Review of the Thermal Energy Standards for Manufactured Housing Proposed by the Manufactured Housing Institute Consensus Committee

C. C. Conner

February 1992

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SUMMARY

Congress passed legislation that requires the U.S. Department of Housing and Urban Development (HUD) to revise the energy efficiency standards for manufactured housing contained in the Manufactured Home Construction and Safety Standards (MHCSS). The Manufactured Housing Institute's Consensus Committee (MHICC) proposed revised standards to HUD based on an analysis contained in a 1989 report by E. Levy. This document is primarily a review of the Levy report, including the methods and inputs to that analysis.

The approach to be used in developing the revised standard was specified by Congress as a cost-benefit analysis in which the costs of energy efficiency measures (EEM) were balanced against the benefits of energy savings. The resulting optimum specified an overall level of energy efficiency in terms of a maximum allowable building shell U-value (overall thermal transmittance) that produced the lowest life-cycle cost to the owner of a manufactured home. In his 1989 analysis, this was the general approach used by Levy.

Levy's development of the MHICC-proposed thermal standard required several types of activities. The life-cycle cost model required the identification of inputs for EEM costs, fuel costs, financial parameters, and economic parameters. The maximum allowable U-values were generated in several steps. Initially, separate U-value optimums by heating fuel were generated for a number of U.S. cities. The separate U-values for each fuel/equipment type were merged to produce a U-value for each state. Next, the states with similar U-values were grouped into zones. Finally the U-values for the four resulting zones were calculated as the sales-weighted average of the U-values for the states in that zone. The result was a specification of maximum U-values for four zones.

In general, Levy followed the guidelines set by Congress for establishing the new thermal standards. As prescribed by Congress, his analysis was based on a life-cycle cost analysis using costs and benefits from the consumer's perspective.

Although Levy's work generally meets the requirements for determining the revised thermal standard, there are a few areas where the author of this review does not agree with Levy's assumptions or methods. The most important disagreements are:

- Levy did not distinguish between homes fueled by natural gas and homes fueled by liquid petroleum gas (LPG). All homes were evaluated using natural gas prices only. As a result, fuel prices are underestimated by over 50% for the ~25% of manufactured homes that use LPG for heating.
- Fuel prices (real) were presumed to be constant, rather than escalating over time. This assumption will likely underestimate the future costs of fuel.
- The DOE ARES (Automated Residential Energy Standard)(a) software was used for the life-cycle cost analysis. The standard version of the ARES computation of a home's resale value was altered to reduce the resale value.
- The period of analysis was 7 years, rather than the "physical life of the structure" as required by Congress.

Other methods and assumptions questioned by the author are defined in the body of this report. As a whole, the use of the methods and assumptions questioned by the author caused the MHICC-recommended U-values to be significantly increased over the U-values that would have been generated without their use. However, these U-values are still significantly less than existing standards. Because Levy's analysis is generally sound, the author recommends that it be performed again incorporating the modifications listed above.

The MHICC-proposed standard is compared to several existing and proposed standards in Table S.1. Because the various standards are defined in terms of different geographical zones, the standards were compared on the basis of national average U-values. The table shows the national average sales-weighted U-value calculated from the U-values for different geographical zones as specified by each standard.

(a) The ARES software is described in this report.

TABLE S.1. National Average U-value for Selected Standards

<u>Status</u>	<u>Average U-value</u>	<u>Standard</u>
Existing	0.145	HUD Title VI (regulates most manufactured homes)
	0.125 to 0.140	Author's estimate of current construction practice
	0.127	HUD Title II-E (30-year mortgage, including land)
Proposed	0.111	MHI MHCSS Consensus Committee (MHICC)
	0.098	Pacific Northwest Laboratory (PNL)
	0.092	American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) SPC 90.2, Residential Energy Standards

As Table S.1 shows, the MHICC-proposed revision requires significantly lower U-values than any of the existing HUD standards. In fact, all three of the recently proposed standards (MHICC, PNL, and ASHRAE) would require U-values well below the current HUD Title VI standard (which regulates most homes). The clustering of the three proposed standard's U-values well below the current U-values required by HUD (primarily Title VI) demonstrates that analyses from the three groups concur that the current HUD standard differs significantly from the consumer's optimum and that the consumer's optimum U-value is significantly below the current HUD required U-values. The proposal by MHICC allows the highest U-values of the three new standards proposed for manufactured homes.

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1.0 INTRODUCTION

Congress passed the Housing and Community Development Act of 1987 (HCDA) requiring the U.S. Department of Housing and Urban Development (HUD) to revise energy efficiency standards for manufactured housing [HCDA 1987; Congressional Record-House (CRH) 1987; Congressional Record-Senate (CRS) 1987]. (All three statutory requirements are listed in Appendix A.) The HUD energy efficiency requirements are contained in the HUD's Manufactured Home Construction and Safety Standards (MHCSS) (24 CFR 3280). The Manufactured Housing Institute (MHI) initiated a committee, the Manufactured Homes Construction and Safety Standards Consensus Committee, which contracted with Emanuel Levy of the Levy Partnership to produce a recommendation on revisions to the HUD thermal standards. (For brevity, the MHI committee will be referred to as the MHICC.) Based primarily on the recommendations in Levy's document, the MHICC recommended thermal standards to HUD. The HUD(a) brought the Pacific Northwest Laboratory (PNL)(b)(c) under contract to review the MHICC standards. This document primarily reviews the Levy report, which was transmitted to HUD by MHI along with the MHICC June 5, 1989, package of recommended changes to the MHCSS.

Several aspects Levy's work are reviewed in this document; these include the general approach, the tools used to do the life-cycle cost, the energy efficiency measure costs, the fuel costs, the economic parameters, the financial parameters, and the aggregation of city optimums to U-value zones. When appropriate, comparisons will be made to the two other recently proposed manufactured home thermal standards done by the American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) committee on Residential Energy Standards (SPC 90.2) and the Pacific Northwest Laboratory (PNL) (Conner

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- (a) The HUD was represented by William Freeborne, Government Technical Representative, Policy Research and Development; and by Donald R. Fairman, Chief, Standards and Products Branch, Manufactured Housing and Construction Standards Division, who served as Government Technical Monitor.
 - (b) Operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.
 - (c) This report was written by Craig C. Conner, who also managed the PNL project that proposed revised MHCSS thermal standards to HUD. Most of this report was written in late 1990.

et al. 1990). The three evaluations (MHICC, ASHRAE, and PNL) all used variants of a life-cycle cost analysis in developing their recommendations. All specified an overall level of required energy efficiency in terms of a maximum allowable building shell U-value.

The general approach used by Levy is sound and appropriate to the problem. He used a life-cycle cost analysis based on costs and benefits to the consumer, as required by Congress. In general, Levy based costs and benefits on the fuels costs and energy conservation costs borne by the consumer. This report reviews the methods and assumptions used in Levy's work. Modifications to some of the assumptions and methods are suggested.

The sections of this report are organized as follows. Section 2 presents an overview of the life-cycle cost model. Section 3 discusses the choice of the financial parameters, economic parameters, fuel prices, and energy efficiency measure (EEM) prices used in the life-cycle cost analysis. Section 4 briefly describes the creation of the zone U-values. Section 5 estimates the impact of four changes suggested by the author on the final MHICC U-values. Section 6 compares the MHICC-proposed U-values with the U-values of several other standards. Section 7 comments on Levy's estimations of the first costs required to meet the MHICC standard. Conclusions are provided in Section 8. Supplemental information including the text of the congressional requirements, fuel prices, and shipments of homes by state are provided in Appendices A, B, and C, respectively.

2.0 LIFE-CYCLE COST MODEL

This section describes the life-cycle cost tool used by Levy to generate the MHICC-recommended thermal standard revision.

2.1 LEGISLATIVE REQUIREMENTS PERTAINING TO OPTIMIZATION

The Housing and Community Development Act of 1987 and the accompanying conference reports (CRH 1987; CRS 1987) define the type of optimization method to be used to set the standard. The optimization methodology should be chosen to "ensure the lowest total of construction and operating costs." (HCDA 1987). The methodology is required to "result in the lowest possible total cost taking into consideration down payment, financing, construction, and energy costs" (CRH 1987). The method was specified to be "a life cycle cost analysis" (CRS 1987).

2.2 LIFE-CYCLE COST ANALYSIS

Life-cycle cost (LCC) analyses are used to select the least cost alternative from a range of possible alternatives. The LCC method sums the (discounted) costs and benefits for several alternatives, selecting the alternative with the lowest life-cycle cost. For the analysis to be credible, the parameters used in the analysis must properly reflect present or expected market conditions.

The basic cost elements of the generic LCC method are shown below. All costs and benefits are computed in present value dollars.

$$\begin{aligned}\text{Life-cycle cost} &= \text{Initial investment} + \text{Operating costs} \\ &\quad + \text{Maintenance costs} - \text{Resale value}\end{aligned}$$

- The first element represents the initial investment outlay. For the MHICC analysis, that outlay would represent the purchase (mortgage) and financing of manufactured home EEMs.
- The second element is the cost of operating the building. This represents the cost of the energy required to keep the building comfortable. (A reduction in the energy costs is the basic benefit of the standard.)

- The third element represents the maintenance, repair, or replacement costs required for the EEMs.
- The final element represents the resale value of the EEMs at the end of the analysis period.

2.3 AUTOMATED RESIDENTIAL ENERGY STANDARD

The MHICC analysis to develop the standard was done with the Automated Residential Energy Standard (ARES) program (Lortz and Taylor 1989). The methods used by the ARES software were defined primarily by the ASHRAE Special Project 53 (SP-53) committee. The ARES computer program was written by PNL for the U.S. Department of Energy's Voluntary Residential Standard Program. The ARES software implements a life-cycle cost methodology for residential energy conservation decisions. Given a set of fuel price, financial, economic, and EEM costs for a building at a specific location, ARES identifies the set of EEMs to invest in, such that the purchaser's total life-cycle cost is minimized. ARES was designed specifically for use in the development of residential energy conservation standards.

Besides a life-cycle cost model, ARES incorporates data from an energy simulation model allowing ARES to project the energy use for a selection of specific EEMs. The energy usage associated with each EEM becomes an input to the ARES life-cycle cost analysis.

The ARES software generates an optimum for a home in a specific city using a specific heating system and fuel. ARES does not generate an optimum for a group of cities or a climate zone. The aggregation of the individual optimum U-values was done by MHICC as a separate series of steps that are described in Section 4 of this report.

2.4 RESALE VALUE

One part of the ARES methodology, the resale value calculation, was altered by Levy. The standard version of ARES assumed that "... the value of the conservation improvement does not keep up with inflation, but rather depreciates in real terms at the rate equal to the inflation rate." [U.S. Department of Energy (DOE) 1989, p. A.72]. For the combination of parameters selected by Levy, the resale value of the conservation investment computed by

the original version of ARES would have been 76% of the purchase price (in real dollars). The MHICC committee directed Levy to reduce the resale value to about 77% of the original ARES calculation (Levy 1989, p. 2.15).(a) This modification of ARES lowered the resale value to about 58% (about 77% of 76%) of the original purchase price (again in real dollars).

The MHICC thought the ARES calculation of resale value was too high. In general, it is difficult to quantify the value purchasers of used homes place on EEMs. Levy did not provide specific estimates of resale value to back up the argument that the resale value estimated by ARES is high. However, pages from the Mobile/Manufactured Home Blue Book (January 1989, inside back cover) were included with the MHICC submission to HUD. This appraisal guide estimated the retail value of 38 items (including "Insulation Package") on a 5-year-old home as 50% of the first cost. A different appraisal guide, the N.A.D.A. Mobile Home, Manufactured Housing Appraisal Guide (NADA 1990, part 3, p. 8) estimated the resale value of high insulation levels as significantly higher. For example, the NADA guide estimated that for homes in HUD zone I with high insulation levels(b) instead of the current HUD minimum(c), the resale values increased by \$1500 for multi-section homes and \$1000 for single-section homes (NADA 1990, part 3, p. 8), which is above the original cost estimated using Levy's EEM costs(d). Some sources state that manufactured homes appreciate in value rather than depreciate(e). In the author's opinion, Levy has not built a strong case for modification of the standard resale value calculation in ARES. In any case, Congress has specified that the "physical lifetime of the structure" will be used in the analysis of the MHCSS thermal standards

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- (a) In contrast, the MHICC says the reduction was to 75% of the original (MHICC 1990, p. 9).
 - (b) High levels of insulation were defined as a minimum of ceiling R-25, wall R-11, floor R-14, and single-pane glass with storm window.
 - (c) The current requirement is about ceiling R-11, walls R-7, floors R-7, and single glazing.
 - (d) Levy's EEM costs are given on page 2.7 (Levy 1989).
 - (e) Don Carlson, the editor and publisher of Automated Builder, states "All phases of factory-built housing appreciate in value in lock step with site built homes providing neighborhood factors, principally location, are equal. Studies show HUD-code homes built as long as 15-years ago have appreciated in value, thereby destroying the myth that HUD-Code units, like some cars, decline in value." (Automated Builder, October 1990, p. 42).

(CRS 1987), which should make the resale value calculation for the first owner a moot point.

Modification of the DOE ARES software to lower the resale value raised the resulting U-values recommended by the MHICC. The author estimates the MHICC change to ARES increased the maximum allowed U-value by about 5%.

3.0 FINANCIAL, ECONOMIC, AND FUEL PRICE PARAMETERS

In this section the financial, economic, and fuel price parameter values necessary to develop the MHICC-recommended standards are discussed. The financial, economic, and fuel price parameters used by Levy are listed below.

- Manufactured home finance parameters
 - mortgage interest rate: 14%
 - loan term: 15 years
 - down payment: 10%
 - loan fees and points: 1%
- Other rates and times
 - discount rate: 14% nominal (about 9.6% real)
 - inflation rate: 4%
 - period of analysis: 7 years
 - property tax rate: 2%
- fuel price escalation rates for all fuels: 0% (real)

3.1 FINANCE PARAMETERS

Levy's analysis assumed that a manufactured home was financed, which is by far the most common case; 81% of new manufactured homes are financed (Foremost Insurance Group 1988). Several financing parameters affecting the cost and duration of the loan are required for a LCC analysis. These parameters are the mortgage interest, loan term, down payment, points, and loan fees.

3.1.1 Mortgage Interest Rate

A mortgage interest rate of 14% was selected for this analysis. This is consistent with the rates reported by other sources (Meetings+Plus 1987, Florida Manufactured Housing Industry Report 1988, U.S. Federal Reserve 1988).

3.1.2 Loan Term

A loan term of 15 years was selected for the MHICC analysis. The average loan term for 1985 was reported to be 11.5 and 13.4 years for single- and double-section manufactured homes, respectively (MHI 1986, p. 4). The average loan term was reported to be 13.8 years in 1987 (Foremost Insurance Group 1988, p. 18). The MHICC-selected 15-year term is higher than the loan term from these sources, but is clearly a reasonable estimate.

3.1.3 Down Payment

A down payment of 10% was selected for the MHICC analysis. According to MHI in its most recent report, the average down payment for manufactured homes was 15.1% for single-section homes and 15.5% for double-section homes (MHI 1986, p. 13). The Levy report used 10%, which is below the average but is common.

3.1.4 Points and Loan Fees

Estimates of the average points associated with manufactured home financing vary. The 1% used by Levy is a good estimate for manufactured home loans. Loan fees on manufactured housing are generally a fixed fee, so that there is no incremental loan fee for energy efficiency measures. Therefore, Levy's assumption of no incremental loan fee is correct.

3.2 ECONOMIC PARAMETERS

For the LCC analysis, a discount rate, inflation rate, and period of analysis needed to be established.

3.2.1 Discount Rate (Alternative Investment Rate)

A life-cycle cost analysis must convert costs and benefits occurring over future years into present dollars. To convert future dollars into present dollars, a discount rate needs to be established. There is a wide range of possible discount rates for which an argument can be made.(a)

The discount rate selected by Levy is the loan mortgage rate of 14%. This represents prepayment of the mortgage, which is an "investment" option

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- (a) Several possible rates are listed below. All are nominal unless noted.
- the rate required for analyzing energy efficiency investments made by government programs (7% real) (Energy Security Act of 1980)
 - the consumer's discount rate as determined by purchases; in practice estimates of this rate vary too widely to use (EPRI 1988, p. 2-22).
 - the credit card rate (about 18%)
 - the rate for consumer investment
 - passbook savings rate (about 5%), which is probably the most common "investment" made by manufactured home consumers
 - U.S. Savings Bonds (about 7%)
 - Certificates of Deposit (CDs) (about 8%)
 - the mortgage loan rate (about 14%, less any tax benefits).

available to homeowners. An argument for using the mortgage interest rate (at a minimum) is that the home buyer has borrowed money at that rate, demonstrating that his implicit discount rate must be at least that high(a); therefore, the mortgage prepayment is a reasonable choice. A similar argument could also be made for the much lower rate of about 5% common on passbook savings because passbook savings are probably the most common "investment" of money by owners of manufactured homes. The passbook savings argument would suggest that the consumer's frequent choice of passbook savings demonstrates that 5% is an adequate return on the consumer's investment(b). The 14% (nominal, about 9.6% real) discount rate used by Levy is higher than discount rates commonly used in most life-cycle cost analyses. However, the discount rate is in the range of justifiable values, and therefore, cannot be considered incorrect. The effect of a high discount rate would be to raise the allowed U-values.

3.2.2 Inflation Rate

Levy selected 4% as the inflation rate. Estimates of inflation rates vary; the Energy Information Administration (EIA) estimate for inflation is 4.8% (EIA 1990, p. 40).(c) The EIA reported inflation rates from four other energy forecasters(d), with the range being 4.4% to 5.3% (EIA 1990, p. 35). Levy's rate of 4.0% is certainly plausible. No source for Levy's estimate was cited. The effect of a lower inflation rate would be to raise the allowed U-values.

3.2.3 Period of Analysis and Building Lifetime

The statutory requirements for development of the standard set the "estimated useful life" (CRH 1987) as the period for the life-cycle cost analysis. This period is clarified as the "effective physical life of the

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- (a) In choosing to prepay the mortgage, the owner may lose liquidity and could incur a penalty for prepayment. If the owner itemizes tax deductions, he will lose a portion of the mortgage tax deduction.
 - (b) As with prepayment of mortgage, other issues also arise including convenience, liquidity, and security.
 - (c) This is the inflation rate for the EIA base case energy forecast, which is termed the "long-range gross national product implicit price deflator".
 - (d) DRI/McGraw Hill, the WEFA Group, the Gas Research Institute, and the American Gas Association.

structure" (CRS 1987). Because the standard applies to new manufactured homes, the estimated life should be that of a newly constructed manufactured home. The average useful life for new manufactured homes that are continuously occupied has been estimated by MHI at 33.4 years (Gates 1986). Therefore, a period of 30+ years would be appropriate. In contrast to the 30+ year useful life, Levy's analysis was based on a 7-year period.

Levy makes several arguments for the 7-year period, which represents the first owner's period of occupancy. Levy states that the Congressional requirement in the conference report (CRH 1987) is ambiguous (p. 1.3), allowing an interpretation as either the number of years the building is in operation (30+) or the period occupied by the first buyer (averaging 7 years). He implies that the 7-year period recommended by the ASHRAE SP-53 represents the "ASHRAE guideline" (Levy 1989, pp. 2.1, 2.2, 2.3). Finally, he argues that long time periods would not represent the required lowest total cost to the new (first) home buyer.

The author believes the statutory references are clear on the period of analysis. The Congressional record clearly requires the building physical lifetime. It states that the costs and benefits are to be considered for the "home over its estimated useful life" (CRH 1987). This is clarified as "the effective physical life of the structure" (CRS 1987). In addition, all statutory references are to owner(s) of the manufactured home; not to the first owner, new homeowner or home buyer; supporting the building's lifetime as the analysis period.

Levy argues that the selection of the longer period (30+) will lead to energy measures that do not represent the first homeowner's (new home buyer's) least cost. This argument presumes that the second home purchaser will not repay the original purchaser for the remaining value of the loan on the EEM features in the home. In general it is difficult to quantify the value home purchasers place on energy efficiency measures. As noted previously, two manufactured home appraisal guides offered significantly different estimates of the resale value of insulation. In any case, because none of the statutory references are exclusively to the first owner and the longer period of analysis is specified (CRS 1987), there would appear to be no justification

for examining exclusively the interests of the first or new homeowner instead of all the owners of the manufactured home over its useful physical life.

Finally, Levy's implication that a shorter period of analysis represents an ASHRAE guideline (Levy 1989; pp. 1.3, 2.1, 2.2, 2.3) is incorrect. The 7-year period was endorsed by the ASHRAE SP-53 committee (but not any other ASHRAE body this author is aware of). The **official published** ASHRAE guidelines, the 1989 ASHRAE Handbook of Fundamentals, recommend that "Generally, longer lifetimes (e.g. 30 years) rather than shorter lifetimes (e.g. 10 years) approach true life cycle cost minimization more closely and avoid the high cost of retrofitting if energy prices rise." (ASHRAE 1989a, p. 20.11).

The selection of the 7-year analysis period raised the MHICC-recommended maximum U-value relative to the longer period of the building's physical lifetime. The author estimates that the use of the shorter period of analysis raised the MHICC-recommended U-values by about 5 or 6% over the values that would have been obtained with a 30+ year analysis period.

3.2.4 Property Tax Rate

A property tax rate of 2% was selected. Property taxes vary widely from state to state and within a particular state. The Electric Power Research Institute (EPRI) has recommended a levelized value of 2% for property taxes and insurance (EPRI 1982). Many owners of manufactured homes do not pay property taxes because such homes are sometimes classified as personal property rather than real property; however, they will often pay personal property taxes that are probably equivalent. Therefore, Levy's selection of a 2% property/personal tax is appropriate.

3.2.5 Income Tax Rate

The marginal income tax rate paid by a homeowner determines the value of the mortgage tax deduction. However, most owners of manufactured homes do not itemize their income tax deductions, as Levy notes (1989, p. 2.14). The correct income tax rate used as input to ARES should have been 0%, so the life-cycle cost calculation done by ARES would reflect the fact that most homeowners do not itemize their income tax deductions. (DOE 1989, pp. A.68, A.69, A.70) Apparently, Levy incorrectly chose to input 15%. Levy also refers

to state income tax rates (1989, p. 2.15), but does not list the rates used. The state tax rates should also have been 0% for the ARES input.

If the author's reasoning correct, setting the income tax rate in ARES to 15% rather than 0%, lowered the MHICC-recommended U-value by an estimated 2%.

3.3 FUEL PRICE PARAMETERS

Both current fuel prices and fuel price escalation rates were required for this analysis.

3.3.1 Fuel Price Data

Levy used a survey of utilities to establish energy costs (1989, p. 2.8). The fuel costs use are listed in the report (1989, pp. 2.11-2.13). It is not clear if fuel costs were collected for the states of Arkansas, Connecticut, Delaware, Iowa, Kansas, Kentucky, Maryland, Mississippi, New Hampshire, New Jersey, North Carolina, Rhode Island, South Dakota, Virginia, West Virginia, and Wisconsin because these states not listed in the table. It is not clear what fuel prices were used for these states, which is significant because these states amount to about 24% of the total national sales of manufactured homes (see Appendix C).

The text states that LPG costs were collected (Levy 1989, p. 2.8); however, these costs do not appear anywhere in the report.

Levy collected energy costs data from cities(a), rather than state averages. The Levy fuel prices are compared to the state averages (EIA 1988) in Appendix B. In some cases, the specific city selected was significantly different from the state average. As a whole, this does not appear to have affected his results because the average prices for each fuel produced by Levy are similar to the average fuel prices produced by the EIA.

(a) Levy states that the energy cost survey intended to "collect energy cost data from representative utilities that provide service to the manufactured housing community" (1989, p. 2.8). If this was the goal, some of the cities selected would appear to be poor choices because the number of manufactured homes in those cities is small. For example, New York City and Washington D.C. have few manufactured homes in their areas.

Levy combined the natural-gas-fueled and LPG-fueled heating systems, because all furnaces sold must be convertible (Levy 1989, p. 2.17). In the process, he applied the natural gas prices to the LPG-fueled homes. This can be determined by examining the optimum U-values produced for each state and the state's energy prices in the energy price table. By using the natural gas price for the LPG-fueled homes, Levy underestimated the fuel cost for the LPG-fueled homes.

Costs for LPG are over 50%(a) higher than natural gas costs. About 24.4% of all manufactured homes use LPG for heating (EIA 1989, p. 48)(b). The implication is that about 25% of the homes, the LPG-fueled homes, should have had fuel prices that were greater than 50% higher.

The use of natural gas prices for LPG-fueled homes raised the MHICC-proposed U-values, relative to the U-values obtained if LPG prices were used for LPG-fueled homes. The author estimates that use of the low prices for LPG-fueled homes raised the MHICC-recommended U-values by about 4%.

3.3.2 Fuel Price Escalation Rates

The Levy report presumed that real fuel prices would remain constant.(c) This author is not aware of any source that predicts all energy prices will remain constant. The assumption of constant real fuel prices over the MHICC period of study (7 years) is reasonable for electricity.(d) However, the assumption of constant real prices for oil and gas is very questionable. For example, the EIA (1990, p. 41) projects that over the next 10 years, residential heating oil prices will escalate at a rate of 2.3% per year and that natural gas will escalate at a rate of 2.4% per year. The effect of the assumption of constant fuel prices is moderated by the selection of a short period of analysis (7 years).

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- (a) For 1990 (National Institute of Standards and Technology 1990, p. 20), the ratio of average LPG prices to natural gas prices is about 9.28/5.64 (\$/MBtu) = 1.65 or an increase of about 65% above current natural gas prices.
 - (b) The same reference gives the fraction of homes heating with natural gas as 32.7%.
 - (c) Another way of saying this is that nominal fuel prices would track inflation.
 - (d) The EIA projects the inflation rate for electricity to be 0.2% per year over the next 10 years (EIA 1990, p. 41).

The assumption of constant real fuel prices runs counter to the generally recommended practice for economic optimization. For example, the ASHRAE guidelines in the 1989 ASHRAE Handbook of Fundamentals include an annual rate of energy price increase in its evaluation of optimum insulation level (ASHRAE 1989a, p. 20.10).

The assumption that real fuel prices will remain constant raised the allowed U-values recommended by the MHICC. The author estimates that the use of constant fuel prices raised the MHICC-recommended U-values by about 2% compared to the use of more realistic fuel escalation rates projected by EIA/DOE.

3.4 ENERGY EFFICIENCY MEASURES

The Levy life-cycle cost analysis required costs for specific EEMs. The cost data was developed from a survey of 27 manufactured housing plants. This cost data was used to determine the homeowner's cost for an EEM. This approach complies with the requirement that the standard is to be developed using "costs to the manufactured homeowner" (CRH 1987).

Other recent surveys of EEM costs are available for comparison, a study done for the Bonneville Power Administration (Baylon, Lubliner and Davis 1990) and others done for HUD (Conner et al. 1990; Lee and Conner 1989; Harkreader, Lee, and Sherman 1987). In practice, EEM costs are somewhat difficult to determine, and some variation should be expected between various sources. A comparison of the three studies by the author (data not shown here) suggests that the MHICC costs for ceilings, walls, and floors tend to be lower than the two other sources. Window costs are more difficult to judge because window U-values must be considered and these three sources did not have comparable U-values.

Levy's costs seem particularly low at low insulation R-values and grow quickly at the highest R-values (even accounting for presumed construction changes). A clear example of this variation in costs as R-value increases is in the window costs. Levy's cost for adding a storm window to a single-glazed window is \$3.01, while the cost of adding a storm window to a double-glazed window is almost double (\$5.78). (Levy 1989, p. 2.7)

3.5 INFILTRATION ENERGY EFFICIENCY MEASURES

One alternative proposed to HUD by the MHICC in the June 5, 1989 submission was a low-infiltration alternative(a). This alternative allowed a higher U-value for homes with a package of infiltration-reduction measures, specified as:

- 1) Access panels in ceiling cavities from conditioned spaces, if provided, shall be weatherstripped or gasketed to seal the conditioned space from outside air leakage.
- 2) An air infiltration barrier (AIB) shall be provided on the exterior side of the wall cavity insulation.
- 3) All joints and penetrations of the AIB shall be taped or sealed to reduce air leakage.
- 4) Windows shall be certified for a maximum leakage rate of 0.41 CFM at a pressure differential of 1.57 PSF."

The author would recommend against the adoption of this option without specification of requirements that would mitigate any moisture and/or air quality problems. It is difficult to predict the air-exchange rates that would result from the specified measures. Many manufactured homes in current production already have moderate to low infiltration rates, some below 0.3 ACH (Hadley and Bailey 1990), which would be further reduced by these measures.

It should be noted that HUD is currently working on regulations to deal with ventilation and moisture problems. Alternative packages for compliance that could produce very low infiltration rates, such as the alternative proposed by MHICC, should not be considered as a part of HUD regulations until HUD is confident that potential moisture and air quality problems can be mitigated.

(a) No requirement for low-infiltration EEMs is present in the legislation or the Congressional report. The Congressional report does state that "In developing these standards, HUD should assume reasonable levels of air infiltration" (CRH 1987), which could be interpreted as suggesting that standard revision should assume the infiltration level as a fixed parameter. The current MHCSS includes several specifications that reduce infiltration, which Congress may have deemed sufficient for now.

4.0 U-VALUE ZONES

The statutory requirements for the standard expected that HUD would establish "maximum transmission heat loss coefficients [U-values] in a number of climate zones" (CRH 1987). Levy produced the required zone U-values in a series of steps.

- 1) An optimum U-value was produced for each of four equipment/fuel types: oil, natural gas, electric resistance, and electric heat pump for a number of cities. (It is not clear from the report how U-values were produced for cities in the 16 states that do not have fuel prices listed in the report. These states represent 24% of the U.S. sales of manufactured homes.)
- 2) City U-values were combined to get state U-values.
- 3) The different fuel types were combined to produce a single optimum for each state, based on a weighting of furnace sales. The author replicated this step based on the data in Levy's report and obtained the same results.
- 4) The states were grouped to create the U-value zones. The grouping was based primarily on the similarity of U-values and secondarily on proximity.
- 5) The state U-values were then aggregated into zone U-values based on a weighting of home sales in each state. The author replicated this step based on the state U-values in Levy's report using a weighting based on the 5-year average home sales in each state (Appendix C). The author obtained the same results as Levy.

Levy considered separate U-values for single- and double-wide homes, as suggested in the Congressional record (CRH 1987). He determined that the U-values for the two types of homes were very similar and could be combined into one standard. This is consistent with the recommendations of the two other proposed standards (ASHRAE and PNL), and with the current HUD standard.

5.0 SENSITIVITY OF THE U-VALUES TO THE ISSUES IDENTIFIED

Several assumptions and methods used by Levy are questioned by the author of this report. Because the Levy work is basically sound, the author recommends that his analysis be repeated with at least the four changes identified in Table 5.1. The author's estimation of the impact of each change is shown in Figure 5.1.

The sensitivity of the MHICC-recommended maximum allowable U-values to the most important issues raised in this report is estimated below. In each case, the author has estimated the average change that would occur in the MHICC U-value requirement if the specified change in Levy's methods or assumptions was applied(a). The first column in Table 5.1 identifies the recommended change in method or assumption. The second column estimates the impact on the U-value requirements resulting from that change. All recommended changes would reduce the maximum allowable U-value. In each case, the impact is expressed as a percentage of the average recommended MHICC U-value.

TABLE 5.1. U-value Sensitivity to Selected Parameters

<u>Recommended Change in Levy Analysis</u>	<u>Estimated Impact on Average MHICC Proposed U-value</u>
Use LPG fuel price for LPG-fueled homes (Natural gas prices were used for LPG-fueled homes. Making this change would increase the fuel price for about 25% of the homes by over 50%.)	-4%
Use EIA/DOE fuel price escalations (Constant real fuel prices were assumed, EIA estimate is about 2% escalation overall)	-2%
Use standard ARES life-cycle cost software (ARES resale value calculation was modified)	-5%
Longer analysis period (Use 30+ year period required by Congress, instead of 7 years)	-5% to -6%

(a) The values given here are based on a sensitivity analysis reported by Conner et al. (1990).

FIGURE 5.1 Estimated Impact of Suggested Changes on Average U-value

6.0 COMPARISON TO OTHER STANDARDS

The MHICC-proposed standard was compared to four other proposed and existing standards. These were:

- HUD's Title VI (regulates most manufactured homes)
- HUD Title II-E (30-year loan, requires that the home include land)
- Pacific Northwest Laboratory (Conner et al. 1990)
- ASHRAE SPC 90.2 on Residential Energy Standards (1989b).

The HUD Title VI and HUD Title II-E standards are summarized by Taylor et al. (1988, Appendix B). The ASHRAE Residential Energy Standard proposal is contained in the ASHRAE SPC 90.2 Public Review draft (ASHRAE 1989b).

Because the various standards are defined in terms of different geographical zones, the national average U-value required by each standard was used for comparison. To compute each standard's average U-value, each state's required U-value was weighted by the number of homes sold during the 5-year period from 1984 to 1988 (Appendix C). As Table 6.1 and Figure 6.1 show, the revision proposed by MHICC is significantly more stringent than the existing HUD standards. It is interesting to note that all three recently proposed standards (those from MHICC, ASHRAE, and PNL) would require U-values well below the current HUD Title VI standard, suggesting that all three organizations agree that the current HUD thermal standard is not the optimum for the homeowner.

TABLE 6.1. National Average U-value Requirement for Selected Standards

Status	Average U-value	Standard
Existing	0.145	HUD Title VI (applies to most homes)
	0.125 to 0.140(a)	Estimated current practice
	0.127	HUD Title II-E (30-year mortgage, requires land)
Proposed	0.111	MHI MHCSS Consensus Committee(b)
	0.098	Pacific Northwest Laboratory
	0.092	ASHRAE 90.2P Residential Standard

FIGURE 6.1 National Average U-values for Selected Standards

- (a) This was estimated based on manufacturer survey data -(Lee and Conner 1989; Harkreader, Lee, and Sherman 1987).
- (b) MHICC proposed two possible U-value zones, one with separate fossil fuel and electric U-values, the other applying to all fuels. The proposal applying to all fuels, recommended by the MHICC, was used here.

7.0 FIRST COSTS TO MEET THE MHICC STANDARD

One significant impact of the proposed standards is the additional first cost required to meet the standard(a). In Section 4 of Levy's report he provided an estimate of the first cost to the consumer to implement the MHICC-proposed standard. This review's author has identified several issues related to this estimation of the first costs to meet the MHICC standard. One of these issues, that of the individual EEM costs, was discussed previously in Section 3.4. (It concluded that Levy's EEM costs appear to be lower in many cases than two other data sources.) Other issues are identified below.

There appears to be an inconsistency in the aggregation of single- and double-wide first costs (Levy 1989, tables on pages 4.2, 4.3, 4.4). Although the fraction single- and double-wide used in weighting the costs to produce the weighted average first cost is not stated, a fraction can be inferred from the weighted average of the cost data in the three Levy tables. The fraction thus inferred appears to be inconsistent in the report. For example, the first cost for the cases of "all fuels", "fossil fuel", and "electric resistance" for "single-section homes", "double-section homes", and "weighted single- and multi-section homes" from the Levy report(b) are shown in Table 7.1. Note that the all-fuels case appears to contain a higher proportion of single-wide homes than either the "fossil fuel" or "electrical resistance" cases. Because "all fuels" is a combination of fossil fuels and electric resistance, the expected result would be for the two subsets to have about the same fraction of single-wide homes as the "all fuels" case; or to have one of the subsets of "all fuels" fall above and the other fall below in fraction of homes that are single-wide.

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- (a) Section 3.4 discussed costs for the range of possible EEMs. This section focuses on the cost for the specific package of EEMs implicitly required by the standard.
 - (b) There is one value for each fuel type from each of Levy 1989, pages 4.2, 4.3, and 4.4.

TABLE 7.1. First Costs and Implied Fraction Single and Double-Wide

<u>Fuel</u>	<u>Single-Wide Cost</u>	<u>Double-Wide Cost</u>	<u>All Homes Cost</u>	<u>Implied % Single</u>
All fuels	\$384	\$621	\$438	77%
Fossil fuels	\$227	\$362	\$272	67%
Electric resistance	\$845	\$1217	\$980	64%

In addition to the inconsistency noted above, the estimation that 77%(a) of the homes are single-wide biases the Levy estimate of costs to be low. Nationally the fraction of homes that were single-wide in 1989 was about 52% (Automated Builder, August 1990, p. 32). In fairness, it should be noted that Levy could not have had the 1989 data on the fraction of the homes that were single-section when his report was written.

Finally, it is not clear that Levy included sales taxes on the materials in estimating the first costs to the home buyer.

All issues identified above will reduce the estimated first cost of the MHICC to the consumer. Therefore, the author's estimate of the MHICC first costs would be above those given in Levy's report. Note that these concerns about the first cost estimates do not affect the selection of the U-values proposed by MHICC, only the estimation of the retail cost of the standard.

(a) This is the fraction apparently used for the all-fuels standard recommended by MHICC.

8.0 CONCLUSIONS

The work by Levy formed the basis of the MHICC recommendation to HUD on thermal standards. The methodology and parameters used generally followed the requirements set by Congress. Levy used a life-cycle cost analysis of the benefits of investing in energy efficiency. The analysis is based on costs and benefits calculated from the homeowner's perspective. Except as noted, the work is sound and represents a reasonable analysis for generating revised manufactured home U-value requirements for consideration by HUD.

The author recommends that consideration be given to repeating the work, in order that a few changes in the methodology and assumptions could be made. The repetition of the work should use the standard version of the DOE life-cycle software (ARES). Appropriate fuel prices should be used for the LPG-fueled homes. Future fuel prices should not be presumed to remain constant (in real dollars), but should escalate as projected by the EIA/DOE. The period of analysis should be the physical life of the building, as prescribed by Congress. As a whole, these changes will cause the optimum U-values to be significantly decreased. If the changes recommended above are made, the author believes the resulting U-values will more accurately reflect the homeowner's optimum for manufactured home U-values as mandated by Congress.

The MHICC-recommended U-values are significantly lower than the current HUD standards. In recommending lower U-values, Levy's analysis has apparently concluded that the current HUD U-value requirements are not optimum for the owners of manufactured homes. In this sense, Levy's analysis concurs with two other proposed standards recommended by ASHRAE and PNL in recommending significantly lower U-values for HUD's Title VI standard.

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APPENDIX A

TEXT OF CONGRESSIONAL REQUIREMENTS

APPENDIX A

TEXT OF CONGRESSIONAL REQUIREMENTS

This appendix reproduces the text of the Congressional requirements for the revised HUD standard. The Housing and Community Development Act of 1987 (HCDA) and the accompanying conference reports (CRH 1987; CRS 1987) defined the general method used to produce the proposed revised thermal standards for HUD's Manufactured Home Construction and Safety Standards (MHCSS) (24 CFR 3280).

From the Housing and Community Development Act of 1987 (HCDA):

Sec. 569. MANUFACTURED HOUSING CONSTRUCTION AND SAFETY STANDARDS.

Section 604 of the National Manufactured Housing Construction and Safety Standards Act of 1974 is amended by adding at the end the following new subsection:

(i)(1) The Federal manufactured home construction and safety standards established by the Secretary under this section shall include preemptive energy conservation standards in accordance with this subsection.

(2) The energy conservation standards established under this subsection shall be cost-effective energy conservation performance standards designed to ensure the lowest total of construction and operating costs.

(3) The energy conservation standards established under this subsection shall take into consideration the design and factory construction techniques of manufactured homes and shall provide for alternative practices that result in net estimated energy consumption equal to or less than the specified standards.

From the Congressional Record of the House (CRH):

Manufactured Homes Energy Conservation Standards

The House amendment contained a provision not included in the Senate bill that would require HUD to establish energy conservation standards for manufactured homes that are equivalent in energy performance to those required for FHA-insured single family homes. The conference report includes a substitute provision that would require HUD to issue preemptive cost-effective energy conservation standards that: 1) are designed to ensure the lowest total of construction and operating costs; 2) take into consideration the

design and factory construction techniques of manufactured homes; and 3) provide for alternative practices that result in net estimated energy consumption equal or less than the specified standard.

The conferees agreed that the present energy conservation standards applicable to manufactured homes are inadequate and the Department's efforts to delegate these standards to a multitude of conflicting State energy codes defeats the requirement of a preemptive national code for manufactured housing. The conferees also recognize that the application of a standard equivalent in energy performance to the FHA Minimum Property Standards in some southern areas of the country would result in decreasing the energy efficiency of these homes, not creating the most cost-effective energy standards as the agreement would require.

The provision would require the Department to develop a standard that results in the lowest total costs to manufactured home owners. Such a goal can be achieved by establishing a standard that assures the combination of construction costs and estimated value of energy saved through the operation of the energy-efficient home over its estimated useful life will result in the lowest possible total cost taking into consideration downpayment, financing, construction and energy costs to the manufactured home owner.

Since the manufactured home standard generally is a performance standard, the energy conservation standard will also be a performance standard and it is expected that HUD will establish separate maximum transmission heat loss coefficients for the overall envelope area for single-wide and double-wide manufactured homes in a number of climatic zones.

In developing these standards, HUD should assume reasonable levels of air infiltration, heating and cooling equipment efficiencies and solar heat gain through glazing and should assure minimum effect on the overall costs of home ownership. In addition, any design claiming, through generally accepted engineering practices, energy performance equal or better than the specified performance standard should be allowed to benefit from improvements to those components.

It is expected that the Department will rely on currently available research in order to develop cost-effective energy standards and make them effective within one year from enactment."

From the Congressional Record of the Senate (CRS):

Mr. ADAMS. Mr. President, I rise to congratulate the subcommittee chairman, Mr. CRANSTON, for his distinguished leadership on this important piece of legislation and to offer my special thanks for his efforts to deal with the provisions that would improve the energy efficiency of manufactured housing built in this country.

This is an extremely important issue in the Pacific Northwest where these structures account for approximately 30 to 40 percent of new electricity heated homes built in this region. The standards that we expect to come out of this legislation should save my region alone approximately \$500 million over the next 20 years.

I want to take this opportunity to clarify my support of the important features related to Section 569 of S. 825.

It is my understanding that the Department of Housing and Urban Development will conduct a life cycle cost analysis, taking into consideration the cost of energy savings from those measures over the effective physical life of the structure and that this important analysis is to be completed within 1 year of this legislation.

Mr CRANSTON. I thank the Senator from Washington for his support and assistance on this important legislation. The Senator is correct that the purpose of this section 569 of S. 825 is to require the Department of Housing and Urban Development to complete a life cycle cost analysis to develop national standards for the energy efficiency of new manufactured housing. This important legislation is to be completed in 1 year.

MR. ADAMS. I thank the distinguished subcommittee chairman from California. This is a very important effort and we need to begin moving as quickly as possible.

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APPENDIX 8

FUEL PRICES

APPENDIX B

FUEL PRICES

This appendix compares the fuel prices used in Levy's report (not including the states that did not have listed fuel prices) to the residential energy prices from an Energy Information Agency report, State Energy Price and Expenditure Report (EIA 1988a). These 1986 EIA fuel prices for each state were updated for the fuel price escalation in 1987 and 1988 (U.S. Department of Commerce 1988) and are shown in Table B.2. The summer/winter variation in electricity prices was accounted for by applying the factors in Table B.3. Table B.1 shows the state average fuel price in each city reported by Levy for comparison to Levy's prices. The comparison is made for electricity (summer and winter), distillate fuel oil, and natural gas.

TABLE B.1. Fuel Price Comparison

Location	Fuel Oil (\$/gal)				Space Heating				Heating Season				Cooling Season			
					Natural Gas (\$/MBtu)				Electricity (\$/kWh)				Electricity (\$/kWh)			
	Levy	EIA	Diff	% Diff	Levy	EIA	Diff	% Diff	Levy	EIA	Diff	% Diff	Levy	EIA	Diff	% Diff
Albuquerque, NM	0.750	0.71	0.040	5.6	5.538	5.2	0.338	6.5	0.083	0.088	-0.005	-5.3	0.097	0.088	0.009	9.7
Atlanta, GA	0.818	0.84	-0.022	-2.6	5.223	6.4	-1.177	-18.4	0.052	0.058	-0.006	-10.3	0.079	0.071	0.008	10.7
Birmingham, AL	0.723	0.67	0.053	7.9	5.045	6.2	-1.155	-18.6	0.053	0.058	-0.005	-8.1	0.065	0.070	-0.005	-7.0
Bismarck, ND	0.723	0.75	-0.027	-3.6	4.353	5.0	-0.647	-12.9	0.082	0.057	0.025	8.9	0.066	0.064	0.002	2.7
Boise, ID	0.723	0.74	-0.017	-2.3	6.167	5.8	0.367	6.3	0.045	0.045	0.000	-0.7	0.045	0.045	0.000	-0.7
Boston, MA	0.841	0.83	0.011	1.3	6.778	7.2	-0.422	-5.9	0.085	0.077	0.008	10.5	0.094	0.087	0.007	8.3
Brownsville, TX	0.723	0.66	0.063	9.5	3.637	5.0	-1.163	-23.3	0.050	0.061	-0.011	-18.7	0.063	0.074	-0.011	-14.3
Buffalo, NY	0.887	0.92	-0.033	-3.6	4.573	7.2	-2.627	-36.5	0.070	0.098	-0.028	-28.3	0.072	0.110	-0.038	-34.6
Burlington, VT	0.856	0.83	0.026	3.1	5.459	6.3	-0.841	-13.3	0.086	0.073	0.015	20.5	0.087	0.083	0.005	5.9
Charleston, SC	0.818	0.87	-0.052	-6.0	6.687	6.3	0.387	6.1	0.059	0.063	-0.004	-6.0	0.068	0.077	-0.009	-11.2
Cheyenne, WY	0.723	0.72	0.003	0.4	2.635	4.6	-1.965	-42.7	0.082	0.051	0.031	1.3	0.048	0.061	-0.013	-20.8
Chicago, IL	0.861	0.73	0.131	17.9	3.680	4.9	-1.220	-24.9	0.052	0.088	-0.036	-41.1	0.131	0.100	0.031	30.5
Cincinnati, OH	0.755	0.78	-0.015	-1.9	4.241	5.5	-1.259	-22.9	0.059	0.071	-0.012	-17.5	0.078	0.080	-0.002	-2.2
Denver, CO	0.723	0.88	-0.063	-9.5	3.659	4.9	-1.031	-21.0	0.049	0.069	-0.020	-29.3	0.055	0.059	-0.004	-5.9
Detroit, MI	0.808	0.82	-0.012	-1.5	4.859	5.5	-0.631	-11.5	0.080	0.070	0.010	14.0	0.107	0.079	0.028	35.4
El Paso, TX	0.723	0.66	0.063	9.5	4.360	5.0	-0.640	-12.8	0.058	0.061	-0.003	-4.3	0.087	0.074	0.012	16.9
Fort Worth, TX	0.723	0.66	0.063	9.5	5.246	5.0	0.246	4.9	0.043	0.061	-0.018	-29.7	0.075	0.074	0.001	1.9
Fresno, CA	0.750	0.77	-0.020	-2.6	6.269	4.9	1.369	27.9	0.121	0.076	0.042	54.5	0.121	0.076	0.042	54.5
Great Falls, MT	0.723	0.69	0.033	4.8	3.729	4.4	-0.671	-15.3	0.050	0.051	-0.001	-2.4	0.043	0.051	-0.008	-16.1
Honolulu, HI	NA	0.77	NA	NA	NA	14.0	NA	NA	NA	0.092	NA	NA	0.086	0.092	-0.004	-26.2
Indianapolis, IN	0.789	0.75	0.019	2.5	4.498	5.4	-0.902	-16.7	0.027	0.067	-0.040	-59.7	0.039	0.076	-0.037	-48.7
Jacksonville, FL	0.818	0.88	-0.062	-7.0	6.069	6.6	-0.531	-8.0	0.093	0.071	0.022	31.5	0.093	0.087	0.006	7.4
Juneau, AK	0.874	0.95	-0.076	-8.0	NA	3.2	NA	NA	0.052	0.098	-0.046	-47.1	NA	0.098	NA	NA
Kansas City, MO	0.861	0.71	0.151	21.3	4.292	4.9	-0.608	-12.4	0.079	0.066	0.013	20.0	0.081	0.075	0.006	7.5
Lake Charles, LA	0.723	0.66	0.063	9.5	4.253	5.5	-1.247	-22.7	0.044	0.063	-0.019	-30.3	0.053	0.077	-0.024	-31.4
Las Vegas, NV	0.750	0.77	-0.020	-2.6	5.021	5.6	-0.579	-10.3	0.051	0.065	-0.014	-21.7	0.051	0.055	-0.004	-21.7
Los Angeles, CA	0.750	0.77	-0.020	-2.6	5.787	4.9	0.887	18.1	0.085	0.078	0.007	9.0	0.085	0.078	0.007	9.0
Medford, OR	0.750	0.71	0.040	5.6	7.123	6.4	0.723	11.3	0.050	0.047	0.003	5.3	0.050	0.047	0.003	5.3
Memphis, TN	0.818	0.89	-0.070	-7.8	3.721	4.0	-1.079	-22.5	0.054	0.046	0.008	17.8	0.054	0.056	-0.002	-3.2
Miami, FL	0.818	0.88	-0.062	-7.0	6.069	6.6	-0.531	-8.0	0.088	0.071	0.017	24.4	0.092	0.087	0.005	5.5
Minneapolis, MN	0.757	0.80	-0.043	-5.4	4.391	5.2	-0.809	-15.6	0.055	0.063	-0.008	-3.3	0.087	0.071	0.016	22.7
Nashville, TN	0.818	0.89	-0.070	-7.8	4.163	4.8	-0.637	-13.3	0.054	0.046	0.008	17.8	0.048	0.056	-0.008	-13.6
New York, NY	0.887	0.92	-0.033	-3.6	8.773	7.2	1.573	21.8	0.087	0.098	-0.011	-11.4	0.157	0.110	0.047	42.5
Oklahoma City, OK	0.723	0.69	0.033	4.8	3.396	4.8	-1.404	-29.3	0.041	0.054	-0.014	-26.7	0.072	0.078	-0.006	-7.6
Omaha, NE	0.861	0.71	0.151	21.3	4.063	4.6	-0.537	-11.7	0.040	0.054	-0.014	-26.7	0.066	0.061	0.005	7.7
Orlando, FL	0.818	0.88	-0.062	-7.0	6.069	6.6	-0.531	-8.0	0.072	0.071	0.001	1.4	0.072	0.087	-0.015	-17.2
Philadelphia, PA	0.826	0.82	0.006	0.7	7.134	6.1	1.034	17.0	0.063	0.082	-0.019	-23.2	0.120	0.093	0.024	25.7
Phoenix, AZ	0.750	0.88	-0.130	-14.8	5.383	6.0	-0.617	-10.3	0.065	0.066	-0.001	-0.7	0.130	0.066	0.052	50.2
Pittsburgh, PA	0.826	0.82	0.006	0.7	4.487	6.1	-1.693	-27.8	0.047	0.082	-0.035	-42.6	0.047	0.093	-0.046	-49.4
Portland, ME	0.796	0.75	0.046	6.1	5.129	6.2	-3.071	-37.6	0.093	0.076	0.017	22.9	0.093	0.085	0.008	9.9
Portland, OR	0.750	0.71	0.040	5.6	6.487	6.4	0.087	1.4	0.051	0.047	0.004	7.4	0.051	0.047	0.004	7.4
Reno, NV	0.750	0.77	-0.020	-2.6	6.700	5.6	1.100	19.6	0.084	0.065	0.019	29.8	0.084	0.065	0.019	29.8
Sacramento, CA	0.750	0.77	-0.020	-2.6	7.524	4.9	2.624	53.6	0.069	0.078	-0.009	-11.9	0.089	0.078	0.011	14.0
Saint Louis, MO	0.861	0.71	0.151	21.3	4.001	4.9	-0.899	-18.3	0.046	0.066	-0.020	-30.3	0.086	0.075	0.011	14.7
Salt Lake City, UT	0.723	0.71	0.013	1.8	5.164	4.8	0.364	7.6	0.066	0.077	-0.009	-11.0	0.086	0.077	0.009	11.0
San Antonio, TX	0.723	0.66	0.063	9.5	5.306	5.0	0.306	6.1	0.061	0.061	0.000	0.2	0.078	0.074	0.004	5.5
San Diego, CA	0.750	0.77	-0.020	-2.6	8.169	4.9	3.269	66.7	0.146	0.078	0.070	89.4	0.146	0.078	0.070	89.4
San Francisco, CA	0.750	0.77	-0.020	-2.6	8.773	4.9	3.873	79.0	0.126	0.078	0.048	62.2	0.126	0.078	0.048	62.2
Seattle, WA	0.821	0.78	0.041	5.3	4.742	5.7	-0.958	-16.8	0.044	0.039	0.005	11.8	0.033	0.039	-0.006	-14.6
Spokane, WA	0.821	0.78	0.041	5.3	4.105	5.7	-1.595	-28.0	0.050	0.039	0.019	49.2	0.046	0.039	0.007	18.2
Tampa, FL	0.818	0.88	-0.062	-7.0	6.069	6.6	-0.531	-8.0	0.079	0.071	0.008	11.1	0.079	0.087	-0.008	-9.3
Washington, DC	0.955	0.88	0.075	8.5	5.376	6.9	-1.524	-22.1	0.058	0.063	-0.005	-8.4	0.059	0.071	-0.002	-2.8
Average	0.787	0.789	0.018	2.9	5.294	5.59	-0.344	-5.5	0.067	0.068	-0.001	-0.3	0.079	0.075	0.004	5.1

TABLE B.2. Nominal Fuel Escalation Rates, 1987 and 1988

<u>Fuel</u>	<u>Escalation Rate (%/2 years)</u>
Fuel oil and LPG	0.6
Gas and electricity	-1.0

TABLE B.3. Seasonal Electricity Price Variation(a)(b)

<u>Census Region</u>	<u>Winter / Summer Adjustment</u>
North East	0.94 / 1.06
North Central	0.94 / 1.06
South	0.90 / 1.10
West	1.00 / 1.00 (constant prices)

-
- (a) The seasonality of electricity prices is clearly demonstrated by examining the variation of monthly electrical prices for the period from 1985 to 1987 using the EIA's Monthly Energy Review "Residential Old Series" prices (EIA 1988b). During this three-year period the annual average national electricity price fluctuated less than one-third of 1%, while the **monthly** average price showed a clear increase every summer and decrease every winter. Nationally, the change from the average prices by month over this 3-year period was

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
-6%	-6%	-4%	-1%	+1%	+4%	+6%	+5%	+5%	+2%	-1%	-5%

- (b) The seasonal electricity variation in price was estimated from a Gas Research Institute report (1986, p. 11). Prices were taken from the residential, 1000 kwh/month category. The price variations for Washington, Oregon, Idaho, and Montana were verified from rates supplied by the Northwest Public Power Association, Portland, Oregon. The estimated variation for each region was the mean of the locations reported. The ratios, used as multipliers on the annual prices, were computed as the summer or winter price divided by the sum of the summer plus winter prices. There was no seasonal adjustment for fuels other than electricity.

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APPENDIX C

HOME SHIPMENTS BY STATE, 1984-1988

TABLE C.1. Mean Home Shipments by State, 1984 to 1988(a)

<u>State</u>	<u>Shipments</u>
Alabama	11,268
Alaska	95
Arizona	5715
Arkansas	4912
California	10,230
Colorado	1093
Connecticut	350
Delaware	2106
Washington D.C.	0
Florida	27,632
Georgia	16,784
Hawaii	1
Idaho	992
Illinois	3331
Indiana	6009
Iowa	882
Kansas	1769
Kentucky	5359
Louisiana	5658
Maine	2158
Maryland	1304
Massachusetts	821
Michigan	8849
Minnesota	1700
Mississippi	5509
Missouri	4987
Montana	759
Nebraska	561
Nevada	1737

(a) Summarized from reports by the Mobile/Manufactured Home Merchandiser, Chicago, Illinois, based on the April issues for 1985 through 1989, which contain the annual shipments by states.

TABLE C.1. Cont.

<u>State</u>	<u>Shipments</u>
New Hampshire	1460
New Jersey	802
New Mexico	3497
New York	7436
North Carolina	23,482
North Dakota	359
Ohio	6354
Oklahoma	2764
Oregon	2862
Pennsylvania	6977
Rhode Island	163
South Carolina	13,156
South Dakota	652
Tennessee	8248
Texas	18,063
Utah	661
Vermont	731
Virginia	6,098
Washington	4844
West Virginia	3103
Wisconsin	2197
Wyoming	<u>339</u>
U.S. Total	246,820

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