‘‘The 1993 Model Energy Code: Energy and Environmental Savings, Costs, and Benefits by State’’

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The Alliance to Save Energy, in cooperation with the North American Insulation Manufacturers Association (NAIMA) and Owens Corning, is in the process of updating a 1991 study of the potential energy and pollution savings from state adoption of the 1989 Model Energy Code (MEC) for residential single family and multi-family buildings. Since 1991, the Council of American Building Officials (CABO) updated the MEC in both 1993 and 1995 (although the two versions are virtually identical). In the present study, energy efficiency and environmental emissions savings that were available in 1994 from adoption of the 1993 MEC are estimated for each state for new residential single family and multi-family homes using updated data on state code adoption and practice, housing starts, fuel use and costs, and HVAC characterization. The cost effectiveness and economics (i.e., paybacks, net present values, and B/C ratios) to new home buyers, as well as to society, are also estimated and reported. This paper will discuss the Alliance’s 1991 study including its methodology and results, and present the results of an Alliance survey of state energy codes. The impacts of changes made to state codes since 1991 will also be presented. *The results of the Alliance’s comparison of state codes with 1993 MEC were not available at the time of this writing but will be presented and discussed at the ACEEE conference session.*

INTRODUCTION

In September 1991, the Alliance to Save Energy published a study of the energy efficiency potential of adoption of model energy codes for residential housing. The study compared the energy standards in the Council of American Building Officials’ (CABO) Model Energy Code (MEC) in 34 states that had not recently updated their building codes. The report’s findings included:

- If the 34 states had adopted the 1989 MEC, 7.24 trillion Btu would have been saved annually, or enough to meet the energy needs of 65 to 70 thousand single family homes;
- 565,000 tons of energy-consumption-related air pollution would have been eliminated per year;
- The benefit-cost ratio of MEC adoption equaled 3.0 for a net present value savings to consumers of $687 million; and
- Average savings per home per year equaled $130, and if the average $874 added home cost were financed through the mortgage, homeowners would benefit from an immediate $60 per year positive cash flow.

The need for an updated study arose with the release of the MEC by CABO in 1993 and the fact that by 1995 only three states—Ohio, Michigan, and Virginia—had adopted the 1993 MEC. (However, the Michigan state legislature repealed the MEC in December 1995, reverting the state back to ASHRAE Standards 90A and 90B for residential buildings). The MEC was also updated in 1995, but the changes affecting energy efficiency were minor. Because the 1993 MEC was available for adoption by every state in 1994, we chose to use the 1993 version in the present study. In addition, on July 9, 1995 the Secretary of Energy, under authority in EPACT, is requiring state review of the 1993 MEC. DOE has determined that the 1993 MEC will achieve greater energy efficiency in residential buildings than the 1992 MEC. Consequently, states must review their residential building codes and certify to DOE by July 15, 1996 whether or not their codes need upgrading to meet or exceed the 1993 MEC.

The scope of the updated study is similar to the original. For each state that had *not* adopted the 1993 MEC during the 1994 calendar year (only Michigan, Ohio, and Virginia adopted the 1993 MEC), we estimated the lost energy savings and environmental pollution reduction for that year. We also estimated the magnitude (in present dollars) of the lost savings from several perspectives: the consumer and society based on both marginal energy prices and marginal energy costs. Three states (Wyoming, West Virginia, and Vermont) possessed low potential for energy savings due to small numbers of new housing starts and were excluded from the study’s analyses.

METHODOLOGY

The first step in the methodology was to update all of the data sets. Primary data requiring updating included marginal fuel prices, marginal fuel costs, housing starts, furnace and air conditioning equipment characteristics, the MEC, state building code (non-1993 MEC) practice, and economic assumptions (e.g., mortgage interest rates and terms).

Before describing the above data updates, our approach needs some further clarification. We collected and/or estimated housing starts, fuel prices and total fuel costs, new equipment sales, new construction characterization, building code practice, etc. for 131 cities/SMSAs (Standard Metropolitan Statistical Area) for 44 states and the District of Columbia. (The three states that had adopted 1993 MEC were excluded from the analysis as well as three states with the lowest number of new housing starts). These data were fed into a computer program that optimizes building design for both current code practice and MEC for 33 residential home prototypes. Output of the model includes the energy savings, the cost savings (marginal and average), and benefit-cost ratios.

Marginal Fuel Prices

Fuel prices paid by consumers serve as a determinant of consumer behavior and the economic benefits of more stringent building codes. Marginal fuel prices were estimated for oil, natural gas, and electricity (both summer cooling and winter heating). For fuel oil, we used data on No. 2 distillate prices to residences (reported by state in DOE/EIA's *Monthly Energy* Review) averaged for the months December 1993—February 1994. For natural gas, we used the space heating rates reported in *Residential Gas Bills: Winter 1993–94*, by the National Association of Regulatory Utility Commissioners (NARUC). For electric heating, we used winter rates reflecting an monthly usage level of 1,000 kWh for December-February as reported in NARUC's *Residential Electric Bills: Winter 1993–94*. For Electric cooling, we used rates reflecting monthly usage of 1,000 kWh for June-August as reported in NARUC's *Residential Electric Bills: Summer 1994*.

Marginal Fuel Costs

Marginal fuel costs serve to determine the cost effectiveness of better building codes to society. However, marginal fuel costs are difficult to measure because cost information or other direct data on marginal fuel costs do not exist on a city or state basis. The 1994 average No. 2 fuel oil refiner price (for resale) was used as a proxy for the marginal cost of fuel oil. A ratio of this price to the average 1994 residential distillate price was use to estimate the refiner price for each state. The 1994 average city gate price of natural gas was used for the marginal natural gas cost. Like for fuel oil, a ratio of the city gate cost to the 1994 average natural gas retail price was calculated and used to estimate city gate gas costs by state. For electricity, a similar procedure was followed using the cost of all fossil fuels for steam electric utility plants as the guide. The oil, gas, and electric fossil fuel cost data were obtained from DOE/EIA's *Monthly Energy Review*.

Based on these data, marginal fuel costs, as a percentage of average residential retail prices during 1994 were 83.8 percent for oil, 52.8 percent for natural gas, and 61.8 percent for electricity.

Housing Starts

Housing starts data were available only at the national level for the year 1994. The source *Housing Starts: April 1995*, U.S. Department of Commerce, reported 1,213,000 single family (SF) and 244,000 multi-family (MF) starts in 1994. The report, *New Construction Report: Insulation: 1993–1997*, by the F. W. Dodge Residential Product Demand Group, showed estimated SF and MF housing starts by state. Because the sum of F. W. Dodge data was less than the Commerce Department's, the F. W. Dodge state estimates were ratioed upward, across-the-board, to equate in total to the Commerce Department data.

Within each state the SF and MF data were assigned to individual cities (and hence weather station cites) by applying weights developed from new construction permit data available in *Housing Units Authorized by Building Permits: December 1994*, U.S. Department of Commerce. Where SMSAs crossed state boundaries, breakouts into the respective states were estimated. In this procedure, the permit data and the cities were simply used as a convenient way to assign housing starts to weather regions.

Furnace and Air Conditioning Equipment Shares

The 1992 F. W. Dodge Residential Statistical Services report, *New Construction Report: Heating, Venting, & Air Conditioning*, provided forecast information by which to estimate 1994 new construction market shares for oil, gas, and electric forced-air furnaces and boilers, electric resistance heating, heat pumps, and air conditioning on a state-by-state basis.

The 1993 MEC

The most widely accepted model energy code is the Model Energy Code of the Council of American Building Officials. The Model Energy Code, or MEC, translates the advisory language of building energy standards into building codes which are intended to be implemented and enforced. The MEC, first developed in 1982, has been maintained by

CABO and is revised each year through an annual code change cycle. By adopting the 1993 MEC, states can most directly comply with the Energy Policy Act of 1992, which contains several provisions related to making buildings more energy efficient. In this study, all states that did not have the 1993 MEC as their mandatory statewide residential building code had their residential building code measured against the model energy code on a building component level. The following components were evaluated in this analysis for single family and multi-family residential buildings: walls, roof/ceilings, floors, heated and unheated slabs, crawl space walls, and basement walls. (Walls were evaluated on a weighted average area basis to account for glazing, doors, and wall space.)

The Alliance compared the heat resistance (R-values) and thermal transmittance (U-value) required under MEC for 131 cities/SMSAs across the country according to heating degree day with existing state codes. This comparison was done on a component-by-component basis for cities representing with the most new housing starts in each state. Individual heat resistance and transmittance values for specific cities under the 1993 MEC were provided electronically by the Department of Energy's Pacific Northwest Laboratory.

Actual State Code Practice (Non-1993 MEC)

Most states do not include the 1993 MEC in their official residential building code. In fact, at the beginning of our analysis only three states did—Ohio, Michigan, and Virginia. The rest of the states fall into one of several code categories: (1) a unique state code; (2) one of the regional codes, such as the Building Code Officials and Code Administrators International (BOCA), the Southern Building Code Congress International, Inc. (SBCCI), the International Conference of Building Official (ICBO); (3) a prior version of the MEC; or (4) no code at all. For the purpose of analysis, all of these state codes are evaluated against the MEC 1993 on a building component level. In cases where a state does not have a code, the closest approximation possible was made using the most applicable American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standard or average builder practice in the state. Actual residential code data was collected at the building component level by the Alliance to Save Energy by surveying state building code offices in the last quarter of 1994. The results of the Alliance's state code survey were presented in a press conference held on February 1, 1995. Both housing start data and residential building code energy requirements were later verified by the Alliance in December 1995.

Economic Assumptions and Modeling

The primary economic assumptions required for the analyses were setting the mortgage interest rate and the cost of capital for the different analysis points of view. During 1994 fixed-rate, 30-year mortgage interest rates averaged 8.325 percent and at year's end fell between 9.125 and 9.250 percent. In 1995, mortgage rates fell and by the fall ranged between 6.875 (at 3 points) and 7.250 (at 2.5 points). We chose a rate reflecting a ''middle'' ground of these rates: 7.500 percent (at 3 points).

We also set the following when analyzing the economics from the point of view of individual homeowners: 1.46 percent property tax rate, 10 percent down payment, and 28 percent federal income tax bracket. The inflation rate was set at 2.6 percent.

Other rates chosen for the analyses were: 5.54 percent (yield on 5-year CDs), 6.28 percent (yield on 30-year T-Bills), and 9.75 percent (prime + 1 percent on home equity loans). The 30-year T-Bill rates was used to reflect society's cost of capital. The other rates were used as alternative consumer discount rates.

The last step was to update the computer model used in the original study and developed by Owens Corning. The 1989 MEC data was updated to the 1993 MEC, as well as equipment energy efficiency data. The ASE model consists of a FORTRAN source program and three major subroutines. ASE—the main program—reads the data, performs calculations, calls the subroutines, accumulates the results, calculates averages, and prints the output. The program calculates the heating and cooling load savings using envelope factors. The load savings are converted into energy savings using distribution loss factors and HVAC equipment efficiencies. Finally, the program converts the energy savings into annual cost savings using either marginal average prices (for consumer savings) or marginal fuel costs (for society savings). In addition, the program calculates the costs to construct homes to meet the 1993 MEC. These calculations also take into account the ability to downsize HVAC systems for the better insulated building shells. All savings (load, energy, and dollars) are statistically weighted by housing starts, house type saturation, foundation type saturation, HVAC equipment saturation, and fuel type.

The three major subroutines are: DESIGN, WALCOMP, and ECON. The DESIGN subroutine calculates the heating and cooling design loads for sizing HVAC equipment. The WALCOMP searches for the lowest cost wall construction package that meets the overall U-value (U_o) criteria. The ECON subroutine calculates the economic and affordability tests: B/C ratio, NPV, and years to positive cash flow (for the homeowner).

RESULTS

The potential load, energy savings, dollar, and environmental savings are presented below by fuel type for the U.S. and for each state that had not adopted the 1989 version of the MEC. *The results of the Alliance's updated comparison of state codes with 1993 MEC were not available at the time of this writing; updated tables and text will be presented and discussed at the ACEEE conference session.*

State Code Update

Since the Alliance's 1991 study, 10 states—Arkansas, Georgia, Indiana, Kentucky, North Carolina, North Dakota, New Mexico, Ohio, Tennessee, and Virginia—have adopted codes that at least meet the requirements of the 1992 MEC (as of January 1, 1995). This represents a significant improvement since the Alliance's 1991 study. By upgrading their codes, these states decreased their total annual energy expenditures by $26 million, saved 2.5 trillion Btu of energy every year and cut air pollution emissions by 197,000 tons. A total of 17 states had not changed their state energy codes since the Alliance's 1991 study. Significant opportunities for energy savings are present in these states through the adoption of the 1992 (or later version) Model Energy Code. Additional energy savings are also possible for states that upgrade their codes from 1992 MEC to the 1993 or 1995 MEC.

National Savings

Since the results of the Alliance's updated comparison of state codes with 1993 MEC were not available at the time of this writing, we have submitted the results from the Alliance's 1989 study.

Table 1-1 shows the savings from more efficient new home construction in 1989—584,595 units—for the nation if all 34 states had adopted the 1989 MEC.

Total energy savings were 7,240 billion Btu. The bulk of these energy savings are for natural gas and electricity with savings of 5,182 million cubic feet of natural gas and 498.4 million kWh of electricity, respectively. These savings are equivalent to the energy used by 65 to 70 thousand single family homes. Dollar savings to consumers are similar, with consumers totaling 511 million with a net present value of $687 million (assuming a discount rate of 10 percent).

Air emissions savings (in tons) arise primarily from CO_2 savings (98.6 percent), which come mostly from savings in electricity use (448,560 tons, or 82.4 percent of total tons), which result from the avoidance of coal-fired generation.

For the average homebuyer, the added cost of a home meeting the 1989 MEC was $874 (see Table 1-2). But the added energy efficiency embodied in the home saves $130 per year in energy costs. This savings stream over 30 years provides a net benefit of $1,176 on a present value basis at a 10 percent discount rate. But because home purchasers invariably finance with a mortgage, and because the added first cost of the home will be included in the mortgage (less the portion going to the down payment), the Consumer Affordability Index (or the cash flow payback) equals 0.79, or a payback of less than one year.

***Table 1-1:** National Savings for the Year 1989 for Adoption of the 1989 Model Energy Code*

Savings	Oil	NG	Electricity
Load (Physical units)	739,850 (gallons)	5,182 (MCF)	498.4 (MkWh)
Energy (billions of BTU)	91	5,337	5,134
Dollars (millions) Consumers	0.40	32.39	41.87
Air emissions (in tons) CO_2	2,449	85,762	448,560
SO_2	41	2,020	2,567
NO_2	15	537	1,445
Particulates	11	537	473
TOTAL EMISSIONS	2,516	88,856	453,045

The study revealed total construction first costs of the MEC to be $511 million while first year savings totaled $76 million, which grow each year at the rate of energy (real) price inflation over the 30-year mortgage length, and beyond for the remaining life of the home.

State-by-State Savings

Load and energy savings, air emission savings, and MEC adoption economics are reported here for the 34 states that had not adopted the 1989 MEC.

Potential for Energy Savings. Table 1-3 shows the state-by-state load and energy savings. Several observations are apparent from examination of Table 1-3. First, housing start activity, as one would expect, is concentrated in large states, popular retirement areas, and major metropolitan areas. Second, in only a handful of states is fuel oil a major home heating energy source; the dominant fuel for heating is natural gas. Correspondingly, electricity is the dominant fuel for air conditioning. Less obvious, because it requires calculating millions of Btus saved per newly constructed home, is the potential savings from adoption of the 1989 MEC.

Table 1-4 shows the states ranked according to potential savings per home. The states of Maine and Colorado all

***Table 1-2:** Economic Benefits for Adoption of the 1989 MEC*

	First Cost of MEC Adoption	First Year Energy Savings	Benefit /Cost Ratio	Net Present Value	Consumer Affordability Index
Average home	$874	$130	3.0	$1,176	0.79
TOTAL (millions)	$511	$76	—	$687	n.a.

***Table 1-3:** State-by-State Load and Energy (Btu) Savings*

State	Housing Starts	Energy (Billions Btu)	Oil (thousands gallons)	NG (MCF)	Electricity (MkWh)
AL	20,000	138.9	0	64.5	20.89
AR	3,400	26.9	0	8.8	5.16
AZ	17,500	37.8	0	8.4	8.49
CO	9,700	309.4	0	262.7	9.91
DC	35,400	628.3	0	267.5	101.90
DE	6,200	62.6	0	26.9	10.18
GA	54,200	410.5	0	323.8	20.76
ID	1,400	40.2	0	28.5	3.00
IL	25,500	597.8	0	556.7	4.05
IN	14,400	279.7	20.4	246.5	5.35
KS	2,900	68.0	0	57.4	2.27
KY	8,300	128.1	0	80.6	12.76
LA	5,100	18.2	0	11.3	1.86
MD	15,000	175.6	0	71.5	29.46
ME	3,000	112.8	261.5	37.1	10.97
MI	31,400	544.1	72.7	491.5	5.36
MO	23,400	584.2	0	477.7	24.34
MS	2,900	113.2	0	5.1	1.73
NC	26,100	157.5	0	94.0	17.25
ND	1,000	15.5	0	11.7	0.95
NE	2,600	76.3	0	67.4	1.63
NH	2,100	48.8	158.6	20.8	1.45
NJ	24,500	266.1	112.1	178.8	18.43
NM	3,000	61.5	0	55.4	0.97
NV	36,600	440.2	0	405.2	4.44
OH	42,700	693.3	0	527.4	41.04
OK	5,600	92.6	0	81.1	2.21
PA	35,900	160.8	58.2	59.3	26.48
SC	11,300	51.0	0	9.2	12.12
SD	400	1.6	0	1.4	0.02
TN	26,900	330.1	56.3	235.8	21.94
TX	60,000	312.6	0	219.9	24.01
VA	25,600	352.7	0	186.5	46.03
WV	600	5.3	0	1.5	1.09
TOTALS	585,000	7,342.2	739.8	5,181.9	498.5

Table 1-4: *Ranking of State by Potential Energy Savings per Newly Constructed Home*

Potential Energy Savings (Millions of Btu per home)	States
0–4.9	AZ, LA, MS, PA, SC, SD
5.0–9.9	AL, AR, GA, NC, TX, WV
10–14.9	DE, MD, NJ, NV, TN, VA
15–19.9	DC, IN, KY, MI, ND, OH, OK
20–24.9	IL, KS, NH, NM
25–29.9	ID, MO, NE
30–34.9	CO
35–39.9	ME

have average savings of 30 million Btu per home or greater. The high potential savings in these states likely stem from the (a) cold winters and/or (b) substantial codes improvement potential. The states of Illinois, Kentucky, New Hampshire, New Mexico, Idaho, Missouri, and Nebraska—with average savings potential of 20 to 29.9 million Btu per home—also exhibit the same characteristics but to a less severe degree. The states of Arizona, Louisiana, Mississippi, Pennsylvania, South Carolina, South Dakota, Alabama, Arkansas, Georgia, North Carolina, Texas, and West Virginia exhibit very low levels of potential energy efficiency improvement either due to (a) their warm climate, and/or (b) their codes being very similar to the 1989 MEC. The remaining states display moderate opportunity for energy savings through code changes.

Potential for Pollution Savings. A good measure for comparing states is to calculate the potential pollution savings per home. These results, displayed in Table 1-5, show that potential pollution savings per home are available in the states of Colorado, Delaware, Kentucky, Maryland, New Hampshire, the District of Columbia, Idaho, Maine, Virginia and West Virginia. In these states larger potential code savings combined with savings in highly polluting fuels offer the best pollution reduction gains (1.51 tons per home per year or more) from the adoption of better, energy-efficient building codes. The states of Louisiana, Michigan, North Carolina, Nevada, South Dakota, and Texas—because of more stringent codes and/or lower polluting fuels—exhibit very low levels (less than 0.5 tons per home per year) of potential pollution reductions from the adoption of better

Table 1-5: *States Ranked by Potential Pollution Savings per Home per Year*

Potential Pollution Savings (Total Tons per Home per Year)	States
0.0–0.5	LA, MI, NC, NV, SD, TX
0.51–1.0	AL, AZ, GA, IL, IN, MS, ND, NJ, NM, OK, PA, SC, TN
1.01–1.5	AR, KS, MO, NE, OH
1.51–2.0	CO, DE, KY, MD, NH
2.01 +	DC, ID, ME, VA, WV

building codes. The remaining states offer potential savings of moderate levels (0.51 to 1.5 tons per year per home).

Potential for Dollar Savings. The 1991 study indicated that by virtually all economic measures, investment in better building codes is economic to society and homebuyers. First, the benefit/cost ratios for *all* states are greater than 1.0, indicating benefits exceed costs on a present value basis (at a 7 percent discount rate). In fact, 19 out of the 34 states have B/C ratios greater than or equal to 3.0.

CONCLUSIONS

The Alliance to Save Energy is conducting an analysis of the potential benefits that could have accrued to society and new home buyers in the year 1994 in 34 states that could have adopted the 1993 Model Energy Code for residential new home construction, but chose not to do so. Once forgone, these benefits are lost—realistically—forever to those homebuyers or anyone who later purchases these homes. We expect our findings will reinforce the ones arrived at in our 1991 study. Conclusions developed from the 1991 study include:

- Adoption of better building codes are economic in *all* states for new home buyers and to society at large.
- If the 1989 MEC had been adopted, the energy savings alone could have supplied the energy needs of 65,000 to 70,000 other—existing—homes.
- If the 1989 MEC had been adopted, over one-half million tons of air pollutants—primarily carbon dioxide—would have entered the atmosphere.

Table 1-6: *Potential Economic Benefits to Society and Homeowners by State*

State	Added First Cost	First Year Savings	Benefit/Cost Ratio (at 7%)	Net Present Value (at 7%)	Years to + Cash Flow
AL	$399	$91	5.7	$1,546	0.44
AR	487	144	6.0	2,569	0.34
AZ	97	71	13.8	1,426	0.14
CO	1,899	220	2.7	3,633	0.86
DC	1,259	299	4.4	5,465	0.42
DE	1,267	133	2.2	1,700	0.95
GA	306	90	6.4	1,713	0.34
ID	1,688	245	2.9	4,358	0.68
IL	1,576	134	1.9	1,896	1.92
IN	1,620	125	2.0	1,651	2.95
KS	1,312	174	2.8	2,563	0.75
KY	1,003	141	3.2	2,211	0.71
LA	116	50	8.8	896	0.23
MD	1,175	188	3.0	2,903	0.62
ME	2,123	500	4.8	10,070	0.42
MI	1,291	108	2.2	1,628	1.93
MO	1,332	198	2.8	2,894	0.67
MS	184	65	8.2	1,181	0.28
NC	630	86	3.2	1,273	0.73
ND	920	127	2.5	2,192	0.72
NE	1,552	192	2.1	2,881	0.80
NH	1,241	221	4.0	4,465	0.56
NJ	1,073	137	2.6	2,073	0.78
NM	792	158	4.7	3,082	0.50
NV	1,005	93	2.1	1,515	1.84
OH	1,471	154	2.1	2,212	0.95
OK	554	132	4.9	2,312	0.42
PA	919	78	4.4	837	1.92
SC	441	93	5.2	1,561	0.47
SD	169	26	1.2	450	0.65
TN	562	109	4.5	1,959	0.51
TX	132	60	8.8	1,132	0.22
VA	806	210	5.1	3,839	0.38
WV	921	130	3.0	1,963	0.70
AVERAGES	$951	$147	4.2	$2.472	0.79

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