THERMAL ENVELOPE COST BENEFIT ANALYSIS FOR REVISIONS TO THE HUD MANUFACTURED HOME STANDARDS

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ABSTRACT

Research was undertaken for the U.S. Department of Housing and Urban Development to examine the cost-effectiveness of the proposed changes in the Manufactured Home Construction and Safety Standards, concerning the required Uo value in each of the three HUD zones. A 25-year period life cycle cost analysis was used, along with a determination of the simple payback period and the impact of improvements upon the first year cash flow.

The energy analysis relied upon the data base generated for the Department of Energy's "Affordable Manufactured Housing Through Energy Conservation" program, determining energy consumption for prototypical manufactured homes, using the DOE 2.1a computer program. An optimum thermal envelope package was determined for each prototype, for four different fuel types, in each of 37 cities, along with related costs and benefits for options that were found to be nonoptimum.

Findings for individual cities, fuels, and configurations were weighted according to manufactured home distribution in each zone. It was found that improvements in the required thermal insulation levels were warranted and that the lower Uo levels proposed by HUD were certainly cost-effective.

INTRODUCTION

Manufactured homes (or mobile homes) are built to a national preemptive building code administered by the Department of Housing and Urban Development (HUD) called the Manufactured Home Construction and Safety Standards (MHCSS). This code has been in effect since 1976 and sets structural, mechanical, safety, and thermal requirements for all manufactured homes in the country (HUD 1976).

Manufactured homes built to this code (approximately 300,000 in the last year, or 19% of the housing units constructed) are not required to meet state, local, or model energy codes; the thermal envelope requirements for these houses are set in Subpart F, "Thermal Protection." Subpart F breaks the country into three climatic zones and establishes standard construction practices, design temperatures, and a maximum Uo for each zone, as shown in Figure 1.

Since the thermal requirements of Subpart F had not been revised since they went into effect in 1976, HUD began in 1981 to examine options for reducing energy consumption in manufactured homes, based upon an analysis of manufactured home energy consumption recently completed (DOE 1981). A further study (SWA 1982), using a simple payback methodology to evaluate the cost-effectiveness of various thermal envelope options, led to a recommendation of lower Uo

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requirements in each zone and for the inclusion of ten northern tier states along with Alaska in the most severe climatic zone. These recommendations were adopted in Title II, governing thermal requirements for manufactured homes with government financing. On August 16, 1983, HUD proposed these levels as an energy option that had to be made available to the homebuyer, and in the summer of 1984, these levels were proposed to be the mandatory requirements of the MHCSS.

This present study was undertaken under contract H-5640 to provide a more extensive examination of the cost-effectiveness of the proposed changes. It reflected important changes in the intervening two years, including changes in construction costs and fuel costs, fuel cost increase projections, a more extensive and accurate manufactured home energy data base, an improved energy analysis program, and a more thorough cost/benefit analysis technique.

METHODOLOGY

The Department of Energy (DOE) Manufactured Home Data Base was selected as the basis for this study, providing energy use data for 37 cities for two prototypical manufactured homes. The appropriate range of envelope options for the study was selected, and manufacturers' costs for these options were determined from surveys. Regional fuel costs and cost escalation projections were assembled, and these were combined with economic assumptions to calculate the optimum Uo value for each prototypical manufactured home, fuel type, and city, according to life-cycle cost and cash flow analyses. Distribution information was gathered for manufactured home type, manufactured home location, and fuel type, to arrive at an average optimum Uo for each zone.

Manufactured Home Energy Data Base

The data base used for this study had previously been generated for the Department of Energy in the development of its "Affordable Manufactured Housing Through Energy Conservation" Manufactured Home Slide Rule (DOE 1984). This data base was created with the DOE 2.1a model, using two prototypical manufactured homes in 44 different locations. The data base had also been reviewed and endorsed by the private sector through a distribution and public comment process sponsored by DOE.

The DOE data base was fully compatible with the MHCSS, since the building prototypes used in the development of the Standard and the data base were virtually identical. The data base included data for a wide range of energy-conserving options, including insulation and glazing levels, infiltration rate, and equipment efficiencies. Not all of these were applicable to this study, since the MHCSS only has a Uo requirement. The irrelevant options were held at constant values, while a range of insulation and glazing levels was analyzed. Table 1 contains a description of the prototypical homes modeled in the DOE data base, the envelope assumptions held constant, and the thermal envelope options analyzed.

Economic Parameters

The study of life-cycle costs requires the assumption of a discount rate. Federal guidelines on life-cycle costing procedures required the use of a constant dollar discount rate of 10% (OMB 1972). As an indication of the relative currency of this estimate, treasury bills at the time of the study (October 1984) had been yielding about 10.25%. This rate is considerably higher than the 7% rate required by the federal government in the cost/benefit analysis of federally procured buildings and would obviously result in a more conservative assessment of cost-effective levels of insulation than would the lower discount rate.

Fuel escalation rates assumed were those published by the Department of Energy (1983). These escalation rates are summarized and averaged in Table 2. Financing rates for the cash flow analysis were assumed to be 16%, based upon a survey of major lenders in the manufactured home field. It was further assumed that there would be a 20% down payment on the manufactured home and that 80% of the cost would be financed.

Costs

Costs of thermal envelope improvement options were determined from surveys of home and materials manufacturers. The prices used reflect the typical prices encountered. Wholesale prices to the home manufacturer were multiplied by a factor of 2.22 to arrive at the cost to the consumer, which is taken as representative of industry practice. The prices also incorporate marginal considerations - the price for the first inch of insulation installed is not necessarily the same as the price for the last. It was assumed that the improvements have no salvage value, do not increase maintenance costs, and have the same useful life as the rest of the building, as there is no available data that suggests otherwise. Costs used are summarized (on a per square foot basis) in Table 3.

The fuel prices used in the analysis were obtained from the most current update (March 1983) by the Department of Energy. DOE publishes average fuel prices for each of ten regions of the United States and for the country as a whole. Separate prices are published for each of the fuels considered in this work, and the prices specifically developed for the residential sector were used.

The use of average regional data is also advisable in that it is less likely to produce skewed results than the use of specific, local fuel prices for any given city. Fuel prices for a particular city may be significantly higher or lower than the average fuel prices for the region. Unless the selection of cities to be studied exactly reflects the distribution of fuel prices within the region, the results will not be accurate except for manufactured homes located in those particular cities. The fuel costs for the ten DOE regions are summarized in Table 4.

Cost Benefit Methodology

Three distinct yet interrelated procedures were used for the economic analysis portion of this work: a full life-cycle cost analysis, a cash flow analysis, and a simple payback analysis. Each of the three is briefly described below.

The life-cycle cost analysis incorporated all quantifiable costs associated with an investment: initial investment costs, salvage values, operation and maintenance costs, and fuel costs. Both costs and benefits were discounted if they were to occur in the future, allowing the results to be compared on a consistent, present value basis. Those conservation measures that achieved the lowest life-cycle cost over a specified period, in this case 25 years, were selected. If a longer term had been selected, more stringent improvements would have been found cost-effective, all other things being equal.

The cash flow analysis measured the cost of an improvement by examining the increase in mortgage payments necessary to pay for the improvement. If this increase was less than the energy benefits (in dollars) during the first year of occupancy, then the improvement was cost-effective by this method.

The simple payback analysis summed the dollar savings due to energy conservation improvements and calculated the amount of time that must pass before the total benefits equal the cost of achieving the improvements. This method did not include a discounting procedure, as per HUD's instructions.

Selection of Optimum Thermal Envelope Options

To determine the cost-effectiveness of any given thermal envelope improvement, the total life-cycle net savings were developed for every option, for each fuel type in each city, i.e., the cost of a given option above the base level was determined, the total life-cycle energy savings above the base level were determined, and the cost was subtracted from the savings, yielding the net benefit over the 25-year life-cycle. The option selected within each category (ceiling, wall, floor, glazing) is the optimum level, the option producing the greatest net savings.

The option selected according to the above procedure was then subjected to one restriction-it could not produce a negative cash flow in the first year of occupancy. This restriction was implemented so as to alleviate any possible increased burden on the homebuyer. In calculating the cash flow, only that part of the option's cost assumed to be financed was considered. That is, the negative cash flow due to the cost of an option was the mortgage payment in the first year on 80% of the cost of the option. If the optimum life-cycle option did produce a negative cash flow, it was discarded, and the next most cost-effective option with a positive first year cash flow was selected and included in the optimum insulation package. If this cash flow restriction had not been included, higher levels of thermal envelope improvement would have been found to be cost-effective.

In addition to the life cycle cost methodology with the cash flow restriction described above, the simple payback period was calculated for each thermal improvement option, because this factor indicated the relative effectiveness of the various options in an easily comprehensible manner. However, the simple payback was only an indicator and was not used in the subsequent computation of the optimum life-cycle improvement package. Once the optimum package had been determined, the simple payback for the package as a whole was computed. Again, this was done simply as an indicator and had no effect upon optimum zone Uo calculations.

CALCULATION OF THE OPTIMUM Uo VALUES

The program output (see Table 5 for a typical output page), indicated the most cost-effective package of thermal envelope improvements for each set of parameters considered. Each package was then converted to a building Uo value, according to NFPA 501 BM calculation procedures (NFPA 1977). These procedures were followed, rather than standard ASHRAE calculations, due to their widespread use in the manufactured home industry and the proposal in the revisions to the MHCSS that they be the sole acceptable methodology to be followed in demonstrating compliance with the MHCSS. Previous work had shown that for a given manufactured home thermal envelope, the NFPA calculations generally yielded a higher Uo than did the ASHRAE calculations (SWA 1982). The result of this was an optimum Uo for each of the 37 cities studied, for both single wide and multisection manufactured homes, for each of the four fuel types, for both heating and cooling loads.

In order to to arrive at single optimum Uo for each of the three HUD zones, these 296 separate Uo values were averaged, weighted according to single wide/multisection distribution and the prevalence of certain fuel types. The single wide/multisection distribution was a simple figure to determine. Based upon industry production figures, 70% of manufactured homes are single wides, while 30% are multisections.

It was more difficult to arrive at appropriate factors by which to weight for fuel type distribution in a given location, as very few data are available on this for manufactured homes. Collected data for site-built houses is not useful, as manufactured houses will not necessarily follow the same trend, and information from home manufacturers is not useful, as it doesn't report the locations where the equipment ends up. Eventually, the information from the Annual Housing Survey was used (USDC 1981), which breaks down fuel distribution in manufactured homes according to the four Census regions. The distribution of the four major fuels and their relative percentage among the four are listed in Table 6.

The optimum Uo for each city was calculated, first by averaging the optimum Uo's weighted according to fuel type. This yielded an optimum Uo for single wide and multisection homes in each city. These values were then averaged according to the single wide/multisection distribution and a single optimum Uo for each city was derived. These three optimum levels for each city are listed in Table 7.

In order to determine the optimum Uo for each of the three HUD zones, the optimum Uo values for the cities in that zone were averaged. This average was weighted according to the number of manufactured homes shipped in each state from 1976 to 1983. (See Table 8 for a listing of this distribution.) If a state contained one or more of the cities under consideration, the optimum Uo for that city (or an average of the cities if more than one) was weighted by the percentage of zone manufactured homes in that state. If a state did not contain one of the base cities studied, an examination of climatic data for the state allowed it to be represented by the one of the 37 cities that most closely represented the state's climate. Table 8 details the calculation of this optimum Uo value for each zone.

The optimum Uo values arrived at for each zone by this method are listed in Table 10 and compared with the existing MHCSS requirements and the existing Title II levels, which have been proposed as the new requirements for the MHCSS. As can be seen, the calculated levels are more stringent than those already in effect and closely approximate the levels that HUD has proposed.

COST BENEFIT COMPARISON FOR TYPICAL MANUFACTURED HOMES

An important part of this study was to estimate the impact of reduced Uo levels upon the cost of the typical manufactured home. The manufactured home industry differs significantly from the rest of the housing industry in the price of its product; the average price of a manufactured home in 1983 was $21,000 (MHI 1984). Obviously, an improved thermal envelope package that added $1000 to the price of a house would have a much greater percentage impact upon the cost of the manufactured home than upon that of the typical site-built house costing four times as much. There was a concern within the industry that the proposed changes to the MHCSS would increase the first cost of a manufactured home so much as to make it unaffordable for a large segment of the potential market, even though operating costs for the home would be reduced.

In order to evaluate the impact of the proposed Uo levels on the consumer, the costs of upgrading typical current construction manufactured homes to meet the requirements of the proposed standard were calculated. For both single and multisections in each zone, least-cost insulation packages were determined that complied with the current MHCSS standard Uo, that complied with the proposed MHCSS standard Uo, or that best represented the current typical construction in that zone. The determination of a typical package for each zone was made based upon the survey of manufacturers' practices. The cost to the consumer of the thermal envelope package for each of these was determined, and then the increase in cost necessary to bring the thermal envelope up to the proposed standard level from the existing or typical packages was calculated. These cost increases are listed in Table 11. The consumer costs listed are above an assumed base level with single-glazed windows and no insulation and incorporate the 2.22 multiplier from manufacturers' costs. It can be seen that the cost of upgrading the minimum manufactured home that just meets the current standard can be as high as $1030.48 (in a northern tier state, where the home is subject not only to a lowering of the required Uo but also is being placed in a zone with a more stringent requirement). However, the cost of upgrading to the proposed standard from insulation levels that are typical of current construction is lower, ranging from no increase at all to a high of $824.42.

The final step in this process was to compare these consumer costs for upgrading to the proposed standard with the lower operating costs that homebuyers could expect. A representative city within each climatic zone was selected, whose optimum Uo most nearly approximated the average optimum Uo for the zone: Lake Charles in Zone I, Salt Lake City in Zone II, Minneapolis in the Northern Tier states that are being added to Zone III, and Juneau in the existing Zone III. Total life-cycle savings and first year cash flow were determined for both single wide and multisection homes for these cities, using a weighted average of the benefits accruing to the two most prevalent fuel types. Table 12 shows this direct comparison between the cost to the consumer to upgrade the minimum and typical packages to comply with the proposed standard against the total savings that would result from this upgrading.

It should be noted that the costs detailed above are already incorporated in the savings figures, i.e., the total net benefits are those presented on the right side of the table, not the savings numbers on the right minus the costs on the left.

CONCLUSION

Examination of the figures in Table 10 leads to the conclusion that the optimum Uo values, as arrived at in this study, are significantly closer to those levels proposed by HUD than the levels currently in effect. A relatively conservative determination of cost-effective levels of insulation (including the restriction that the first year cash flow due to the envelope improvements must be positive) has shown that the proposed changes to the HUD Manufactured Home Construction and Safety Standards appear to be warranted and will make housing affordable for more homebuyers, since their total operating and maintenance expenses will be lower.

These proposed revisions to the Manufactured Home Standard have not been implemented, due to the opposition of the Office of Management and Budget to any further regulation of the manufactured home industry.

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TABLE 1

Manufactured Home Prototype Parameters

	Single Wide	Multisection
Prototype parameters held constant for energy analysis		
Length	66 feet	56 feet
Width	13.67 feet	23.5 feet
Ceiling Height	7.5 feet	7.5 feet
Floor Area	902 sf	1316 sf
Roofing	Galvanized sheet steel	Asphalt shingles on 3/8" plywood
Attic	Sealed	Vented
Ceiling Vapor Retarder	6 mil polyethylene	4 mil polyethylene
Exterior Wall Framing	2x3 stud, 1x2 belt rail	2x4 stud
Exterior Wall Siding	.019" aluminum vert. siding	8" aluminum lap siding
Interior Finish	5/32" lauan wood paneling	5/32" lauan wood paneling
Floor Exterior	1/16" asphalt impregnated bottom board	1/16" asphalt impregnated bottom board
Floor Framing	2x6 transverse floor joists	2x6 transverse floor joists
Subfloor	5/8" particle board	5/8" particle board
Floor Finish	carpet and pad, sheet vinyl in kitchen and baths	carpet and pad, sheet vinyl in kitchen and baths
Exterior Door Type	Hollow core honeycomb aluminum	Hollow core honeycomb aluminum
Exterior Door Area	33.78 sf	33.78 sf
Window Type	Aluminum sash, single hung	Aluminum sash, single hung
Window Area	98.3 sf 10.9% of floor area	135.3 sf 10.3% of floor area
HVAC Ducts	Aluminum, located below floor but above floor insulation	Aluminum, located below floor but above floor insulation
HVAC Registers	4"x14" (7)	4"x14" (10)
Thermostat	standard	standard
HVAC Equipment Efficiencies		
Propane (LP Gas):	AFUE = 63%	AFUE = 63%
Natural Gas:	AFUE = 63%	AFUE = 63%
Oil	AFUE = 75%	AFUE = 75%
Electric Resistance:	AFUE = 100%	AFUE = 100%
Electric Cooling:	SEER = 8.0	SEER = 8.0
Thermal envelope options varied in energy analysis		
Ceiling Insulation Options:	R-7, 11, 14, 19, 22, 30, 33	R-7, 11, 14, 19, 22, 30, 33, 38
Wall Insulation Options:	R-7, 11, 13, 19, 18, 24	R-7, 11, 13, 19, 18, 24
Floor Insulation Options:	R-4, 7, 11, 14, 19, 22	R-4, 7, 11, 14, 19, 22, 28
Glazing Options:	Single glazing Single glazing, storm windows Double glazing, storm windows	Single glazing Single glazing, storm windows Double glazing, storm windows

TABLE 2

Fuel Cost Escalation Projections (%)

FUEL	1983-85	85-90	90-95	95-2000	Weighted Average
Elec.	-.32	1.42	2.47	3.48	2.13
Oil	-7.71	7.54	8.18	1.40	4.13
LPG	6.49	7.05	7.87	1.36	5.55
Natural Gas	8.28	5.11	9.25	1.54	5.65

TABLE 3

Average Thermal Envelope Options Costs to Manufacturer

Costs reflect insulation materials' costs, labor costs, and the cost of any necessary modifications to standard construction.

		Single Wide		Double Wide	
Component	Option	Total Cost	Cost per sq foot	Total Cost	Cost per sq foot
Floors	R-4	$301.64	$0.33	$440.44	$0.33
	R-7	318.37	0.35	465.20	0.35
	R-11	357.89	0.40	523.68	0.40
	R-14	397.52	0.44	582.33	0.44
	R-19	443.01	0.47	649.64	0.49
	R-22	523.49	0.58	768.74	0.58
	R-28	644.41	0.71	948.82	0.72
Walls	R-7	295.13	0.28	348.80	0.34
	R-11	337.66	0.32	389.26	0.38
	R-13	392.29	0.37	441.23	0.44
	R-14	380.11	0.36	429.64	0.42
	R-18(5+13)	747.40	0.70	756.45	0.75
	R-19	601.34	0.57	634.66	0.63
	R-24(5+19)	895.08	0.84	945.60	0.94
Ceilings	R-7	243.43	0.27	329.85	0.25
	R-11	267.81	0.30	365.41	0.28
	R-14	295.01	0.33	405.10	0.31
	R-19	347.29	0.39	457.46	0.35
	R-22	377.53	0.42	525.49	0.40
	R-30	462.13	0.51	635.66	0.48
	R-33	490.21	0.54	676.63	0.51
	R-38	531.81	0.59	737.32	0.56
Glazing	Single	156.34	1.59	234.51	1.73
	Double	289.88	2.95	434.82	3.21
	Triple	537.29	5.47	805.93	5.96

TABLE 4

Fuel Prices by DOE Region

All prices given are for the base period of mid 1983.

DOE Region	Electricity $/100 kWh	Fuel Oil $/gallon	Propane $/gallon	Natural Gas $/1000 cf
1	8.012	1.090	0.515	9.026
2	8.542	1.077	0.508	8.190
3	6.924	1.065	0.499	6.245
4	5.407	1.031	0.481	6.186
5	6.145	1.053	0.496	5.632
6	6.197	1.044	0.481	5.102
7	6.405	1.038	0.489	4.984
8	6.069	1.016	0.469	4.937
9	6.602	1.028	0.472	6.245
10	3.051	1.041	0.467	8.661

TABLE 5

Typical Cost Benefit Program Output Sheet

Location : Pittsburgh, PA
Prototype : Single-section
Equipment : Electric Air Conditioner and Gas Furnace

	Life Cycle Savings (dollars)	Cash Flow (dollars)	Simple Payback (years)
Ceiling Insulation:			
R-7	.00	.00	.00
R11	327.92	18.76	2.19
R14	443.27	22.52	3.02
R19	491.09	17.13	4.66
R22	570.08	18.31	4.89
R30	513.89	1.20	6.85
R33	479.45	-5.60	7.51
Wall Insulation:			
R-7	.00	.00	.00
R11	299.81	14.49	3.37
R13	354.63	9.87	5.26
R19	551.18	-9.92	7.75
R13S	256.84	-52.99	11.11
R19S	240.33	-78.07	11.85
Floor Insulation:			
R-7	.00	.00	.00
R11	595.91	33.97	2.07
R14	813.91	43.17	2.61
R19	1008.39	49.25	3.13
R22	985.66	34.32	4.59
R28	841.66	3.56	6.74
Glazing:			
SINGLE	.00	.00	.00
DOUBLE	346.20	3.61	6.42
TRIPLE	99.56	-53.62	12.47

OPTIMUM PACKAGE:

Ceiling Option	R22
Wall Option	R13
Floor Option	R19
Glass Option	Double

OPTIMUM PACKAGE	LIFE CYCLE SAVINGS	($)	:	2279.30
	CASH FLOW	($)	:	81.04
	SIMPLE PAYBACK	(yrs)	:	4.59
	HEATING LOAD	(mBtu)	:	41.46
	COOLING LOAD	(mBtu)	:	9.07

TABLE 6

Distribution of Fuel Types in Manufactured Homes

	North East	North Central	South	West
Natural Gas	75,000	309,000	473,000	540,000
% of region	25%	42%	29%	56%
Electricity	11,000	81,000	424,000	258,000
% of region	4%	11%	26%	26%
Liquid Propane	24,000	270,000	578,000	169,000
% of region	8%	37%	34%	17%
Oil	186,000	70,000	182,000	11,000
% of region	63%	10%	11%	1%
Total number of manufactured homes	296,000	730,000	1,657,000	978,000

TABLE 7

Optimum Uo for Each of 37 Cities Studied

HUD Zone	City	Single Wide Optimum Uo	Multi-Section Optimum Uo	Average* Optimum Uo
Zone I	Albuquerque	.108	.112	.109
	Atlanta	.124	.122	.123
	Brownsville	.157	.158	.157
	Corona	.114	.115	.114
	El Paso	.116	.121	.118
	Ft. Worth	.116	.121	.118
	Fresno	.113	.113	.113
	Jacksonville	.146	.141	.145
	Lake Charles	.139	.133	.137
	Memphis	.120	.122	.121
	Miami	.198	.200	.199
	Phoenix	.121	.122	.121
	Raleigh	.121	.122	.121
	San Antonio	.123	.125	.124
	Savannah	.128	.122	.126
Zone II	Boise	.097	.102	.099
	Boston	.090	.090	.090
	Buffalo	.089	.090	.089
	Cincinnati	.111	.116	.113
	Denver	.105	.108	.106
	Kansas City	.111	.116	.113
	Medford	.108	.119	.111
	Omaha	.096	.114	.101
	Peoria	.093	.112	.099
	Philadelphia	.108	.116	.110
	Pittsburgh	.106	.110	.107
	Reno	.096	.112	.101
	Richmond	.109	.112	.110
	Salt Lake	.102	.108	.104
	Seattle	.096	.102	.098
Zone III	Bismarck	.080	.079	.080
	Burlington	.075	.085	.078
	Cheyenne	.090	.092	.091
	Juneau	.079	.081	.080
	Great Falls	.087	.089	.088
	Minneapolis	.080	.087	.082
	Portland	.079	.085	.081

* Average Uo = 70% single wide Uo + 30% double wide Uo

TABLE 8

Distribution of Manufactured Homes by HUD Zone

Distribution Factor	National Totals	Zone I	Zone II	Zone III
Number of manufacturing plants	406-7	265	118	23-4
% of total national	100%	65%	29%	6%
Number of manufactured homes produced 1983	295,573	207,704	78,706	9,163
% of national total	100%	70.3%	26.6%	3.1%
Number of manufactured homes produced 6/76 to 12/83	1,946,248	1,232,070	624,227	89,951
% of national total	100%	63.3%	32.1%	4.6%
Number of manufaccured homes shipped in 1983	289,756	199,123	73,914	17,175
% of national total	100%	68.7%	25.5%	9.0%
Number of manufactured homes shipped from 6/76 to 12/83	1,939,047	1,173,245	590,765	175,037
Percent of national total	100%	60.5%	30.5%	9.0%

TABLE 9

Optimum Uo for Manufactured Homes in Each Zone

HUD Zone	State	Percent of Zone M.H. in State	Reference City for State	City Optimum Uo	Weighted Average Factor
		percent	x	Uo =	
Zone I	Alabama	4.7	Atlanta	.123	.005800
	Arizona	4.3	Phoenix	.121	.005216
	Arkansas	2.0	Memphis	.121	.002412
	California	10.6	Fresno Corona	.114	.012047
	Florida	16.0	Jacksonville Miami	.172	.027472
	Georgia	6.7	Atlanta Savannah	.125	.008362
	Louisiana	8.2	Lake Charles	.137	.011250
	Mississippi	2.9	Memphis	.121	.003497
	New Mexico	2.6	Albuquerque	.109	.002839
	North Carolina	9.0	Raleigh	.121	.010917
	Oklahoma	4.9	Ft. Worth	.118	.005758
	South Carolina	4.9	Raleigh	.121	.005944
	Tennessee	3.2	Memphis	.121	.003859
	Texas	20.0	El Paso Ft. Worth San Antonio Brownsville	.129	.025780
		100.0	Zone Optimum Uo		.131153

TABLE 9 (cont.)

Zone II	Colorado	4.2	Denver	.106	.004448
	Connecticut	0.5	Boston	.090	.000450
	Delaware	1.7	Philadelphia	.110	.001877
	Idaho	2.9	Boise	.099	.002857
	Illinois	5.3	Peoria	.099	.005231
	Indiana	6.3	Omaha	.101	.006388
	Iowa	2.3	Omaha	.101	.002332
	Kansas	3.7	Kansas City	.113	.004163
	Kentucky	6.8	Cincinnati	.113	.007650
	Maryland	1.5	Philadelphia	.110	.001656
	Massachusetts	0.8	Boston	.090	.000720
	Missouri	5.3	Kansas City	.113	.005963
	Nebraska	1.6	Omaha	.101	.001622
	Nevada	2.9	Reno	.101	.002923
	New Jersey	1.1	Philadelphia	.110	.001214
	New York	5.2	Buffalo	.089	.004644
	Ohio	7.9	Cincinnati	.113	.008888
	Oregon	6.5	Medford	.111	.007235
	Pennsylvania	8.8	Pittsburgh Philadelphia	.109	.009574
	Rhode Island	0.2	Boston	.090	.000180
	Utah	2.1	Salt Lake	.104	.002180
	Virginia	6.5	Richmond	.110	.007144
	Washington	11.1	Seattle	.098	.010856
	West Virginia	4.8	Pittsburgh	.107	.005146
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		100.0	Zone Optimum Uo		.105338
Zone III	Alaska	1.7	Juneau	.080	.001353
	Maine	5.0	Portland	.081	.004040
	Michigan	26.5	Minneapolis	.082	.021757
	Minnesota	22.7	Minneapolis	.082	.018637
	Montana	8.8	Great Falls	.088	.007709
	New Hampshire	3.9	Burlington	.078	.003042
	North Dakota	5.6	Bismarck	.080	.004463
	South Dakota	3.9	Minneapolis	.082	.003202
	Vermont	2.4	Burlington	.078	.001872
	Wisconsin	12.1	Minneapolis	.082	.009934
	Wyoming	7.4	Cheyenne	.091	.006704
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		100.0	Zone Optimum Uo		.082713

TABLE 10

Comparison of Existing, Proposed and Optimum Uo Values

HUD Zone	Existing MHCSS	Proposed MHCSS	Optimum by Life-Cycle
I	.157	.145	.131
II	.126	.099	.105
III	.104	.087	.083

TABLE 11

Insulation Packages and Costs

HUD Zone	Construction Type	Uo	Insulation Level C	W	F	G	Total Insulation Package Costs	Net Increase in Cost to Meet Proposed Std.
Single Wides								
Zone I	Proposed	.145	7	11	11	SG	$2084.54	
	Existing	.157	7	7	11	SG	1990.12	$ 94.42
	Typical	.134	14	11	11	SG	2199.04	No inc.
Zone II	Proposed	.099	19	11	19	DG	2800.53	
	Existing	.126	7	11	11	DG	2380.99	419.54
	Typical	.125	19	11	7	DG	2523.83	276.70
Proposed Zone III (Northern Tier)	Proposed	.087	14	19	19	DG	3269.84	
	Existing	.126	7	11	11	DG	2380.99	888.85
	Typical	.111	19	11	11	DG	2611.56	658.27
Existing Zone III (Alaska)	Proposed	.087	14	19	19	DG	3269.84	
	Existing	.104	14	11	19	DG	2684.47	585.37
	Typical	.088	22	19	14	DG	3352.04	No inc.
Multisections								
Zone I	Proposed	.145	11	11	11	SG	2837.94	
	Existing	.157	11	7	11	SG	2748.12	89.82
	Typical	.140	14	11	11	SG	2926.05	No inc.
Zone II	Proposed	.099	14	13	19	DG	3765.74	
	Existing	.126	14	7	11	DG	3280.92	484.83
	Typical	.128	19	11	7	DG	3357.15	408.59
Proposed Zone III (Northern Tier)	Proposed	.087	19	19	19	DG	4311.40	
	Existing	.126	14	7	11	DG	3280.92	1030.48
	Typical	.112	19	11	11	DG	3486.98	824.42
Existing Zone III (Alaska)	Proposed	.087	19	19	19	DG	4311.40	
	Existing	.104	19	11	14	DG	3617.18	694.22
	Typical	.094	22	19	14	DG	4312.99	No inc.

TABLE 12

Cost Benefit Comparison by Zone

HUD Zone	Increased Retail Costs to Meet Proposed Standard: from Minimum Existing Standard	Increased Retail Costs to Meet Proposed Standard: from Typical Existing Construction	Net Benefits of Proposed Standard at 10% Discount Rate — First Year Cash Flow: from Minimum Existing Standard	First Year Cash Flow: from Typical Existing Construction	25 Year Life Cycle Savings: from Minimum Existing Standard	25 Year Life Cycle Savings: from Typical Existing Construction
Single Wides						
Zone I	$ 94.42	*	$ 10.27	*	$127.56	*
Zone II	419.54	276.70	53.63	70.28	1038.27	1142.69
Proposed Zone III	888.85	658.27	108.52	39.21	2353.91	1143.44
Existing Zone III	585.37	*	16.97	*	606.36	*
Multisections						
Zone I	$ 89.82	*	$ 3.58	*	$122.18	*
Zone II	484.83	408.59	51.68	90.17	1070.08	1530.50
Proposed Zone III	1030.48	824.42	83.08	42.91	1995.24	1808.88
Existing Zone III	694.22	*	44.23	*	1089.08	*

* No increased costs or savings accrue in meeting proposed standard, since typical package already meets the proposed standard.

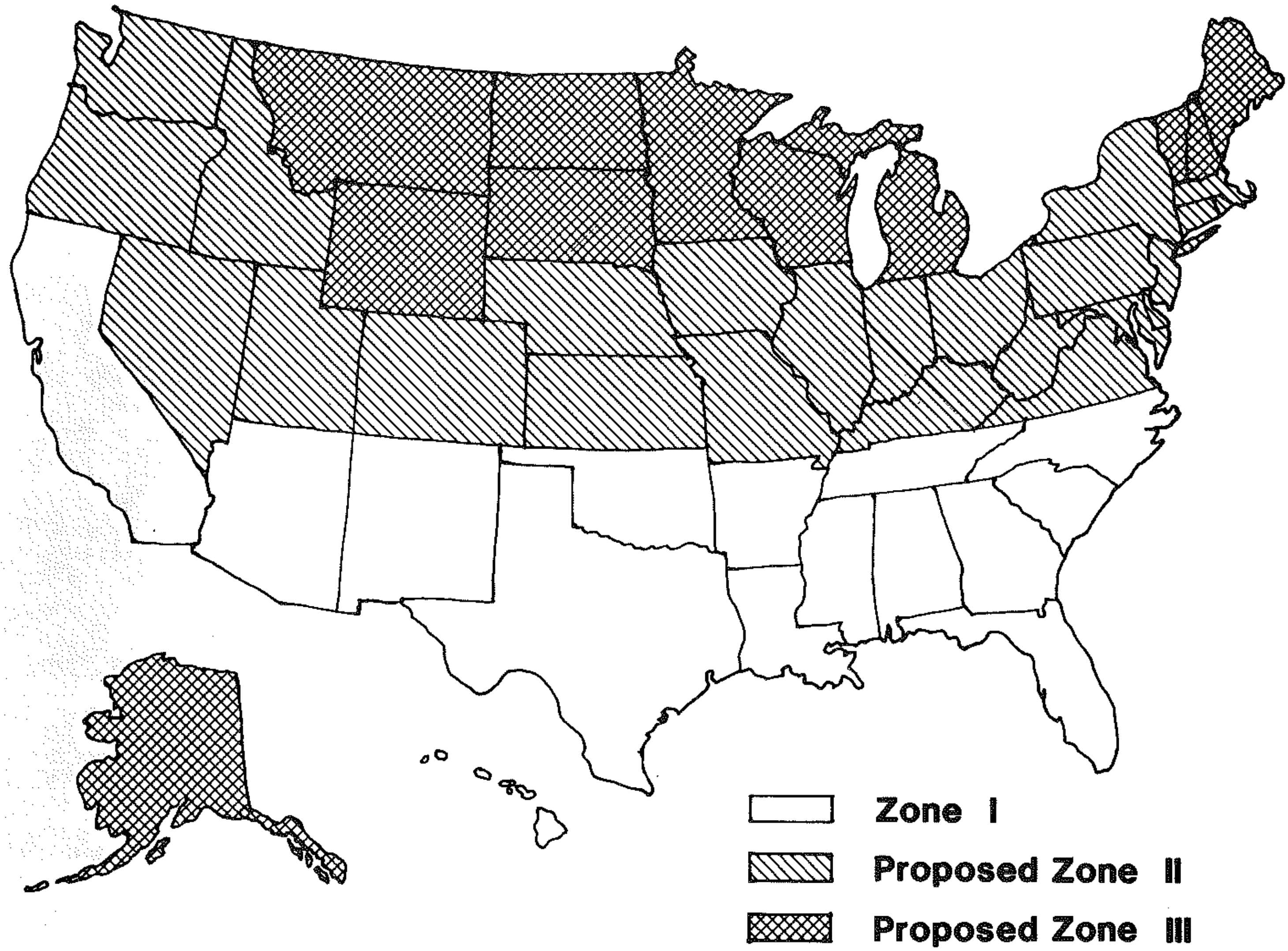

Figure 1. HUD manufactured home construction and safety standards proposed thermal zone map