor differences in material specifications. The NBSLD data points are interpolated to provide results which correspond exactly to the HUD-FHA wall specifications. The analysis of the thermal performance of isocyanurate insulation is also accomplished by interpolating the NBSLD data points, using the thermal properties of the isocyanurate insulation provided by HUD-FHA in Table 1.

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\* For example, using the highest and lowest U-values for 8" (200 mm) block walls in Washington, D.C., .2417 and .0693 (U-metric 1.37 and 0.39), interpolation for U = .1443 (U-metric = 0.82) results in annual heating and cooling requirements, respectively, of 14.99 and 16.13 x 10<sup>6</sup> Btu (15.82 and 17.02 GJ). NBSLD calculations at U = .1443 (U-metric = 0.82) result in Annual Heating Requirements and Annual Cooling Requirements of 14.92 and 15.94 (15.74 and 16.82 GJ), respectively. In general interpolations are made over a considerably narrower range.

The effects of the alternative insulation specifications on actual energy savings are analyzed for four heating system types: gas furnace, oil furnace, electric resistance furnace, and heat pump. Seasonal performances assumed for all systems in each location are shown in Table 7. The seasonal performances of combustion heating systems are based on an analysis by Chi, Kelly, and Didion of good quality gas and oil furnaces in a range of climates [7]. In all cases an electric pilot light is assumed. In locations other than Jacksonville, Tampa, and Phoenix, a stack damper is assumed to be installed on gas furnaces. (A stack damper is not likely to be cost effective in climates with small annual heating requirements. Stack dampers for oil furnaces are not commonly available at present.) Note that there is some small variation, by climate, in the seasonal performance of combustion furnaces, consistent with NBS research results. Heat pump seasonal performance data are based on research by Gordian Associates [8]. In most cases interpolations were made from the Gordian data using heating degree-day data for the locations examined.

The seasonal coefficient of performance (COP) for central air conditioners varies little by climate. The COP of 2.3 is approximately equivalent to an SEER (seasonal energy efficiency ratio) of 8.0, consistent with most manufacturers' middle-of-the-line products.

#### 4.0 TECHNIQUES OF ECONOMIC ANALYSIS

In order to establish the cost effectiveness of the alternative insulation levels to be examined, a life-cycle analysis of the insulation costs and savings is performed. That is, the present value of all energy savings over the life of the wall, in dollar terms, due to each improvement

Table 7. Heating and Cooling System Efficiencies (Seasonal)

	<u>Gas Furnace</u>	<u>Oil Furnace</u>	<u>Electric Furnace</u>	<u>Heat Pump</u>	<u>Central Air Conditioner</u>
Albuquerque	.76	.78	1.0	2.05	2.3
Atlanta	.76	.78	1.0	2.15	2.3
Indianapolis	.76	.78	1.0	1.85	2.3
Jacksonville	.69	.78	1.0	2.30	2.3
Madison	.74	.76	1.0	1.55	2.3
Phoenix	.69	.78	1.0	2.20	2.3
Tampa	.69	.78	1.0	2.30	2.3
Washington, D.C.	.74	.78	1.0	2.05	2.3

in insulation is compared with the cost of that improvement to determine whether or not it is cost justified. Only if the incremental savings of additional levels of insulation, over the next lower level, are greater than or equal to their incremental cost can those additional levels be cost justified on a life-cycle basis.

Consistent with the previous economic analysis of conservation measures performed by NBS for the HUD-FHA, a 30-year life, 10 percent (nominal) discount rate, and regional fuel price projections published by DoE [9] were used. The 30-year life is based on the length of a typical mortgage, which, in effect, testifies to the fact that the expected life of the average house and, by inference, the wall insulation, is at least that long.

Life-cycle savings (LCS) are computed as follows:\*

$$LCS = \frac{\Delta AHR}{\eta_H} \cdot \text{cost/unit}_H \cdot \text{unit}_H / 10^6 \text{Btu} \cdot PWF_H$$

$$+ \frac{\Delta ACR}{\eta_C} \cdot \text{cost/kWh} \cdot \text{kWh} / 10^6 \text{Btu} \cdot PWF_C,$$

where  $\Delta AHR$  is the change in annual heating requirements, in  $10^6 \text{Btu}$ ,

$\Delta ACR$  is the change in annual cooling requirements, in  $10^6 \text{Btu}$ ,

$\eta_H$  is the seasonal efficiency of the heating system,

$\eta_C$  is the seasonal coefficient of performance of the cooling system,

$\text{cost/unit}_H$  is the current cost per unit (e.g., therm, gallon, kWh) of heating fuel,

$\text{cost/kWh}$  is current cost per kilowatt hour,

$\text{unit}_H / 10^6 \text{Btu}$  is the number of heating fuel units per million Btu (e.g., therm = 10, gallon of oil = 7.14, kWh = 293), and

$PWF_H$  and  $PWF_C$  are the present worth factors for the heating fuel and kWh, respectively.

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\* For metric equivalent, use GJ instead of  $10^6 \text{Btu}$ .

DoE projections for regional energy prices are based on the "Trend-long" series with an assumption of 5 percent increase in oil constant dollar costs each year. Energy costs are shown in Table 8.

The present worth factor (PWF) is critical to the life-cycle-cost analysis because it converts first-year dollar savings to present-value, life-cycle savings. The PWF is a function of the life (30 years), discount rate (10 percent) and projected rate of fuel price increases. Since the projected rate of fuel price increases published by DoE vary by fuel type and region, different PWF are used for each city and heating fuel used. The PWF for each city and fuel type used in the economic analysis are shown in Table 9.

Insulation costs for masonry walls were based on the 1978 Means' Building Construction Cost Data [10] where practical. The material cost of isocyanurate was taken from the 1978 "Masonry Cost Guide" [11], but the insulation cost and overhead and profit factors are the same as used for polystyrene in Means. The costs for R-11 and R-13 (R-metric 1.9 and 2.3) fiberglass insulation in a nominal 2" x 4" (38 x 89 mm) wood-frame house were based on NAHB Research Foundation data provided under contract to NBS. These costs are slightly lower than Means but are probably more typical of current residential construction. The cost of the polystyrene sheathing is based on the additional material cost net of the cost of normal asphalt impregnated sheathing, with no additional installation cost, since the former essentially substitutes for the latter. All cost data are shown in Table 10. In order to determine the sensitivity of the results to installed insulation costs, a second analysis with costs increased by 25 percent was made.

Table 8. Energy Costs<sup>a</sup> - 1978 Dollars

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	<u>Gas</u> (Therm)	<u>Oil</u> (Gallon)	<u>Electric</u> (kWh)
Albuquerque	.180	.470	.035
Atlanta	.210	.490	.035
Indianapolis	.220	.470	.040
Jacksonville	.210	.490	.035
Madison	.220	.470	.040
Phoenix	.220	.510	.042
Tampa	.210	.490	.035
Washington, D.C.	.270	.500	.046

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<sup>a</sup> Based on [9], Trendlong Scenario with 5% annual increase in real oil prices. These are regional energy prices, not specific to the city indicated.

<sup>b</sup> No metric equivalents are shown. In SI units, all energy costs can be compared in terms of \$/MJ.

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Table 9. Present Worth Factors<sup>a</sup> for Energy Savings

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	<u>Gas</u>	<u>Oil</u>	<u>Electric</u>
Albuquerque	25.6	25.8	19.9
Atlanta	33.1	25.9	18.5
Indianapolis	34.5	25.0	18.2
Jacksonville	33.1	25.9	18.5
Madison	34.5	25.0	18.2
Phoenix	29.0	24.2	20.3
Tampa	33.1	25.9	18.5
Washington, D.C.	27.9	25.3	18.8

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<sup>a</sup> Based on 30-year life, 10% discount rate, projected energy cost increases in [9].

Table 10. Insulation Cost Data<sup>a</sup>

Code	Name	Cost		
		\$/ft <sup>2</sup>	(\$/m <sup>2</sup> )	1120 ft <sup>2</sup> (104 m <sup>2</sup> ) <sup>b</sup>
B3, B4	Reflective foil backing	0.09	(0.97)	\$101
C3, C4	3/4" (19 mm) isocyanurate	0.51	(5.49)	571
EXTRA	1/2" (13 mm) isocyanurate, 1" (25 mm) reflective air space	0.53	(5.70)	597
D3, D4	3/4" (19 mm) polystyrene	0.33	(3.55)	370
F2, F5	1-1/2" (38 mm) polystyrene	0.48	(5.17)	538
--	Cores filled with perlite	0.48	(5.17)	538
R-11	R-11 (R-metric 1.9) fiberglass in wood frame	0.19	(2.05)	213
R-13	R-13 (R-metric 2.3) fiberglass in wood frame	0.25	(2.69)	280
R-19	R-13 (R-metric 2.3) fiberglass and 1" (25 mm) polystyrene sheathing	0.45	(4.84)	504

<sup>a</sup> Includes materials, installation, overhead and profit

<sup>b</sup> Costs are applicable to gross wall area.

If an increase in the insulation level of the wall can reduce peak heating or cooling loads to the point where smaller heating and cooling equipment can be used, the dollar savings in equipment procurement, if any, should be deducted from the cost of the insulation. While a substantial reduction in peak heating requirements is realized, in general the savings in heating equipment cost is likely to be insignificant. The reduction in peak cooling loads due to an additional increment of insulation is generally small (less than 1000 Btu/h (300 W)) and thus no reduction in cooling equipment tonnage is expected. (Cooling equipment is typically sized in approximately 6000 Btu/h (1800 W) output capacity increments.) As a result, no increase in the wall insulation level above the maximum cost-effective level determined through the analysis of energy savings alone is generally found to be cost effective due to the additional savings from reductions in equipment sizing. (It is possible to construct a specific example where additional insulation would be cost effective because of a reduction in equipment size made possible by the reduction in design loads. However, no generalization can be made from such an example.)

A summary computer program was developed to allow the user to perform the incremental life-cycle-cost analysis of alternative insulation strategies for any wall type on which thermal performance data are available. The user enters the base (i.e., uninsulated) U-value of the appropriate wall system type, the name, corresponding wall U-value and total cost for each of the increasing insulation levels to be analyzed. Savings due to reductions in heating requirements are always calculated. However, the



user can specify whether to consider (1) cooling savings based on cooling only when the outdoor temperature is above the thermostat setpoint, (2) no cooling savings due to insulation, or (3) net cooling savings (losses) regardless of the outdoor temperature (i.e., no natural ventilation).

The program uses the thermal performance data developed with NBSLD analysis for the appropriate wall system in order to interpolate the thermal performance of the insulated wall systems to be analyzed. It then determines the incremental change in heating and cooling requirements (as specified by the user) due to each additional level of insulation. Using the method shown above it calculates the incremental life-cycle heating and cooling savings and compares their sum to the incremental insulation costs. Both the incremental net savings (incremental savings minus incremental cost) and cumulative net savings to that point are shown. The level of insulation with the greatest cumulative net savings is the most cost-effective level for the climatic and cost conditions considered. Any additional level(s) of insulation will not provide incremental savings greater than the costs incurred. If two or more alternative methods of insulating the same wall are to be evaluated, the method with the greatest cumulative net savings is the most cost effective.

## 5.0 RESULTS OF THERMAL AND ECONOMIC ANALYSIS

In order to evaluate the cost effectiveness of the insulation measures specified by the sponsor, the analysis was divided into five insulation groups, designated as:

HUD 1 - insulation of hollow 8" (200 mm) block walls with reflective air space and isocyanurate (B3, C3, "EXTRA")

- HUD 2 - insulation of hollow 8" (200 mm) block walls with reflective air space and polystyrene (B3, D3, F2)
- HUD 3 - insulation of 8" (200 mm) block walls with cores filled, reflective air space and isocyanurate (B4, C4)
- HUD 4 - insulation of 8" (200 mm) block walls with cores filled, reflective air space and polystyrene (B4, D4, F5)
- HUD 5 - insulation of wood-frame walls with fiberglass (R-11 and R-13) and polystyrene sheathing (R-19) (R-metric 1.9, 2.3 and 3.3).

Each group was analyzed to determine the most cost-effective level of insulation, starting with an uninsulated wall with a non-reflective air space. All cases were analyzed with the assumption of no cooling savings. A number of cases, including Phoenix, Tampa, and Jacksonville were analyzed where the effects of insulation on cooling requirements were calculated as well in order to determine whether this had any significant effect on the results. Computer printouts for each run made are included in Appendix A (no cooling savings), Appendix B (cooling based on windows closed) and Appendix C (cooling savings above 78°F (25.5°C) outdoor temperature). All printouts in the appendices are calculated using the base insulation cost data shown in Table 10. Tabulations of these runs are presented in Table 11. The tabulations show the optimal (i.e., most cost-effective) level of insulation for each group along with its corresponding life-cycle net savings. All data in Table 11 are based on no cooling savings from insulation, except for Phoenix, where the data are based on the thermal analysis with windows closed at all times (C). In other cities, the assumption of no cooling savings generally provides the same results in terms of optimal insulation levels as the two other assumptions regarding cooling savings. Table 12 presents similar tabulations based on the 25 percent increase in insulation costs.

Table 11. OPTIMAL INSULATION LEVEL AND NET SAVINGS<sup>a</sup> BY FURNACE TYPE, CITY, AND INSULATION GROUP (INSULATION PRICES BASED ON TABLE 10)<sup>b</sup>

A. GAS FURNACE

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	B3 \$294	B3 \$294	0 \$0	0 \$0	R-11 <sup>c</sup> \$362
Atlanta	B3 282	B3 282	0 0	0 0	R-11 350
Indianapolis	EXTRA 1048	F2 1151	B4 926	B4 926	R-19 1268
Jacksonville	B3 21	B3 21	0 0	0 0	0 0
Madison	EXTRA 1441	F2 1554	B4 1303	F5 1306	R-19 1701
Phoenix	B3 222	B3 222	0 0	0 0	R-11 441
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	B3 561	B3 561	B4 375	B4 375	R-11 726

B. OIL FURNACE

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	B3 \$621	F2 \$640	B4 \$494	B4 \$494	R-11 \$838
Atlanta	B3 386	B3 386	B4 138	B4 138	R-11 504
Indianapolis	EXTRA 1125	F2 1229	B4 999	B4 999	R-19 1350
Jacksonville	B3 40	B3 40	0 0	0 0	R-11 16
Madison	EXTRA 1593	F2 1709	B4 1448	F5 1483	R-19 1865
Phoenix	B3 250	B3 250	B4 38	B4 38	R-11 490
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	B3 654	F2 696	B4 517	B4 517	R-11 858

<sup>a</sup> Net savings = present dollar value of energy savings over 30 years less cost of insulation.

<sup>b</sup> Tabulated from Appendices A and B. See Table 1 for description of insulation codes.

<sup>c</sup> R-11 = R-metric 1.9, R-19 = R-metric 3.3.

TABLE 11. (Continued)

## C. ELECTRIC FURNACE

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	EXTRA \$1514	F2 \$1627	B4 \$1444	B4 \$1444	R-19 \$1817
Atlanta	B3 693	F2 759	B4 627	B4 627	R-11 955
Indianapolis	EXTRA 2827	F2 2976	C4 2645	F5 2924	R-19 3183
Jacksonville	B3 128	B3 128	0 0	0 0	R-11 160
Madison	EXTRA 3645	F2 3815	C4 3545	F5 3881	R-19 4084
Phoenix	B3 435	B3 435	B4 363	B4 363	R-11 819
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	EXTRA 2035	F2 2161	B4 1889	F5 1998	R-19 2300

## D. HEAT PUMP

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	B3 \$546	B3 \$546	B4 \$377	B4 \$377	R-11 \$729
Atlanta	B3 268	B3 268	0 0	0 0	R-11 330
Indianapolis	EXTRA 1254	F2 1361	B4 1121	B4 1121	R-19 1489
Jacksonville	0 0	0 0	0 0	0 0	0 0
Madison	EXTRA 2139	F2 2271	B4 1969	F5 2122	R-19 2456
Phoenix	B3 253	B3 253	B4 46	B4 46	R-11 499
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	B3 704	F2 778	B4 594	B4 594	R-11 929

Table 12. OPTIMAL INSULATION LEVEL AND NET SAVINGS BY FURNACE TYPE, CITY, AND INSULATION GROUP (INSULATION PRICES BASED ON TABLE 10 + 25%)<sup>a</sup>

A. GAS FURNACE

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	B3 \$268	B3 \$268	0 \$0	0 \$0	R-11 \$309
Atlanta	B3 256	B3 256	0 0	0 0	R-11 296
Indianapolis	EXTRA 899	F2 1016	B4 766	B4 766	R-11 1205
Jacksonville	0 0	0 0	0 0	0 0	0 0
Madison	EXTRA 1292	F2 1419	B4 1144	B4 1144	R-19 1575
Phoenix	B3 197	B3 197	0 0	0 0	R-11 388
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	B3 536	B3 536	B4 215	B4 215	R-11 673

B. OIL FURNACE

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	B3 \$596	B3 \$596	B4 \$335	B4 \$335	R-11 \$785
Atlanta	B3 361	B3 361	0 0	0 0	R-11 450
Indianapolis	EXTRA 976	F2 1095	B4 839	B4 839	R-19 1274
Jacksonville	B3 14	B3 14	0 0	0 0	0 0
Madison	EXTRA 1443	F2 1575	B4 1288	B4 1288	R-19 1739
Phoenix	B3 225	B3 225	0 0	0 0	R-11 436
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	B3 629	B3 629	B4 357	B4 357	R-11 805

<sup>a</sup> Based on Appendices A and B. See Table 1 for description of insulation codes.

TABLE 12. (Continued)

## C. ELECTRIC FURNACE

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	EXTRA \$1365	F2 \$1493	B4 \$1284	B4 \$1284	R-19 \$1691
Atlanta	B3 668	B3 668	B4 467	B4 467	R-19 902
Indianapolis	EXTRA 2678	F2 2842	B4 2458	F5 2655	R-19 3057
Jacksonville	B3 103	B3 103	0 0	0 0	R-11 106
Madison	EXTRA 3495	F2 3681	C4 3268	F5 3612	R-19 3958
Phoenix	B3 409	B3 409	B4 203	B4 203	R-11 765
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	EXTRA 1886	F2 2026	B4 1730	B4 1730	R-19 2174

## D. HEAT PUMP

CITY	INSULATION GROUP				
	CORES OPEN		CORES FILLED		WOOD-FRAME
	HUD 1	HUD 2	HUD 3	HUD 4	HUD 5
Albuquerque	B3 \$521	B3 \$521	B4 \$217	B4 \$217	R-19 \$ 676
Atlanta	B3 243	B3 243	0 0	0 0	R-11 277
Indianapolis	EXTRA 1104	F2 1227	B4 962	B4 962	R-11 1389
Jacksonville	0 0	0 0	0 0	0 0	0 0
Madison	EXTRA 1990	F2 2136	B4 1809	F5 1853	R-19 2330
Phoenix	B3 228	B3 228	0 0	0 0	R-11 446
Tampa	0 0	0 0	0 0	0 0	0 0
Washington	B3 679	B3 679	B4 434	B4 434	R-11 876

In the cases where insulation is added to hollow block walls, the foil-backed gypsum wallboard over the 3/4" (19 mm) airspace (B3)\* appears to be the most cost-effective insulation level for gas, oil, and heat pump in the milder climates while either the 1/2" (13 mm) isocyanurate with foil-backed gypsum board and air space ("EXTRA") or the 1-1/2" (38 mm) polystyrene insulation (F2) appears cost effective for most applications in the colder climates and where an electric furnace is used. The use of either 3/4" (19 mm) isocyanurate (C3) or 3/4" (19 mm) polystyrene (D3) is never cost effective when compared to the 3/4" (19 mm) reflective airspace (B3) because the additional savings are relatively minor and the additional cost relatively high. In the cases where the cores of the 8" (200 mm) blocks are filled with perlite insulation, the foil-backed gypsum wallboard appears most cost effective in all but the coldest climates with an electric furnace. However, the cumulative net savings for the cases where core insulation is examined (HUD 3, HUD 4) are less than those for the cases with no insulation in the cores (HUD 1 and HUD 2). This shows that it is generally more cost effective to insulate the inside wall and leave the cores empty. In general, the 8" (200 mm) block wall with 1-1/2" (38 mm) of polystyrene insulation and hollow cores (F2) has a lower U-value and higher net savings than the same wall with 1/2" (13 mm) isocyanurate insulation and a reflective air space (EXTRA).

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\* Potentially, condensation on the foil-backed gypsum wallboard during the air conditioning season in locations such as the Gulf Coast, or dust deposits in the drier regions of the U.S. could degrade the long-term thermal performance of this insulation technique. However, these phenomena have not been widely noted as problems in the field.

In the colder climates, even more insulation than has been examined may be cost effective on the inside. However, beyond 1-1/2" (38 mm) insulation the additional cost of the insulation should be adjusted to offset the effects of the reduced living area. This adjustment can be made by determining the additional cost of moving the end wall outwards by several inches in order to maintain an equivalent interior area.

A minimum of R-11 (R-metric 1.9) insulation in wood-frame walls appears cost effective in all locations except Tampa and in Jacksonville with gas heat or a heat pump. R-19 (R-metric 3.3) insulation appears cost effective in all electrically heated houses except in southern areas and in gas-, oil-, and heat pump-heated houses in northern areas of the U.S.

Similar patterns appear in the analysis using installed insulation costs increased by 25 percent. Foil-backed gypsum is indicated in slightly colder climates than indicated using the lower costs. Results for insulation in wood-frame walls using the higher insulation costs are nearly identical to those based on the lower costs.

Sensitivity analysis to the house orientation was performed in order to determine the effects of rotation on the cost effectiveness of the insulation in masonry walls. The house was rotated 90° to the west, so that the long walls ran north-to-south and the largest window exposure was to the west instead of south. NBSLD simulation of the 8" (200 mm) hollow block wall were made for Phoenix, Washington, and Madison. Annual heating and cooling requirements were increased by as much as 17 percent and 12 percent respectively over the same house in its original orientation. The savings due to



insulating the exterior walls of the rotated house were slightly, but not significantly, greater than those resulting from insulation of the walls in the original orientation. As a result, the maximum cost-effective level of insulation did not change with respect to building orientation. The economic analysis for these three cities are provided in Appendix D.

## 6.0 CONCLUSIONS

Although the energy savings due to an equivalent decrease in U-value for masonry walls are nearly the same as those for wood-frame walls, the maximum economic level of insulation is significantly lower for the masonry walls. This is due to the fact that the insulation of masonry walls is significantly more expensive than insulation in wood-frame walls, thereby reducing the cost effectiveness of the insulation. As a result, houses with optimally insulated 8" (200 mm) concrete block walls (100 pcf, 1600 kg/m<sup>3</sup>), are likely to use somewhat more energy for heating each year than optimally insulated wood-frame houses and slightly less (1 to 5 percent) for cooling.

In extreme southern climates, where heating requirements are small, foil-backed gypsum board with 3/4" (19 mm) air space is generally the maximum cost-effective insulation level in the 8" (200 mm) block wall. Except in climates like that of Phoenix, which tends to have extremely hot days, insulation has only marginal effects on cooling requirements and may actually increase cooling requirements if natural ventilation is not used when adequate for cooling purposes.

In general, insulation in the cores of the 8" (200 mm) blocks is not as cost effective as insulation on the inside wall surface. This is because of the high cost of this method and the low change in overall thermal transmittance relative to that for insulation on the inside surfaces. Although the analysis was limited to a maximum of 1-1/2" (38 mm) of rigid foam insulation in the wall cavity, more may be cost effective in the colder climates, especially if electric heat is used.

It should be recognized that the results discussed in this report are limited in scope in that only an 8" (200 mm) block wall with a concrete density of 100 pcf (1600 kg/m<sup>3</sup>) and a conventional wood-frame wall were examined in conjunction with a limited analysis of insulation strategies. The key to improving the cost effectiveness of insulation in masonry walls appears to lie in finding lower cost methods for insulating these walls, since the savings from the insulation are quite similar to those for wood frame construction. A more complete analysis of masonry wall types and insulation strategies will be included in the final report to be prepared for DoE later in 1979.

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APPENDIX A

Computer Printouts of Economic Analyses  
for All Cities Assuming  
No Cooling Savings

HUD1

ALBUQUERQUE NEW MEXICO 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.384	13.006
B3	.153	\$ 101	15.873	13.006
C3	.110	\$ 571	13.016	13.006
EXTRA	.095	\$ 597	12.025	13.006

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	6.511	.000
C3	.043	\$ 470	2.857	.000
EXTRA	.015	\$ 26	.991	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .180/THERM : PWF = 25.626  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 395	\$ 0	\$ 395	\$ 101	\$ 294	\$ 294
C3	\$ 173	\$ 0	\$ 173	\$ 470	\$ -296	\$ -2
EXTRA	\$ 60	\$ 0	\$ 60	\$ 26	\$ 34	\$ 31

OIL FURNACE @ \$ .470/GALLON : PWF = 25.785  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 722	\$ 0	\$ 722	\$ 101	\$ 621	\$ 621
C3	\$ 316	\$ 0	\$ 316	\$ 470	\$ -153	\$ 468
EXTRA	\$ 109	\$ 0	\$ 109	\$ 26	\$ 83	\$ 552

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 1327	\$ 0	\$ 1327	\$ 101	\$ 1226	\$ 1226
C3	\$ 582	\$ 0	\$ 582	\$ 470	\$ 112	\$ 1338
EXTRA	\$ 202	\$ 0	\$ 202	\$ 26	\$ 176	\$ 1514

HEAT PUMP @ \$ .035/KWH : PWF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 647	\$ 0	\$ 647	\$ 101	\$ 546	\$ 546
C3	\$ 284	\$ 0	\$ 284	\$ 470	\$ -185	\$ 360
EXTRA	\$ 98	\$ 0	\$ 98	\$ 26	\$ 72	\$ 433

HUD1

ATLANTA GEORGIA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	17.124	16.800
B3	.153	\$ 101	12.929	16.800
C3	.110	\$ 571	11.088	16.800
EXTRA	.095	\$ 597	10.449	16.800
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	4.195	.000
C3	.043	\$ 470	1.841	.000
EXTRA	.015	\$ 26	.639	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 383	\$ 0	\$ 383	\$ 101	\$ 282	\$ 282
C3	\$ 168	\$ 0	\$ 168	\$ 470	\$ -301	\$ -19
EXTRA	\$ 58	\$ 0	\$ 58	\$ 26	\$ 32	\$ 12

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 487	\$ 0	\$ 487	\$ 101	\$ 386	\$ 386
C3	\$ 214	\$ 0	\$ 214	\$ 470	\$ -255	\$ 131
EXTRA	\$ 74	\$ 0	\$ 74	\$ 26	\$ 48	\$ 179

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 794	\$ 0	\$ 794	\$ 101	\$ 693	\$ 693
C3	\$ 348	\$ 0	\$ 348	\$ 470	\$ -121	\$ 572
EXTRA	\$ 121	\$ 0	\$ 121	\$ 26	\$ 95	\$ 667

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 369	\$ 0	\$ 369	\$ 101	\$ 268	\$ 268
C3	\$ 162	\$ 0	\$ 162	\$ 470	\$ -307	\$ -38
EXTRA	\$ 56	\$ 0	\$ 56	\$ 26	\$ 30	\$ -8

HUD1

INDIANAPOLIS INDIANA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	42.098	10.652
B3	.153	\$ 101	32.157	10.652
C3	.110	\$ 571	27.638	10.652
EXTRA	.095	\$ 597	26.056	10.652

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	9.941	.000
C3	.043	\$ 470	4.518	.000
EXTRA	.015	\$ 26	1.582	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1019	\$ 0	\$ 1019	\$ 101	\$ 918	\$ 918
C3	\$ 463	\$ 0	\$ 463	\$ 470	\$ -6	\$ 912
EXTRA	\$ 162	\$ 0	\$ 162	\$ 26	\$ 136	\$ 1048

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1067	\$ 0	\$ 1067	\$ 101	\$ 966	\$ 966
C3	\$ 485	\$ 0	\$ 485	\$ 470	\$ 15	\$ 981
EXTRA	\$ 169	\$ 0	\$ 169	\$ 26	\$ 143	\$ 1125

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 2122	\$ 0	\$ 2122	\$ 101	\$ 2021	\$ 2021
C3	\$ 964	\$ 0	\$ 964	\$ 470	\$ 494	\$ 2515
EXTRA	\$ 337	\$ 0	\$ 337	\$ 26	\$ 311	\$ 2827

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1147	\$ 0	\$ 1147	\$ 101	\$ 1046	\$ 1046
C3	\$ 521	\$ 0	\$ 521	\$ 470	\$ 51	\$ 1097
EXTRA	\$ 182	\$ 0	\$ 182	\$ 26	\$ 156	\$ 1254



HUD1

JACKSONVILLE FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.593	32.704
B3	.153	\$ 101	2.380	32.704
C3	.110	\$ 571	1.905	32.704
EXTRA	.095	\$ 597	1.745	32.704

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.213	.000
C3	.043	\$ 470	.475	.000
EXTRA	.015	\$ 26	.160	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PwF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 122	\$ 0	\$ 122	\$ 101	\$ 21	\$ 21
C3	\$ 47	\$ 0	\$ 47	\$ 470	\$ -422	\$ -401
EXTRA	\$ 16	\$ 0	\$ 16	\$ 26	\$ -9	\$ -411

OIL FURNACE @ \$ .490/GALLON : PwF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 141	\$ 0	\$ 141	\$ 101	\$ 40	\$ 40
C3	\$ 55	\$ 0	\$ 55	\$ 470	\$ -414	\$ -374
EXTRA	\$ 18	\$ 0	\$ 18	\$ 26	\$ -7	\$ -382

ELECTRIC FURNACE @ \$ .035/KWH : PwF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 229	\$ 0	\$ 229	\$ 101	\$ 128	\$ 128
C3	\$ 90	\$ 0	\$ 90	\$ 470	\$ -379	\$ -251
EXTRA	\$ 30	\$ 0	\$ 30	\$ 26	\$ 4	\$ -246

HEAT PUMP @ \$ .035/KWH : PwF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 99	\$ 0	\$ 99	\$ 101	\$ -1	\$ -1
C3	\$ 39	\$ 0	\$ 39	\$ 470	\$ -430	\$ -431
EXTRA	\$ 13	\$ 0	\$ 13	\$ 26	\$ -12	\$ -444

HUD1

MADISON WISCONSIN 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	49.645	5.363
B3	.153	\$ 101	37.344	5.363
C3	.110	\$ 571	31.738	5.363
EXTRA	.095	\$ 597	29.774	5.363

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	12.302	.000
C3	.043	\$ 470	5.606	.000
EXTRA	.015	\$ 26	1.964	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1262	\$ 0	\$ 1262	\$ 101	\$ 1161	\$ 1161
C3	\$ 575	\$ 0	\$ 575	\$ 470	\$ 105	\$ 1266
EXTRA	\$ 201	\$ 0	\$ 201	\$ 26	\$ 175	\$ 1441

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1355	\$ 0	\$ 1355	\$ 101	\$ 1254	\$ 1254
C3	\$ 617	\$ 0	\$ 617	\$ 470	\$ 147	\$ 1402
EXTRA	\$ 216	\$ 0	\$ 216	\$ 26	\$ 190	\$ 1593

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 2626	\$ 0	\$ 2626	\$ 101	\$ 2525	\$ 2525
C3	\$ 1196	\$ 0	\$ 1196	\$ 470	\$ 726	\$ 3251
EXTRA	\$ 419	\$ 0	\$ 419	\$ 26	\$ 393	\$ 3645

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1694	\$ 0	\$ 1694	\$ 101	\$ 1593	\$ 1593
C3	\$ 772	\$ 0	\$ 772	\$ 470	\$ 302	\$ 1895
EXTRA	\$ 270	\$ 0	\$ 270	\$ 26	\$ 244	\$ 2139

HUD1

PHOENIX ARIZONA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.035	42.003
B3	.153	\$ 101	2.685	42.003
C3	.110	\$ 571	2.157	42.003
EXTRA	.095	\$ 597	1.980	42.003

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.349	.000
C3	.043	\$ 470	.528	.000
EXTRA	.015	\$ 26	.177	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 124	\$ 0	\$ 124	\$ 101	\$ -23	\$ 23
C3	\$ 48	\$ 0	\$ 48	\$ 470	\$ -421	\$ -397
EXTRA	\$ 16	\$ 0	\$ 16	\$ 26	\$ -9	\$ -406

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 152	\$ 0	\$ 152	\$ 101	\$ 51	\$ 51
C3	\$ 59	\$ 0	\$ 59	\$ 470	\$ -410	\$ -359
EXTRA	\$ 20	\$ 0	\$ 20	\$ 26	\$ -5	\$ -365

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 337	\$ 0	\$ 337	\$ 101	\$ -236	\$ 236
C3	\$ 131	\$ 0	\$ 131	\$ 470	\$ -338	\$ -101
EXTRA	\$ 44	\$ 0	\$ 44	\$ 26	\$ -18	\$ -83

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 146	\$ 0	\$ 146	\$ 101	\$ 45	\$ 45
C3	\$ 57	\$ 0	\$ 57	\$ 470	\$ -412	\$ -367
EXTRA	\$ 19	\$ 0	\$ 19	\$ 26	\$ -6	\$ -373

HUD1

TAMPA FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.240	\$ 0	.850	38.162
B3	.153	\$ 101	.505	38.162
C3	.110	\$ 571	.363	38.162
EXTRA	.095	\$ 597	.343	38.152
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	.345	.000
C3	.043	\$ 470	.122	.000
EXTRA	.015	\$ 26	.040	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 34	\$ 0	\$ 34	\$ 101	\$ -66	\$ -66
C3	\$ 12	\$ 0	\$ 12	\$ 470	\$ -457	\$ -523
EXTRA	\$ 4	\$ 0	\$ 4	\$ 26	\$ -21	\$ -545

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 40	\$ 0	\$ 40	\$ 101	\$ -60	\$ -60
C3	\$ 14	\$ 0	\$ 14	\$ 470	\$ -455	\$ -516
EXTRA	\$ 4	\$ 0	\$ 4	\$ 26	\$ -21	\$ -538

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 65	\$ 0	\$ 65	\$ 101	\$ -35	\$ -35
C3	\$ 23	\$ 0	\$ 23	\$ 470	\$ -446	\$ -482
EXTRA	\$ 7	\$ 0	\$ 7	\$ 26	\$ -18	\$ -500

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 28	\$ 0	\$ 28	\$ 101	\$ -72	\$ -72
C3	\$ 10	\$ 0	\$ 10	\$ 470	\$ -459	\$ -532
EXTRA	\$ 3	\$ 0	\$ 3	\$ 26	\$ -22	\$ -555

HUD1

WASHINGTON D.C. 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.025	15.734
B3	.153	\$ 101	15.508	15.734
C3	.110	\$ 571	12.637	15.734
EXTRA	.095	\$ 597	11.639	15.734
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	6.517	.000
C3	.043	\$ 470	2.871	.000
EXTRA	.015	\$ 26	.998	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .270/THERM : PWF = 27.860  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 662	\$ 0	\$ 662	\$ 101	\$ 561	\$ 561
C3	\$ 291	\$ 0	\$ 291	\$ 470	\$ -178	\$ 383
EXTRA	\$ 101	\$ 0	\$ 101	\$ 26	\$ 75	\$ 458

OIL FURNACE @ \$ .500/GALLON : PWF = 25.324  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 755	\$ 0	\$ 755	\$ 101	\$ 654	\$ 654
C3	\$ 332	\$ 0	\$ 332	\$ 470	\$ -137	\$ 517
EXTRA	\$ 115	\$ 0	\$ 115	\$ 26	\$ 89	\$ 606

ELECTRIC FURNACE @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1651	\$ 0	\$ 1651	\$ 101	\$ 1550	\$ 1550
C3	\$ 727	\$ 0	\$ 727	\$ 470	\$ 257	\$ 1808
EXTRA	\$ 253	\$ 0	\$ 253	\$ 26	\$ 227	\$ 2035

HEAT PUMP @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 805	\$ 0	\$ 805	\$ 101	\$ 704	\$ 704
C3	\$ 354	\$ 0	\$ 354	\$ 470	\$ -115	\$ 589
EXTRA	\$ 123	\$ 0	\$ 123	\$ 26	\$ 97	\$ 687

HUD2

ALBUQUERQUE NEW MEXICO 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
CASE CASE	.249	\$ 0	22.384	13.006
E3	.153	\$ 101	15.873	13.006
D3	.143	\$ 370	15.197	13.006
F2	.091	\$ 538	11.761	13.006

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
E3	.096	\$ 101	6.511	.000
D3	.010	\$ 269	.676	.000
F2	.052	\$ 168	3.436	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .180/THERM : PwF = 25.626  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
E3	\$ 395	\$ 0	\$ 395	\$ 101	\$ 294	\$ 294
D3	\$ 41	\$ 0	\$ 41	\$ 269	\$ -227	\$ 66
F2	\$ 208	\$ 0	\$ 208	\$ 168	\$ 40	\$ 106

OIL FURNACE @ \$ .470/GALLON : PwF = 25.785  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
E3	\$ 722	\$ 0	\$ 722	\$ 101	\$ 621	\$ 621
D3	\$ 74	\$ 0	\$ 74	\$ 269	\$ -194	\$ 427
F2	\$ 381	\$ 0	\$ 381	\$ 168	\$ 213	\$ 640

ELECTRIC FURNACE @ \$ .035/KWH : PwF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
E3	\$ 1327	\$ 0	\$ 1327	\$ 101	\$ 1226	\$ 1226
D3	\$ 137	\$ 0	\$ 137	\$ 269	\$ -131	\$ 1095
F2	\$ 700	\$ 0	\$ 700	\$ 168	\$ 532	\$ 1627

HEAT PUMP @ \$ .035/KWH : PwF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
E3	\$ 647	\$ 0	\$ 647	\$ 101	\$ 546	\$ 546
D3	\$ 67	\$ 0	\$ 67	\$ 269	\$ -201	\$ 344
F2	\$ 341	\$ 0	\$ 341	\$ 168	\$ 173	\$ 518

HUD2

ATLANTA GEORGIA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	17.124	16.800
B3	.153	\$ 101	12.929	16.800
D3	.143	\$ 370	12.494	16.800
F2	.091	\$ 538	10.279	16.800

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	4.195	.000
D3	.010	\$ 269	.436	.000
F2	.052	\$ 168	2.215	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 383	\$ 0	\$ 383	\$ 101	\$ 282	\$ 282
D3	\$ 39	\$ 0	\$ 39	\$ 269	\$ -229	\$ 52
F2	\$ 202	\$ 0	\$ 202	\$ 168	\$ 34	\$ 87

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 487	\$ 0	\$ 487	\$ 101	\$ 386	\$ 386
D3	\$ 50	\$ 0	\$ 50	\$ 269	\$ -218	\$ 168
F2	\$ 257	\$ 0	\$ 257	\$ 168	\$ 89	\$ 258

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 794	\$ 0	\$ 794	\$ 101	\$ 693	\$ 693
D3	\$ 82	\$ 0	\$ 82	\$ 269	\$ -186	\$ 507
F2	\$ 419	\$ 0	\$ 419	\$ 168	\$ 251	\$ 759

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 369	\$ 0	\$ 369	\$ 101	\$ 268	\$ 268
D3	\$ 38	\$ 0	\$ 38	\$ 269	\$ -230	\$ 38
F2	\$ 195	\$ 0	\$ 195	\$ 168	\$ 27	\$ 65

HUD2

INDIANAPOLIS INDIANA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	42.098	10.652
B3	.153	\$ 101	32.157	10.652
D3	.143	\$ 370	31.119	10.652
F2	.091	\$ 538	25.635	10.652
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	9.941	.000
D3	.010	\$ 269	1.038	.000
F2	.052	\$ 168	5.484	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1019	\$ 0	\$ 1019	\$ 101	\$ 918	\$ 918
D3	\$ 106	\$ 0	\$ 106	\$ 269	\$ -163	\$ 755
F2	\$ 562	\$ 0	\$ 562	\$ 168	\$ 394	\$ 1151

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1067	\$ 0	\$ 1067	\$ 101	\$ 966	\$ 966
D3	\$ 111	\$ 0	\$ 111	\$ 269	\$ -157	\$ 809
F2	\$ 588	\$ 0	\$ 588	\$ 168	\$ 420	\$ 1229

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 2122	\$ 0	\$ 2122	\$ 101	\$ 2021	\$ 2021
D3	\$ 221	\$ 0	\$ 221	\$ 269	\$ -47	\$ 1973
F2	\$ 1170	\$ 0	\$ 1170	\$ 168	\$ 1002	\$ 2976

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1147	\$ 0	\$ 1147	\$ 101	\$ 1046	\$ 1046
D3	\$ 119	\$ 0	\$ 119	\$ 269	\$ -149	\$ 896
F2	\$ 632	\$ 0	\$ 632	\$ 168	\$ 464	\$ 1361



HUD2

JACKSONVILLE FLORIDA 8 IN BLOCK (OPEN CORE)

1200 SQ FT HOUSE

COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.593	32.704
B3	.153	\$ 101	2.380	32.704
D3	.143	\$ 370	2.256	32.704
F2	.091	\$ 538	1.703	32.704

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.213	.000
D3	.010	\$ 269	.124	.000
F2	.052	\$ 168	.553	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 122	\$ 0	\$ 122	\$ 101	\$ 21	\$ 21
D3	\$ 12	\$ 0	\$ 12	\$ 269	\$ -256	\$ -235
F2	\$ 55	\$ 0	\$ 55	\$ 168	\$ -112	\$ -347

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 141	\$ 0	\$ 141	\$ 101	\$ 40	\$ 40
D3	\$ 14	\$ 0	\$ 14	\$ 269	\$ -254	\$ -214
F2	\$ 64	\$ 0	\$ 64	\$ 168	\$ -103	\$ -318

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 229	\$ 0	\$ 229	\$ 101	\$ 128	\$ 128
D3	\$ 23	\$ 0	\$ 23	\$ 269	\$ -245	\$ -116
F2	\$ 104	\$ 0	\$ 104	\$ 168	\$ -63	\$ -179

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 99	\$ 0	\$ 99	\$ 101	\$ -1	\$ -1
D3	\$ 10	\$ 0	\$ 10	\$ 269	\$ -258	\$ -259
F2	\$ 45	\$ 0	\$ 45	\$ 168	\$ -122	\$ -362

HUD2

MADISON WISCONSIN 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	49.645	5.363
B3	.153	\$ 101	37.344	5.363
D3	.143	\$ 370	36.059	5.363
F2	.091	\$ 538	29.250	5.363
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	12.302	.000
D3	.010	\$ 269	1.285	.000
F2	.052	\$ 168	6.809	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1262	\$ 0	\$ 1262	\$ 101	\$ 1161	\$ 1161
D3	\$ 131	\$ 0	\$ 131	\$ 269	\$ -137	\$ 1023
F2	\$ 698	\$ 0	\$ 698	\$ 168	\$ 530	\$ 1554

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1355	\$ 0	\$ 1355	\$ 101	\$ 1254	\$ 1254
D3	\$ 141	\$ 0	\$ 141	\$ 269	\$ -127	\$ 1127
F2	\$ 750	\$ 0	\$ 750	\$ 168	\$ 582	\$ 1709

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 2626	\$ 0	\$ 2626	\$ 101	\$ 2525	\$ 2525
D3	\$ 274	\$ 0	\$ 274	\$ 269	\$ 0	\$ 2530
F2	\$ 1453	\$ 0	\$ 1453	\$ 168	\$ 1285	\$ 3815

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1694	\$ 0	\$ 1694	\$ 101	\$ 1593	\$ 1593
D3	\$ 176	\$ 0	\$ 176	\$ 269	\$ -92	\$ 1501
F2	\$ 937	\$ 0	\$ 937	\$ 168	\$ 769	\$ 2271

HUD2

PHOENIX ARIZONA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.035	42.003
B3	.153	\$ 101	2.685	42.003
D3	.143	\$ 370	2.548	42.003
F2	.091	\$ 538	1.933	42.003

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.349	.000
D3	.010	\$ 269	.138	.000
F2	.052	\$ 168	.615	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 124	\$ 0	\$ 124	\$ 101	\$ -23	\$ -23
D3	\$ 12	\$ 0	\$ 12	\$ 269	\$ -256	\$ -232
F2	\$ 56	\$ 0	\$ 56	\$ 168	\$ -111	\$ -343

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 152	\$ 0	\$ 152	\$ 101	\$ 51	\$ 51
D3	\$ 15	\$ 0	\$ 15	\$ 269	\$ -253	\$ -202
F2	\$ 69	\$ 0	\$ 69	\$ 168	\$ -98	\$ -300

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
E3	\$ 337	\$ 0	\$ 337	\$ 101	\$ 236	\$ 236
D3	\$ 34	\$ 0	\$ 34	\$ 269	\$ -234	\$ 1
F2	\$ 153	\$ 0	\$ 153	\$ 168	\$ -14	\$ -12

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 146	\$ 0	\$ 146	\$ 101	\$ 45	\$ 45
D3	\$ 14	\$ 0	\$ 14	\$ 269	\$ -254	\$ -208
F2	\$ 66	\$ 0	\$ 66	\$ 168	\$ -101	\$ -309

HUD2

TAMPA FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.850	38.162
B3	.153	\$ 101	.505	38.162
D3	.143	\$ 370	.471	38.162
F2	.091	\$ 538	.333	38.162

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	.345	.000
D3	.010	\$ 269	.035	.000
F2	.052	\$ 168	.138	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 34	\$ 0	\$ 34	\$ 101	\$ -66	\$ -66
D3	\$ 3	\$ 0	\$ 3	\$ 269	\$ -265	\$ -331
F2	\$ 13	\$ 0	\$ 13	\$ 168	\$ -154	\$ -455

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 40	\$ 0	\$ 40	\$ 101	\$ -60	\$ -60
D3	\$ 4	\$ 0	\$ 4	\$ 269	\$ -264	\$ -325
F2	\$ 16	\$ 0	\$ 16	\$ 168	\$ -151	\$ -477

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 65	\$ 0	\$ 65	\$ 101	\$ -35	\$ -35
D3	\$ 6	\$ 0	\$ 6	\$ 269	\$ -262	\$ -298
F2	\$ 26	\$ 0	\$ 26	\$ 168	\$ -141	\$ -439

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 28	\$ 0	\$ 28	\$ 101	\$ -72	\$ -72
D3	\$ 2	\$ 0	\$ 2	\$ 269	\$ -266	\$ -338
F2	\$ 11	\$ 0	\$ 11	\$ 168	\$ -156	\$ -495

HUD2

WASHINGTON D.C. 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.025	15.734
B3	.153	\$ 101	15.508	15.734
D3	.143	\$ 370	14.833	15.734
F2	.091	\$ 538	11.377	15.734

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	6.517	.000
D3	.010	\$ 269	.675	.000
F2	.052	\$ 168	3.457	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .270/THERM : PWF = 27.860  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 662	\$ 0	\$ 662	\$ 101	\$ 561	\$ 561
D3	\$ 68	\$ 0	\$ 68	\$ 269	\$ -200	\$ 361
F2	\$ 351	\$ 0	\$ 351	\$ 168	\$ 183	\$ 544

OIL FURNACE @ \$ .500/GALLON : PWF = 25.324  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 755	\$ 0	\$ 755	\$ 101	\$ 654	\$ 654
D3	\$ 78	\$ 0	\$ 78	\$ 269	\$ -190	\$ 463
F2	\$ 400	\$ 0	\$ 400	\$ 168	\$ 232	\$ 696

ELECTRIC FURNACE @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1651	\$ 0	\$ 1651	\$ 101	\$ 1550	\$ 1550
D3	\$ 170	\$ 0	\$ 170	\$ 269	\$ -98	\$ 1452
F2	\$ 876	\$ 0	\$ 876	\$ 168	\$ 708	\$ 2161

HEAT PUMP @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 805	\$ 0	\$ 805	\$ 101	\$ 704	\$ 704
D3	\$ 83	\$ 0	\$ 83	\$ 269	\$ -185	\$ 519
F2	\$ 427	\$ 0	\$ 427	\$ 168	\$ 259	\$ 778

HUD3

ALBUQUERQUE NEW MEXICO 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.407	13.006
CORES FILLED	.141	\$ 538	14.749	13.006
B4	.104	\$ 639	12.186	13.006
C4	.082	\$ 1109	10.801	13.006
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	7.658	.000
B4	.037	\$ 101	2.563	.000
C4	.022	\$ 470	1.384	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .180/THERM : PWF = 25.626  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
CORES FILLED	\$ 464	\$ 0	\$ 464	\$ 538	\$ -73	\$ -73
B4	\$ 155	\$ 0	\$ 155	\$ 101	\$ 54	\$ -18
C4	\$ 84	\$ 0	\$ 84	\$ 470	\$ -385	\$ -404

OIL FURNACE @ \$ .470/GALLON : PWF = 25.785  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
CORES FILLED	\$ 849	\$ 0	\$ 849	\$ 538	\$ 311	\$ 311
B4	\$ 284	\$ 0	\$ 284	\$ 101	\$ 183	\$ 494
C4	\$ 153	\$ 0	\$ 153	\$ 470	\$ -316	\$ 178

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
CORES FILLED	\$ 1561	\$ 0	\$ 1561	\$ 538	\$ 1023	\$ 1023
B4	\$ 522	\$ 0	\$ 522	\$ 101	\$ 421	\$ 1444
C4	\$ 282	\$ 0	\$ 282	\$ 470	\$ -187	\$ 1256

HEAT PUMP @ \$ .035/KWH : PWF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
CORES FILLED	\$ 761	\$ 0	\$ 761	\$ 538	\$ 223	\$ 223
B4	\$ 254	\$ 0	\$ 254	\$ 101	\$ 153	\$ 377
C4	\$ 137	\$ 0	\$ 137	\$ 470	\$ -332	\$ 45

HUD3

ATLANTA GEORGIA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	17.144	16.800
CORES FILLED	.141	\$ 538	12.134	16.800
B4	.104	\$ 639	10.461	16.800
C4	.082	\$ 1109	9.565	16.800

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	5.010	.000
B4	.037	\$ 101	1.673	.000
C4	.022	\$ 470	.896	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 457	\$ 0	\$ 457	\$ 538	\$ -80	\$ -80
B4	\$ 152	\$ 0	\$ 152	\$ 101	\$ 51	\$ -28
C4	\$ 81	\$ 0	\$ 81	\$ 470	\$ -388	\$ -416

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 582	\$ 0	\$ 582	\$ 538	\$ 44	\$ 44
B4	\$ 194	\$ 0	\$ 194	\$ 101	\$ 93	\$ 138
C4	\$ 104	\$ 0	\$ 104	\$ 470	\$ -365	\$ -227

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 949	\$ 0	\$ 949	\$ 538	\$ 411	\$ 411
B4	\$ 317	\$ 0	\$ 317	\$ 101	\$ 216	\$ 627
C4	\$ 169	\$ 0	\$ 169	\$ 470	\$ -300	\$ 327

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 441	\$ 0	\$ 441	\$ 538	\$ -96	\$ -96
B4	\$ 147	\$ 0	\$ 147	\$ 101	\$ 46	\$ -49
C4	\$ 78	\$ 0	\$ 78	\$ 470	\$ -391	\$ -440

HUD3

INDIANAPOLIS INDIANA 8 IN BLOCK (PERLITE FILLED)

1200 SQ FT HOUSE

COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	42.110	10.652
CORES FILLED	.141	\$ 538	30.748	10.652
B4	.104	\$ 639	25.851	10.652
C4	.082	\$ 1109	24.522	10.652

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	11.362	.000
B4	.037	\$ 101	3.897	.000
C4	.022	\$ 470	2.329	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1165	\$ 0	\$ 1165	\$ 538	\$ 627	\$ 627
B4	\$ 390	\$ 0	\$ 399	\$ 101	\$ 298	\$ 926
C4	\$ 238	\$ 0	\$ 238	\$ 470	\$ -231	\$ 695

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1220	\$ 0	\$ 1220	\$ 538	\$ 682	\$ 682
B4	\$ 418	\$ 0	\$ 418	\$ 101	\$ 317	\$ 999
C4	\$ 250	\$ 0	\$ 250	\$ 470	\$ -219	\$ 779

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 2425	\$ 0	\$ 2425	\$ 538	\$ 1887	\$ 1887
B4	\$ 832	\$ 0	\$ 832	\$ 101	\$ 731	\$ 2618
C4	\$ 497	\$ 0	\$ 497	\$ 470	\$ 27	\$ 2645

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1311	\$ 0	\$ 1311	\$ 538	\$ 773	\$ 773
B4	\$ 449	\$ 0	\$ 449	\$ 101	\$ 348	\$ 1121
C4	\$ 268	\$ 0	\$ 268	\$ 470	\$ -201	\$ 920



HUD3

JACKSONVILLE FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.608	32.704
CORES FILLED	.141	\$ 538	2.026	32.704
B4	.104	\$ 639	1.538	32.704
C4	.082	\$ 1109	1.368	32.704

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.581	.000
B4	.037	\$ 101	.489	.000
C4	.022	\$ 470	.169	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PwF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 159	\$ 0	\$ 159	\$ 538	\$ -378	\$ -378
B4	\$ 49	\$ 0	\$ 49	\$ 101	\$ -51	\$ -430
C4	\$ 17	\$ 0	\$ 17	\$ 470	\$ -452	\$ -683

OIL FURNACE @ \$ .490/GALLON : PwF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 183	\$ 0	\$ 183	\$ 538	\$ -354	\$ -354
B4	\$ 56	\$ 0	\$ 56	\$ 101	\$ -44	\$ -398
C4	\$ 19	\$ 0	\$ 19	\$ 470	\$ -450	\$ -848

ELECTRIC FURNACE @ \$ .035/KWH : PwF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 299	\$ 0	\$ 299	\$ 538	\$ -238	\$ -238
B4	\$ 92	\$ 0	\$ 92	\$ 101	\$ -8	\$ -246
C4	\$ 32	\$ 0	\$ 32	\$ 470	\$ -437	\$ -684

HEAT PUMP @ \$ .035/KWH : PwF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 130	\$ 0	\$ 130	\$ 538	\$ -407	\$ -407
B4	\$ 40	\$ 0	\$ 40	\$ 101	\$ -60	\$ -468
C4	\$ 13	\$ 0	\$ 13	\$ 470	\$ -456	\$ -924

HUD3

MADISON WISCONSIN 1200 SQ FT HOUSE 8 IN BLOCK (PERLITE FILLED)  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	49.664	5.363
CORES FILLED	.141	\$ 538	35.556	5.363
B4	.104	\$ 639	30.725	5.363
C4	.082	\$1109	27.859	5.363
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	14.108	.000
B4	.037	\$ 101	4.831	.000
C4	.022	\$ 470	2.866	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1447	\$ 0	\$ 1447	\$ 538	\$ 909	\$ 909
B4	\$ 495	\$ 0	\$ 495	\$ 101	\$ 394	\$ 1303
C4	\$ 294	\$ 0	\$ 294	\$ 470	\$ -175	\$ 1128

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1554	\$ 0	\$ 1554	\$ 538	\$ 1016	\$ 1016
B4	\$ 532	\$ 0	\$ 532	\$ 101	\$ 431	\$ 1448
C4	\$ 315	\$ 0	\$ 315	\$ 470	\$ -154	\$ 1294

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 3011	\$ 0	\$ 3011	\$ 538	\$ 2473	\$ 2473
B4	\$ 1031	\$ 0	\$ 1031	\$ 101	\$ 930	\$ 3404
C4	\$ 611	\$ 0	\$ 611	\$ 470	\$ 141	\$ 3545

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1943	\$ 0	\$ 1943	\$ 538	\$ 1405	\$ 1405
B4	\$ 665	\$ 0	\$ 665	\$ 101	\$ 564	\$ 1969
C4	\$ 394	\$ 0	\$ 394	\$ 470	\$ -75	\$ 1894

HUD3

PHOENIX ARIZONA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.055	42.003
CORES FILLED	.141	\$ 538	2.233	42.003
B4	.104	\$ 639	1.680	42.003
C4	.082	\$ 1109	1.514	42.003
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.822	.000
B4	.037	\$ 101	.553	.000
C4	.022	\$ 470	.166	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 168	\$ 0	\$ 168	\$ 538	\$ -369	\$ -369
B4	\$ 51	\$ 0	\$ 51	\$ 101	\$ -49	\$ -419
C4	\$ 15	\$ 0	\$ 15	\$ 470	\$ -454	\$ -873

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 205	\$ 0	\$ 205	\$ 538	\$ -332	\$ -332
B4	\$ 62	\$ 0	\$ 62	\$ 101	\$ -38	\$ -370
C4	\$ 18	\$ 0	\$ 18	\$ 470	\$ -451	\$ -822

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 455	\$ 0	\$ 455	\$ 538	\$ -82	\$ -82
B4	\$ 138	\$ 0	\$ 138	\$ 101	\$ 37	\$ -45
C4	\$ 41	\$ 0	\$ 41	\$ 470	\$ -428	\$ -473

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 197	\$ 0	\$ 197	\$ 538	\$ -340	\$ -340
B4	\$ 60	\$ 0	\$ 60	\$ 101	\$ -40	\$ -380
C4	\$ 18	\$ 0	\$ 18	\$ 470	\$ -451	\$ -832

HUD3

TAMPA FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
EASE CASE	.249	\$ 0	.854	38.162
CORES FILLED	.141	\$ 538	.415	38.162
E4	.104	\$ 639	.281	38.162
C4	.082	\$ 1109	.239	38.162

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	.439	.000
E4	.037	\$ 101	.134	.000
C4	.022	\$ 470	.042	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 44	\$ 0	\$ 44	\$ 538	\$ -493	\$ -493
E4	\$ 13	\$ 0	\$ 13	\$ 101	\$ -87	\$ -581
C4	\$ 4	\$ 0	\$ 4	\$ 470	\$ -465	\$ -1047

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 51	\$ 0	\$ 51	\$ 538	\$ -486	\$ -486
E4	\$ 15	\$ 0	\$ 15	\$ 101	\$ -85	\$ -572
C4	\$ 4	\$ 0	\$ 4	\$ 470	\$ -465	\$ -1037

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 83	\$ 0	\$ 83	\$ 538	\$ -454	\$ -454
E4	\$ 25	\$ 0	\$ 25	\$ 101	\$ -75	\$ -530
C4	\$ 7	\$ 0	\$ 7	\$ 470	\$ -462	\$ -992

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 36	\$ 0	\$ 36	\$ 538	\$ -501	\$ -501
E4	\$ 11	\$ 0	\$ 11	\$ 101	\$ -89	\$ -591
C4	\$ 3	\$ 0	\$ 3	\$ 470	\$ -466	\$ -1058

HUD3

WASHINGTON D.C. 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.035	15.674
CORES FILLED	.141	\$ 538	14.589	15.674
E4	.104	\$ 639	12.058	15.674
C4	.082	\$ 1109	10.603	15.674
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	7.446	.000
E4	.037	\$ 101	2.531	.000
C4	.022	\$ 470	1.455	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .270/THERM : PWF = 27.860  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 756	\$ 0	\$ 756	\$ 538	\$ 218	\$ 218
E4	\$ 257	\$ 0	\$ 257	\$ 101	\$ 156	\$ 375
C4	\$ 147	\$ 0	\$ 147	\$ 470	\$ -322	\$ 53

OIL FURNACE @ \$ .500/GALLON : PWF = 25.324  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 863	\$ 0	\$ 863	\$ 538	\$ 325	\$ 325
E4	\$ 293	\$ 0	\$ 293	\$ 101	\$ 192	\$ 517
C4	\$ 168	\$ 0	\$ 168	\$ 470	\$ -301	\$ 216

ELECTRIC FURNACE @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 1887	\$ 0	\$ 1887	\$ 538	\$ 1349	\$ 1349
E4	\$ 641	\$ 0	\$ 641	\$ 101	\$ 540	\$ 1889
C4	\$ 368	\$ 0	\$ 368	\$ 470	\$ -101	\$ 1788

HEAT PUMP @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 920	\$ 0	\$ 920	\$ 538	\$ 382	\$ 382
E4	\$ 312	\$ 0	\$ 312	\$ 101	\$ 211	\$ 594
C4	\$ 179	\$ 0	\$ 179	\$ 470	\$ -290	\$ 304

HUD4

ALBUQUERQUE NEW MEXICO 1200 SQ FT HOUSE 8 IN BLOCK (PERLITE FILLED)  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.407	13.006
CORES FILLED	.141	\$ 538	14.749	13.006
B4	.104	\$ 639	12.186	13.006
D4	.099	\$ 908	11.871	13.006
F5	.071	\$1076	10.137	13.006

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	7.658	.000
B4	.037	\$ 101	2.563	.000
D4	.005	\$ 269	.315	.000
F5	.028	\$ 168	1.734	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .180/THERM : PWF = 25.626  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 464	\$ 0	\$ 464	\$ 538	\$ -73	\$ -73
B4	\$ 155	\$ 0	\$ 155	\$ 101	\$ 54	\$ -18
D4	\$ 19	\$ 0	\$ 19	\$ 269	\$ -249	\$ -268
F5	\$ 105	\$ 0	\$ 105	\$ 168	\$ -62	\$ -331

GIL FURNACE @ \$ .470/GALLON : PWF = 25.785  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 849	\$ 0	\$ 849	\$ 538	\$ 311	\$ 311
B4	\$ 284	\$ 0	\$ 284	\$ 101	\$ 183	\$ 494
D4	\$ 34	\$ 0	\$ 34	\$ 269	\$ -234	\$ 260
F5	\$ 192	\$ 0	\$ 192	\$ 168	\$ 24	\$ 285

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 1561	\$ 0	\$ 1561	\$ 538	\$ 1023	\$ 1023
B4	\$ 522	\$ 0	\$ 522	\$ 101	\$ 421	\$ 1444
D4	\$ 64	\$ 0	\$ 64	\$ 269	\$ -204	\$ 1239
F5	\$ 353	\$ 0	\$ 353	\$ 168	\$ 185	\$ 1425

HEAT PUMP @ \$ .035/KWH : PWF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 761	\$ 0	\$ 761	\$ 538	\$ 223	\$ 223
B4	\$ 254	\$ 0	\$ 254	\$ 101	\$ 153	\$ 377
D4	\$ 31	\$ 0	\$ 31	\$ 269	\$ -237	\$ 139
F5	\$ 172	\$ 0	\$ 172	\$ 168	\$ 4	\$ 144

HUD4

ATLANTA GEORGIA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	17.144	16.800
CORES FILLED	.141	\$ 538	12.134	16.800
B4	.104	\$ 639	10.461	16.800
D4	.099	\$ 908	10.257	16.800
F5	.071	\$ 1076	9.141	16.800

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	5.010	.000
B4	.037	\$ 101	1.673	.000
D4	.005	\$ 269	.204	.000
F5	.028	\$ 168	1.116	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 457	\$ 0	\$ 457	\$ 538	\$ -80	\$ -80
B4	\$ 152	\$ 0	\$ 152	\$ 101	\$ 51	\$ -28
D4	\$ 18	\$ 0	\$ 18	\$ 269	\$ -250	\$ -278
F5	\$ 101	\$ 0	\$ 101	\$ 168	\$ -66	\$ -345

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 582	\$ 0	\$ 582	\$ 538	\$ 44	\$ 44
B4	\$ 194	\$ 0	\$ 194	\$ 101	\$ 93	\$ 138
D4	\$ 23	\$ 0	\$ 23	\$ 269	\$ -245	\$ -107
F5	\$ 129	\$ 0	\$ 129	\$ 168	\$ -38	\$ -145

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 949	\$ 0	\$ 949	\$ 538	\$ 411	\$ 411
B4	\$ 317	\$ 0	\$ 317	\$ 101	\$ 216	\$ 627
D4	\$ 38	\$ 0	\$ 38	\$ 269	\$ -230	\$ 397
F5	\$ 211	\$ 0	\$ 211	\$ 168	\$ 43	\$ 440

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 441	\$ 0	\$ 441	\$ 538	\$ -96	\$ -96
B4	\$ 147	\$ 0	\$ 147	\$ 101	\$ 46	\$ -49
D4	\$ 17	\$ 0	\$ 17	\$ 269	\$ -251	\$ -300
F5	\$ 98	\$ 0	\$ 98	\$ 168	\$ -69	\$ -370

HUD4

INDIANAPOLIS INDIANA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	42.110	10.652
CORES FILLED	.141	\$ 538	30.748	10.652
B4	.104	\$ 639	26.851	10.652
D4	.099	\$ 908	26.321	10.652
F5	.071	\$ 1076	23.371	10.652

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	11.362	.000
B4	.037	\$ 101	3.897	.000
D4	.005	\$ 269	.529	.000
F5	.028	\$ 168	2.950	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 1165	\$ 0	\$ 1165	\$ 538	\$ 627	\$ 627
B4	\$ 399	\$ 0	\$ 399	\$ 101	\$ 298	\$ 926
D4	\$ 54	\$ 0	\$ 54	\$ 269	\$ -214	\$ 711
F5	\$ 302	\$ 0	\$ 302	\$ 168	\$ 134	\$ 846

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 1220	\$ 0	\$ 1220	\$ 538	\$ 682	\$ 682
B4	\$ 418	\$ 0	\$ 418	\$ 101	\$ 317	\$ 999
D4	\$ 56	\$ 0	\$ 56	\$ 269	\$ -212	\$ 787
F5	\$ 316	\$ 0	\$ 316	\$ 168	\$ 148	\$ 936

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 2425	\$ 0	\$ 2425	\$ 538	\$ 1887	\$ 1887
B4	\$ 832	\$ 0	\$ 832	\$ 101	\$ 731	\$ 2618
D4	\$ 112	\$ 0	\$ 112	\$ 269	\$ -156	\$ 2462
F5	\$ 629	\$ 0	\$ 629	\$ 168	\$ 461	\$ 2924

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
CORES FILLED	\$ 1311	\$ 0	\$ 1311	\$ 538	\$ 773	\$ 773
B4	\$ 449	\$ 0	\$ 449	\$ 101	\$ 348	\$ 1121
D4	\$ 61	\$ 0	\$ 61	\$ 269	\$ -207	\$ 913
F5	\$ 340	\$ 0	\$ 340	\$ 168	\$ 172	\$ 1086



HUD4

JACKSONVILLE FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.608	32.704
CORES FILLED	.141	\$ 538	2.026	32.704
B4	.104	\$ 639	1.538	32.704
D4	.099	\$ 908	1.499	32.704
F5	.071	\$ 1076	1.296	32.704

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.581	.000
B4	.037	\$ 101	.489	.000
D4	.005	\$ 269	.038	.000
F5	.028	\$ 168	.203	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 159	\$ 0	\$ 159	\$ 538	\$ -378	\$ -378
B4	\$ 49	\$ 0	\$ 49	\$ 101	\$ -51	\$ -430
D4	\$ 3	\$ 0	\$ 3	\$ 269	\$ -265	\$ -695
F5	\$ 20	\$ 0	\$ 20	\$ 168	\$ -147	\$ -843

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 183	\$ 0	\$ 183	\$ 538	\$ -354	\$ -354
B4	\$ 56	\$ 0	\$ 56	\$ 101	\$ -44	\$ -398
D4	\$ 4	\$ 0	\$ 4	\$ 269	\$ -264	\$ -662
F5	\$ 23	\$ 0	\$ 23	\$ 168	\$ -144	\$ -807

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 299	\$ 0	\$ 299	\$ 538	\$ -238	\$ -238
B4	\$ 92	\$ 0	\$ 92	\$ 101	\$ -8	\$ -246
D4	\$ 7	\$ 0	\$ 7	\$ 269	\$ -261	\$ -508
F5	\$ 38	\$ 0	\$ 38	\$ 168	\$ -129	\$ -637

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 130	\$ 0	\$ 130	\$ 538	\$ -407	\$ -407
B4	\$ 40	\$ 0	\$ 40	\$ 101	\$ -60	\$ -468
D4	\$ 3	\$ 0	\$ 3	\$ 269	\$ -265	\$ -734
F5	\$ 16	\$ 0	\$ 16	\$ 168	\$ -151	\$ -885

HUD4

MADISON WISCONSIN 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	49.664	5.363
CORES FILLED	.141	\$ 538	35.556	5.363
B4	.104	\$ 639	30.725	5.363
D4	.099	\$ 908	30.074	5.363
F5	.071	\$ 1076	26.440	5.363

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	14.108	.000
B4	.037	\$ 101	4.831	.000
D4	.005	\$ 269	.651	.000
F5	.028	\$ 168	3.633	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
CORES FILLED	\$ 1447	\$ 0	\$ 1447	\$ 538	\$ 909	\$ 909
B4	\$ 495	\$ 0	\$ 495	\$ 101	\$ 394	\$ 1303
D4	\$ 66	\$ 0	\$ 66	\$ 269	\$ -202	\$ 1101
F5	\$ 372	\$ 0	\$ 372	\$ 168	\$ 204	\$ 1306

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
CORES FILLED	\$ 1554	\$ 0	\$ 1554	\$ 538	\$ 1016	\$ 1016
B4	\$ 532	\$ 0	\$ 532	\$ 101	\$ 431	\$ 1448
D4	\$ 71	\$ 0	\$ 71	\$ 269	\$ -197	\$ 1251
F5	\$ 400	\$ 0	\$ 400	\$ 168	\$ 232	\$ 1483

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
CORES FILLED	\$ 3011	\$ 0	\$ 3011	\$ 538	\$ 2473	\$ 2473
B4	\$ 1031	\$ 0	\$ 1031	\$ 101	\$ 930	\$ 3404
D4	\$ 139	\$ 0	\$ 139	\$ 269	\$ -129	\$ 3274
F5	\$ 775	\$ 0	\$ 775	\$ 168	\$ 607	\$ 3881

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
CORES FILLED	\$ 1943	\$ 0	\$ 1943	\$ 538	\$ 1405	\$ 1405
B4	\$ 665	\$ 0	\$ 665	\$ 101	\$ 564	\$ 1969
D4	\$ 89	\$ 0	\$ 89	\$ 269	\$ -179	\$ 1790
F5	\$ 500	\$ 0	\$ 500	\$ 168	\$ 332	\$ 2122

HUD4

PHOENIX ARIZONA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.055	42.003
CORES FILLED	.141	\$ 538	2.233	42.003
B4	.104	\$ 639	1.680	42.003
D4	.099	\$ 908	1.642	42.003
F5	.071	\$ 1076	1.445	42.003

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.822	.000
B4	.037	\$ 101	.553	.000
D4	.005	\$ 269	.038	.000
F5	.028	\$ 168	.197	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 168	\$ 0	\$ 168	\$ 538	\$ -369	\$ -369
B4	\$ 51	\$ 0	\$ 51	\$ 101	\$ -49	\$ -419
D4	\$ 3	\$ 0	\$ 3	\$ 269	\$ -265	\$ -684
F5	\$ 18	\$ 0	\$ 18	\$ 168	\$ -149	\$ -834

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 205	\$ 0	\$ 205	\$ 538	\$ -332	\$ -332
B4	\$ 62	\$ 0	\$ 62	\$ 101	\$ -38	\$ -370
D4	\$ 4	\$ 0	\$ 4	\$ 269	\$ -264	\$ -635
F5	\$ 22	\$ 0	\$ 22	\$ 168	\$ -145	\$ -781

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 455	\$ 0	\$ 455	\$ 538	\$ -82	\$ -82
B4	\$ 138	\$ 0	\$ 138	\$ 101	\$ -37	\$ -45
D4	\$ 9	\$ 0	\$ 9	\$ 269	\$ -259	\$ -304
F5	\$ 49	\$ 0	\$ 49	\$ 168	\$ -118	\$ -423

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 197	\$ 0	\$ 197	\$ 538	\$ -340	\$ -340
B4	\$ 60	\$ 0	\$ 60	\$ 101	\$ -40	\$ -380
D4	\$ 4	\$ 0	\$ 4	\$ 269	\$ -264	\$ -645
F5	\$ 21	\$ 0	\$ 21	\$ 168	\$ -146	\$ -792

HUD4

TAMPA FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.854	38.162
CORES FILLED	.141	\$ 538	.415	38.162
B4	.104	\$ 239	.281	38.162
D4	.099	\$ 906	.271	38.162
F5	.071	\$ 1076	.223	38.162

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	.439	.000
B4	.037	\$ 101	.134	.000
D4	.005	\$ 269	.010	.000
F5	.028	\$ 168	.048	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 44	\$ 0	\$ 44	\$ 538	\$ -403	\$ -403	
B4	\$ 13	\$ 0	\$ 13	\$ 101	\$ -87	\$ -581	
D4	\$ 0	\$ 0	\$ 0	\$ 269	\$ -268	\$ -849	
F5	\$ 4	\$ 0	\$ 4	\$ 168	\$ -163	\$ -1012	

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 51	\$ 0	\$ 51	\$ 538	\$ -486	\$ -486	
B4	\$ 15	\$ 0	\$ 15	\$ 101	\$ -85	\$ -572	
D4	\$ 1	\$ 0	\$ 1	\$ 269	\$ -267	\$ -840	
F5	\$ 5	\$ 0	\$ 5	\$ 168	\$ -162	\$ -1002	

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 83	\$ 0	\$ 83	\$ 538	\$ -454	\$ -454	
B4	\$ 25	\$ 0	\$ 25	\$ 101	\$ -75	\$ -530	
D4	\$ 1	\$ 0	\$ 1	\$ 269	\$ -267	\$ -797	
F5	\$ 9	\$ 0	\$ 9	\$ 168	\$ -158	\$ -956	

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 36	\$ 0	\$ 36	\$ 538	\$ -501	\$ -501	
B4	\$ 11	\$ 0	\$ 11	\$ 101	\$ -89	\$ -591	
D4	\$ 0	\$ 0	\$ 0	\$ 269	\$ -268	\$ -859	
F5	\$ 3	\$ 0	\$ 3	\$ 168	\$ -164	\$ -1024	

HUD4

WASHINGTON D.C. 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	22.035	15.674
CORES FILLED	.141	\$ 538	14.589	15.674
B4	.104	\$ 639	12.058	15.674
D4	.099	\$ 908	11.726	15.674
F5	.071	\$ 1076	9.904	15.674

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	7.446	.000
B4	.037	\$ 101	2.531	.000
D4	.005	\$ 269	.332	.000
F5	.028	\$ 168	1.822	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .270/THERM : PWF = 27.860  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 756	\$ 0	\$ 756		\$ 538	\$ 218	\$ 218
B4	\$ 257	\$ 0	\$ 257		\$ 101	\$ 156	\$ 375
D4	\$ 33	\$ 0	\$ 33		\$ 269	\$ -235	\$ 139
F5	\$ 185	\$ 0	\$ 185		\$ 168	\$ 17	\$ 157

OIL FURNACE @ \$ .500/GALLON : PWF = 25.324  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 863	\$ 0	\$ 863		\$ 538	\$ 325	\$ 325
B4	\$ 293	\$ 0	\$ 293		\$ 101	\$ 192	\$ 517
D4	\$ 38	\$ 0	\$ 38		\$ 269	\$ -230	\$ 286
F5	\$ 211	\$ 0	\$ 211		\$ 168	\$ 43	\$ 330

ELECTRIC FURNACE @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 1887	\$ 0	\$ 1887		\$ 538	\$ 1349	\$ 1349
B4	\$ 641	\$ 0	\$ 641		\$ 101	\$ 540	\$ 1889
D4	\$ 84	\$ 0	\$ 84		\$ 269	\$ -184	\$ 1704
F5	\$ 461	\$ 0	\$ 461		\$ 168	\$ 293	\$ 1998

HEAT PUMP @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 920	\$ 0	\$ 920		\$ 538	\$ 382	\$ 382
B4	\$ 312	\$ 0	\$ 312		\$ 101	\$ 211	\$ 594
D4	\$ 40	\$ 0	\$ 40		\$ 269	\$ -228	\$ 366
F5	\$ 225	\$ 0	\$ 225		\$ 168	\$ 57	\$ 423

HUD5

ALBUQUERQUE NEW MEXICO 1200 SQ FT HOUSE WOOD FRAME WALL  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	20.869	14.517
R-11	.082	\$ 213	11.386	14.517
R-13	.076	\$ 280	10.966	14.517
R-19	.055	\$ 504	9.482	14.517

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	9.483	.000
R-13	.006	\$ 67	.420	.000
R-19	.021	\$ 224	1.483	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .180/THERM : PwF = 25.626  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 575	\$ 0	\$ 575	\$ 213	\$ 362	\$ 362
R-13	\$ 25	\$ 0	\$ 25	\$ 67	\$ -41	\$ 321
R-19	\$ 90	\$ 0	\$ 90	\$ 224	\$ -133	\$ 187

OIL FURNACE @ \$ .470/GALLON : PwF = 25.785  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 1051	\$ 0	\$ 1 51	\$ 213	\$ 838	\$ 838
R-13	\$ 46	\$ 0	\$ 46	\$ 67	\$ -20	\$ 818
R-19	\$ 164	\$ 0	\$ 164	\$ 224	\$ -59	\$ 759

ELECTRIC FURNACE @ \$ .035/KWH : PwF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 1933	\$ 0	\$ 1933	\$ 213	\$ 1720	\$ 1720
R-13	\$ 85	\$ 0	\$ 85	\$ 67	\$ 18	\$ 1738
R-19	\$ 302	\$ 0	\$ 302	\$ 224	\$ 78	\$ 1817

HEAT PUMP @ \$ .035/KWH : PwF = 19.878  
 ELECTRIC AIR COND. @ \$ .035/KWH : PwF = 19.878

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 942	\$ 0	\$ 942	\$ 213	\$ 729	\$ 729
R-13	\$ 41	\$ 0	\$ 41	\$ 67	\$ -25	\$ 704
R-19	\$ 147	\$ 0	\$ 147	\$ 224	\$ -76	\$ 628

HUDS

ATLANTA GEORGIA WOOD FRAME WALL  
 1200. SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	16.266	17.889
R-11	.082	\$ 213	10.101	17.889
R-13	.076	\$ 280	9.826	17.889
R-19	.055	\$ 504	8.841	17.889

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	6.165	.000
R-13	.006	\$ 67	.275	.000
R-19	.021	\$ 224	.985	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 563	\$ 0	\$ 563	\$ 213	\$ 350	\$ 350
R-13	\$ 25	\$ 0	\$ 25	\$ 67	\$ -41	\$ 308
R-19	\$ 89	\$ 0	\$ 89	\$ 224	\$ -134	\$ 174

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 717	\$ 0	\$ 717	\$ 213	\$ 504	\$ 504
R-13	\$ 32	\$ 0	\$ 32	\$ 67	\$ -34	\$ 469
R-19	\$ 114	\$ 0	\$ 114	\$ 224	\$ -109	\$ 359

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 1168	\$ 0	\$ 1168	\$ 213	\$ 955	\$ 955
R-13	\$ 52	\$ 0	\$ 52	\$ 67	\$ -14	\$ 940
R-19	\$ 186	\$ 0	\$ 186	\$ 224	\$ -37	\$ 903

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 543	\$ 0	\$ 543	\$ 213	\$ 330	\$ 330
R-13	\$ 24	\$ 0	\$ 24	\$ 67	\$ -42	\$ 287
R-19	\$ 86	\$ 0	\$ 86	\$ 224	\$ -137	\$ 150

HUD5

INDIANAPOLIS INDIANA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	39.155	11.451
R-11	.082	\$ 213	24.810	11.451
R-13	.076	\$ 280	24.170	11.451
R-19	.055	\$ 504	21.882	11.451

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	14.345	.000
R-13	.006	\$ 67	.640	.000
R-19	.021	\$ 224	2.288	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
R-11	\$ 1471	\$ 0	\$ 1471	\$ 213	\$ 1258	\$ 1258	
R-13	\$ 65	\$ 0	\$ 65	\$ 67	\$ -1	\$ 1257	
R-19	\$ 234	\$ 0	\$ 234	\$ 224	\$ 10	\$ 1268	

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
R-11	\$ 1540	\$ 0	\$ 1540	\$ 213	\$ 1327	\$ 1327	
R-13	\$ 68	\$ 0	\$ 68	\$ 67	\$ 1	\$ 1329	
R-19	\$ 245	\$ 0	\$ 245	\$ 224	\$ 21	\$ 1350	

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
R-11	\$ 3062	\$ 0	\$ 3062	\$ 213	\$ 2849	\$ 2849	
R-13	\$ 136	\$ 0	\$ 136	\$ 67	\$ 69	\$ 2919	
R-19	\$ 488	\$ 0	\$ 488	\$ 224	\$ 264	\$ 3183	

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
R-11	\$ 1655	\$ 0	\$ 1655	\$ 213	\$ 1442	\$ 1442	
R-13	\$ 73	\$ 0	\$ 73	\$ 67	\$ 6	\$ 1449	
R-19	\$ 264	\$ 0	\$ 264	\$ 224	\$ 40	\$ 1489	



HUD5

JACKSONVILLE FLORIDA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	3.721	33.837
R-11	.082	\$ 213	1.752	33.837
R-13	.076	\$ 280	1.668	33.837
R-19	.055	\$ 504	1.393	33.837

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	1.969	.000
R-13	.006	\$ 67	.084	.000
R-19	.021	\$ 224	.275	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 198	\$ 0	\$ 198	\$ 213	\$ -14	\$ -14
R-13	\$ 8	\$ 0	\$ 8	\$ 67	\$ -58	\$ -73
R-19	\$ 27	\$ 0	\$ 27	\$ 224	\$ -196	\$ -269

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 229	\$ 0	\$ 229	\$ 213	\$ 16	\$ 16
R-13	\$ 9	\$ 0	\$ 9	\$ 67	\$ -57	\$ -41
R-19	\$ 32	\$ 0	\$ 32	\$ 224	\$ -191	\$ -233

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 373	\$ 0	\$ 373	\$ 213	\$ 160	\$ 160
R-13	\$ 15	\$ 0	\$ 15	\$ 67	\$ -51	\$ 109
R-19	\$ 52	\$ 0	\$ 52	\$ 224	\$ -171	\$ -62

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 162	\$ 0	\$ 162	\$ 213	\$ -50	\$ -50
R-13	\$ 6	\$ 0	\$ 6	\$ 67	\$ -60	\$ -110
R-19	\$ 22	\$ 0	\$ 22	\$ 224	\$ -201	\$ -312

HUD5

MADISON WISCONSIN WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	46.100	6.381
R-11	.082	\$ 213	28.236	6.381
R-13	.076	\$ 280	27.440	6.381
R-19	.055	\$ 504	24.604	6.381
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	17.863	.000
R-13	.006	\$ 67	.796	.000
R-19	.021	\$ 224	2.837	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 1832	\$ 0	\$ 1832	\$ 213	\$ 1619	\$ 1619
R-13	\$ 81	\$ 0	\$ 81	\$ 67	\$ 14	\$ 1634
R-19	\$ 291	\$ 0	\$ 291	\$ 224	\$ 67	\$ 1701

GIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 1968	\$ 0	\$ 1968	\$ 213	\$ 1755	\$ 1755
R-13	\$ 87	\$ 0	\$ 87	\$ 67	\$ 20	\$ 1776
R-19	\$ 312	\$ 0	\$ 312	\$ 224	\$ 88	\$ 1865

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 3813	\$ 0	\$ 3813	\$ 213	\$ 3600	\$ 3600
R-13	\$ 169	\$ 0	\$ 169	\$ 67	\$ 102	\$ 3703
R-19	\$ 605	\$ 0	\$ 605	\$ 224	\$ 381	\$ 4084

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 2460	\$ 0	\$ 2460	\$ 213	\$ 2247	\$ 2247
R-13	\$ 109	\$ 0	\$ 109	\$ 67	\$ 42	\$ 2289
R-19	\$ 390	\$ 0	\$ 390	\$ 224	\$ 166	\$ 2456

HUD5

PHOENIX ARIZONA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	4.479	43.617
R-11	.082	\$ 213	2.079	43.617
R-13	.076	\$ 280	1.975	43.617
R-19	.055	\$ 504	1.625	43.617

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	2.400	.000
R-13	.006	\$ 67	.104	.000
R-19	.021	\$ 224	.350	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 222	\$ 0	\$ 222	\$ 213	\$ 9	\$ 9
R-13	\$ 9	\$ 0	\$ 9	\$ 67	\$ -57	\$ -48
R-19	\$ 32	\$ 0	\$ 32	\$ 224	\$ -191	\$ -239

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 270	\$ 0	\$ 270	\$ 213	\$ 57	\$ 57
R-13	\$ 11	\$ 0	\$ 11	\$ 67	\$ -55	\$ 2
R-19	\$ 39	\$ 0	\$ 39	\$ 224	\$ -184	\$ -181

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 599	\$ 0	\$ 599	\$ 213	\$ 386	\$ 386
R-13	\$ 25	\$ 0	\$ 25	\$ 67	\$ -41	\$ 345
R-19	\$ 87	\$ 0	\$ 87	\$ 224	\$ -136	\$ 209

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 260	\$ 0	\$ 260	\$ 213	\$ 47	\$ 47
R-13	\$ 11	\$ 0	\$ 11	\$ 67	\$ -55	\$ -7
R-19	\$ 38	\$ 0	\$ 38	\$ 224	\$ -185	\$ -193

HUD5

TAMPA FLORIDA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	.882	39.031
R-11	.082	\$ 213	.349	39.031
R-13	.076	\$ 280	.326	39.031
R-19	.055	\$ 504	.244	39.031

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	.532	.000
R-13	.006	\$ 67	.023	.000
R-19	.021	\$ 224	.082	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 53	\$ 0	\$ 53	\$ 213	\$ -159	\$ -159
R-13	\$ 2	\$ 0	\$ 2	\$ 67	\$ -64	\$ -224
R-19	\$ 8	\$ 0	\$ 8	\$ 224	\$ -215	\$ -439

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 61	\$ 0	\$ 61	\$ 213	\$ -151	\$ -151
R-13	\$ 2	\$ 0	\$ 2	\$ 67	\$ -64	\$ -215
R-19	\$ 9	\$ 0	\$ 9	\$ 224	\$ -214	\$ -429

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 100	\$ 0	\$ 100	\$ 213	\$ -112	\$ -112
R-13	\$ 4	\$ 0	\$ 4	\$ 67	\$ -62	\$ -174
R-19	\$ 15	\$ 0	\$ 15	\$ 224	\$ -208	\$ -383

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 43	\$ 0	\$ 43	\$ 213	\$ -169	\$ -169
R-13	\$ 1	\$ 0	\$ 1	\$ 67	\$ -65	\$ -234
R-19	\$ 6	\$ 0	\$ 6	\$ 224	\$ -217	\$ -451

HUD5

WASHINGTON D.C. WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	20.155	16.265
R-11	.082	\$ 213	10.910	16.265
R-13	.076	\$ 280	10.504	16.265
R-19	.055	\$ 504	9.088	16.265

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	9.244	.000
R-13	.006	\$ 67	407	.000
R-19	.021	\$ 224	1.415	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .270/THERM : PWF = 27.860  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
R-11	\$ 939	\$ 0	\$ 939	\$ 213	\$ 726	\$ 726
R-13	\$ 41	\$ 0	\$ 41	\$ 67	\$ -25	\$ 701
R-19	\$ 143	\$ 0	\$ 143	\$ 224	\$ -80	\$ 620

OIL FURNACE @ \$ .500/GALLON : PWF = 25.324  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
R-11	\$ 1071	\$ 0	\$ 1071	\$ 213	\$ 858	\$ 858
R-13	\$ 47	\$ 0	\$ 47	\$ 67	\$ -19	\$ 838
R-19	\$ 164	\$ 0	\$ 164	\$ 224	\$ -59	\$ 778

ELECTRIC FURNACE @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
R-11	\$ 2343	\$ 0	\$ 2343	\$ 213	\$ 2130	\$ 2130
R-13	\$ 103	\$ 0	\$ 103	\$ 67	\$ 36	\$ 2166
R-19	\$ 358	\$ 0	\$ 358	\$ 224	\$ 134	\$ 2300

HEAT PUMP @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INCREMENTAL						CUMULATIVE
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	NET SAVINGS
R-11	\$ 1142	\$ 0	\$ 1142	\$ 213	\$ 929	\$ 929
R-13	\$ 50	\$ 0	\$ 50	\$ 67	\$ -16	\$ 913
R-19	\$ 175	\$ 0	\$ 175	\$ 224	\$ -48	\$ 864



APPENDIX B

Computer Printouts of Economic Analyses  
for Tampa, Phoenix and Jacksonville --  
for Cooling Savings Based on Windows Closed

HUD1

JACKSONVILLE FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.593	32.665
B3	.153	\$ 101	2.380	33.177
C3	.110	\$ 571	1.905	33.566
EXTRA	.095	\$ 597	1.745	33.715

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.213	-.512
C3	.043	\$ 470	.475	-.389
EXTRA	.015	\$ 26	.160	-.150

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 122	\$ -42	\$ 79	\$ 101	\$ -21	\$ -21
C3	\$ 47	\$ -32	\$ 15	\$ 470	\$ -454	\$ -475
EXTRA	\$ 16	\$ -12	\$ 3	\$ 26	\$ -22	\$ -497

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 141	\$ -42	\$ 98	\$ 101	\$ -2	\$ -2
C3	\$ 55	\$ -32	\$ 23	\$ 470	\$ -448	\$ -448
EXTRA	\$ 18	\$ -12	\$ 6	\$ 26	\$ -19	\$ -468

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 229	\$ -42	\$ 187	\$ 101	\$ 86	\$ 86
C3	\$ 90	\$ -32	\$ 57	\$ 470	\$ -412	\$ -325
EXTRA	\$ 30	\$ -12	\$ 17	\$ 26	\$ -8	\$ -333

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 99	\$ -44	\$ 55	\$ 101	\$ -45	\$ -45
C3	\$ 39	\$ -33	\$ 5	\$ 470	\$ -464	\$ -509
EXTRA	\$ 13	\$ -12	\$ 0	\$ 26	\$ -25	\$ -535



HUD 1

PHOENIX ARIZONA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.035	42.142
B3	.153	\$ 101	2.685	40.310
C3	.110	\$ 571	2.157	39.602
EXTRA	.095	\$ 597	1.980	39.364

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.349	1.832
C3	.043	\$ 470	.528	.706
EXTRA	.015	\$ 26	.177	.237

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
B3	\$ 124	\$ 199	\$ 323	\$ 101	\$ 222	\$ 222	
C3	\$ 48	\$ 76	\$ 125	\$ 470	\$ -344	\$ -121	
EXTRA	\$ 16	\$ 25	\$ 42	\$ 26	\$ -16	\$ -105	

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
B3	\$ 152	\$ 199	\$ 351	\$ 101	\$ 250	\$ 250	
C3	\$ 59	\$ 76	\$ 136	\$ 470	\$ -333	\$ -83	
EXTRA	\$ 20	\$ 25	\$ 45	\$ 26	\$ -19	\$ -63	

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
B3	\$ 337	\$ 199	\$ 536	\$ 101	\$ 435	\$ 435	
C3	\$ 131	\$ 76	\$ 208	\$ 470	\$ -261	\$ 174	
EXTRA	\$ 44	\$ 25	\$ 70	\$ 26	\$ 44	\$ 218	

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
B3	\$ 146	\$ 208	\$ 354	\$ 101	\$ 253	\$ 253	
C3	\$ 57	\$ 80	\$ 137	\$ 470	\$ -332	\$ -78	
EXTRA	\$ 19	\$ 26	\$ 46	\$ 26	\$ -20	\$ -58	

HUD1

TAMPA FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.850	38.104
B3	.153	\$ 101	.505	38.866
C3	.110	\$ 571	.383	39.329
EXTRA	.095	\$ 597	.343	39.501

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	.345	-.762
C3	.043	\$ 470	.122	-.463
EXTRA	.015	\$ 26	.040	-.172

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 34	\$ -62	\$ -28	\$ 101	\$ -129	\$ -129
C3	\$ 12	\$ -38	\$ -25	\$ 470	\$ -495	\$ -624
EXTRA	\$ 4	\$ -14	\$ -10	\$ 26	\$ -36	\$ -661

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 40	\$ -62	\$ -22	\$ 101	\$ -123	\$ -123
C3	\$ 14	\$ -38	\$ -23	\$ 470	\$ -493	\$ -617
EXTRA	\$ 4	\$ -14	\$ -9	\$ 26	\$ -35	\$ -653

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 65	\$ -62	\$ 2	\$ 101	\$ -98	\$ -98
C3	\$ 23	\$ -38	\$ -14	\$ 470	\$ -484	\$ -583
EXTRA	\$ 7	\$ -14	\$ -6	\$ 26	\$ -32	\$ -616

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 28	\$ -65	\$ -37	\$ 101	\$ -138	\$ -138
C3	\$ 10	\$ -39	\$ -29	\$ 470	\$ -499	\$ -637
EXTRA	\$ 3	\$ -14	\$ -11	\$ 26	\$ -37	\$ -675

HUD2

JACKSONVILLE FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.593	32.665
B3	.153	\$ 101	2.380	33.177
D3	.143	\$ 370	2.256	33.236
F2	.091	\$ 538	1.703	33.755

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.213	-.512
D3	.010	\$ 269	.124	-.059
F2	.052	\$ 168	.553	-.519

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 122	\$ -42	\$ 79	\$ 101	\$ -21	\$ -21
D3	\$ 12	\$ -4	\$ 7	\$ 269	\$ -261	\$ -282
F2	\$ 55	\$ -42	\$ 12	\$ 168	\$ -155	\$ -437

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 141	\$ -42	\$ 98	\$ 101	\$ -2	\$ -2
D3	\$ 14	\$ -4	\$ 9	\$ 269	\$ -259	\$ -261
F2	\$ 64	\$ -42	\$ 21	\$ 168	\$ -146	\$ -407

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 229	\$ -42	\$ 187	\$ 101	\$ 86	\$ 86
D3	\$ 23	\$ -4	\$ 18	\$ 269	\$ -250	\$ -163
F2	\$ 104	\$ -42	\$ 62	\$ 168	\$ -105	\$ -269

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 99	\$ -44	\$ 55	\$ 101	\$ -45	\$ -45
D3	\$ 10	\$ -5	\$ 5	\$ 269	\$ -263	\$ -309
F2	\$ 45	\$ -44	\$ 0	\$ 168	\$ -167	\$ -476

HUD2

PHOENIX ARIZONA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.035	42.142
B3	.153	\$ 101	2.655	40.310
D3	.143	\$ 370	2.548	40.123
F2	.091	\$ 538	1.933	39.301

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.349	1.832
D3	.010	\$ 269	.138	.187
F2	.052	\$ 168	.615	.822

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 124	\$ 199	\$ 323	\$ 101	\$ 222	\$ 222
D3	\$ 12	\$ 20	\$ 33	\$ 269	\$ -235	\$ -13
F2	\$ 56	\$ 89	\$ 146	\$ 168	\$ -21	\$ -34

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 152	\$ 199	\$ 351	\$ 101	\$ 250	\$ 250
D3	\$ 15	\$ 20	\$ 35	\$ 269	\$ -233	\$ 17
F2	\$ 69	\$ 89	\$ 158	\$ 168	\$ -9	\$ 7

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 337	\$ 199	\$ 536	\$ 101	\$ 435	\$ 435
D3	\$ 34	\$ 20	\$ 54	\$ 269	\$ -214	\$ 220
F2	\$ 153	\$ 89	\$ 243	\$ 168	\$ 75	\$ 295

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 146	\$ 208	\$ 354	\$ 101	\$ 253	\$ 253
D3	\$ 14	\$ 21	\$ 36	\$ 269	\$ -232	\$ 20
F2	\$ 66	\$ 93	\$ 160	\$ 168	\$ -7	\$ 13

HUD2

TAMPA FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.850	38.104
B3	.153	\$ 101	.505	38.866
D3	.143	\$ 370	.471	38.950
F2	.091	\$ 538	.333	39.547
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	.345	-.762
D3	.010	\$ 269	.035	-.084
F2	.052	\$ 168	.138	-.597

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 34	\$ -62	\$ -28	\$ 101	\$ -129	\$ -129
D3	\$ 3	\$ -6	\$ -3	\$ 269	\$ -272	\$ -401
F2	\$ 13	\$ -49	\$ -35	\$ 168	\$ -203	\$ -604

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 40	\$ -62	\$ -22	\$ 101	\$ -123	\$ -123
D3	\$ 4	\$ -6	\$ -2	\$ 269	\$ -271	\$ -395
F2	\$ 16	\$ -49	\$ -33	\$ 168	\$ -201	\$ -596

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 65	\$ -62	\$ 2	\$ 101	\$ -98	\$ -98
D3	\$ 6	\$ -6	\$ 0	\$ 269	\$ -269	\$ -367
F2	\$ 26	\$ -49	\$ -23	\$ 168	\$ -191	\$ -558

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 28	\$ -65	\$ -37	\$ 101	\$ -138	\$ -138
D3	\$ 2	\$ -7	\$ -4	\$ 269	\$ -273	\$ -411
F2	\$ 11	\$ -51	\$ -40	\$ 168	\$ -208	\$ -619

HUD3

JACKSONVILLE FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.608	32.697
CORES FILLED	.141	\$ 538	2.026	32.798
B4	.104	\$ 639	1.538	32.971
C4	.082	\$ 1109	1.368	33.392

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.581	-.101
B4	.037	\$ 101	.489	-.173
C4	.022	\$ 470	.169	-.420

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 159	\$ -8	\$ 150	\$ 538	\$ -387	\$ -387
B4	\$ 49	\$ -14	\$ 34	\$ 101	\$ -66	\$ -453
C4	\$ 17	\$ -34	\$ -17	\$ 470	\$ -487	\$ -940

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 183	\$ -8	\$ 175	\$ 538	\$ -362	\$ -362
B4	\$ 56	\$ -14	\$ 42	\$ 101	\$ -58	\$ -420
C4	\$ 19	\$ -34	\$ -14	\$ 470	\$ -484	\$ -905

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 299	\$ -8	\$ 291	\$ 538	\$ -246	\$ -246
B4	\$ 92	\$ -14	\$ 78	\$ 101	\$ -22	\$ -269
C4	\$ 32	\$ -34	\$ -2	\$ 470	\$ -472	\$ -741

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 130	\$ -8	\$ 121	\$ 538	\$ -416	\$ -416
B4	\$ 40	\$ -14	\$ 25	\$ 101	\$ -75	\$ -492
C4	\$ 13	\$ -36	\$ -22	\$ 470	\$ -492	\$ -984

HUD3

PHOENIX ARIZONA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.055	42.203
CORES FILLED	.141	\$ 538	2.233	39.241
B4	.104	\$ 639	1.680	38.438
C4	.082	\$ 1109	1.514	38.445

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.822	2.962
B4	.037	\$ 101	.553	.804
C4	.022	\$ 470	.166	-.007

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 168	\$ 321	\$ 490	\$ 538	\$ -47	\$ -47
B4	\$ 51	\$ 87	\$ 138	\$ 101	\$ -37	\$ -10
C4	\$ 15	\$ 0	\$ 14	\$ 470	\$ -455	\$ -465

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 205	\$ 321	\$ 527	\$ 538	\$ -10	\$ -10
B4	\$ 62	\$ 87	\$ 149	\$ 101	\$ -48	\$ 38
C4	\$ 18	\$ 0	\$ 17	\$ 470	\$ -452	\$ -413

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 455	\$ 321	\$ 777	\$ 538	\$ 239	\$ 239
B4	\$ 138	\$ 87	\$ 225	\$ 101	\$ 124	\$ 363
C4	\$ 41	\$ 0	\$ 40	\$ 470	\$ -429	\$ -65

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 197	\$ 336	\$ 534	\$ 538	\$ -3	\$ -3
R4	\$ 60	\$ 91	\$ 151	\$ 101	\$ 50	\$ 46
C4	\$ 18	\$ 0	\$ 17	\$ 470	\$ -452	\$ -406

HUD3

TAMPA FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.854	38.133
CORES FILLED	.141	\$ 538	.415	38.568
B4	.104	\$ 639	.281	38.841
C4	.082	\$ 1109	.239	39.289
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	.439	-.435
B4	.037	\$ 101	.134	-.273
C4	.022	\$ 470	.042	-.448

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 44	\$ -35	\$ 8	\$ 538	\$ -529	\$ -529
B4	\$ 13	\$ -22	\$ -9	\$ 101	\$ -110	\$ -539
C4	\$ 4	\$ -36	\$ -32	\$ 470	\$ -502	\$ -1142

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 51	\$ -35	\$ 15	\$ 538	\$ -522	\$ -522
B4	\$ 15	\$ -22	\$ -6	\$ 101	\$ -107	\$ -630
C4	\$ 4	\$ -36	\$ -32	\$ 470	\$ -502	\$ -1132

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 83	\$ -35	\$ 47	\$ 538	\$ -490	\$ -490
B4	\$ 25	\$ -22	\$ 2	\$ 101	\$ -98	\$ -588
C4	\$ 7	\$ -36	\$ -28	\$ 470	\$ -498	\$ -1087

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 36	\$ -37	\$ -1	\$ 538	\$ -539	\$ -539
B4	\$ 11	\$ -22	\$ -12	\$ 101	\$ -113	\$ -652
C4	\$ 3	\$ -38	\$ -35	\$ 470	\$ -505	\$ -1157



HUD4

JACKSONVILLE FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.608	32.697
CORES FILLED	.141	\$ 538	2.026	32.798
B4	.104	\$ 639	1.538	32.971
D4	.099	\$ 908	1.499	33.067
F5	.071	\$ 1076	1.296	33.608

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.581	-.101
B4	.037	\$ 101	.489	-.173
D4	.005	\$ 269	.038	-.096
F5	.028	\$ 168	.203	-.541

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 159	\$ -8	\$ 150	\$ 538	\$ -387	\$ -387
B4	\$ 49	\$ -14	\$ 34	\$ 101	\$ -66	\$ -453
D4	\$ 3	\$ -7	\$ -4	\$ 269	\$ -273	\$ -726
F5	\$ 20	\$ -44	\$ -24	\$ 168	\$ -192	\$ -918

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 183	\$ -8	\$ 175	\$ 538	\$ -362	\$ -362
B4	\$ 56	\$ -14	\$ 42	\$ 101	\$ -58	\$ -420
D4	\$ 4	\$ -7	\$ -3	\$ 269	\$ -272	\$ -693
F5	\$ 23	\$ -44	\$ -20	\$ 168	\$ -188	\$ -882

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 299	\$ -8	\$ 291	\$ 538	\$ -246	\$ -246
B4	\$ 92	\$ -14	\$ 78	\$ 101	\$ -22	\$ -269
D4	\$ 7	\$ -7	\$ 0	\$ 269	\$ -269	\$ -538
F5	\$ 38	\$ -44	\$ -6	\$ 168	\$ -174	\$ -712

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 130	\$ -8	\$ 121	\$ 538	\$ -416	\$ -416
B4	\$ 40	\$ -14	\$ 25	\$ 101	\$ -75	\$ -492
D4	\$ 3	\$ -8	\$ -5	\$ 269	\$ -274	\$ -766
F5	\$ 16	\$ -46	\$ -29	\$ 168	\$ -197	\$ -963

HUD4

PHOENIX ARIZONA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.055	42.203
CORES FILLED	.141	\$ 538	2.233	39.241
B4	.104	\$ 639	1.680	38.438
D4	.099	\$ 908	1.642	38.439
F5	.071	\$ 1076	1.445	38.439

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.822	2.962
B4	.037	\$ 101	.553	.804
D4	.005	\$ 269	.038	-.002
F5	.028	\$ 168	.197	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 168	\$ 321	\$ 490	\$ 538	\$ -47	\$ -47	
B4	\$ 51	\$ 87	\$ 138	\$ 101	\$ 37	\$ -10	
D4	\$ 3	\$ 0	\$ 3	\$ 269	\$ -265	\$ -275	
F5	\$ 18	\$ 0	\$ 18	\$ 168	\$ -149	\$ -425	

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 205	\$ 321	\$ 527	\$ 538	\$ -10	\$ -10	
B4	\$ 62	\$ 87	\$ 149	\$ 101	\$ 48	\$ 38	
D4	\$ 4	\$ 0	\$ 4	\$ 269	\$ -264	\$ -226	
F5	\$ 22	\$ 0	\$ 22	\$ 168	\$ -145	\$ -372	

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 455	\$ 321	\$ 777	\$ 538	\$ 239	\$ 239	
B4	\$ 138	\$ 87	\$ 225	\$ 101	\$ 124	\$ 363	
D4	\$ 9	\$ 0	\$ 9	\$ 269	\$ -259	\$ 103	
F5	\$ 49	\$ 0	\$ 49	\$ 168	\$ -118	\$ -14	

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS				
CORES FILLED	\$ 197	\$ 336	\$ 534	\$ 538	\$ -3	\$ -3	
B4	\$ 60	\$ 91	\$ 151	\$ 101	\$ 50	\$ 46	
D4	\$ 4	\$ 0	\$ 3	\$ 269	\$ -265	\$ -218	
F5	\$ 21	\$ 0	\$ 21	\$ 168	\$ -146	\$ -364	

HUD4

TAMPA FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.854	38.133
CORES FILLED	.141	\$ 538	.415	38.566
B4	.104	\$ 639	.281	38.841
D4	.099	\$ 908	.271	38.943
F5	.071	\$ 1076	.223	39.507

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	.439	-.435
B4	.037	\$ 101	.134	-.273
D4	.005	\$ 269	.010	-.102
F5	.028	\$ 168	.048	-.564

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 44	\$ -35	\$ 8	\$ 538	\$ -529	\$ -529
B4	\$ 13	\$ -22	\$ -9	\$ 101	\$ -110	\$ -639
D4	\$ 0	\$ -8	\$ -7	\$ 269	\$ -276	\$ -916
F5	\$ 4	\$ -46	\$ -41	\$ 168	\$ -209	\$ -1125

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 51	\$ -35	\$ 15	\$ 538	\$ -522	\$ -522
B4	\$ 15	\$ -22	\$ -6	\$ 101	\$ -107	\$ -630
D4	\$ 1	\$ -8	\$ -7	\$ 269	\$ -276	\$ -906
F5	\$ 5	\$ -46	\$ -40	\$ 168	\$ -208	\$ -1115

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 83	\$ -35	\$ 47	\$ 538	\$ -490	\$ -490
B4	\$ 25	\$ -22	\$ 2	\$ 101	\$ -98	\$ -588
D4	\$ 1	\$ -8	\$ -6	\$ 269	\$ -275	\$ -864
F5	\$ 9	\$ -46	\$ -37	\$ 168	\$ -205	\$ -1069

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 36	\$ -37	\$ -1	\$ 538	\$ -539	\$ -539
B4	\$ 11	\$ -23	\$ -12	\$ 101	\$ -113	\$ -652
D4	\$ 0	\$ -8	\$ -7	\$ 269	\$ -276	\$ -929
F5	\$ 3	\$ -48	\$ -44	\$ 168	\$ -212	\$ -1142

HUD5

JACKSONVILLE FLORIDA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	3.721	33.827
R-11	.082	\$ 213	1.752	34.090
R-13	.076	\$ 280	1.668	34.111
R-19	.055	\$ 504	1.393	34.242

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	1.969	-.263
R-13	.006	\$ 67	.084	-.021
R-19	.021	\$ 224	.275	-.131

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 198	\$ -21	\$ 176	\$ 213	\$ -36	\$ -36
R-13	\$ 8	\$ -1	\$ 6	\$ 67	\$ -60	\$ -96
R-19	\$ 27	\$ -10	\$ 16	\$ 224	\$ -207	\$ -303

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 229	\$ -21	\$ 207	\$ 213	\$ -5	\$ -5
R-13	\$ 9	\$ -1	\$ 8	\$ 67	\$ -58	\$ -64
R-19	\$ 32	\$ -10	\$ 21	\$ 224	\$ -202	\$ -267

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 373	\$ -21	\$ 351	\$ 213	\$ 138	\$ 138
R-13	\$ 15	\$ -1	\$ 14	\$ 67	\$ -52	\$ 85
R-19	\$ 52	\$ -10	\$ 41	\$ 224	\$ -182	\$ -96

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 162	\$ -22	\$ 139	\$ 213	\$ -73	\$ -73
R-13	\$ 6	\$ -1	\$ 5	\$ 67	\$ -61	\$ -135
R-19	\$ 22	\$ -11	\$ 11	\$ 224	\$ -212	\$ -347

HUD5

PHOENIX ARIZONA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	4.479	43.763
R-11	.082	\$ 213	2.079	39.785
R-13	.076	\$ 280	1.975	39.614
R-19	.055	\$ 504	1.625	39.043

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	2.400	3.978
R-13	.006	\$ 67	.104	.171
R-19	.021	\$ 224	.350	.571

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 222	\$ 432	\$ 654	\$ 213	\$ 441	\$ 441
R-13	\$ 9	\$ 18	\$ 28	\$ 67	\$ -38	\$ 402
R-19	\$ 32	\$ 62	\$ 94	\$ 224	\$ -129	\$ 272

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 270	\$ 432	\$ 703	\$ 213	\$ 490	\$ 490
R-13	\$ 11	\$ 18	\$ 30	\$ 67	\$ -36	\$ 453
R-19	\$ 39	\$ 62	\$ 101	\$ 224	\$ -122	\$ 330

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 599	\$ 432	\$ 1032	\$ 213	\$ 819	\$ 819
R-13	\$ 25	\$ 18	\$ 44	\$ 67	\$ -22	\$ 796
R-19	\$ 87	\$ 62	\$ 149	\$ 224	\$ -74	\$ 722

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 260	\$ 451	\$ 712	\$ 213	\$ 499	\$ 499
R-13	\$ 11	\$ 19	\$ 30	\$ 67	\$ -36	\$ 463
R-19	\$ 38	\$ 64	\$ 102	\$ 224	\$ -121	\$ 342

HUDS

TAMPA FLORIDA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON WINDOWS CLOSED

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	.882	39.001
R-11	.082	\$ 213	.349	39.809
R-13	.076	\$ 280	.326	39.844
R-19	.055	\$ 504	.244	39.969

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	.532	-.808
R-13	.006	\$ 67	.023	-.036
R-19	.021	\$ 224	.082	-.125

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 53	\$ -66	\$ -12	\$ 213	\$ -225	\$ -225
R-13	\$ 2	\$ -2	\$ 0	\$ 67	\$ -67	\$ -293
R-19	\$ 8	\$ -10	\$ -2	\$ 224	\$ -226	\$ -519

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 61	\$ -66	\$ -4	\$ 213	\$ -217	\$ -217
R-13	\$ 2	\$ -2	\$ 0	\$ 67	\$ -67	\$ -284
R-19	\$ 9	\$ -10	\$ 0	\$ 224	\$ -224	\$ -509

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 100	\$ -66	\$ 34	\$ 213	\$ -178	\$ -178
R-13	\$ 4	\$ -2	\$ 1	\$ 67	\$ -65	\$ -244
R-19	\$ 15	\$ -10	\$ 5	\$ 224	\$ -218	\$ -462

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 43	\$ -69	\$ -25	\$ 213	\$ -238	\$ -238
R-13	\$ 1	\$ -3	\$ -1	\$ 67	\$ -68	\$ -306
R-19	\$ 6	\$ -10	\$ -3	\$ 224	\$ -227	\$ -534

APPENDIX C

Computer Printouts of Economic Analyses

for Tampa, Phoenix and Jacksonville --

Cooling Savings Based on Cooling Above 78°F (25.5°C) Outdoor Temperature

HUD1

JACKSONVILLE FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.593	21.692
B3	.153	\$ 101	2.380	21.251
C3	.110	\$ 571	1.905	21.088
EXTRA	.095	\$ 597	1.745	21.034

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	-.096	\$ 101	1.213	-.441
C3	-.043	\$ 470	.475	-.163
EXTRA	-.015	\$ 26	.160	-.054

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 122	\$ 36	\$ 158	\$ 101	\$ 57	\$ 57
C3	\$ 47	\$ 13	\$ 61	\$ 470	\$ -408	\$ -351
EXTRA	\$ 16	\$ 4	\$ 20	\$ 26	\$ -5	\$ -356

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 141	\$ 36	\$ 177	\$ 101	\$ -76	\$ 76
C3	\$ 55	\$ 13	\$ 68	\$ 470	\$ -401	\$ -324
EXTRA	\$ 18	\$ 4	\$ 23	\$ 26	\$ -2	\$ -327

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 229	\$ 36	\$ 266	\$ 101	\$ 165	\$ 165
C3	\$ 90	\$ 13	\$ 103	\$ 470	\$ -366	\$ -201
EXTRA	\$ 30	\$ 4	\$ 34	\$ 26	\$ 8	\$ -192

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 99	\$ 37	\$ 137	\$ 101	\$ 36	\$ 36
C3	\$ 39	\$ 14	\$ 53	\$ 470	\$ -416	\$ -379
EXTRA	\$ 13	\$ 4	\$ 17	\$ 26	\$ -8	\$ -388



HUD1

PHOENIX ARIZONA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.035	36.630
B3	.153	\$ 101	2.685	34.074
C3	.110	\$ 571	2.157	32.937
EXTRA	.095	\$ 597	1.960	32.542

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.349	2.557
C3	.043	\$ 470	.528	1.136
EXTRA	.015	\$ 26	.177	.396

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 124	\$ 277	\$ 402	\$ 101	\$ 301	\$ 301
C3	\$ 48	\$ 123	\$ 172	\$ 470	\$ -297	\$ 3
EXTRA	\$ 16	\$ 42	\$ 59	\$ 26	\$ 33	\$ 37

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 152	\$ 277	\$ 430	\$ 101	\$ 329	\$ 329
C3	\$ 59	\$ 123	\$ 183	\$ 470	\$ -286	\$ 42
EXTRA	\$ 20	\$ 42	\$ 62	\$ 26	\$ 36	\$ 79

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 337	\$ 277	\$ 614	\$ 101	\$ 513	\$ 513
C3	\$ 131	\$ 123	\$ 255	\$ 470	\$ -214	\$ 299
EXTRA	\$ 44	\$ 42	\$ 87	\$ 26	\$ 61	\$ 360

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 146	\$ 290	\$ 436	\$ 101	\$ 335	\$ 335
C3	\$ 57	\$ 129	\$ 186	\$ 470	\$ -283	\$ 52
EXTRA	\$ 19	\$ 44	\$ 64	\$ 26	\$ 38	\$ 90

HUD1

TAMPA FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.850	24.292
B3	.153	\$ 101	.505	23.831
C3	.110	\$ 571	.383	23.661
EXTRA	.095	\$ 597	.343	23.606

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	.345	.461
C3	.043	\$ 470	.122	.169
EXTRA	.015	\$ 26	.040	.056

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 34	\$ 38	\$ 72	\$ 101	\$ -28	\$ -28
C3	\$ 12	\$ 13	\$ 26	\$ 470	\$ -443	\$ -472
EXTRA	\$ 4	\$ 4	\$ 8	\$ 26	\$ -17	\$ -489

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 40	\$ 38	\$ 78	\$ 101	\$ -22	\$ -22
C3	\$ 14	\$ 13	\$ 28	\$ 470	\$ -441	\$ -464
EXTRA	\$ 4	\$ 4	\$ 9	\$ 26	\$ -16	\$ -481

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 65	\$ 38	\$ 103	\$ 101	\$ -2	\$ -2
C3	\$ 23	\$ 13	\$ 37	\$ 470	\$ -432	\$ -430
EXTRA	\$ 7	\$ 4	\$ 12	\$ 26	\$ -13	\$ -444

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 28	\$ 39	\$ 68	\$ 101	\$ -32	\$ -32
C3	\$ 10	\$ 14	\$ 24	\$ 470	\$ -445	\$ -478
EXTRA	\$ 3	\$ 4	\$ 8	\$ 26	\$ -17	\$ -496

HUD2

JACKSONVILLE FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.593	21.692
B3	.153	\$ 101	2.380	21.251
D3	.143	\$ 370	2.256	21.206
F2	.097	\$ 538	1.703	21.019

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.213	.441
D3	.010	\$ 269	.124	.045
F2	.052	\$ 168	.553	.187

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 122	\$ 36	\$ 158	\$ 101	\$ 57	\$ 57
D3	\$ 12	\$ 3	\$ 16	\$ 269	\$ -252	\$ -195
F2	\$ 55	\$ 15	\$ 71	\$ 168	\$ -96	\$ -292

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 141	\$ 36	\$ 177	\$ 101	\$ -76	\$ -76
D3	\$ 14	\$ 3	\$ 18	\$ 269	\$ -250	\$ -174
F2	\$ 64	\$ 15	\$ 79	\$ 168	\$ -88	\$ -262

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 229	\$ 36	\$ 266	\$ 101	\$ 165	\$ 165
D3	\$ 23	\$ 3	\$ 27	\$ 269	\$ -241	\$ -76
F2	\$ 104	\$ 15	\$ 120	\$ 168	\$ -47	\$ -124

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 99	\$ 37	\$ 137	\$ 101	\$ 36	\$ 36
D3	\$ 10	\$ 3	\$ 14	\$ 269	\$ -254	\$ -218
F2	\$ 45	\$ 16	\$ 61	\$ 168	\$ -106	\$ -324

HUD2

PHOENIX ARIZONA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.035	36.630
B3	.153	\$ 101	2.685	34.074
D3	.143	\$ 370	2.548	33.808
F2	.091	\$ 538	1.933	32.436

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.349	2.557
D3	.010	\$ 269	.138	.266
F2	.052	\$ 168	.615	1.371

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 124	\$ 277	\$ 402	\$ 101	\$ 301	\$ 301
D3	\$ 12	\$ 28	\$ 41	\$ 269	\$ -227	\$ 74
F2	\$ 56	\$ 148	\$ 205	\$ 168	\$ -37	\$ 112

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 152	\$ 277	\$ 430	\$ 101	\$ 329	\$ 329
D3	\$ 15	\$ 28	\$ 44	\$ 269	\$ -224	\$ 104
F2	\$ 69	\$ 148	\$ 218	\$ 168	\$ 50	\$ 154

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 337	\$ 277	\$ 614	\$ 101	\$ 513	\$ 513
D3	\$ 34	\$ 28	\$ 63	\$ 269	\$ -205	\$ 308
F2	\$ 153	\$ 148	\$ 302	\$ 168	\$ 134	\$ 442

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 146	\$ 290	\$ 436	\$ 101	\$ 335	\$ 335
D3	\$ 14	\$ 30	\$ 45	\$ 269	\$ -223	\$ 112
F2	\$ 66	\$ 155	\$ 222	\$ 168	\$ 54	\$ 166

HUD2

TAMPA FLORIDA 8 IN BLOCK (OPEN CORE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.850	24.292
B3	.153	\$ 101	.505	23.831
D3	.143	\$ 370	.471	23.734
F2	.091	\$ 538	.333	23.591

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	.345	.461
D3	.010	\$ 269	.035	.047
F2	.052	\$ 168	.138	.193

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 34	\$ 38	\$ 72	\$ 101	\$ -28	\$ -28
D3	\$ 3	\$ 3	\$ 7	\$ 269	\$ -261	\$ -289
F2	\$ 13	\$ 15	\$ 29	\$ 168	\$ -138	\$ -428

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 40	\$ 38	\$ 78	\$ 101	\$ -22	\$ -22
D3	\$ 4	\$ 3	\$ 7	\$ 269	\$ -261	\$ -283
F2	\$ 16	\$ 15	\$ 31	\$ 168	\$ -136	\$ -420

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 65	\$ 38	\$ 103	\$ 101	\$ -2	\$ -2
D3	\$ 6	\$ 3	\$ 10	\$ 269	\$ -258	\$ -256
F2	\$ 26	\$ 15	\$ 42	\$ 168	\$ -125	\$ -382

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 28	\$ 39	\$ 68	\$ 101	\$ -32	\$ -32
D3	\$ 2	\$ 4	\$ 6	\$ 269	\$ -262	\$ -294
F2	\$ 11	\$ 16	\$ 28	\$ 168	\$ -139	\$ -434

HUD3

JACKSONVILLE FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.608	21.727
CORES FILLED	.141	\$ 538	2.026	20.708
B4	.104	\$ 639	1.538	20.466
C4	.082	\$ 1109	1.368	20.571

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.581	1.019
B4	.037	\$ 101	.489	.241
C4	.022	\$ 470	.169	-.105

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 159	\$ 83	\$ 243	\$ 538	\$ -294	\$ -294
B4	\$ 49	\$ 19	\$ 69	\$ 101	\$ -31	\$ -326
C4	\$ 17	\$ -8	\$ 8	\$ 470	\$ -461	\$ -788

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 183	\$ 83	\$ 267	\$ 538	\$ -270	\$ -270
B4	\$ 56	\$ 19	\$ 76	\$ 101	\$ -24	\$ -294
C4	\$ 19	\$ -8	\$ 11	\$ 470	\$ -458	\$ -753

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 299	\$ 83	\$ 383	\$ 538	\$ -154	\$ -154
B4	\$ 92	\$ 19	\$ 112	\$ 101	\$ 11	\$ -142
C4	\$ 32	\$ -8	\$ 23	\$ 470	\$ -446	\$ -589

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 130	\$ 87	\$ 218	\$ 538	\$ -319	\$ -319
B4	\$ 40	\$ 20	\$ 61	\$ 101	\$ -39	\$ -359
C4	\$ 13	\$ -9	\$ 4	\$ 470	\$ -465	\$ -824

HUD3

PHOENIX ARIZONA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.055	36.678
CORES FILLED	.141	\$ 538	2.233	33.102
B4	.104	\$ 639	1.680	32.005
C4	.082	\$ 1109	1.514	31.646

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.822	3.575
B4	.037	\$ 101	.553	1.097
C4	.022	\$ 470	.166	.359

===== INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES =====

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 168	\$ 388	\$ 557	\$ 538	\$ 19	\$ 19
B4	\$ 51	\$ 119	\$ 170	\$ 101	\$ 69	\$ 88
C4	\$ 15	\$ 38	\$ 54	\$ 470	\$ -415	\$ -327

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 205	\$ 388	\$ 594	\$ 538	\$ 56	\$ 56
B4	\$ 62	\$ 119	\$ 181	\$ 101	\$ 80	\$ 136
C4	\$ 18	\$ 38	\$ 57	\$ 470	\$ -412	\$ -275

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 455	\$ 388	\$ 843	\$ 538	\$ 305	\$ 305
B4	\$ 138	\$ 119	\$ 257	\$ 101	\$ 156	\$ 462
C4	\$ 41	\$ 38	\$ 80	\$ 470	\$ -389	\$ 72

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL						
INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 197	\$ 406	\$ 604	\$ 538	\$ 66	\$ 66
B4	\$ 60	\$ 124	\$ 184	\$ 101	\$ 83	\$ 149
C4	\$ 18	\$ 40	\$ 58	\$ 470	\$ -411	\$ -261

HUD3

TAMPA FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.854	24.327
CORES FILLED	.141	\$ 538	.415	23.288
B4	.104	\$ 639	.281	23.039
C4	.082	\$ 1109	.239	23.139
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	.439	1.039
B4	.037	\$ 101	.134	.249
C4	.022	\$ 470	.042	-.100

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 44	\$ 85	\$ 129	\$ 538	\$ -408	\$ -408
B4	\$ 13	\$ 20	\$ 33	\$ 101	\$ -67	\$ -475
C4	\$ 4	\$ -8	\$ -3	\$ 470	\$ -473	\$ -949

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 51	\$ 85	\$ 136	\$ 538	\$ -401	\$ -401
B4	\$ 15	\$ 20	\$ 36	\$ 101	\$ -64	\$ -466
C4	\$ 4	\$ -8	\$ -3	\$ 470	\$ -473	\$ -939

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 83	\$ 85	\$ 168	\$ 538	\$ -369	\$ -369
B4	\$ 25	\$ 20	\$ 45	\$ 101	\$ -55	\$ -424
C4	\$ 7	\$ -8	\$ 0	\$ 470	\$ -470	\$ -894

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 36	\$ 89	\$ 125	\$ 538	\$ -412	\$ -412
B4	\$ 11	\$ 21	\$ 32	\$ 101	\$ -68	\$ -480
C4	\$ 3	\$ -8	\$ -5	\$ 470	\$ -475	\$ -955



HUD4

JACKSONVILLE FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	3.608	21.727
CORES FILLED	.141	\$ 538	2.026	20.708
B4	.104	\$ 638	1.538	20.488
D4	.099	\$ 908	1.499	20.490
F5	.071	\$ 1076	1.296	20.616

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.581	1.019
B4	.037	\$ 101	.489	.241
D4	.005	\$ 269	.038	-.024
F5	.028	\$ 168	.203	-.126

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 159	\$ 83	\$ 243	\$ 538	\$ -294	\$ -294
B4	\$ 49	\$ 19	\$ 69	\$ 101	\$ -31	\$ -326
D4	\$ 3	\$ -1	\$ 1	\$ 269	\$ -267	\$ -593
F5	\$ 20	\$ -10	\$ 10	\$ 168	\$ -157	\$ -751

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 183	\$ 83	\$ 267	\$ 538	\$ -270	\$ -270
B4	\$ 56	\$ 19	\$ 76	\$ 101	\$ -24	\$ -294
D4	\$ 4	\$ -1	\$ 2	\$ 269	\$ -266	\$ -560
F5	\$ 23	\$ -10	\$ 13	\$ 168	\$ -154	\$ -715

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 299	\$ 83	\$ 383	\$ 538	\$ -154	\$ -154
B4	\$ 92	\$ 19	\$ 112	\$ 101	\$ 11	\$ -142
D4	\$ 7	\$ -1	\$ 5	\$ 269	\$ -263	\$ -406
F5	\$ 38	\$ -10	\$ 28	\$ 168	\$ -139	\$ -546

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 130	\$ 87	\$ 218	\$ 538	\$ -319	\$ -319
B4	\$ 40	\$ 20	\$ 61	\$ 101	\$ -39	\$ -359
D4	\$ 3	\$ -2	\$ 1	\$ 269	\$ -267	\$ -627
F5	\$ 16	\$ -10	\$ 5	\$ 168	\$ -162	\$ -789

HUD4

PHOENIX ARIZONA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.055	36.678
CORES FILLED	.141	\$ 538	2.233	33.102
B4	.104	\$ 639	1.680	32.005
D4	.099	\$ 908	1.642	31.924
F5	.071	\$ 1076	1.445	31.459

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	1.822	3.575
B4	.037	\$ 101	.553	1.097
D4	.005	\$ 269	.038	.082
F5	.028	\$ 168	.197	.464

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 168	\$ 388	\$ 557	\$ 538	\$ 19	\$ 19
B4	\$ 51	\$ 119	\$ 170	\$ 101	\$ 69	\$ 88
D4	\$ 3	\$ 8	\$ 12	\$ 269	\$ -256	\$ -168
F5	\$ 18	\$ 50	\$ 68	\$ 168	\$ -99	\$ -267

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 205	\$ 388	\$ 594	\$ 538	\$ 56	\$ 56
B4	\$ 62	\$ 119	\$ 181	\$ 101	\$ 80	\$ 136
D4	\$ 4	\$ 8	\$ 13	\$ 269	\$ -255	\$ -119
F5	\$ 22	\$ 50	\$ 72	\$ 168	\$ -95	\$ -214

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 455	\$ 388	\$ 843	\$ 538	\$ 305	\$ 305
B4	\$ 138	\$ 119	\$ 257	\$ 101	\$ 156	\$ 462
D4	\$ 9	\$ 8	\$ 18	\$ 269	\$ -250	\$ 211
F5	\$ 49	\$ 50	\$ 99	\$ 168	\$ -68	\$ 143

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 197	\$ 406	\$ 604	\$ 538	\$ 66	\$ 66
B4	\$ 60	\$ 124	\$ 184	\$ 101	\$ 83	\$ 149
D4	\$ 4	\$ 9	\$ 13	\$ 269	\$ -255	\$ -105
F5	\$ 21	\$ 52	\$ 74	\$ 168	\$ -93	\$ -199

HUD4

TAMPA FLORIDA 8 IN BLOCK (PERLITE FILLED)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	.854	24.327
CORES FILLED	.141	\$ 538	.415	23.288
B4	.104	\$ 639	.281	23.039
D4	.099	\$ 908	.271	23.062
F5	.071	\$ 1076	.223	23.182

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
CORES FILLED	.108	\$ 538	.439	1.039
B4	.037	\$ 101	.134	.249
D4	.005	\$ 269	.010	-.023
F5	.028	\$ 168	.048	-.120

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 44	\$ 85	\$ 129	\$ 538	\$ -408	\$ -408
B4	\$ 13	\$ 20	\$ 33	\$ 101	\$ -67	\$ -475
D4	\$ 0	\$ -1	\$ 0	\$ 269	\$ -269	\$ -745
F5	\$ 4	\$ -9	\$ -5	\$ 168	\$ -173	\$ -918

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 51	\$ 85	\$ 136	\$ 538	\$ -401	\$ -401
B4	\$ 15	\$ 20	\$ 36	\$ 101	\$ -64	\$ -466
D4	\$ 1	\$ -1	\$ 0	\$ 269	\$ -269	\$ -735
F5	\$ 5	\$ -9	\$ -4	\$ 168	\$ -172	\$ -908

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 83	\$ 85	\$ 168	\$ 538	\$ -369	\$ -369
B4	\$ 25	\$ 20	\$ 45	\$ 101	\$ -55	\$ -424
D4	\$ 1	\$ -1	\$ 0	\$ 269	\$ -269	\$ -693
F5	\$ 9	\$ -9	\$ 0	\$ 168	\$ -168	\$ -862

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
CORES FILLED	\$ 36	\$ 89	\$ 125	\$ 538	\$ -412	\$ -412
B4	\$ 11	\$ 21	\$ 32	\$ 101	\$ -68	\$ -480
D4	\$ 0	\$ -1	\$ -1	\$ 269	\$ -270	\$ -750
F5	\$ 3	\$ -10	\$ -6	\$ 168	\$ -174	\$ -925

HUD5

JACKSONVILLE FLORIDA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	3.721	23.181
R-11	.082	\$ 213	1.752	21.524
R-13	.076	\$ 280	1.668	21.450
R-19	.055	\$ 504	1.393	21.184

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	1.969	1.656
R-13	.006	\$ 67	.084	.074
R-19	.021	\$ 224	.275	.266

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 198	\$ 136	\$ 334	\$ 213	\$ 121	\$ 121
R-13	\$ 8	\$ 6	\$ 14	\$ 67	\$ -52	\$ 69
R-19	\$ 27	\$ 21	\$ 49	\$ 224	\$ -174	\$ -105

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 229	\$ 136	\$ 365	\$ 213	\$ 152	\$ 152
R-13	\$ 9	\$ 6	\$ 15	\$ 67	\$ -51	\$ 101
R-19	\$ 32	\$ 21	\$ 53	\$ 224	\$ -170	\$ -68

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 373	\$ 136	\$ 509	\$ 213	\$ 296	\$ 296
R-13	\$ 15	\$ 6	\$ 22	\$ 67	\$ -44	\$ 251
R-19	\$ 52	\$ 21	\$ 74	\$ 224	\$ -149	\$ 101

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 162	\$ 142	\$ 304	\$ 213	\$ 91	\$ 91
R-13	\$ 6	\$ 6	\$ 13	\$ 67	\$ -53	\$ 38
R-19	\$ 22	\$ 22	\$ 45	\$ 224	\$ -178	\$ -140

HUD5

PHOENIX ARIZONA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	4.479	37.733
R-11	.082	\$ 213	2.079	32.939
R-13	.076	\$ 280	1.975	32.718
R-19	.055	\$ 504	1.625	31.883

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	2.400	4.794
R-13	.006	\$ 67	.104	.221
R-19	.021	\$ 224	.350	.836

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 222	\$ 520	\$ 742	\$ 213	\$ 529	\$ 529
R-13	\$ 9	\$ 24	\$ 33	\$ 67	\$ -33	\$ 496
R-19	\$ 32	\$ 90	\$ 123	\$ 224	\$ -100	\$ 395

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 270	\$ 520	\$ 791	\$ 213	\$ 578	\$ 578
R-13	\$ 11	\$ 24	\$ 35	\$ 67	\$ -31	\$ 547
R-19	\$ 39	\$ 90	\$ 130	\$ 224	\$ -93	\$ 453

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 599	\$ 520	\$ 1120	\$ 213	\$ 907	\$ 907
R-13	\$ 25	\$ 24	\$ 49	\$ 67	\$ -17	\$ 890
R-19	\$ 87	\$ 90	\$ 178	\$ 224	\$ -45	\$ 844

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 260	\$ 544	\$ 805	\$ 213	\$ 592	\$ 592
R-13	\$ 11	\$ 25	\$ 36	\$ 67	\$ -30	\$ 561
R-19	\$ 38	\$ 94	\$ 132	\$ 224	\$ -91	\$ 470

HUD5

TAMPA FLORIDA WOOD FRAME WALL  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON COOLING ABOVE 78 F OUTSIDE

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.218	\$ 0	.882	25.671
R-11	.082	\$ 213	.349	24.087
R-13	.076	\$ 280	.326	24.018
R-19	.055	\$ 504	.244	23.773
INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
R-11	.136	\$ 213	.532	1.584
R-13	.006	\$ 67	.023	.070
R-19	.021	\$ 224	.082	.245

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .210/THERM : PWF = 33.059  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 53	\$ 130	\$ 184	\$ 213	\$ -28	\$ -28
R-13	\$ 2	\$ 5	\$ 8	\$ 67	\$ -58	\$ -87
R-19	\$ 8	\$ 20	\$ 28	\$ 224	\$ -195	\$ -283

OIL FURNACE @ \$ .490/GALLON : PWF = 25.931  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 61	\$ 130	\$ 192	\$ 213	\$ -20	\$ -20
R-13	\$ 2	\$ 5	\$ 8	\$ 67	\$ -58	\$ -79
R-19	\$ 9	\$ 20	\$ 29	\$ 224	\$ -194	\$ -273

ELECTRIC FURNACE @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 100	\$ 130	\$ 231	\$ 213	\$ 18	\$ 18
R-13	\$ 4	\$ 5	\$ 10	\$ 67	\$ -56	\$ -38
R-19	\$ 15	\$ 20	\$ 35	\$ 224	\$ -188	\$ -226

HEAT PUMP @ \$ .035/KWH : PWF = 18.480  
 ELECTRIC AIR COND. @ \$ .035/KWH : PWF = 18.480

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
R-11	\$ 43	\$ 136	\$ 180	\$ 213	\$ -32	\$ -32
R-13	\$ 1	\$ 6	\$ 7	\$ 67	\$ -59	\$ -91
R-19	\$ 6	\$ 21	\$ 27	\$ 224	\$ -196	\$ -267

APPENDIX D

Computer Printouts of Economic Analyses  
for Madison, Phoenix and Washington, D.C.  
Assuming 90° Rotation of Building

HUD1

MADISON WISCONSIN 90 DEGREE ROTATION (A CASE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	51.917	6.513
B3	.153	\$ 101	39.702	6.513
C3	.110	\$ 571	34.126	6.513
EXTRA	.095	\$ 597	32.172	6.513

INSULATION SPECS	INCREMENTAL U	INCREMENTAL CGST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	12.215	.000
C3	.043	\$ 470	5.576	.000
EXTRA	.015	\$ 26	1.954	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1253	\$ 0	\$ 1253	\$ 101	\$ 1152	\$ 1152
C3	\$ 572	\$ 0	\$ 572	\$ 470	\$ 102	\$ 1254
EXTRA	\$ 200	\$ 0	\$ 200	\$ 26	\$ 174	\$ 1428

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1346	\$ 0	\$ 1346	\$ 101	\$ 1245	\$ 1245
C3	\$ 614	\$ 0	\$ 614	\$ 470	\$ 144	\$ 1389
EXTRA	\$ 215	\$ 0	\$ 215	\$ 26	\$ 189	\$ 1579

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 2607	\$ 0	\$ 2607	\$ 101	\$ 2506	\$ 2506
C3	\$ 1190	\$ 0	\$ 1190	\$ 470	\$ 720	\$ 3226
EXTRA	\$ 417	\$ 0	\$ 417	\$ 26	\$ 391	\$ 3618

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 1682	\$ 0	\$ 1682	\$ 101	\$ 1581	\$ 1581
C3	\$ 767	\$ 0	\$ 767	\$ 470	\$ 297	\$ 1879
EXTRA	\$ 269	\$ 0	\$ 269	\$ 26	\$ 243	\$ 2122



HUD 1

PHOENIX ARIZONA 1200 SQ FT HOUSE 90 DEGREE ROTATION (A CASE)  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.762	44.675
B3	.153	\$ 101	3.245	44.675
C3	.110	\$ 571	2.622	44.675
EXTRA	.095	\$ 597	2.410	44.675

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.518	.000
C3	.043	\$ 470	.623	.000
EXTRA	.015	\$ 26	.212	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 140	\$ 0	\$ 140	\$ 101	\$ -39	\$ -39
C3	\$ 57	\$ 0	\$ 57	\$ 470	\$ -412	\$ -372
EXTRA	\$ 19	\$ 0	\$ 19	\$ 26	\$ -6	\$ -379

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 171	\$ 0	\$ 171	\$ 101	\$ -70	\$ -70
C3	\$ 70	\$ 0	\$ 70	\$ 470	\$ -399	\$ -329
EXTRA	\$ 23	\$ 0	\$ 23	\$ 26	\$ -2	\$ -331

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 379	\$ 0	\$ 379	\$ 101	\$ -278	\$ -278
C3	\$ 155	\$ 0	\$ 155	\$ 470	\$ -314	\$ -36
EXTRA	\$ 53	\$ 0	\$ 53	\$ 26	\$ -27	\$ -9

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INSULATION SPECS	INCREMENTAL				NET SAVINGS	CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST		
B3	\$ 164	\$ 0	\$ 164	\$ 101	\$ -63	\$ -63
C3	\$ 67	\$ 0	\$ 67	\$ 470	\$ -402	\$ -338
EXTRA	\$ 23	\$ 0	\$ 23	\$ 26	\$ -2	\$ -341

HUD1

WASHINGTON D.C. 1200 SQ FT HOUSE 90 DEGREE ROTATION (A CASE)  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	23.580	17.662
B3	.153	\$ 101	17.019	17.662
C3	.110	\$ 571	14.121	17.662
EXTRA	.095	\$ 597	13.114	17.662

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	6.561	.000
C3	.043	\$ 470	2.897	.000
EXTRA	.015	\$ 26	1.007	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .270/THERM : PWF = 27.860  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 666	\$ 0	\$ 666	\$ 101	\$ 565	\$ 565
C3	\$ 294	\$ 0	\$ 294	\$ 470	\$ -175	\$ 390
EXTRA	\$ 102	\$ 0	\$ 102	\$ 26	\$ 76	\$ 466

OIL FURNACE @ \$ .500/GALLON : PWF = 25.324  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 760	\$ 0	\$ 760	\$ 101	\$ 659	\$ 659
C3	\$ 335	\$ 0	\$ 335	\$ 470	\$ -134	\$ 525
EXTRA	\$ 116	\$ 0	\$ 116	\$ 26	\$ 90	\$ 616

ELECTRIC FURNACE @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 1663	\$ 0	\$ 1663	\$ 101	\$ 1562	\$ 1562
C3	\$ 724	\$ 0	\$ 724	\$ 470	\$ 264	\$ 1826
EXTRA	\$ 255	\$ 0	\$ 255	\$ 26	\$ 229	\$ 2055

HEAT PUMP @ \$ .046/KWH : PWF = 18.806  
 ELECTRIC AIR COND. @ \$ .046/KWH : PWF = 18.806

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 811	\$ 0	\$ 811	\$ 101	\$ 710	\$ 710
C3	\$ 358	\$ 0	\$ 358	\$ 470	\$ -112	\$ 598
EXTRA	\$ 124	\$ 0	\$ 124	\$ 26	\$ 98	\$ 696

HUD2

MADISON WISCONSIN 90 DEGREE ROTATION (A CASE)  
 1200 SQ FT HOUSE  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	51.917	6.513
B3	.153	\$ 101	38.702	6.513
D3	.143	\$ 370	38.426	6.513
F2	.091	\$ 538	31.651	6.513

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	12.215	.000
D3	.010	\$ 269	1.276	.000
F2	.052	\$ 168	6.775	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 34.508  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 1253	\$ 0	\$ 1253	\$ 101	\$ 1152	\$ 1152
D3	\$ 130	\$ 0	\$ 130	\$ 269	\$ -138	\$ 1014
F2	\$ 695	\$ 0	\$ 695	\$ 168	\$ 527	\$ 1541

OIL FURNACE @ \$ .470/GALLON : PWF = 24.960  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 1346	\$ 0	\$ 1346	\$ 101	\$ 1245	\$ 1245
D3	\$ 140	\$ 0	\$ 140	\$ 269	\$ -128	\$ 1116
F2	\$ 746	\$ 0	\$ 746	\$ 168	\$ 578	\$ 1695

ELECTRIC FURNACE @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 2607	\$ 0	\$ 2607	\$ 101	\$ 2506	\$ 2506
D3	\$ 272	\$ 0	\$ 272	\$ 269	\$ 3	\$ 2510
F2	\$ 1446	\$ 0	\$ 1446	\$ 168	\$ 1278	\$ 3788

HEAT PUMP @ \$ .040/KWH : PWF = 18.215  
 ELECTRIC AIR COND. @ \$ .040/KWH : PWF = 18.215

INSULATION SPECS	INCREMENTAL					CUMULATIVE NET SAVINGS
	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	
B3	\$ 1682	\$ 0	\$ 1682	\$ 101	\$ 1581	\$ 1581
D3	\$ 175	\$ 0	\$ 175	\$ 269	\$ -93	\$ 1488
F2	\$ 933	\$ 0	\$ 933	\$ 168	\$ 765	\$ 2253

HUD2

PHOENIX ARIZONA 1200 SQ FT HOUSE 90 DEGREE ROTATION (A CASE)  
 COOLING LOADS BASED ON NO COOLING SAVINGS

INSULATION SPECS	U VALUE	INSUL COST	ANNUAL HTG (MILLION BTU)	ANNUAL CLG (MILLION BTU)
BASE CASE	.249	\$ 0	4.762	44.675
B3	.153	\$ 101	3.245	44.675
D3	.143	\$ 370	3.089	44.675
F2	.091	\$ 538	2.353	44.675

INSULATION SPECS	INCREMENTAL U	INCREMENTAL COST	INCREMENTAL ANNUAL HTG	INCREMENTAL ANNUAL CLG
B3	.096	\$ 101	1.518	.000
D3	.010	\$ 269	.156	.000
F2	.052	\$ 168	.736	.000

INCREMENTAL AND CUMULATIVE LIFE-CYCLE COST ANALYSES

GAS FURNACE @ \$ .220/THERM : PWF = 29.017  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 140	\$ 0	\$ 140	\$ 101	\$ 39	\$ 39
D3	\$ 14	\$ 0	\$ 14	\$ 269	\$ -254	\$ -215
F2	\$ 68	\$ 0	\$ 68	\$ 168	\$ -99	\$ -315

OIL FURNACE @ \$ .510/GALLON : PWF = 24.167  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 171	\$ 0	\$ 171	\$ 101	\$ 70	\$ 70
D3	\$ 17	\$ 0	\$ 17	\$ 269	\$ -251	\$ -181
F2	\$ 82	\$ 0	\$ 82	\$ 168	\$ -85	\$ -266

ELECTRIC FURNACE @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 379	\$ 0	\$ 379	\$ 101	\$ 278	\$ 278
D3	\$ 38	\$ 0	\$ 38	\$ 269	\$ -230	\$ 48
F2	\$ 183	\$ 0	\$ 183	\$ 168	\$ 15	\$ 64

HEAT PUMP @ \$ .042/KWH : PWF = 20.306  
 ELECTRIC AIR COND. @ \$ .042/KWH : PWF = 20.306

INCREMENTAL

INSULATION SPECS	HEATING SAVINGS	COOLING SAVINGS	H + C SAVINGS	INSUL. COST	NET SAVINGS	CUMULATIVE NET SAVINGS
B3	\$ 164	\$ 0	\$ 164	\$ 101	\$ 63	\$ 63
D3	\$ 16	\$ 0	\$ 16	\$ 269	\$ -252	\$ -188
F2	\$ 79	\$ 0	\$ 79	\$ 168	\$ -88	\$ -276

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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) This report provides a life-cycle cost-benefit analysis of several alternative methods for insulating 8" (200 mm) concrete masonry walls in new single-family residences. In addition, a cost-benefit analysis for insulation in wood-frame walls is provided, consistent with the assumptions used in the masonry wall analysis. A dynamic load simulation model, NBSLD, was used to calculate the heating and cooling requirements for a 1176 square foot (110 m <sup>2</sup> ) house with different levels of thermal resistance for both wall types in eight geographic locations. These data are used to calculate the reduction in annual heating and cooling requirements due to several different types of insulation in the cores and furring spaces of the masonry wall and the cavities of the wood-frame wall. Economic analysis is applied to determine estimates of life-cycle savings from insulation for different locations and furnace types in order to determine the most cost-effective insulation level. In general it is found that the maximum economically justifiable level of insulation in the masonry wall is considerably lower than for the wood-frame wall because of the significantly higher cost of insulating masonry walls.		13. Type of Report & Period Covered FINAL	
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