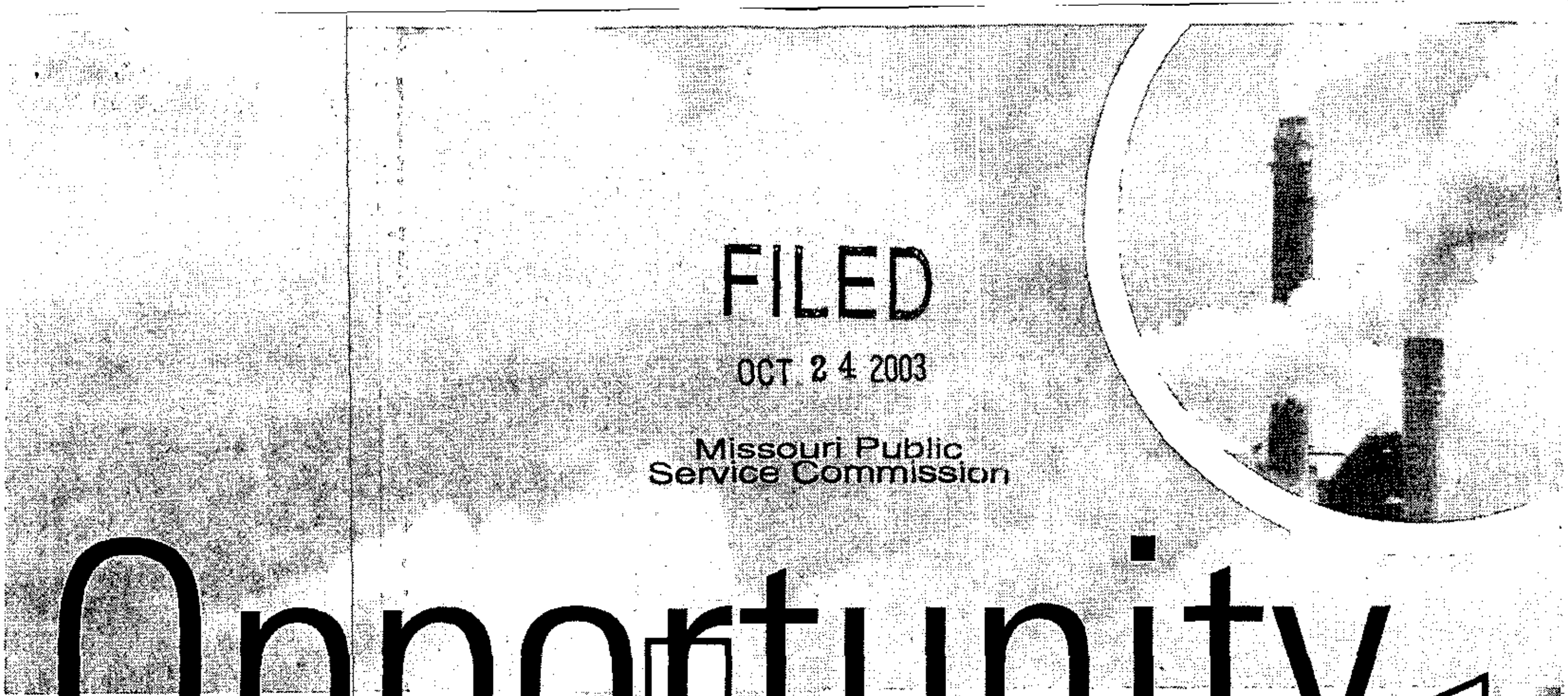


FILED

OCT 2 4 2003

Missouri Public
Service Commission

Opportunity Lost

Better Energy Codes for Affordable Housing and A Cleaner Environment

ALLIANCE TO
SAVE ENERGY

Exhibit G

For more information contact:

Alliance to Save Energy
1200 18th Street NW
Suite 900
Washington, DC 20036
Telephone: (202) 857-0666
Fax: (202) 331-9588
E-mail: info@ase.org
Web: www.ase.org

The Alliance to Save Energy is a coalition of prominent business, government, environmental, and consumer leaders who promote the efficient and clean use of energy worldwide to benefit consumers, the environment, economy, and national security.

Opportunity Lost

Better Energy Codes for Affordable Housing and A Cleaner Environment

A National and State Analysis Of the 1993 Model Energy Code

By
Ted Jones, Program Manager
Douglas Norland, Chief Economist
Bill Prindle, Senior Program Manager

Alliance to Save Energy
1200 18th Street NW
Suite 900
Washington, DC 20036

Table of Contents

Acknowledgments

The researchers and authors of this report are:

Ted Jones, Program Manager
Douglas Norland, Chief Economist
Bill Prindle, Senior Program Manager

The authors wish to thank the North American Insulation Manufacturers Association for funding this study. We also thank Merle McBride, Owens Corning, for updating the Alliance to Save Energy computer model and Brian Shipp, who made the computer runs.

We also thank the National Association of Home Builders Research Center for allowing us to use its research library and David Dacquisto, Vice President of Technology, and Will Biddle, Market Researcher, for their time in reviewing the study and answering our technical questions. Our thanks also go to Robin Raichenbach at the U.S. Department of Energy's Energy Information Administration for providing us updated and detailed energy use, price, and cost data otherwise not available. We also thank the individuals and staff from the state energy offices for their review and comments on our codes and housing starts data. Finally, but not least, we thank Laurie Klevgard at Battelle's Pacific Northwest National Laboratory for providing us their data on state codes, and Kate McQueen and Mike DeWein, Building Codes Assistance Project, for their willingness to answer our technical questions.

List of Tables

Executive Summary

This report shows that modern building energy codes save consumers money and energy, making housing more affordable while reducing air pollution. It is the result of a major Alliance to Save Energy study that conducted a detailed analysis of the costs and benefits of adopting the International Code Council's Model Energy Code (MEC), 1993 version, in the states whose codes are less stringent. The study developed information on the energy, dollar, and air pollution emission savings that would occur if these states upgraded their codes to the 1993 MEC. It compared these benefits with the added construction costs involved in complying with the 1993 MEC.

ENERGY CODES ARE A ONCE-IN-A-LIFETIME OPPORTUNITY

The states in this study—which do not yet use the MEC—are hosts to more than half a million new homes a year. Every year we have a unique chance to build these half-million homes right. Once they are built, it is very expensive and often impossible to achieve the energy efficiency that can be built in so economically at the time of construction. This is an opportunity that we cannot afford to lose. Today's homes may last 75 to 100 years or longer. We should not deny either half a million homebuyers each year, or their children and grandchildren, the chance to live in homes that save energy, money, and pollution.

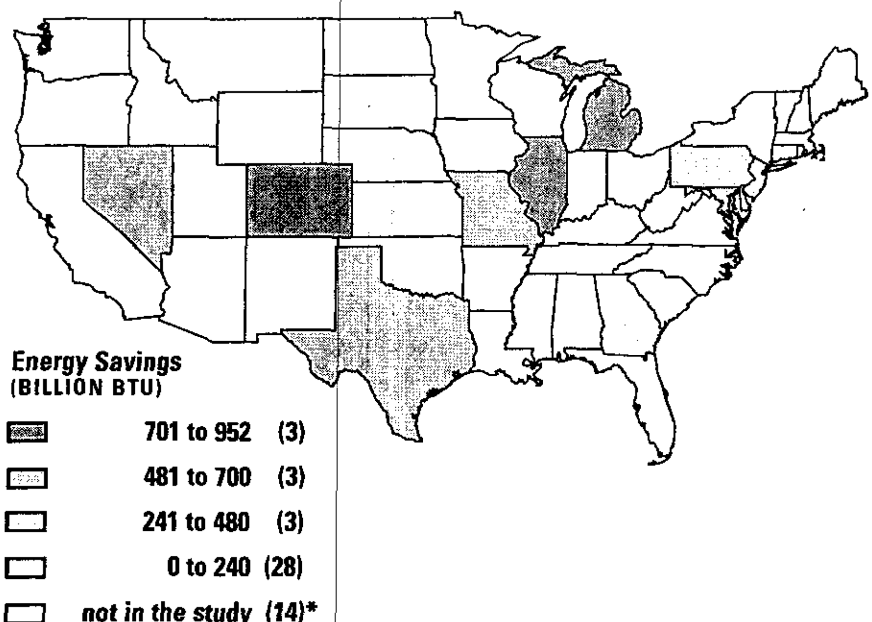
BETTER ENERGY CODES SAVE ENERGY AND MONEY, AND PREVENT AIR POLLUTION

The study found that if the states in the analysis used the 1993 MEC, American homebuyers would save **7 trillion Btu, $81 million,** and almost **226,000 tons of air pollution** each year. These energy savings are enough to serve the energy needs of all the new homes built in a typical year in Michigan and Pennsylvania combined.

The energy and pollution savings can be attained very cost-effectively: the typical homebuyer enjoys positive cash flow within two years. That is, the energy bill savings

Category	Savings: Nationwide	Savings: Per Home
Energy	7.4 trillion Btu/year	10 million Btu/year
Money	$81 million/year	$122/year
Air Pollution	226,000 tons/year	588 pounds/year
Housing Affordability	Homeowner sees positive cash flow within two years	

Annual Energy Savings Potential
BY STATE



***Alaska and Hawaii not in study. District of Columbia included in study.**

(about $122/year) typically exceed the small increase in mortgage payments. So the 1993 MEC makes housing more affordable for the initial homebuyer.

Over 30 years, the net present value of the dollar savings is $529 million for each year's production of new homes built to the 1993 MEC, or about $800 per home. So the nation's homebuyers as a whole benefit from the 1993 MEC, as well as the first buyer of the home.

SOME STATES STAND OUT IN SAVINGS POTENTIAL

The maps illustrate the leading states on various measures of benefit for adoption of the 1993 MEC. The leaders in total energy savings potential are Michigan, Illinois, and Colorado. Total dollar savings are greatest in Texas, Illinois, and Arizona. The potential for cutting air pollution emissions is highest in Texas, Kentucky, and Missouri.

ENERGY CODES ARE ESSENTIAL FOR CONSUMER PROTECTION

Special interests in the building industry are mounting political campaigns in some states to roll back energy codes as too expensive for builders and homebuyers. While their efforts in most cases have failed, they did succeed in repealing the 1993 MEC in Michigan, giving Michigan the dubious distinction of being the only state ever to go backward on energy codes.

These special interests have touted their involvement in voluntary programs, such as the U.S. Environmental Protection Agency's (EPA) Energy Star Homes program and the electric utility industry's E-Seal program, as evidence that codes are not needed. While the Alliance is a staunch supporter of these voluntary programs as vital to the future of energy efficiency in the housing market, so far they have reached only a small fraction of the market. The total estimated participation in these programs combined in 1996 was less than 30,000 homes, which is less than 2 percent of total housing starts.

In light of these market realities, energy and other building codes are essential for the protection of the average consumer against substandard construction and needlessly high energy bills. Until the time that voluntary programs dominate the market, codes will be needed to protect consumers and ensure that they and society as a whole receive the dollar savings and environmental protection they deserve. Even then, codes will continue to be needed to protect consumers against poor-quality products.

Some building industry organizations claim that home builders cannot afford to build homes to the MEC, yet the voluntary programs they embrace, such as Energy Star Homes, are based on the MEC and in fact exceed the MEC by 30 percent or more. So it is simply contradictory to say that codes are bad for homebuyers and programs with higher energy standards are good. The truth is that codes like the MEC are good for buyers, and the voluntary programs are better.

ENERGY CODES ARE VITAL TO HOUSING AFFORDABILITY

The MEC makes housing more affordable. No homebuyer has ever been denied a mortgage loan because the home met MEC standards. In fact, the nation's two mortgage programs aimed at helping low- and moderate-income homebuyers—FHA and VA—require homes to meet the MEC. The MEC does add first cost to the home, but since buyers nearly always finance their home purchases through mortgages, these costs show up as small increases in monthly payments, typically less than $10. Our study shows that energy bill savings typically exceed $10 per month, so the buyer is better off financially with an MEC-built home. Mortgage lenders recognize this value in their underwriting through energy-efficient mortgage (EEM) policies. The nation's largest mortgage institution, Fannie Mae, recognizes MEC compliance software as a tool to qualify for its EEM program.

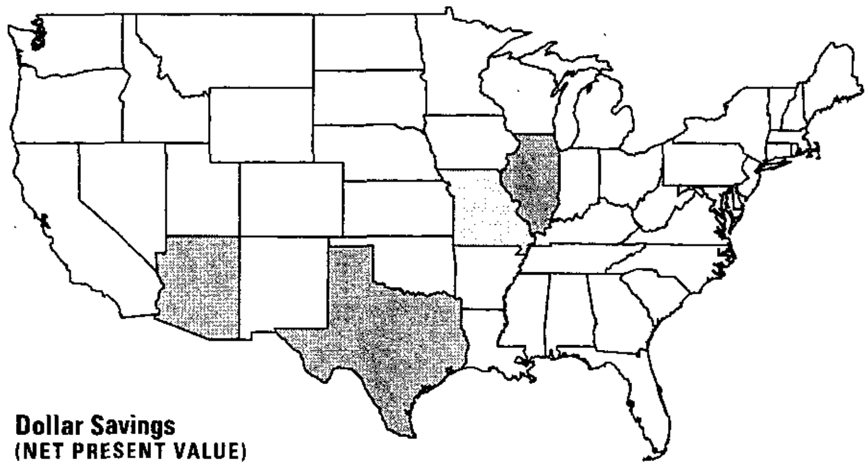
ENERGY CODES IMPROVE AIR QUALITY

While the MEC improves the finances of homebuyers, it also protects all citizens from air pollution by preventing the emission of 250,000 tons of carbon dioxide, sulfur dioxide, and other gases. Protecting the health and property of its citizens alone gives governments an imperative to adopt modern energy codes; when doing so is also economically beneficial, as shown in our study, failure to take this step is indefensible.

Beyond the immediate benefits of improved air quality, the MEC provides

Annual Dollar Savings Potential

BY STATE



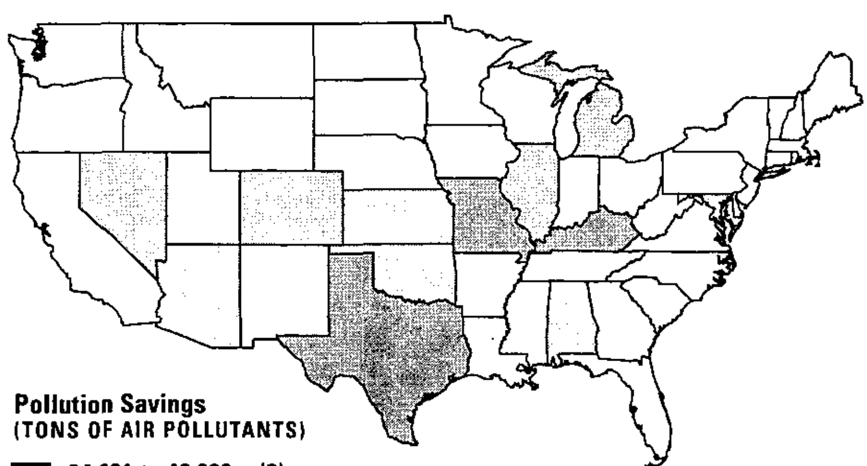
Dollar Savings
(NET PRESENT VALUE)

- 54,400,001 to 81,500,000 (3)
- 27,200,001 to 54,400,000 (2)
- 0 to 27,200,000 (32)
- not in study (14)*

***Alaska and Hawaii not in study. District of Columbia included in study.**

Annual Pollution Savings Potential

BY STATE



Pollution Savings
(TONS OF AIR POLLUTANTS)

- 34,001 to 46,000 (3)
- 23,001 to 34,000 (4)
- 11,501 to 23,000 (5)
- 0 to 11,500 (25)
- not in study (14)*

***Alaska and Hawaii not in study. District of Columbia included in study.**

sensible, low-cost insurance against the potential effects of climate change. Scientists generally agree that energy consumption is the greatest cause of increased carbon dioxide in the atmosphere, and that the resulting increase in the "greenhouse effect" is having an effect on our climate. While the severity and timing of the effects of climate change are hard to predict, it is easy to see the value in taking out "insurance policies" against climate change damage through proven, cost-effective policies, such as modern energy codes.

Introduction

In September 1991, the Alliance to Save Energy published a study of the energy, economic, and environmental benefits of adopting the 1989 version of the Council of American Building Officials' (CABO) Model Energy Code (MEC) for residential buildings. The study compared MEC-1989 energy standards to current code criteria in 34 states that had not recently updated their building codes. The 1991 report's findings included:

- If the 34 states had adopted the 1989 MEC, 7.2 trillion Btu would have been saved annually, or enough to meet the *total* energy needs of 65,000 to 70,000 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, with a net present value to consumers of $687 million; and

- Average savings per home per year equaled $130. With the average $874-added-home-cost typically financed through the mortgage, the average homebuyer would enjoy an immediate $60 per year positive cash flow.

The need for the present study arose with the updating of the MEC by CABO in 1993. (The MEC was also updated in 1995, but the changes affecting energy efficiency were minor compared to the efficiency gains in the 1993 version.) By the end of 1994 only three states—Michigan, Ohio, and Virginia—had adopted the 1993 MEC. Michigan, however, reversed itself in 1995, rescinding its adoption under severe pressure from home builders. 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, in 1996 and 1997 the U.S. Department of Energy (DOE), under its authority in the Energy Policy Act of 1992 (EPAct), required all states to consider adopting the 1993 and 1995 versions of the MEC, respectively. In EPAct, all states were initially required to consider adopting the 1992 version of the MEC. DOE was also mandated to review later versions of the MEC and, if it determined that a later version was significantly more energy efficient, to require states to consider adopting the later version. DOE determined that the 1993 and 1995 versions of the MEC would achieve greater energy efficiency in residential buildings. Consequently, many states are now involved in reviewing their codes and responding to DOE's reporting requirement. This study provides strong support for adopting the 1993 MEC in those states that have not yet done so.

The scope of the present study is similar to the original. For each state that had *not* adopted the 1993 MEC during the 1994 calendar year, we estimated the lost opportunities in energy and dollar savings as well as reductions in air pollution. We also estimated the magnitude (in present dollars) of the lost savings from two perspectives: the individual consumer and society as a whole.

UPDATE ON ADOPTION OF 1993 AND 1995 VERSIONS OF THE MEC

As of summer 1997, eight of the 31 states in the study had begun adoption of the 1993 or 1995 versions of the MEC. In various stages of implementing the 1995 MEC are Massachusetts, Georgia, Rhode Island, Maryland, and South Carolina. The 1993 MEC has been adopted in Delaware, Kansas, and North Dakota.

These changes occurred too recently to include in this analysis; in some cases the code has not yet taken effect, and in others training and other forms of administrative support are still being developed. The decisions of these eight states do not affect the overall findings of the study—that the MEC saves significant energy and pollution and is very cost effective. In fact, they support these conclusions by proving that states are indeed finding the newer MEC versions attractive. They demonstrate an encouraging trend that other states could follow by adopting the MEC's 1993 or 1995 versions.

Findings

This section presents the potential energy, environmental, and economic benefits of adopting the 1993 MEC. Findings are broken out by energy type, housing type (single-family versus multi-family) for the United States as a whole, and for each state in which the 1993 MEC is cost effective but had not been adopted by the end of 1994.

NATIONAL-LEVEL BENEFITS

Homeowner's Perspective

Energy Savings Benefits

Table A (next page) shows 1994 national energy savings if all states for which the 1993 MEC is cost effective had adopted it. From the homeowner's perspective, energy savings are valued at the consumer's retail price—the price they would have paid for the energy they saved. The discount rate used in the homeowner's perspective calculation is that of the prevailing mortgage rate in 1994, under the assumption that a new mortgage is the predominant funding vehicle for home purchases.

Total energy savings are 7,419 billion Btu: 7,093 billion Btu for single-family (SF) and 326 billion Btu for multi-family (MF). These savings occur in 716,400 SF homes and 129,590 MF dwellings built in 1994 in the affected states. The Btu savings are equivalent to the energy used by 70,705 single-family homes. Combined (SF and MF) savings by fuel type are: 5,023 million cubic feet of natural gas, 457 million kWh of electricity, and 4.3 million gallons of heating oil. On a per SF home basis (averaged from state values), the savings by fuel type are: 12,689 cubic feet natural gas, 2,309 kWh, and 106 gallons of oil.

Greenhouse Gas and Other Air Pollution Prevention

Greenhouse gas emissions savings (in tons of carbon equivalent) occur primarily as carbon dioxide (CO_2) savings (99.7 percent), which result primarily from savings in electricity use (123,885 tons carbon, or 56.1 percent), followed by natural gas (84,492 tons carbon, or 38.3 percent). Prevention of other air pollutants derives almost exclusively from savings in coal-fired electric generation; electricity (in total) accounts for 94.4 percent of other air pollution savings. Table B (next page) shows pollution avoidance by greenhouse gas and air pollutant. As can be seen in Table B, adoption of the 1993 MEC would help mitigate global climate change across the board by fuel type but would primarily reduce other air pollution where savings in electric heating and cooling occurred.

Economic Benefits

Table C (see page 5) shows the benefits for the average homeowner of adopting the 1993 MEC.

Table A. Potential National Energy Savings—1994
(Homeowner's Perspective)
Btu

Savings / Dwelling Type	Energy Per Home (MMBtu)	Energy Total (BBtu)	Natural Gas Per Home (MMBtu)	Natural Gas Total (BBtu)	Electricity Per Home (MMBtu)	Electricity Total (BBtu)	Oil Per Home (MMBtu)	Oil Total (BBtu)
Single-Family	9.90	7,093	12.68	5,063	7.65*	1,443*	12.51	595
					23.02†	4,349†		
Multi-Family	2.64	326	3.09	213	4.02*	113*	0.13	0.04
					12.10†	342†		
Totals		7,419		5,276		1,556		595

Note: Per home figures are averages of state values; thus, total Btu savings do not equal the sum of Btu savings by fuel type.
*Equals Btu of electricity saved per home as measured at the point of consumption.
†Equals Btu of electricity saved per home as measured at the source of generation.

Energy Units

Savings / Dwelling Type	Energy Per Home (MMBtu)	Energy Total (BBtu)	Natural Gas Per Home (Cu. Ft.)	Natural Gas Total (MMCF)	Electricity Per Home (kWh)	Electricity Total (MkWh)	Oil Per Home (Gallons)	Oil Total (M Gal.)
Single-Family	9.90	7,093	12,689	4,815	2,309*	423*	106	4.3
					6,953†	1,274†		
Multi-Family	2.64	331	3,046	208	1,205*	34*	1	0.0
					3,629†	101†		
Totals		7,424		5,023		457		4.3

Note: Per home figures are averages of state values.
*Equals Btu of electricity saved per home as measured at the point of consumption.
†Equals Btu of electricity saved per home as measured at the source of generation.

Table B. Potential National Pollution Prevention—1994
(SF and MF—Homeowner's Perspective)

	Electricity	Natural Gas	Oil	Totals
Greenhouse Gases (as tons of carbon):				
Carbon Dioxide (CO_2)	123,331	84,364	12,271	219,996
Nitrous Oxide (NO_x)	538	94	39	617
Methane	16	34	14	64
Total	123,885	84,492	12,324	220,701
Air Pollutants (in tons):				
Sulfur Dioxide (SO_2)	3,363	0	64	3,427
NO_x	1,620	0	160	1,780
Carbon Monoxide (CO)	73	0	71	144
PM-10 (Particulates)	59	0	8	67
Total	5,115	0	303	5,418

Table C. Potential National Economic Savings—1994
(Homeowner's Perspective)

	Added First Year Cost of MEC Adoption	Incremental Annual Dollar Savings	Benefit/Cost Ratio (at 7.5%)	Net Present Value (at 7.5%)	Consumer Affordability Index*
Average Home:[†]					
SF	$1,161	$122	1.8	$804	1.8
MF	340	40	2.2	285	2.2
Total (Millions)					
SF	$720	$77	—	$500	—
MF	37	4	—	29	—
Total	757	81	—	529	—

*Years to positive cash flow—added down payment plus added mortgage payment minus energy bill savings.
[†]Average home values equal the average of the state values.

It shows that the 1993 MEC is very cost-effective and makes housing more affordable for homebuyers. Because home purchasers typically 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 (down payment plus added mortgage payment minus energy bills savings) equals 1.8 years and 2.2 years, respectively, for SF and MF homeowners. This means the added investment (as represented by the added cost of their mortgage) pays back in two years or less. All remaining years (years 3 through 30), the families living in MEC-built homes will experience a positive cash flow. On a benefit-cost basis, adoption of the 1993 MEC produces a benefit/cost ratio of 1.8 for SF homeowners and 2.2 for MF homeowners.

The average added cost per home to meet the 1993 MEC is $1,161 and $340, respectively, for SF and MF homes. But the added energy efficiency embodied in the home saves the household $122 and $40 in annual energy costs for SF and MF dwellers, respectively. These savings streams over 30 years provide each SF and MF household a net benefit of $804 and $285, respectively, on a present value basis at a 7.5 percent discount rate. Total dollar savings to consumers in the 842,000 homes affected by this study equal $529 million on a net present value basis.

Societal Perspective

The above results are based on the consumer's point of view. The consumer's perspective uses the marginal (retail) energy price paid by the homeowner as the value of the benefits of the energy savings. In addition, we calculated the benefit/cost ratio and net present value of energy cost savings from the 1993 MEC at the homeowner's marginal cost of capital, which we assume to be the prevailing mortgage rate on 30-year mortgages. For 1994, the average mortgage rate was approximately 7.5 percent.

An alternative way to evaluate the economics of the 1993 MEC is from the "societal" perspective. This perspective analyzes the MEC as if all new home purchasers—or all consumers—could act together. In such a case, the societal group would use a lower discount rate, close to the risk-free rate on U.S. government securities. This "society" would evaluate economic benefits based on the marginal costs of fuel supply and the value of reduced air pollution and climate change costs. The environmental benefits are based on the estimated avoided costs of air pollution damage and the costs of mitigating global climate change.

We use a discount rate of 6.28 percent—the average 1994 rate on 30-year T-bills—as the proxy for the risk-free discount rate. Marginal cost of production—as a percent of retail energy prices—for the purposes of this study are 53 percent for natural gas, 51 percent for oil, and 62 percent for electricity, based on national energy industry statistics.

Mid-range estimates of the cost of air pollution—expressed also as a percentage of fuel price—were obtained from the work of Viscusi[1] and are 0.5 percent for natural gas, 13 percent for oil, and 261 percent for coal used in electric generation. Mid-range estimates of the cost of global climate change mitigation based on carbon dioxide emissions—again expressed as a percent of fuel price—were obtained from Nordhous[2] and are 14 percent for natural gas, 21 percent for oil, and 79 percent for coal. By adding the two percentages to each fuel price, we derived combined monetized social costs for each energy type: 15 percent for natural gas, 34 percent for oil, and 340 percent for coal.

These percentages were directly applied to natural gas and oil prices where these fuels were burned directly in homes. For electricity, the percentages were applied based on each state's electric generation fuel mix. The effects on retail prices of natural gas and oil used by homeowners are $.09/therm for natural gas and $.20/gallon for heating oil. For these fuels, the added environmental costs are well below their current retail price; "social-cost" pricing raises their base prices by 15 to 34 percent.

For electricity, however, the percentage of "social cost" prices accounted for by environmental costs is much greater. Where power plants are mostly coal-fired, environmental costs can dramatically increase electricity prices. The inclusion of environmental costs results in substantial variations state-by-state in the relationship of electricity's social marginal costs (SMC) to its private marginal costs (PMC). The ratio of SMC to PMC varies for 1994 from a high of 4.376 in Kentucky, Montana, North Dakota, and Wyoming, to a low of 1.015 in Vermont. However, because fuel costs are not the only cost of producing electricity, the percentage impact of social costs on retail electricity prices is less than the impact on fuel costs alone. For example, while Kentucky, Montana, North Dakota, and Wyoming each would see fuel costs increase 337 percent because of the inclusion of environmental damage costs, the total impact on retail electric prices was 106 percent for Kentucky, 77 percent for Montana, 173 percent for North Dakota, and 255 percent for Wyoming. In contrast, because very little electricity in Vermont is generated by coal, the impact of the inclusion of environmental damage costs on the retail price of electricity is only 1.5 percent.

Energy Savings Benefits

Table D shows 1994 potential national energy savings from the societal perspective if all states for which the 1993 MEC is cost effective had adopted it. The energy savings projected from this perspective are very similar in magnitude to the energy savings from the homeowner's perspective. The societal perspective was used to analyze the potential savings from 694,140 SF homes and 119,890 MF dwellings. Total energy savings are 7,158 billion Btu from the societal perspective compared to homeowner-perspective savings of 7,424 billion Btu. This finding indicates that energy savings potential is not very sensitive to the perspective used for analysis.

SF energy savings equal 6,851 billion Btu compared to homeowner-perspective SF savings

[1] See Viscusi, W. Kip, Wesley A. Magat, Alan Curlin, and Mark Dreyfus. 1994 "Environmentally Responsible Energy Pricing." *The Energy Journal*. Vol 15, No. 2.

[2] Nordhaus, William D. 1994. *Managing the Global Commons*. Cambridge and London: The MIT Press.

Table D. Potential National Energy Savings—1994
(Societal Perspective)

Savings / Dwelling Type	Energy Per Home (MBtu)	Energy Total (BBtu)	Natural Gas Per Home (MBtu)	Natural Gas Total (MCF)	Electricity Per Home (MBtu)	Electricity Total (MkWh)	Oil Per Home (MBtu)	Oil Total (M Gal.)
Single-Family	9.87	6,851	13.33	4,715	7.99* 24.06†	419	13.40	3.3
Multi-Family	2.56	307	2.49	189	3.67* 11.04†	32	0.11	0.0
Totals		7,158		4,904		451		3.3

Note: Per home values are average of state values; thus total energy per home does not equal the sum of fuel types per home.
*Equals Btu of electricity saved per home as measured at the point of consumption.
†Equals Btu of electricity saved per home as measured at the source of generation.

Table E. Potential National Pollution Avoidance—1994
(SF and MF—Societal Perspective)

	Electricity	Natural Gas	Oil	Totals
Greenhouse Gases (as tons of carbon):				
Carbon Dioxide (CO_2)	121,886	82,381	9,712	213,979
Nitrous Oxide (NO_x)	532	92	31	655
Methane	16	33	11	60
Total	122,434	82,506	9,754	214,694
Air Pollutants (in tons):				
Sulfur Dioxide (SO_2)	3,323	0	51	3,374
NO_x	1,600	0	127	1,727
Carbon Monoxide (CO)	72	0	56	128
PM-10 (Particulates)	58	0	6	64
Total	5,053	0	240	5,293

of 7,093 billion Btu, and MF savings are 307 billion Btu compared to homeowner-perspective savings of 331 billion Btu. These Btu savings are equivalent to the annual home energy used by 68,293 SF households. Combined (SF and MF) savings by fuel type are 4,904 million cubic feet of natural gas, 451 million kWh of electricity, and 3.3 million gallons of heating oil. On a per SF home basis (averaged from state values), the savings by fuel type are: 12,951 cubic feet natural gas, 2,343 kWh, and 109 gallons of oil.

Greenhouse Gas and Other Air Pollution Avoidance

Greenhouse gas emissions savings (in tons carbon) occur primarily as CO_2 avoidance (99.7 percent), which in turn results primarily from savings in electricity use (122,434 tons carbon, or 57.0 percent), followed by natural gas (82,506 tons carbon, or 38.4 percent). Emissions avoidance of other air pollutants derives almost exclusively from savings in coal-fired electricity generation. Electricity savings account for 95.5 percent of other air pollution savings. Table E shows the emissions savings by greenhouse gas and air pollutant. As can be seen in Table E, adoption of the 1993 MEC would help mitigate global climate change across the board by fuel type, but would primarily reduce other air pollution where savings in electric heating and cooling occurred.

Economic Benefits

Table F summarizes the economic benefits of adopting the 1993 MEC from the societal perspective. It shows that the MEC is very cost-effective and makes housing more affordable. Because home purchasers typically 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 (down payment plus added mortgage payments minus energy bill savings) equals 4.1 years and 6.4 years, respectively, for SF and MF homeowners. This means the added investment (as represented by the added cost of their mortgage) pays back in four to six years. All remaining years (years 4 or 6 through 30), the homeowner will experience a positive cash flow.

The average added cost per home to meet the 1993 MEC is $1,156 and $336, respectively, for SF and MF homes. But the added energy efficiency embodied in the home saves the homeowner $102 and $40, respectively, for SF and MF dwellers, in annual energy costs. These savings streams over 30 years provide SF and MF homeowners a net benefit of $765 and $384, respectively, on a present value basis at a 6.28 percent discount rate. On a benefit-cost basis, adoption of the 1993 MEC produces a benefit/cost ratio of 1.8 for SF homeowners and 2.7 for MF homeowners. Total dollar savings to consumers equal $544 million on a net present value basis.

Discount Rate Sensitivity Analysis

We conducted a sensitivity analysis to determine how our findings might have been affected by different discount rate assumptions. Mortgage rates—the proxy for the discount rate for the homeowner's perspective—were varied from a low of 5.54 percent to a high of 9.75 percent. From the homeowner's perspective, we ran the analyses for both the high and low case to determine the impact on our results.

As Table G shows, the magnitude of the energy savings results are largely insensitive to discount rates on the low end. For discount rates above the base case, however, cost-effective energy savings drop—by about 25 percent of the base case for the highest discount rate. Still, even with higher discount rates, adoption of the 1993

Table F. Potential National Economic Benefits—1994
(Societal Perspective)

	Added First Year Cost of MEC Adoption	Incremental Annual Dollar Savings	Benefit/Cost Ratio (at 6.28%)	Net Present Value (at 6.28%)	Consumer Affordability Index*
Average Home:					
SF	$1,156	$102	1.8	$765	4.1
MF	336	40	2.7	384	6.4
Total (Millions)					
SF	$689	$64	—	$506	—
MF	34	4	—	38	—
Total	723	68	—	544	—

* Down payment plus added mortgage payments minus energy bill savings.

Table G. Sensitivity of Findings to Discount Rates—Homeowner's Perspective

Savings (1994 National)	Low—5.54 Percent	Medium—7.50 Percent	High—9.75 Percent
Btu (Billions)	7,557	7,424	5,068
Natural Gas (Million CF)	5,115	5,022	3,268
Electricity (Million kWh)	465	456	347
Oil (Thousands Gallons)	4,312	4,228	3,285
Dollars (Millions - NPV)	871	529	276

MEC remains economical for many of the states that had not updated their energy codes.

STATE-BY-STATE SAVINGS

This section reports state-by-state energy savings, air pollution avoidance, and economic benefits of MEC adoption for the states that had not adopted the 1993 MEC by December 31, 1994, and for which the 1993 MEC was cost-effective given our economic assumptions.

While three states (Michigan, Ohio, and Virginia) had adopted the 1993 MEC by December 31, 1994, only two carried through their decision (Michigan rescinded its adoption in 1995 under pressure from home builders). While not officially adopting the 1993 MEC, another five states had adopted state and/or local codes that were at least as stringent as the 1993 MEC. These states were California, Florida, Minnesota, Oregon, and Washington. An additional six states—Alaska, Hawaii, Montana, Vermont, West Virginia, and Wyoming—were left out of the analysis due to lack of available complete data or too few housing starts. One state, North Carolina, was left out of the study because it failed to be cost effective for both single-family and multi-family housing. Overall, 36 states and the District of Columbia were analyzed. They had either (a) not adopted the 1993 MEC, and/or (b) did not have state codes as stringent as the 1993 MEC. The 1993 MEC proved cost effective for single-family construction in 31 out of these 37 states. For multi-family construction, the MEC was cost effective in 30 states.

The fact that states "fell out" of the analysis indicates that their residential code requirements were stringent enough to make adoption of the 1993 MEC non-cost-effective. In every case, this occurred in states that had recently adopted the 1992 MEC. Also, as mentioned earlier, eight states have begun adoption of the 1993 or 1995 MEC since this analysis began. If the analysis were to be rerun, these states would also drop out. However, this does not invalidate the current study; it simply means that some states are beginning to take advantage of the benefits identified in this analysis.

Potential Energy Savings

Table H (next page) shows the state-by-state energy savings potential by Btu and fuel type from the homeowner's perspective. Several observations are apparent from examination of the table. 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 Btu saved per newly constructed home, is the potential savings from the adoption of the 1993 MEC.

Table H. State-by-State Potential Energy Savings—1994
(Homeowner's Perspective)

	Housing Starts		Btu (Billions)		Natural Gas (Millions Cubic Feet)		Electricity (Millions kWh)		Oil (Thousands Gallons)	
	SF	*MF*	*SF*	*MF*	*SF*	*MF*	*SF*	*MF*	*SF*	*MF*
Alabama	21,490	2,890	164	6	67	1	26	1.5	52	0
Arizona	43,370	7,480	164	8	86	4	19	1.0	64	0
Arkansas	15,680	4,920	10	14	6	10	1	0.8	0	0
Colorado	30,990	6,760	645	25	534	18	23	1.9	52	0
Connecticut	8,520	—	16	—	7	—	<1	—	54	—
DC	90	10	1	<1	<1	<1	<1	<0.1	0	0
Delaware	4,610	210	63	<1	40	<1	6	0.1	0	0
Georgia	66,910	6,850	52	9	25	<1	7	2.6	0	0
Idaho	9,880	2,370	208	9	168	7	8	0.7	33	0
Illinois	37,760	7,760	914	38	656	29	31	2.3	859	0
Indiana	—	7,190	—	19	—	14	—	1.1	—	0
Iowa	—	3,090	—	13	—	8	—	1.3	—	0
Kansas	12,900	2,440	224	9	169	6	12	1.0	37	0
Kentucky	20,930	4,450	197	12	82	2	31	2.7	21	0
Louisiana	15,910	2,290	67	3	51	2	4	0.3	0	0
Maine	6,030	330	184	2	84	2	5	0.1	581	<1
Maryland	29,580	2,770	280	5	189	<1	24	1.4	0	0
Massachusetts	17,440	—	152	—	60	—	2	—	589	—
Michigan	36,700	9,240	741	46	623	35	23	2.7	58	0
Mississippi	12,230	1,300	81	2	36	<1	12	0.5	16	0
Missouri	27,210	3,470	567	14	419	9	30	1.5	183	0
Nebraska	—	1,500	—	5	—	3	—	0.6	—	0
Nevada	23,330	—	474	—	350	—	25	—	167	—
New Hampshire	5,020	300	145	2	54	2	2	0.1	594	<1
New Jersey	17,370	3,000	271	11	154	10	19	0.4	314	0
New Mexico	—	2,010	—	4	—	3	—	0.3	—	0
New York	24,700	—	141	—	82	—	7	—	220	—
North Dakota	—	1,280	—	6	—	3	—	0.6	—	0
Oklahoma	13,950	1,490	213	5	146	4	18	0.3	0	0
Pennsylvania	36,370	—	258	—	184	—	17	—	36	—
Rhode Island	2,790	—	26	—	9	—	<1	—	108	—
South Carolina	23,090	—	100	—	48	—	14	—	28	—
South Dakota	3,050	1,010	9	3	6	2	<1	0.3	3	0
Tennessee	35,760	5,670	22	10	7	2	4	2.3	0	0
Texas	91,010	30,320	599	45	398	28	47	4.5	143	0
Utah	—	3,190	—	7	—	5	—	0.5	—	0
Wisconsin	21,730	—	102	—	74	—	4	—	74	—
Totals	716,400	125,590	7,093	331	4,815	207	423	33.2	4,288	<1

Table I. Ranking of States by Potential Energy Savings Per Newly Constructed SF Home—1994

Potential Energy Savings (Millions Btu per SF Home)	States
25–29.9+	ME
20–24.9	CO, ID, IL, MI, MO, NV
15–19.9	KS, NJ, OK
10–14.9	DC, DE
5–9.9	KY, MA, MD, MS, NY, PA, RI, TX
0–4.9	AR, AZ, CT, GA, LA, SC, SD, TN, WI

State Btu savings ranged from a high of 914 billion for Illinois to a low of 9 billion for South Dakota (and 1 billion for the District of Columbia). Energy savings per SF home varied from a low of 0.6 million Btu in Tennessee to a high of 30.1 million Btu in Maine. SF home savings average 9.9 million Btu per home.

Table I shows states ranked according to potential energy savings per home. Maine, Colorado, Idaho, Illinois, Michigan, Missouri, and Nevada all have average savings of 20 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. Kansas, New Jersey, Oklahoma, and Delaware along with the District of Columbia show average savings potential of 10 to 19.9 million Btu per home. Kentucky, Massachusetts, Maryland, Mississippi, New York, Rhode Island, Texas, Pennsylvania, Arkansas, Arizona, Connecticut, Georgia, Louisiana, South Carolina, South Dakota, Tennessee, and Wisconsin 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 1993 MEC.

Table J. Ranking of States by Potential Pollution Prevention Per SF Home—1994

Potential Pollution Prevention: Greenhouse Gases Plus Other Air Pollutants (Tons per SF Home)	States
2.01+	NH
1.51–2.0	CO, DE, IL, KS, KY, ME, MI, MO, NV, OK
1.01–1.5	AL, DC, ID, NJ
0.51–1.0	MA, MD, MS, PA, RI, TX
0–0.5	AR, AZ, CT, GA, LA, NY, SC, SD, TN, WI

Potential Pollution Avoidance

Table B showed potential pollution avoidance in total tons per year by pollutant. As discussed before, the primary pollutant is carbon dioxide, which affects global climate change. The other major pollutants are sulfur dioxide and nitrous oxide. The total pollution avoidance per state depends on both the number of housing starts and the dominant heating fuel. The highest levels of potential pollution avoidance are found where housing starts are numerous, heating energy use is high, and heat is supplied by fuel oil or coal-fired electricity.

We also compared states in terms of potential pollution avoidance per home; the results are displayed in Table J. It shows that high potential pollution savings per home are available in Colorado, Delaware, Illinois, Kansas, Kentucky, Maine, Michigan, Missouri, Nevada, New Hampshire, and Oklahoma. In these states the combination of large energy savings potential and a high proportion of more-polluting fuels create the greatest pollution avoidance potential (1.51 tons per home per year or more). Arkansas, Arizona, Connecticut, Georgia, Louisiana, New York, South Carolina, South Dakota, Tennessee, and Wisconsin—because of relatively stringent existing codes and/or less-polluting fuels—exhibit very low levels (less than 0.5 tons per home per year) of potential pollution prevention from the adoption of better building codes.

Table K. Potential Economic Benefits to Individual Homeowners by State—1994

State	Added First Cost	First Year Savings	Benefit/Cost Ratio (at 7.5%)	Net Present Value (at 7.5%)	Years to Positive Cash Flow
AL	$881	$130	2.2	$1,073	0.6
AR	100	13	1.6	84	1.8
AZ	248	88	5.2	1,046	0.3
CO	1,814	145	1.1	643	2.9
CT	123	19	1.5	201	1.7
DC	1,398	133	1.4	744	0.7
DE	2,155	203	1.4	1,054	1.7
GA	134	14	1.3	67	0.8
ID	1,819	158	1.2	863	0.6
IL	2,206	219	1.6	1,477	1.3
KS	1,752	204	1.6	1,285	2.1
KY	1,587	113	1.1	162	4.4
LA	250	47	2.7	401	0.6
MA	1,307	80	1.0	101	6.9
MD	1,036	125	1.7	905	0.7
ME	2,169	304	2.1	3,062	0.5
MI	2,094	160	1.1	572	4.6
MO	1,718	205	1.8	1,409	1.4
MS	551	126	3.6	1,315	0.4
NH	2,114	248	1.5	2,237	0.5
NJ	2,101	209	1.6	1,291	3.2
NV	2,687	175	1.1	338	5.2
NY	459	77	2.3	827	0.4
OK	1,152	159	2.1	1,205	1.0
PA	1,353	98	1.1	246	4.0
RI	1,121	83	1.0	353	2.6
SC	630	76	2.2	482	1.4
SD	117	26	1.2	291	0.1
TN	108	12	1.6	66	0.9
TX	414	89	3.6	837	0.5
WI	385	41	1.6	301	1.8
AVERAGES	$1,161	$122	1.8	$804	1.8

Table L. Top 10 States Ranked by Total Energy Savings, Savings Per Home, and Economic Measures (SF Homes)—1994

Total Energy Savings (Billion Btu)		Energy Savings Per Home (Million Btu)		Benefit/Cost Ratio		Net Present Value		Consumer Affordability Index (years to positive cash flow)	
1. IL	914	1. ME	30.6	1. AZ	5.2	1. ME	3,062	1. SD	0.1
2. MI	741	2. NH	28.9	2. MS	3.6	2. NH	2,237	2. AZ	0.3
3. CO	645	3. IL	24.2	3. TX	3.6	3. IL	1,477	3. NY	0.4
4. TX	599	4. ID	21.2	4. LA	2.7	4. MO	1,409	4. MS	0.4
5. MO	567	5. MO	20.8	5. NY	2.3	5. MS	1,315	5. TX	0.5
6. NV	474	6. CO	20.8	6. AL	2.2	6. NJ	1,291	6. NH	0.5
7. MD	280	7. NV	20.3	7. SC	2.2	7. KS	1,285	7. ME	0.5
8. NJ	271	8. MI	20.2	8. ME	2.1	8. OK	1,205	8. LA	0.6
9. PA	258	9. KS	17.4	9. OK	2.1	9. AL	1,073	9. AL	0.6
10. KS	224	10. NJ	15.6	10. MO	1.8	10. DE	1,054	10. ID	0.6

Potential Economic Benefits

Table K shows the potential economic benefits to homeowners if all states in which it is cost-effective had adopted the 1993 MEC. By virtually all economic measures, investment in better building codes is economical to 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 7.5 percent discount rate). In fact, 9 out of the 31 states have benefit/cost ratios of 2.0 or greater.

Second, all states in the study show a positive net present value (again at a 7.5 percent discount rate). From the homeowner's point of view—when taking mortgage financing into account—in most states the Consumer Affordability Index (years to positive cash flow) is less than 1.0, meaning that the savings in energy costs exceed the added mortgage cost in the first year of homeownership.

SUMMARY STATE-BY-STATE COMPARISONS

Table L lists the top ten states by total energy savings, savings per home, benefit/cost ratio, net present value, and Consumer Affordability Index. A review of the table leads to the following observations:

- As one would expect, the larger states dominate the ranking of total potential energy savings. Seven of the top 10 are large or moderately large states in terms of population. These states are Illinois, Michigan, Colorado, Texas, Missouri, Pennsylvania, and New Jersey. The other states—Nevada, Maryland, and Kansas—are smaller, but are experiencing high rates of housing starts.

- For potential savings per home, Maine and New Hampshire top the list with savings above 25 million Btu per home. Illinois, Idaho, Missouri, Colorado, Nevada, and Michigan contain potential savings between 20 million and 25 million Btu per home. The remaining states, Kansas and New Jersey, have per home savings of 17.4 million Btu and 15.6 million Btu, respectively. A common characteristic of these states is that they all experience cold winters.

■ The top-ranked states according to benefit/cost ratio are predominantly southern or western states where the added cost of meeting the 1993 MEC is low, but potential savings are relatively high, resulting in high benefit/cost ratios. Arizona has a benefit/cost ratio of 5.2, Mississippi and Texas have ratios of 3.6, and the rest of the states have ratios between 1.8 and 3.0. The northern states in the group are New York and Maine, which experience severe winters.

■ Examination of the net present value top ten shows this list is dominated by states that have high potential Btu savings per home (5 out of the top 10). They are also states with relatively high energy prices. Thus where energy savings per home and energy prices are high, consumers benefit most from MEC adoption.

■ The states having low Consumer Affordability Index values, like those with high benefit/cost ratios, include both southern and northern states. In the south, the MEC boosts affordability because its compliance costs are relatively low. In northern states like Maine, the large energy bill savings are more important factors.

Methodology

As a first step in the study, we updated all of the data sets used in the 1991 study. These included marginal fuel prices, marginal fuel costs, housing starts, furnace and air conditioning equipment characteristics, technical criteria in the MEC, current state building code technical criteria, and such economic assumptions as mortgage interest rates.

We next assigned the data on housing starts, fuel prices and costs, new equipment sales, new construction characterization, building code practice, and other data for 131 cities/ Standard Metropolitan Statistical Areas (SMSAs). This city-level database was used as the basis for calculations we developed for 44 states and the District of Columbia.

The city/SMSA-level data were fed into a mainframe computer model that optimizes building design for both current code criteria and the 1993 MEC for 33 residential home prototypes. The model produced a number of outputs, including energy savings, cost savings (marginal and average), and economic analysis results.

MARGINAL FUEL PRICES

Retail energy prices determine the consumer's perceived economic benefits from more stringent building energy codes. Marginal retail energy prices were estimated for oil, natural gas, and electricity (both summer cooling and winter heating). For heating 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 a 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 to energy suppliers, as distinct from retail prices to consumers, serve to determine the cost-effectiveness of better building codes from the societal perspective. 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 heating oil retail price was used to estimate the refiner price for each state. The 1994 average city gate (wholesale) price of natural gas was used as the marginal natural gas cost. As with 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 of 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 51.1 percent for oil, 52.8 percent for natural gas, and 61.8 percent for electricity.

In order to take into account environmental externalities, we also estimated the cost of air pollution damages, which were then added to the above marginal fuel costs. To estimate air pollution damage costs, we relied on work by Kip Viscusi performed for the U.S. Environmental Protection Agency. Viscusi (Viscusi, et al., "Environmentally Responsible Energy Pricing," *The Energy Journal*, Vol. 15, No. 2, 1994, pp. 23–42) used the scientific and economics literature and EPA research to estimate environmental damage costs associated with energy use. This work resulted in estimates of "full social cost" prices for the following fuels: petroleum, wood, coal, gasoline, diesel, aircraft fuel, heating oil, and natural gas. Each fuel contributes varying degrees of the following seven externalities: residual lead in gasoline, emitted particulates, sulfur oxides (excluding and including mortality), ozone, visibility, and air pollution toxics from motor vehicles.

Viscusi's estimates are based on the assumption that existing compliance costs have achieved a 25 percent reduction in emissions. Thus, he assumes the current compliance costs need to be multiplied by a factor of three to measure the cost of achieving *zero* emissions (the other 75 percent). This estimate is very conservative, since experience shows that the incremental cost of reducing additional percentages of pollutants tends to increase dramatically.

We also obtained mid-range estimates of the cost of air pollution—expressed as a percent of fuel price—from the work of Viscusi. These are: 261 percent for coal, 13 percent for oil, and 0.5 percent for natural gas. In addition, we also incorporated estimates for global climate change costs. Mid-range estimates of the cost of global climate carbon emissions—expressed as a percent of fuel price—were obtained from the work of Nordhaus (Nordhaus, W. D., "An Optimal Transition Path for Controlling Greenhouse Gases," *Science*, 258, November 20, 1992, pp. 1315–1319). These are 79 percent for coal, 21 percent for oil, and 14 percent for natural gas. The combined environmental costs, thus, equal 240 percent for coal, 34 percent for oil, and 15 percent for natural gas. We applied the natural gas and oil percentages directly to 1994 fuel prices. For electricity, we applied fuel-based environmental cost percentages state-by-state based on each state's generation fuel mix.

HOUSING STARTS

For 1994, housing starts data were available only at the national level. *Housing Starts: April 1995*, U.S. Department of Commerce, reported 1.2 million single-family (SF) and 244,000 multifamily (MF) starts in 1994. We also consulted *New Construction Report: Insulation: 1993–1997*, by the F. W. Dodge Residential Product Demand Group for estimates of SF and MF housing starts by state. Because the F. W. Dodge data totaled fewer starts than the Commerce data, we adjusted the F. W. Dodge state estimates upward in each state proportionally for congruence with Commerce's national totals.

Within each state we assigned the SF and MF data to the 131 city/SMSAs used in the computer model 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 we used to estimate 1994 new construction market shares for oil, gas, and electric furnaces, electric resistance heating, heat pumps, and air conditioning on a state-by-state basis.

THE 1993 MEC

The most widely accepted model energy code in the United States is the Model Energy Code of the Council of American Building Officials (CABO), now administered by the International Code Council (ICC). The 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 now ICC and is revised each year through an annual code change cycle.

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. The thermal performance criteria for these components in the 1993 MEC, broken out by the 131 cities/SMSAs in our model, were provided electronically by the Department of Energy's Pacific Northwest National Laboratory.

CURRENT STATE CODE CRITERIA

Most states do not use the 1993 MEC as their official residential building code, though many use earlier versions. In fact, at the beginning of our analysis only three states did—Ohio, Michigan, and Virginia. (Note: because Michigan never truly enforced the 1993 MEC and rescinded it in 1995, we added them to the list of states *not* having adopted the 1993 MEC in 1994.) The rest of the states fall into one of four code categories:

- a state-written code;
- a code that references or adopts language in one of the regional codes, such as the Building Officials and Code Administrators International (BOCA), the Southern Building Code Congress International, Inc. (SBCCI), or the International Conference of Building Official (ICBO);
- a prior version of the MEC or American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standards; or
- no code at all.

For the purpose of analysis, we compared each state's current code criteria to the MEC 1993 on a building component level. Some state-written codes are more stringent than the MEC, while others are less stringent. Of the three regional model codes, only the 1996 version of BOCA is more stringent than the 1993 MEC (it includes the 1995 MEC). Where an earlier MEC version was in force, we simply compared component thermal performance values. In cases where a state did not have a code, we made estimates of current practice using ASHRAE Standard 90-A, or average builder practice in the state if this data was available. Current residential code data was collected at the building component level by the

Alliance to Save Energy by surveying state building code offices. Both housing start data and residential building code energy requirements were later verified by the Alliance.

ECONOMIC ASSUMPTIONS AND MODELING

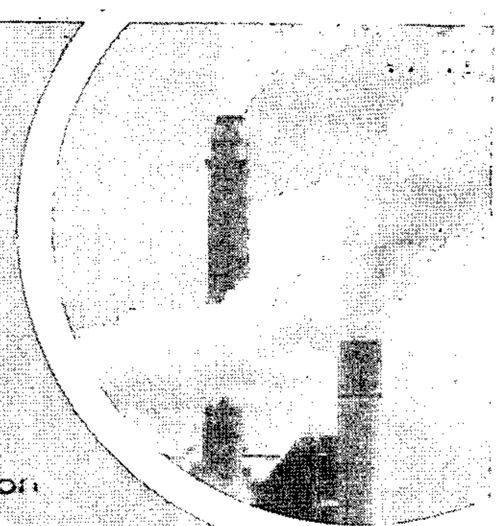
The primary economic assumptions required for the analyses were setting the mortgage interest rate and the cost of capital for the different analytic points of view. During 1994, fixed-rate, 30-year mortgage interest rates averaged 8.325 percent and at year's end fell between 9.125 and 9.250 percent.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

We also used the following assumptions when analyzing mortgage cash flow economics from the point of view of individual homeowners: 1.46 percent property tax rate, 15 percent down payment, and 28 percent federal income tax bracket. The inflation rate was set at 2.6 percent.

Other interest rate assumptions used in the analysis 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 rate was used to reflect society's cost of capital. The other rates were used as alternative consumer discount rates for sensitivity analyses.

We updated the computer model—called ASE and developed by Owens Corning—that was used in the 1991 study. 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 societal 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 based on 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 subroutine 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 Consumer Affordability Index (years to positive cash flow for the homeowner).



Opportunity Lost

Better Energy Codes for Affordable Housing and A Cleaner Environment

198

ALLIANCE TO
SAVE ENERGY

ALLIANCE TO
SAVE ENERGY

1200 18th Street NW
Suite 900
Washington, DC 20036
Telephone: (202) 857-0666
Fax: (202) 331-9588
E-mail: info@ase.org
Web: www.ase.org