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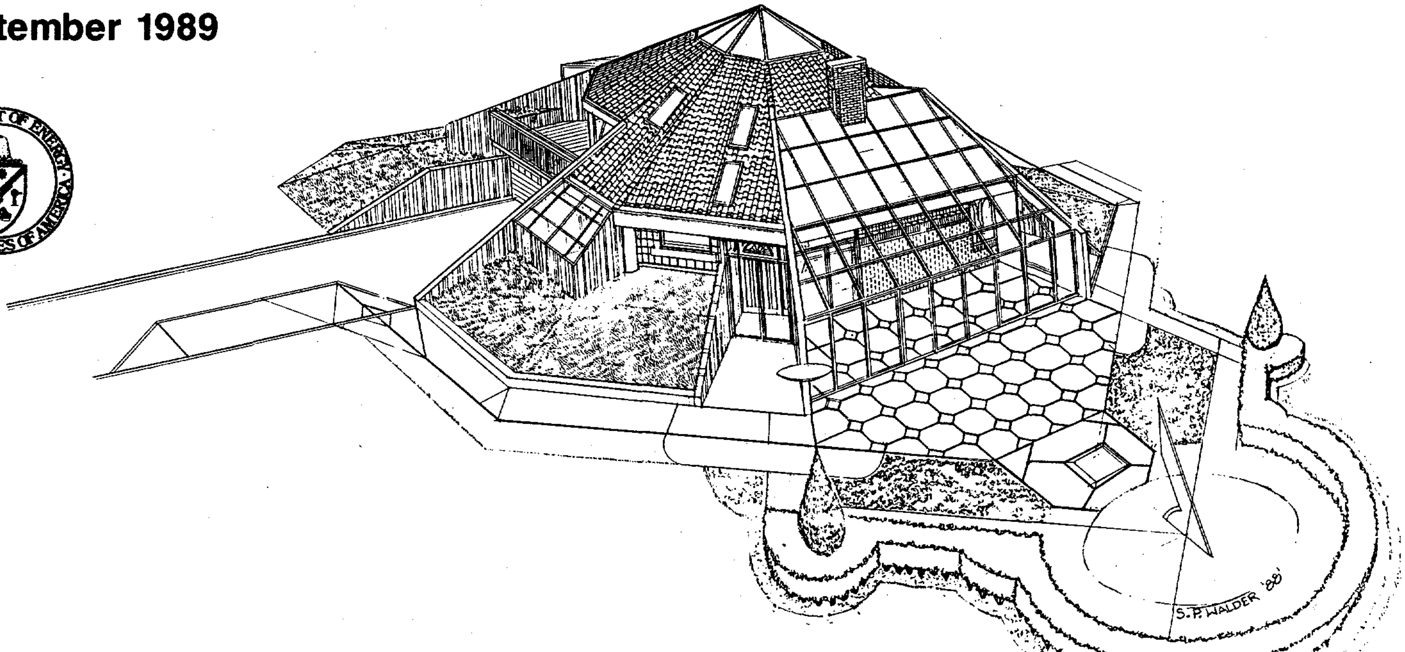
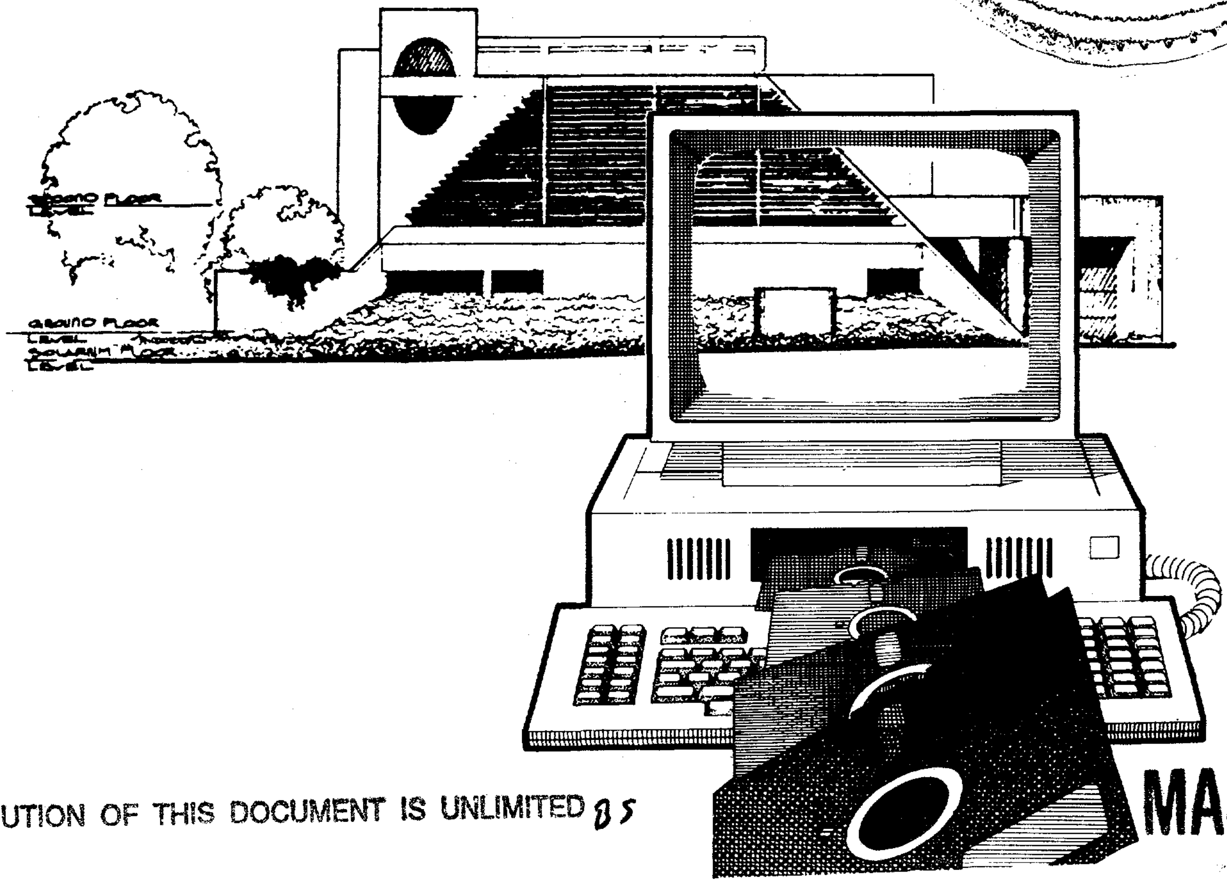
Economic Analysis

In Support of Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings

September 1989





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PREFACE

The Energy Conservation for New Buildings Act of 1976, as amended, 42 U.S.C Section 6831 et. seq. requires the U.S. Department of Energy (DOE) to issue energy conservation standards for the design of new residential and commercial buildings. The standards will be mandatory only for the design of new federal buildings and will serve as voluntary guidelines for the design of new non-federal buildings.

The original recommendations for the non-federal residential standards were produced by the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE) Special Projects Committee No. 53 under contract to Pacific Northwest Laboratory (PNL). Those recommendations were published in four volumes entitled Recommendations for Energy Conservation Standards for New Residential Buildings. DOE modified the original recommendations to accommodate an optional, more flexible economic analysis procedure. DOE also directed PNL to produce additional technical documentation for the software that embodies the standards and to assess the economic and environmental effects of the standards.

The final standards are documented in seven publications in support of the Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings:

- ARES 1.2 User's Guide (Automated Residential Energy Standard) - Explains the use of the ARES program to develop location-specific energy conservation requirements.

- Technical Support Documentation for the Automated Residential Energy Standard (ARES) - Explains the data and algorithms used by the ARES program to optimize energy-related features of new residences.

- Background to the Development Process for the Automated Residential Energy Standard (ARES) - Explains the background and philosophy of the standard development process.

- Technical Support Documentation for the Automated Residential Energy Standard (ARES) Data Base - Documents the assumptions and procedures used to develop the residential energy consumption data base in ARES.

- Description of the Testing Process for the Automated Residential Energy Standard (ARES) - Describes the process used by the development committee to initially test the ARES computer program.

- Economic Analysis - Describes an assessment of the likely impacts of the new standards on the nation's economy.

- Environmental Assessment - Describes an assessment of the likely impacts of the new standards on new home habitability, on institutions associated with residential construction, and on the economy in general.

SUMMARY

The economic analysis of the proposed voluntary residential energy (VOLRES) standard for new residential buildings concludes that there are no significant adverse effects from adopting the VOLRES standard. When compared with current practice, the proposed standard will result in a positive net flow of benefits from energy savings that more than offsets higher capital construction and other costs. By calculating the life-cycle cost of new construction as currently practiced and the life-cycle cost of construction that would be required by the standard, the regional and national net benefits of the standard over a 15-year period have been estimated.

The analysis leads to the following major conclusions, expressed in constant 1986 dollars:

- The national net effect of the standard, assuming its immediate and full penetration, ranges from nearly $930 million in net benefits for 1988 construction to $1035 million for 1992 construction.
- This net effect is based on the net present value of energy savings and capital costs over the 15-year period. For 1992 construction, the year with the largest net effect, the capital costs of construction to comply with the standard are $1.2 billion. The energy savings accrued over the 15-year period for 1992 construction are nearly $2.2 billion. The difference represents a net benefit of $1.0 billion.
- Because the standard is voluntary, there is some question about how rapidly it will be adopted. To examine the impact of this, the net benefits were also calculated assuming a ramped penetration of the standard over five years (20 percent per year). The national net effect of the standard ranges from nearly $186 million in net benefit for construction in 1988 to $1035 million for construction in 1992. (Full penetration of the standard occurs in 1992.)

The standard creates a net benefit for all regions. Assuming full penetration of the standard, the Northeast receives the greatest benefit until 1993 when the net benefits in the South overtake those of the Northeast. The net benefit to the Northeast increases from $336 million for 1988 construction to $384 million for 1992 construction, after which the net benefits drop steadily until the construction period from 2001 to 2005, when they reach $220 million. In magnitude, the West region's net benefit is the lowest of all regional benefits from 1988 to 2005. Changes in the relative share of net costs and benefits are attributable to changes in the distribution of regional housing forecasts.

The total impact of the standard, as measured in the gross value of industry output and employment, was estimated using the U.S. input-output table (DOC 1984). For the purposes of this analysis, the effects of the energy savings have been assumed to occur in the year of construction when, in reality, the energy savings are spread over fifteen years. In 1992, the construction year with the greatest indirect impacts, the combined effect of output changes results in a net loss of approximately $2.5 billion in output. This decrease in output is the difference between a $2.2 billion increase in output resulting from increased capital expenditures for construction and the $4.7 billion decrease in output resulting from lower energy expenditures. Even when all of the output effects of changes in energy costs over fifteen years are assumed to occur in the initial year of construction, the output change represents only 0.05 percent of the total U.S. Gross National Product.

The greatest total effect on employment is the net loss of 10,800 jobs associated with 1991 construction. While nearly 31,800 jobs are gained as a result of increased construction, over 42,600 are lost as a result of decreased energy expenditures. This estimate of employment effects, probably an overestimate since it does not take into account alternative patterns of consumption, is less than 0.01 percent of total U.S. employment.

These findings are predicated on assumptions about current energy prices, social discount rates, and the distribution of new residential construction, fuel/equipment and foundation type preferences. A sensitivity analysis was performed on fuel prices, and the ramifications of changes in other economic variables were assessed.

The sensitivity analysis reveals that ARES is sensitive to fuel prices. When fuel prices are increased by 50 percent, the net benefit of the proposed standard increases substantially. The national net benefit reaches its highest level for construction in 1992 with a net benefit of $2.2 billion. On the other hand, when fuel prices decrease, the proposed standard could result in less energy-efficient construction than is currently required by state codes.

The calculation of the net benefit of the proposed standard under alternative time horizons, reveals that under a seven-year time horizon, the proposed standard would result in a net cost to society in all construction years. Under a 30-year time horizon, the national net benefit is substantially higher than the net benefit over the 15-year time horizon.

The homeowner's perspective is also assessed as part of the sensitivity analysis. For all years of construction, the proposed standard would generate a net benefit for homeowners.

ACKNOWLEDGMENTS

We would like to express gratitude for help and guidance in the completion of this report. This report was authored by Sarah J. Marsh and Joseph M. Roop. Allen Lee, Ray Reilly, and Michael R. Brambley served as project managers, with Jenifer W. Callaway providing leadership for the component tasks that comprise the Regulatory Analysis. The characterization of the base case was also done under the direction of Jenifer W. Callaway. John Rivera wrote the Notice of Proposed Regulation (NOPR). Z. Todd Taylor managed the development and provided the technical description of the standard. Technical recommendations were provided by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers Special Project 53 Committee. Steven Walder acted as the contract monitor for the Department of Energy. At Pacific Northwest Laboratory, we owe special thanks to Cynthia Turney and other capable staff who helped organize and construct the data for this report.

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1.0 INTRODUCTION

The objective of this document is to present an analysis of the impacts of the proposed voluntary energy conservation standard for the construction of new residential buildings. This analysis examines the impacts of having the proposed residential standard apply immediately and, alternatively, having the proposed standard phased in over a five-year period. It does not address the question of whether realistically the standard would be adopted by states, nor does it weight the improbable impact of states with higher energy efficiency standards modifying their standard to comply with this voluntary standard.

1.1 BACKGROUND

The proposed voluntary standard for new residential buildings has undergone considerable revision since its inception in 1977. This section provides a brief legislative history of the standard and then describes the original and present proposals.

1.1.1 Legislative Background

As originally enacted, Title III of the Energy Conservation and Production Act, Pub. L. No. 94-385, 90 Stat. 1144 et seq., required action to develop, promulgate, implement and enforce compliance with performance standards to improve energy efficiency of all new buildings in the nation. The regulatory nature of this action was modified by the Energy Conservation Standards for New Buildings Act of 1976, as amended, (the Act) (42 U.S.C. 6831 et. seq.). Responsibility for this action was transferred to the U.S. Department of Energy (DOE) on August 4, 1977, with the passage of Section 304(a), 42 U.S.C. Sec. 7154, of the Department of Energy Organization Act, Pub. L. No. 95-91.

In November 1979, DOE published proposed performance standards in the Federal Register, 44 FR 68120, et seq. The standards, expressed as maximum energy consumption levels (Btu's per square foot per year), were very controversial, generating over 1800 comments. Many commenters expressed concern that the proposed standards were not technically practicable or economically achievable. Furthermore, many commenters stated that the proposed standards placed too great a reliance upon the use of a complex computer program which many commenters said they neither understood nor could afford to use.

Less than a year after the publication of the proposed standard, the Act was again amended by Section 326 of the Housing and Community Development Act of 1980, Pub. L. No. 96-399 (October 8, 1980). This amendment required that DOE promulgate interim standards and extended the promulgation date of the final standard to April 1, 1983. In addition, the Act required that demonstration projects be conducted in at least two geographical areas.

In August 1981, Congress again amended the Act and deferred the appropriation for the program from the 1981 fiscal year to the 1982 fiscal year. Subtitle D of Title 10 of the Omnibus Reconciliation Act of 1981, Pub. L. No. 97-35, amended the Act to create the term "voluntary performance standard," eliminated the provision for a possible statutory sanction for noncompliance, and added a provision that, except for federal buildings, "voluntary standards will be developed solely as guidelines to provide technical assistance for the design and construction of energy efficient buildings."

1.1.2 Summary of the Original Proposal

The most significant aspect of the proposed Building Energy Performance Standards (BEPS), issued in 1979, was that they were a performance standard that set energy limits for the building as a whole. BEPS attempted to combine energy use of, and permit trade-offs for, specific energy-using systems such as heating, cooling or domestic hot water. The proposed standards consisted of three requirements. First, energy budget levels would be set; second, they would be applied to a specific building design to obtain an annual rate of consumption; and third, the estimated general rate of energy consumption would be calculated using a method established by DOE. The whole process required the use of a computer simulation to demonstrate that the designed energy consumption of a new building did not exceed the energy level specified for a residential building of its type in its applicable climate area. The BEPS was based on life-cycle cost analyses and defined different residential building types (multi-family high-rise, multi-family low-rise, single-family attached and single-family detached) as well as a procedure to select an appropriate climate zone from 78 Standard Metropolitan Statistical Areas (SMSA).

DOE recognized that many aids, such as model codes or building energy simulation software, would be needed to reduce compliance complexities. It also acknowledged that tools needed to be in formats familiar to members of the building industry. These compliance assistance tools were in the process of being developed by DOE when the implementation sections of the statutes were repealed by the Omnibus Reconciliation Act. The entire package of compliance assistance tools was never completed, but a slide rule and A Guide to Designing and Constructing Energy Efficient Homes was issued in 1983.

1.1.3 The Present Proposal

In response to the revised legislation and to comments made on the proposed BEPS, DOE is now reproposing performance standards for the private sector. Because of the difference in the economics and process of federal design and construction of residential buildings, DOE is issuing separate standards for the federal and private sector. Mandatory standards for new federal residential building had been developed previously and are soon to be issued by DOE.

The proposed voluntary standard is for private sector construction and for federally-subsidized private housing only. As such, DOE would not be regulating private sector construction, but rather issuing guidelines to provide technical assistance for the designs and construction of energy-efficient buildings. The proposal represents a significant federal effort to help the private sector develop energy conservation standards without regulatory intrusion. To develop the proposed standard DOE has worked closely with a special projects committee from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). The research project jointly undertaken by DOE and ASHRAE culminated in the proposed interim voluntary standard.

The proposed standard is presented in the format commonly used by the private sector standards-setting organization rather than as a federal regulation. For example, the proposal contains extensive explanatory material not normally included in federal standards. By submitting the proposed interim standards in a form that is likely to be better understood and more readily used in the private sector, DOE hopes to improve the standard's transferability.

As defined by the Act, the proposed standard serves as a guideline for the design of new residences; it does not apply to the operation, maintenance or energy consumption of a building once it is built. The proposed standard operates by setting an energy cost goal for a building (i.e., a quantified target for energy cost at the design stage) and a method to calculate whether the design meets that goal. Through the use of the software ARES (Automated Residential Energy Standard) which supports the proposed standard, users can also create "packages" of energy conservation components that meet the energy consumption goal.

1.2 REPORT STRUCTURE

Section 2.0 of this report is a description of the proposed standard and alternatives considered. In addition to the proposed standard, the major alternative is a set of state-mandated standards that reflect current practice. Both the proposed standard and the alternative are evaluated under assumptions about the economic parameters.

Section 3.0 of this report first examines the economic impact of the proposed standard. The analysis examines the consequence of reconfiguring three building prototypes to meet the proposed standard; each building was analyzed with four alternative foundation types, in ten geographical locations subject to alternative fuel/equipment choices. The building configurations are generated using the ARES software, which selects conservation measures so as to minimize life-cycle costs to the consumer. In the economic analysis, the life-cycle costs are evaluated from society's perspective rather than from the consumer's perspective. The sensitivity of these results is also assessed.

The remainder of Section 3.0 then explores the potential impacts on a variety of different agents--sectors, industries and small businesses--in an effort to determine who might be most directly affected by the adoption of the proposed standard. The sectors and industries are identified by an examination of these changes to the national economy using an input-output table.

Section 4.0 outlines the methodology used to perform the economic analysis. In this section, the method for calculating the costs and benefits of the proposed standard and data is described in detail.

2.0 DESCRIPTION OF THE PROPOSED STANDARD AND ALTERNATIVES

This section provides information on the proposed voluntary residential energy (VOLRES) standard and the no-action alternative considered in this assessment. Although the development of the proposed standard was mandated by legislation, adoption of the standard by the private sector is voluntary.

Therefore, neither the DOE nor any branch of the federal government would be involved in implementing either the VOLRES standard or the no-action alternative, which is defined as a continuation of current practices and existing energy codes. Adoption of the VOLRES to replace existing energy codes or building practices is a voluntary action on the part of state and local governments or organizations that sponsor model building codes, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) or the Council of American Building Officials (CABO).

2.1 THE PROPOSED STANDARD

The VOLRES standard has been developed and proposed by DOE in response to legislation requiring the Secretary of Energy to promulgate voluntary energy performance standards that are designed to achieve the maximum practicable improvements in energy efficiency in new residential buildings and to encourage the use of nondepletable energy sources. In response to this legislative mandate, the VOLRES standard sets forth requirements for the design of new residential buildings that would have the most cost-effective combination of energy conservation options integrated into their envelope and equipment components. This standard should lead to residential building designs that produce the maximum practicable energy savings given the criterion of economic cost-effectiveness.

This standard relies on minimizing life-cycle costs using estimated energy consumption data, construction cost data, climate data, and appropriate consumer financial parameters. The standard is implemented through computer program documented in ARES 1.2 User's Guide (Automated Residential En y

Standard) - In Support of Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings.[a]

The proposed standard sets forth recommended requirements for the energy construction components that affect the energy use of residential buildings; these components include insulation levels, windows (amount, glazing layers, sash type), infiltration control measures, space conditioning equipment, and domestic hot water conditioning equipment. The standard includes separate requirements for each of three generic housing types: 1) single-family detached housing, 2) multi-family attached housing, and 3) manufactured housing. Within each housing type, separate requirements are set forth for each of five space conditioning equipment combinations: 1) natural gas heat with electric cooling, 2) oil heat with electric cooling, 3) LPG heat with electric cooling, 4) electric resistance heat with electric cooling, and 5) electric heat pump heating and cooling.

The standard requires that residential housing be constructed to minimize the overall costs to the homeowner over the period of ownership. The cash flows included in the assessment of these life-cycle costs are initial construction costs, operation and maintenance costs, energy costs, tax effects, and resale value of the home, all of which are discounted to adjust for inflation and lost opportunity costs. A house complies with this standard if its annual space conditioning energy cost is shown to be less than or equal to an energy cost budget defined as the annual energy cost of a similar house constructed in accordance with the VOLRES Standard, given local construction costs, fuel prices, and economic conditions.

The proposed standard includes minimum requirements for infiltration control measures, but allows stricter measures to be implemented at the user's option if necessary to meet the energy cost budget. The minimum requirements reflect current building practices, such that air exchange rates (assumed to average approximately 0.5 air changes per hour) and indoor air quality are not adversely affected by the standard. The optional tighter measures are specified such that air exchange rates do not fall below 0.35

(a) To be published by DOE.

air changes per hour, the rate below which forced ventilation would be required to maintain acceptable air quality. The tighter measures are never required, but are offered as an option.

2.1.1 The Automated Residential Energy Standard Computer Software

Procedures that automate the development of specific criteria for complying with this standard are embodied in the ARES computer program. ARES maintains data bases of estimated residential energy consumption for a variety of locations, construction costs, economic and financial parameters, and typical building characteristics. Using these data, ARES identifies for each locality the combination of energy conservation measures that results in the minimum overall life-cycle costs to the homeowner. The annual energy costs of the optimal house constitute the target energy costs required by this standard. ARES then provides one set of prescriptive requirements (a package) that meets this energy budget, the option to generate additional packages, and a point system designed to allow evaluation of specific building designs against the prescriptive target.

ARES is designed to be used by code officials who are responsible for establishing energy codes in specific jurisdictions. ARES allows the user to modify the various economic, financial, and climatic inputs to tailor the resulting standard to specific localities. It also specifies compliance materials in the form of prescriptive packages and a flexible point system.

2.1.2 The Energy Data Base

The ARES energy data base contains annual heating and cooling loads for residential housing built to any common level of thermal integrity in any of 881 locations throughout the United States. The energy data are derived from parametric computer simulations of residential energy performance. The development and formatting of these data are documented in Technical Support Documentation for the Automated Residential Energy Standard Data Base - In Support of Proposed Interim Energy Conservation Voluntary Performance Standards for New Non-Federal Residential Buildings.(a)

(a) To be published by DOE.

2.1.3 The Cost Data Base

ARES' cost data base contains 1986 construction costs for all common ceiling insulation levels, wall insulation levels, crawlspace insulation levels, basement insulation levels, window types, and HVAC equipment. Cost data are included for the following 12 regions of the United States:

Region	States in Region
National Average	All
New England	Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont
Mid-Atlantic	District of Columbia, Delaware, Maryland, New Jersey, New York, Pennsylvania
Mid-South	Georgia, North Carolina, South Carolina, Virginia, West Virginia
Florida	Florida
South Central	Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas
Central	Iowa, Kansas, Missouri, Nebraska
North Central	Illinois, Indiana, Michigan, Minnesota, North Dakota, Ohio, South Dakota, Wisconsin
Mountain	Colorado, Nevada, Utah, Wyoming
Southwest	Arizona, New Mexico
Pacific Southwest	Alaska, California, Hawaii
Pacific Northwest	Idaho, Montana, Oregon, Washington

When using ARES, local jurisdictions may choose the most appropriate data base. These data may be altered if necessary to reflect local conditions. Prices may be changed and levels added or deleted as appropriate.

2.1.4 The Life-Cycle Cost Optimization

The life-cycle cost calculations required by the proposed standard reflect the value of energy conservation measures to a typical homeowner. The life-cycle cost is defined as the sum of the net present values of the following cash flows:

- down payment on loan
- loan fees and other closing costs of loan
- up-front interest charges (points) on loan
- tax deductions on points
- mortgage payments over the analysis period
- tax deductions on mortgage interest over the analysis period
- space conditioning energy costs over the analysis period
- nonfuel operation and maintenance costs over the analysis period
- resale value of ECMs at the end of the analysis period.

A seven-year period of analysis is used to reflect the median turnover period of home ownership and mortgages. All cash flows are discounted at a user-modifiable alternative investment rate. Mortgage payments and interest payments are based on common financial calculations and current economic parameters that must be supplied by the user. The resale value of the energy conservation measure is assumed to be identical to its initial cost in current dollars at the end of the period of analysis. Thus the energy conservation measures real value is assumed to decline at the rate of inflation.

ARES identifies the minimum life-cycle cost house via an exhaustive search of all combinations of insulation levels, equipment efficiencies, and window types available in the cost data base. In concept, the energy and construction costs of houses built to every unique combination of conservation options are calculated and compared. The combination with the lowest overall life-cycle cost is used as the basis for the energy cost budget. However, there are several constraints applied during the optimization. First, the optimization assumes that the window area of the house is equally distributed on the four cardinal orientations. Though this seldom matches the construction of a particular house, it represents the average condition of large numbers of residences. Second, the optimal levels of ceiling insulation, wall insulation, windows, and equipment efficiencies are forced to be the same regardless of the foundation type. This is accomplished by identifying a prevalent foundation type for each location, and optimizing a prototypical house with that foundation. Once the upper envelope conservation levels are established, the insulation levels for each additional foundation type are optimized assuming the same upper envelope is installed. Thus, each foundation type results in a unique energy cost budget.

2.1.5 Prescriptive Package Compliance Alternative

ARES provides prescriptive packages of options that will meet the energy cost budget associated with the optimal combination of components identified by the life-cycle cost optimization. One prescriptive package is created for each of the five fuel/equipment combinations. However, because of a constraint applied in the program, each prescriptive package differs from the original optimal combination of options (that produced the energy budget). The prescriptive packages assume that windows are equally distributed on the east and west faces of the house, rather than on all four faces as is done in the original optimization. This constrained configuration is intended to approximate the worst possible orientation scenario, so that virtually any house, regardless of its window placement, would have energy performance at least as good. The purpose is to minimize the possibility that a house allowable under the prescriptive compliance path would not be allowable under the points compliance path (described below). Given this constraint, the ARES prescriptive package identifies the combination of options that meets the energy cost budget with the minimum construction cost.

In addition to the five standard prescriptive packages, the user (state or local governments or building code officials) may develop additional packages to satisfy local preferences. This is accomplished by applying specific constraints, such as a fixed wall insulation level, or window-to-floor area ratio, then allowing ARES to identify the other components of the house that result in acceptable energy use at a minimum construction cost. This facility allows code officials to create simple compliance approaches for technologies and preferences common to their localities.

2.1.6 Point System Compliance Alternative

The point system printed by ARES is designed to allow builders to deviate from the prescriptive packages identified by the cost optimization, while maintaining thermal integrity. Various levels of conservation options are assigned "points," which are tabulated in the compliance materials printed by the program. The points are directly proportional to the annual energy costs of the home, enabling builders to evaluate the energy cost impacts of various construction options. Options that may be evaluated by the point system include various insulation levels, equipment efficiencies, and various window parameters including number of glazings, solar transmittance, and orientation.

2.1.7 Performance Compliance Alternative

The proposed standard allows for the construction of any house that has annual energy costs less than or equal to those of the optimal house. To accommodate new and innovative technologies, the standard provides the option of evaluating the energy performance of a design against that of a similar house that complies with the prescriptive requirements. An energy analysis must be conducted for both the design house and the target house using a calculation technique appropriate for the technologies involved. Typically, this requires use of a computer simulation tool.

2.2 NO-ACTION ALTERNATIVE (CURRENT ENERGY CODES AND ENERGY-RELATED BUILDING PRACTICES)

As noted above, the proposed standard is a recommended level of energy efficiency for residential building components, the adoption and implementation of which is voluntary in the private sector. For the purpose of this assessment of potential impacts of the standard's implementation, the no-action alternative is the continued application of the energy standards and codes currently in use by states, local governments and other organizations.

At the present time, 33 states have adopted mandatory energy-efficiency standards for residential buildings. Most other states have adopted model energy codes that are enforced at the discretion of local governments. Most of these mandatory and model standards are based on several prominent standards that were developed in the late 1970s and early 1980s by such organizations as ASHRAE, CABO, and Building Officials and Code Administrators International, Inc. (BOCA). These parent standards tend to be technically compatible; the requirements are usually expressed as maximum allowable overall thermal transmittance values (U_0) for major envelope components and minimum allowable thermal resistance values (R) for perimeter insulation of slabs-on-grade (NCSBCS 1985). Criteria are expressed as, or drawn from graphs based on, annual heating degree days.

In the process of adopting their codes, most states with mandatory codes have modified parent standards. States will often establish state code levels for a limited number of geographic (climatic) zones to avoid the problems of enforcing a code that could fluctuate substantially from one community to another. Other modifications, such as prescribing minimum envelope performance on the basis of heating and appliances (and their efficiencies), are often adopted. State energy codes are reviewed and updated from time to time. Most states have updated the code at least once since initial adoption (NCSBCS 1985).

Several states (including California, Florida, Hawaii, Louisiana, Nevada, North Carolina, Washington, Oregon and Alaska) have developed their own codes rather than adopting modified versions of the parent codes (although there frequently is a perceptible relationship to the latter). Some of these codes have sophisticated compliance mechanisms using computer software; almost all have a variety of paths to compliance so as to not limit design of and construction techniques for homes.

2.2.1 Base Case Energy-Efficiency Requirements

Estimation of the potential impacts of the VOLRES was based on a limited number of case studies, since the inherent flexibility of the standard permits an almost limitless variety of code packages to be developed. For each location included as a case study, the corresponding base (existing) code or level of current building practices was also determined. The following discussion provides some information on how the base efficiency levels were developed.

As noted above, state energy codes are often expressed as performance levels for individual envelope and space conditioning components. Quite frequently, the efficiency of the wall components (opaque areas, windows and doors) is expressed as a single U_0 value, to permit tradeoffs among levels of insulation, window area, etc. However, life-cycle cost calculations for the base codes and comparison with the proposed standard required component-specific values.

In addition, consumer demand, utility incentive programs or other factors often influence home builders in states without mandatory codes to opt for component efficiencies that exceed model code levels. (This also occurs in states with mandatory code.)

Therefore, the base case for each study location (for site-built homes) was determined by obtaining information about the most prevalent levels of energy conservation measures currently installed by builders in that location, either to meet code, or as currently practiced (for locations with no mandatory code). Sources of this information included code enforcement officials at the state and local level, prominent builders, developers and designers, utility staff and other knowledgeable persons. Three to four sources of information were sought for each location; more were used if it was difficult to obtain a consensus.

Component levels for the base case manufactured homes were obtained in a similar manner, but the source was a survey of manufacturers conducted in the fall of 1987 by Pacific Northwest Laboratory (Nesse et al. 1988). The levels of components installed by the surveyed manufacturers often exceeded those required to meet the Department of Housing and Urban Development's (HUD) Manufactured Homes Construction and Safety Standards (MHCSS), a mandatory minimum required for this type of housing.

3.0 ECONOMIC IMPACTS OF THE PROPOSED STANDARD

This section presents the results of the economic analysis of the proposed standard. Direct and indirect impacts of the standard are presented, as well as results of the sensitivity analysis. A detailed description of the methodology used is in Section 4.0.

3.1 DIRECT IMPACTS OF PROPOSED STANDARD

The direct impacts of the proposed standard have been estimated using life-cycle costs over the 15-year time horizon. The life-cycle cost is the sum of the net present value of the capital costs (or initial costs) of the energy conservation measure and the net present value of the energy costs incurred over the time horizon. Because the median turnover period for home ownership and mortgages is assumed to be seven years, the configuration generated by ARES is based on a seven-year time horizon. Society, however, continues to reap the benefits of the energy savings that occur over the life of the building. Thus, for the analysis of regional and national impacts, the net present value of the energy savings was calculated for a 15-year period.

3.1.1 National Impacts

Tables 3.1 and 3.2 present the energy costs, capital costs, and total life-cycle cost (LCC) of the proposed standard under alternative penetration rates for the Census regions and the United States. By calculating the life-cycle cost of new construction as currently practiced and the construction that would be required by the proposed standard, our analysis results in regional and national net benefits of the standard over a 15-year period.

For this analysis, two different penetration rates were considered: full penetration and ramped penetration. Full penetration assumes an immediate and complete adoption of the proposed standard, and for this reason, represents the most extreme case. Ramped penetration is a step-wise penetration of the proposed standard, beginning at 20 percent in 1988 and increasing by 20 percent increments until full penetration is reached in 1992.

TABLE 3.1. Net Change of Regional and National Life-Cycle Costs (LCC), 15-Year Time Horizon, Full Penetration of the Standard

Year of Construction	Net Present Value in $ thousands[b]				
	Northeast	South	North Central	West	U.S.
1988					
Energy Costs	(696,006)[a]	(717,551)	(300,079)	(236,428)	(1,950,065)
Capital Costs	359,766	420,296	89,021	150,945	1,020,027
Total LCC	(336,240)	(297,256)	(211,058)	(85,484)	(930,038)
1989					
Energy Costs	(740,579)	(703,872)	(281,724)	(226,189)	(1,952,364)
Capital Costs	382,898	412,055	83,894	144,141	1,022,987
Total LCC	(357,681)	(291,818)	(197,830)	(82,048)	(929,377)
1990					
Energy Costs	(802,694)	(779,869)	(296,762)	(252,771)	(2,132,096)
Capital Costs	414,992	456,479	88,259	161,033	1,120,763
Total LCC	(387,702)	(323,390)	(208,503)	(91,738)	(1,011,332)
1991					
Energy Costs	(801,505)	(818,236)	(301,209)	(263,251)	(2,184,202)
Capital Costs	414,360	478,983	89,483	167,646	1,150,472
Total LCC	(387,146)	(339,253)	(211,726)	(95,605)	(1,033,730)
1992					
Energy Costs	(795,039)	(842,924)	(290,725)	(267,266)	(2,195,955)
Capital Costs	411,013	493,246	86,485	170,265	1,161,009
Total LCC	(384,027)	(349,678)	(204,241)	(97,001)	(1,034,946)
1993					
Energy Costs	(560,201)	(808,480)	(200,216)	(297,904)	(1,866,802)
Capital Costs	289,628	477,381	57,600	190,077	1,014,686
Total LCC	(270,573)	(331,100)	(142,616)	(107,828)	(852,116)
1994					
Energy Costs	(515,273)	(816,065)	(184,646)	(266,302)	(1,782,287)
Capital Costs	266,422	482,089	52,914	169,537	970,963
Total LCC	(248,851)	(333,976)	(131,732)	(96,766)	(811,324)
1995					
Energy Costs	(483,110)	(855,120)	(176,862)	(248,434)	(1,763,525)
Capital Costs	249,799	505,812	50,571	158,005	964,187
Total LCC	(233,311)	(349,308)	(126,290)	(90,429)	(799,338)
1996-2000					
Energy Costs	(2,683,573)	(3,750,091)	(1,015,783)	(1,409,193)	(8,858,640)
Capital Costs	1,387,523	2,219,708	293,846	883,061	4,784,137
Total LCC	(1,296,051)	(1,530,383)	(721,937)	(526,132)	(4,074,503)
2001-2005					
Energy Costs	(2,277,678)	(3,623,586)	(847,624)	(1,048,427)	(7,797,316)
Capital Costs	1,177,964	2,149,670	245,794	669,239	4,242,667
Total LCC	(1,099,714)	(1,473,917)	(601,829)	(379,188)	(3,554,649)

(a) Values in parentheses are negative values.
(b) Totals may not equal sum of components due to independent rounding.

TABLE 3.2. Net Change of Regional and National Life-Cycle Costs (LCC), 15-Year Time Horizon, Ramped Penetration of the Standard

Year of Construction	Net Present Value in $ Thousands[b]				
	Northeast	South	North Central	West	U.S.
1988					
Energy Costs	(139,201)[a]	(143,510)	(60,016)	(47,286)	(390,013)
Capital Costs	71,953	84,059	17,804	30,189	204,005
Total LCC	(67,248)	(59,451)	(42,212)	(17,097)	(186,008)
1989					
Energy Costs	(296,232)	(281,549)	(112,689)	(90,475)	(780,946)
Capital Costs	153,159	164,822	33,557	57,656	409,195
Total LCC	(143,073)	(116,727)	(79,132)	(32,819)	(371,751)
1990					
Energy Costs	(481,617)	(467,921)	(178,057)	(151,662)	(1,279,257)
Capital Costs	248,995	273,887	52,956	96,620	672,458
Total LCC	(232,621)	(194,034)	(125,102)	(55,043)	(606,799)
1991					
Energy Costs	(641,204)	(654,589)	(240,968)	(210,601)	(1,747,361)
Capital Costs	331,488	383,187	71,587	134,116	920,378
Total LCC	(309,716)	(271,402)	(169,381)	(76,484)	(826,984)
1992					
Energy Costs	(795,039)	(842,924)	(290,725)	(267,266)	(2,195,955)
Capital Costs	411,013	493,246	86,485	170,265	1,161,009
Total LCC	(384,027)	(349,678)	(204,241)	(97,001)	(1,034,946)
1993					
Energy Costs	(560,201)	(808,480)	(200,216)	(297,904)	(1,866,802)
Capital Costs	289,628	477,381	57,600	190,077	1,014,686
Total LCC	(270,573)	(331,100)	(142,616)	(107,828)	(852,116)
1994					
Energy Costs	(515,273)	(816,065)	(184,646)	(266,302)	(1,782,287)
Capital Costs	266,422	482,089	52,914	169,537	970,963
Total LCC	(248,851)	(333,976)	(131,732)	(96,766)	(811,324)
1995					
Energy Costs	(483,110)	(855,120)	(176,862)	(248,434)	(1,763,525)
Capital Costs	249,799	505,812	50,571	158,005	964,187
Total LCC	(233,311)	(349,308)	(126,290)	(90,429)	(799,338)
1996-2000					
Energy Costs	(2,683,573)	(3,750,091)	(1,015,783)	(1,409,193)	(8,858,640)
Capital Costs	1,387,523	2,219,708	293,846	883,061	4,784,137
Total LCC	(1,296,051)	(1,530,383)	(721,937)	(526,132)	(4,074,503)
2001-2005					
Energy Costs	(2,277,678)	(3,623,586)	(847,624)	(1,048,427)	(7,797,316)
Capital Costs	1,177,964	2,149,670	245,794	669,239	4,242,667
Total LCC	(1,099,714)	(1,473,917)	(601,829)	(379,188)	(3,554,649)

(a) Values in parentheses are negative values.
(b) Totals may not equal sum of components due to independent rounding.

The national net effect of the standard, assuming its immediate and full penetration, ranges from nearly $930 million in net benefit for 1988 construction to $1035 million for 1992 construction. This net effect is based on the net present value of energy savings and capital costs for each year over the life cycle of 15 years. In 1992 construction, the year with the largest net effect, the capital costs of construction to comply with the standard are approximately $1.2 billion. The energy savings accrued over the 15-year period are nearly $2.2 billion. The difference represents a net benefit of $1.0 billion.

Because the standard is voluntary, the net benefits were also calculated assuming a ramped penetration of the standard. The national net effect of the standard ranges from nearly $186 million in net benefit for construction in 1988 to $1035 million for construction in 1992. (Full penetration of the standard does not occur until 1992.)

3.1.2 Regional Impacts

The standard creates a net benefit for all Census regions, as shown in Tables 3.1 and 3.2. Assuming full penetration of the standard, the Northeast receives the greatest benefit until 1993 when the net benefits in the South overtake those of the Northeast. The net benefit to the Northeast increases from $336 million for 1988 construction to $384 million in 1992, after which the net benefit drops steadily until the 2001 to 2005 construction period when it reaches $220 million per year. The West receives the smallest benefit of all regions until 1993 when its benefits become greater than those of the North Central region. In the construction period 2001 to 2005, the net benefit in the West increases beyond that of the North Central region. In relative magnitude, the Western region's net benefit is approximately 25 percent of the Northeast's net benefit until 1993 when the West's share of the total U.S. benefit increases substantially. Changes in the relative share of costs and benefits is attributable to changes in forecast housing for each region.

3.1.3 Sensitivity Analysis Results

The following subsection describes the results of the sensitivity analysis performed on fuel prices, the time horizon, and the discount rate (alternative investment rate).

Fuel Prices

An extensive analysis of the sensitivity of ARES and the resulting life-cycle cost to fuel prices was performed. Fuel prices were increased and decreased by 50 percent in the ARES runs, and the new life-cycle cost was calculated for the ARES-configured housing using the increased and decreased fuel prices. As would be anticipated, ARES is sensitive to these major changes in fuel prices.

When fuel prices were decreased 50 percent, the ARES-configured housing consistently fell below the current practice in terms of energy-efficiency standards. In other words, a 50 percent decrease in current fuel prices could result in less energy-efficient construction under the proposed standard than is currently being built under state codes. If the proposed standard remains voluntary and coexists with current state codes, (i.e., current state codes remain mandatory) the effect of the proposed standard under the decreased fuel price scenario could be nil, as the more stringent current codes would take precedence and mandate the current (higher) energy-efficiency standards.

An increase in fuel prices of 50 percent, however, would have substantial effects under the proposed standard. Table 3.3 presents the resulting energy savings and capital costs when fuel prices are increased 50 percent. In summary, an increase in fuel prices would increase the national net benefit of the proposed standard substantially. That is, the increase in fuel prices results in substantially higher energy savings which exceed the increase in capital costs. The national net benefit reaches its highest level for construction in 1992 with a net benefit of $2.2 billion. This net benefit is composed of $2.0 billion in increased capital costs and $4.2 billion in decreased energy costs.

For all regions, the standard results in a net benefit under increased fuel prices. The Southern region's net benefit exceeds the benefit received by the other regions. By comparing the net benefit under increased fuel prices to the net benefit of the proposed standard under current fuel prices, the North Central and Western regions show the greatest increase in capital costs and energy savings when fuel prices increase.

TABLE 3.3. Net Change of Regional and National Life-Cycle Costs (LCC), 15-Year Time Horizon, Full Penetration of the Standard, Fuel Prices Increased by 50%

Year of Construction	Net Present Value in $ Thousands[b]				
	Northeast	South	North Central	West	U.S.
1988					
Energy Costs	(1,103,959)[a]	(1,298,488)	(781,243)	(538,810)	(3,722,500)
Capital Costs	502,973	618,438	303,521	319,995	1,744,926
Total LCC	(600,986)	(680,050)	(477,722)	(218,815)	(1,977,573)
1989					
Energy Costs	(1,177,418)	(1,274,355)	(734,225)	(514,546)	(3,700,545)
Capital Costs	532,801	607,002	286,135	303,554	1,729,492
Total LCC	(644,618)	(667,353)	(448,090)	(210,992)	(1,971,053)
1990					
Energy Costs	(1,275,547)	(1,412,123)	(773,147)	(574,852)	(4,035,668)
Capital Costs	578,028	672,640	300,992	338,771	1,890,431
Total LCC	(697,518)	(739,483)	(472,155)	(236,081)	(2,145,237)
1991					
Energy Costs	(1,273,128)	(1,481,468)	(784,495)	(598,463)	(4,137,554)
Capital Costs	577,629	705,659	305,137	352,197	1,940,622
Total LCC	(695,500)	(775,809)	(479,358)	(246,266)	(2,196,932)
1992					
Energy Costs	(1,262,729)	(1,526,680)	(757,469)	(607,808)	(4,154,686)
Capital Costs	573,080	727,243	294,945	358,172	1,953,440
Total LCC	(689,649)	(799,438)	(462,524)	(249,636)	(2,201,247)
1993					
Energy Costs	(909,030)	(1,477,555)	(542,261)	(692,486)	(3,621,332)
Capital Costs	411,455	730,429	223,264	429,688	1,794,837
Total LCC	(497,575)	(747,125)	(318,997)	(262,798)	(1,826,495)
1994					
Energy Costs	(835,622)	(1,489,409)	(501,152)	(618,953)	(3,445,137)
Capital Costs	377,369	735,839	206,591	382,905	1,702,705
Total LCC	(458,253)	(753,570)	(294,561)	(236,049)	(1,742,432)
1995					
Energy Costs	(783,319)	(1,555,001)	(480,598)	(577,391)	(3,396,310)
Capital Costs	353,503	766,968	198,254	356,714	1,675,440
Total LCC	(429,816)	(788,033)	(282,344)	(220,677)	(1,720,870)
1996-2000					
Energy Costs	(4,352,454)	(6,806,382)	(2,742,830)	(3,272,574)	(17,174,240)
Capital Costs	1,966,400	3,354,158	1,127,325	1,981,281	8,429,164
Total LCC	(2,386,054)	(3,452,224)	(1,615,505)	(1,291,293)	(8,745,076)
2001-2005					
Energy Costs	(3,687,188)	(6,534,525)	(2,285,718)	(2,437,153)	(14,944,585)
Capital Costs	1,654,000	3,210,647	938,721	1,513,159	7,316,526
Total LCC	(2,033,189)	(3,323,879)	(1,346,997)	(923,995)	(7,628,059)

(a) Values in parentheses are negative values.

(b) Totals may not equal sum of components due to independent rounding.

Alternative Investment Rate

The choice of the alternative investment rate, or social discount rate, used to calculate the net benefit of the proposed standard also affects the national net benefit. If the default discount rate (alternative investment rate) of 5.5 percent is used in ARES, but the life-cycle cost of that house is calculated using a different social discount rate to more accurately reflect society's discount rate in the economic analysis, the resulting life-cycle cost calculation is affected. Sensitivity runs reveal that if a 4 percent discount rate is selected in lieu of the 5.5 percent discount rate in the life-cycle cost calculation, energy costs would increase by 5 percent. This is also true for energy costs in the base case. There is a net increase in savings when changing from the 5.5 percent to the 4.0 percent discount rate, that is, the difference between energy savings due to the proposed standard and current practice would increase. On the other hand, if the social discount rate was 10 percent, energy costs would be 15 percent lower than calculated (savings would decrease). Because the capital costs are incurred in the construction of the housing, they are not discounted; therefore, the capital costs would not be affected by the choice of the social discount rate.

Time Horizon

The time horizon over which capital and energy costs are calculated also affects the total life-cycle cost. As presented in Table 3.4, a net cost to society results when the life-cycle cost is calculated for 7 years, compared with the net benefit that occurs under a 15-year time horizon.

The capital costs are the same under the 7- and 15-year horizons, because these costs are incurred by society at construction. The net present value of the stream of energy savings under the 7-year horizon, however, is decreased substantially. For this reason, the proposed standard creates a net cost to society in all construction years under the 7-year time horizon. This cost ranges from $58 million in 1988 to $94.2 million in 1995. Again, the shortened time horizon decreases the energy savings, while the capital costs incurred in complying with the standard do not change.

TABLE 3.4. Net Change of Regional and National Life-Cycle Costs (LCC), 7-Year Time Horizon, Full Penetration of the Standard

Year of Construction	Net Present Value in $ Thousands[b]				
	Northeast	South	North Central	West	U.S.
1988					
Energy Costs	(343,368)[a]	(353,997)	(148,041)	(116,639)	(962,045)
Capital Costs	359,766	420,296	89,021	150,945	1,020,027
Total LCC	16,398	66,299	(59,020)	34,305	57,982
1989					
Energy Costs	(365,357)	(347,248)	(138,985)	(111,588)	(963,179)
Capital Costs	382,898	412,055	83,894	144,141	1,022,987
Total LCC	17,541	64,806	(55,092)	32,553	59,808
1990					
Energy Costs	(396,001)	(384,740)	(146,405)	(124,702)	(1,051,848)
Capital Costs	414,992	456,479	88,259	161,033	1,120,763
Total LCC	18,991	71,738	(58,145)	36,331	68,915
1991					
Energy Costs	(395,415)	(403,669)	(148,599)	(129,872)	(1,077,554)
Capital Costs	414,360	478,983	89,483	167,646	1,150,472
Total LCC	18,945	75,315	(59,115)	37,773	72,918
1992					
Energy Costs	(392,225)	(415,848)	(143,426)	(131,853)	(1,083,352)
Capital Costs	411,013	493,246	86,485	170,265	1,161,009
Total LCC	18,788	77,398	(56,942)	38,412	77,657
1993					
Energy Costs	(276,369)	(398,856)	(98,775)	(146,968)	(920,968)
Capital Costs	289,628	477,381	57,600	190,077	1,014,686
Total LCC	13,259	78,525	(41,175)	43,109	93,718
1994					
Energy Costs	(254,205)	(402,598)	(91,093)	(131,378)	(879,273)
Capital Costs	266,422	482,089	52,914	169,537	970,963
Total LCC	12,218	79,492	(38,179)	38,159	91,689
1995					
Energy Costs	(238,337)	(421,865)	(87,253)	(122,562)	(870,017)
Capital Costs	249,799	505,812	50,571	158,005	964,187
Total LCC	11,461	83,947	(36,682)	35,443	94,170
1996-2000					
Energy Costs	(1,323,914)	(1,850,069)	(501,126)	(695,211)	(4,370,321)
Capital Costs	1,387,523	2,219,708	293,846	883,061	4,784,137
Total LCC	63,609	369,638	(207,280)	187,850	413,817
2001-2005					
Energy Costs	(1,123,670)	(1,787,660)	(418,167)	(517,231)	(3,846,727)
Capital Costs	1,177,964	2,149,670	245,794	669,239	4,242,667
Total LCC	54,294	362,010	(172,372)	152,008	395,940

(a) Values in parentheses are negative values.

(b) Totals may not equal sum of components due to independent rounding.

The time horizon of 30 years, one that more closely approximates the physical life of the average home, creates substantial national net benefits. The life-cycle costs in Table 3.5 show that energy savings over 30 years increase considerably. For example, 1992 construction would increase savings to nearly $4.0 billion while capital costs remain at $1.1 billion. This overstated net benefit of $2.8 billion must be adjusted because of several factors that must be taken into account when using a 30-year horizon. The decreased efficiency of the aging home (packed insulation, leaking window casings, etc.) would decrease the calculated energy savings, and the replacement of heating and cooling equipment that would be required over the 30-year period would increase capital costs. On the other hand, as the equipment is replaced over the 30-year time horizon, technologically more advanced equipment could increase energy savings and perhaps costs, as well. These factors are not included in the analysis of the 30-year life-cycle cost of the proposed standard.

Homeowners' Perspective

The calculation of the impacts of the proposed standard on the homeowner, the perspective taken by ARES, relies on a different method of analysis from that used to calculate the impacts on society. The homeowner faces a different life-cycle cost because of changes in income and property taxes, loan fees, down payment, and the resale value that occur when capital improvements are incorporated into the new residence. (See Section 4.3 for a detailed discussion of the difference in perspective.) Secondly, because the median length of home ownership is seven years, the life-cycle cost of energy and capital costs is calculated for a 7-year time horizon, instead of the 15-year time horizon used to calculate the benefits in Section 3.1.

In Table 3.6, the results of the life-cycle cost calculation for the homeowner are presented. For all years of construction, the proposed standard would generate a net benefit for homeowners. For 1992 construction, the greatest net benefit accrues to homeowners. While capital costs reach $575.8 million, the net present value of the energy savings reaches $1.1 billion over the seven-year time horizon. This results in a net benefit of $507.5 million to homeowners for 1992 construction.

TABLE 3.5. Net Change of Regional and National Life-Cycle Costs (LCC), 30-Year Time Horizon, Full Penetration of the Standard

	Net Present Value in $ Thousands(b)				
Year of Construction	Northeast	South	North Central	West	U.S.
1988					
Energy Costs	(1,257,241)(a)	(1,296,159)	(542,051)	(427,076)	(3,522,527)
Capital Costs	359,766	420,296	89,021	150,945	1,020,027
Total LCC	(897,475)	(875,864)	(453,031)	(276,131)	(2,502,500)
1989					
Energy Costs	(1,337,756)	(1,271,449)	(508,895)	(408,579)	(3,526,680)
Capital Costs	382,898	412,055	83,894	144,141	1,022,987
Total LCC	(954,858)	(859,395)	(425,002)	(264,438)	(2,503,693)
1990					
Energy Costs	(1,449,958)	(1,408,727)	(536,060)	(456,596)	(3,851,341)
Capital Costs	414,992	456,479	88,259	161,033	1,120,763
Total LCC	(1,034,966)	(952,248)	(447,801)	(295,563)	(2,730,578)
1991					
Energy Costs	(1,447,811)	(1,478,032)	(544,094)	(475,527)	(3,945,464)
Capital Costs	414,360	478,983	89,483	167,646	1,150,472
Total LCC	(1,033,451)	(999,049)	(454,611)	(307,881)	(2,794,992)
1992					
Energy Costs	(1,436,131)	(1,522,628)	(525,156)	(482,780)	(3,966,695)
Capital Costs	411,013	493,246	86,485	170,265	1,161,009
Total LCC	(1,025,118)	(1,029,381)	(438,671)	(312,515)	(2,805,686)
1993					
Energy Costs	(1,011,926)	(1,460,410)	(361,664)	(538,124)	(3,372,123)
Capital Costs	289,628	477,381	57,600	190,077	1,014,686
Total LCC	(722,298)	(983,029)	(304,063)	(348,047)	(2,357,438)
1994					
Energy Costs	(930,770)	(1,474,111)	(333,539)	(481,039)	(3,219,459)
Capital Costs	266,422	482,089	52,914	169,537	970,963
Total LCC	(664,348)	(992,022)	(280,624)	(311,502)	(2,248,497)
1995					
Energy Costs	(872,672)	(1,544,658)	(319,476)	(448,762)	(3,185,568)
Capital Costs	249,799	505,812	50,571	158,005	964,187
Total LCC	(622,874)	(1,038,845)	(268,905)	(290,757)	(2,221,381)
1996-2000					
Energy Costs	(4,847,510)	(6,774,029)	(1,834,875)	(2,545,516)	(16,001,930)
Capital Costs	1,387,523	2,219,708	293,846	883,061	4,784,137
Total LCC	(3,459,988)	(4,554,322)	(1,541,028)	(1,662,455)	(11,217,792)
2001-2005					
Energy Costs	(4,114,316)	(6,545,516)	(1,531,117)	(1,893,842)	(14,084,791)
Capital Costs	1,177,964	2,149,670	245,794	669,239	4,242,667
Total LCC	(2,936,352)	(4,395,846)	(1,285,323)	(1,224,603)	(9,842,124)

(a) Values in parentheses are negative values.

(b) Totals may not equal sum of components due to independent rounding.

TABLE 3.6. Net Change of Regional and National Life-Cycle Costs (LCC), 7-Year Time Horizon, Full Penetration of the Standard, Homeowners' Perspective

	Net Present Value in $ Thousands[b]				
Year of Construction	Northeast	South	North Central	West	U.S.
1988					
Owner's Capital Cost	180,109	205,054	47,271	74,003	506,438
Energy Costs	(343,368)[a]	(353,997)	(148,041)	(116,639)	(962,045)
Owner's Total LCC	(163,258)	(148,943)	(100,770)	(42,636)	(455,607)
1989					
Owner's Capital Cost	191,634	201,053	44,557	70,680	507,924
Energy Costs	(365,357)	(347,248)	(138,985)	(111,588)	(963,179)
Owner's Total LCC	(173,724)	(146,195)	(94,428)	(40,908)	(455,255)
1990					
Owner's Capital Cost	207,709	222,734	46,873	78,966	556,282
Energy Costs	(396,001)	(384,740)	(146,405)	(124,702)	(1,051,848)
Owner's Total LCC	(188,292)	(162,006)	(99,532)	(45,736)	(495,566)
1991					
Owner's Capital Cost	207,403	233,711	47,520	82,211	570,846
Energy Costs	(395,415)	(403,669)	(148,599)	(129,872)	(1,077,554)
Owner's Total LCC	(188,011)	(169,958)	(101,078)	(47,661)	(506,708)
1992					
Owner's Capital Cost	205,731	240,687	45,931	83,493	575,841
Energy Costs	(392,225)	(415,848)	(143,426)	(131,853)	(1,083,352)
Owner's Total LCC	(186,494)	(175,161)	(97,496)	(48,360)	(507,511)
1993					
Owner's Capital Cost	144,960	232,674	30,537	93,194	501,365
Energy Costs	(276,369)	(398,856)	(98,775)	(146,968)	(920,968)
Owner's Total LCC	(131,410)	(166,182)	(68,237)	(53,774)	(419,603)
1994					
Owner's Capital Cost	133,332	234,950	28,048	83,141	479,470
Energy Costs	(254,205)	(402,598)	(91,093)	(131,378)	(879,273)
Owner's Total LCC	(120,873)	(167,648)	(63,046)	(48,236)	(399,803)
1995					
Owner's Capital Cost	125,008	246,456	26,803	77,493	475,761
Energy Costs	(238,337)	(421,865)	(87,253)	(122,562)	(870,017)
Owner's Total LCC	(113,329)	(175,409)	(60,450)	(45,069)	(394,256)
1996-2000					
Owner's Capital Cost	694,402	1,081,424	155,829	433,728	2,365,382
Energy Costs	(1,323,914)	(1,850,069)	(501,126)	(695,211)	(4,370,321)
Owner's Total LCC	(629,512)	(768,646)	(345,298)	(261,484)	(2,004,939)
2001-2005					
Owner's Capital Cost	589,340	1,046,894	130,362	328,112	2,094,708
Energy Costs	(1,123,670)	(1,787,660)	(418,167)	(517,231)	(3,846,727)
Owner's Total LCC	(534,330)	(740,765)	(287,804)	(189,119)	(1,752,019)

(a) Values in parentheses are negative values.

(b) Totals may not equal sum of components due to independent rounding.

3.2 OUTPUT AND EMPLOYMENT IMPACTS

In this section, the total impacts of the proposed standard have been estimated in terms of changes in output and employment, industry impacts, and institutional impacts. In this discussion of output and employment, the perspective of analysis changes. A switch is made from the resource perspective used above, to an economic-effects perspective. Had funding allowed a simultaneous approach, these would be flip sides of the same coin: additional resource use (a cost) generates additional output and employment (a benefit), while resource savings (a benefit) reduces employment and output (a cost). Only in the most cursory way are output and employment effects treated, and then without due consideration for the implication of these additional resource savings (use) in other sectors of the economy.

. Total impacts were estimated using the 1977 U.S. input-output (I/O) structure of the economy. The difference between capital costs that would be incurred in the construction of the ARES-configured building and those of the buildings constructed according to current practice are introduced as changes in final demands. These changes are then forced through the I/O table to simulate the effect of the direct costs of the standard on the U.S. economy. The changes in energy expenditures, allocated to the different fuels, are likewise introduced as changes in final demand and used to simulate the changes that result from the proposed standard. These changes in industry output, in turn, are multiplied by labor-intensity for each industry to yield the change in employment that would result from the standard.

The total (direct plus indirect) impacts of the proposed standard are assessed in terms of the additional output and employment that would result from the increase in capital costs and the loss of output and employment that would occur because of lower energy expenditures. The 1977 I/O table indicates that for every $100 million of new residential construction, $197 million of additional output is generated. On the other hand, for every $100 million of residential energy savings, output is decreased by $212 million. The employment effects are as follows: for every $100 million of new construction, 2760 jobs are generated, and for every $100 million of energy savings, 1950 jobs are lost.

In Table 3.7, the total output and employment effects are presented by construction year, assuming full and immediate penetration of the proposed standard. The total changes in output and employment resulting from the standard are minimal compared with the entire U.S. economy. For purposes of illustration the effects of the energy savings have been assumed to occur in the year of construction, when in reality the energy savings presented in Tables 3.1 and 3.2 occur over the 15-year time horizon. In 1992, the year with the greatest total impacts, the combined effect of output changes results in a net loss of approximately $2.5 billion in output because of the joint effect of the standard in 1992. This net decrease in output is the difference between a $2.2 billion increase in output resulting from increased capital expenditures for construction and a $4.7 billion decrease in output resulting from lower energy expenditures. The greatest total effect on employment results from 1991 construction and shows a loss of over 10,800 jobs. This net loss is the difference between an increase of 31,800 jobs from increased capital costs and a loss of 42,600 jobs from decreased energy expenditures.

Even when all of the effects on output resulting from decreased energy expenditures over the 15-year period are assumed to occur in the initial year, the output change represents only 0.05 percent of the U.S. Gross National Product. If, in fact, the effects on output due to energy savings were distributed over the 15-year period, the loss of output would be greatly reduced. For example, if only the reduction in output due to the initial year of energy savings for 1988 construction is considered (as opposed to the full 15-year total), the reduced output associated with energy savings would be $616.4 million. When the reduced output from energy savings is combined with the increase in output from capital cost, the result is a net increase in output of $1.3 billion for 1988 construction, which represents 0.03 percent of the total output of the U.S. economy.

3.3 INDUSTRY IMPACTS

The industries most affected by a change in construction activity are the two industries directly affected--construction and miscellaneous transportation equipment (under which manufactured housing is classified). A

TABLE 3.7. Total Impacts of the Proposed Standard, Full Penetration

Year of Construction	Changes in Gross Output ($ thousands)[b]	Changes in Employment[b]
1988		
Due to Changes in Energy Costs	(4,134,137)[a]	(38,026)
Due to Changes in Capital Costs	2,009,912	28,153
Net effect	(2,124,226)	(9,874)
1989		
Due to Changes in Energy Costs	(4,139,011)	(38,071)
Due to Changes in Capital Costs	2,015,745	28,234
Net effect	(2,123,267)	(9,837)
1990		
Due to Changes in Energy Costs	(4,520,043)	(41,576)
Due to Changes in Capital Costs	2,208,408	30,933
Net effect	(2,311,635)	(10,643)
1991		
Due to Changes in Energy Costs	(4,630,508)	(42,592)
Due to Changes in Capital Costs	2,266,947	31,753
Net effect	(2,363,560)	(10,839)
1992		
Due to Changes in Energy Costs	(4,655,425)	(42,821)
Due to Changes in Capital Costs	2,287,710	32,044
Net effect	(2,367,715)	(10,777)
1993		
Due to Changes in Energy Costs	(3,957,619)	(36,403)
Due to Changes in Capital Costs	1,999,387	28,005
Net effect	(1,958,232)	(8,397)
1994		
Due to Changes in Energy Costs	(3,778,449)	(34,755)
Due to Changes in Capital Costs	1,913,233	26,799
Net effect	(1,865,215)	(7,956)
1995		
Due to Changes in Energy Costs	(3,738,673)	(34,389)
Due to Changes in Capital Costs	1,899,882	26,612
Net effect	(1,838,790)	(7,777)
1996-2000		
Due to Changes in Energy Costs	(18,780,317)	(172,743)
Due to Changes in Capital Costs	9,426,904	132,042
Net effect	(9,353,414)	(40,701)
2001-2005		
Due to Changes in Energy Costs	(16,530,309)	(152,048)
Due to Changes in Capital Costs	8,359,963	117,098
Net effect	(8,170,347)	(34,950)

(a) Values in parentheses are negative values.

(b) Totals may not equal sum of components due to independent rounding.

$100 million increase in demand (distributed 88.5 percent to construction, 11.5 percent to manufactured housing) would increase gross output of construction by $90.1 million and manufactured housing by $11.4 million. Five other industries would have an increase in gross output of more than $4 million: wholesale trade ($7.8 million), lumber and wood products ($5.6 million), basic iron and steel ($5.6 million), primary nonferrous metals ($4.5 million), and fabricated structural products ($4.8 million). Several other industries would be affected by $2 to 4 million: stone and clay mining ($2.2 million), petroleum refining ($2.4 million), rubber and miscellaneous products ($2.7 million), cement ($3.0 million), stone and clay products ($2.1 million), other fabricated metals ($3.2 million), truck transportation ($3.1 million), retail trade ($3.6 million) and business services ($3.9 million). Of the 100 producing industries contained in the input-output table used to calculate these impacts, 13 other industries had more than $1 million increase as a result of the increase in construction activity. The employment impacts, except for the construction industry (1070 jobs of the total 2760), are negligible.

The impact of a $100 million increase in fuel consumption is not distributed as broadly across the economy as is a change in construction activity. The $100 million fuel consumption change was allocated $55 million to natural gas, $30 million to electricity, and $15 million to petroleum products. Accordingly, the most affected industries as a result of a change of $100 million in fuel consumption are gas utilities ($77.5 million), electric utilities ($32.4 million), petroleum refining ($17.0 million) and petroleum and natural gas mining ($28.3 million). Only six other industries had increases in output in excess of $2 million: real estate ($8.2 million), construction ($7.8 million), business services ($3.7 million), mining ($3.6 million), wholesale trade ($3.0 million) and finance and insurance ($2.7 million). Only five other industries had increases in output greater than $1 million. The employment impacts are largest in gas and electric utilities (550 and 295 jobs, respectively) but are quite small relative to employment (about 0.1 percent in both industries).

3.3.1 Institutional Impacts

The proposed standard is intended to be a voluntary guideline for the private sector construction of residential buildings. As it is not a binding standard, there are no institutional impacts that directly result from its issuance by DOE. However, adoption of the proposed standard as a mandatory code by states and local code entities could have several significant institutional effects, which are discussed below. This discussion is conjectural, since the ultimate use of the VOLRES standard cannot be predicted.

Because of the widespread existence of mandatory energy codes that stipulate efficiency levels for energy conservation measures in new residences, adoption of VOLRES (to update existing codes) is not likely to adversely impact state and local institutions. This does not imply, however, that adoption would be straightforward or politically uncontroversial. On the contrary, adoption of and changes to state energy codes have often been accompanied by intensive lobbying by the building trades, utilities, homeowner groups, code official organizations and others. Adoption of the VOLRES standard is likely to generate at least as much political controversy as was the case with present state codes. While the large number of user-modifiable parameters in the proposed standard makes it very flexible, this feature also increases the likelihood that when the standard is adopted as a code, it will contain a number of politically-negotiated settings.

In a majority of states with mandatory codes, performance requirements for energy conservation measures are based on average statewide values for heating and cooling degree days. However, other states attempt to account for climate diversity by designating requirements by climate zone. The most prominent example of the latter is California, where code variations were developed for 14 zones. The climate zone approach is typically used to strike a balance between two principal (but somewhat contradictory) needs of energy codes--climate sensitivity and simplicity of compliance and enforcement. While the use of zones gives an energy code relatively more climate sensitivity, it also serves to <u>limit</u> the potential geographic variability of requirements (important to the building trades). The latter need increases the possibility that states will modify the climate-related flexibility of the proposed standard if they choose to adopt it to update current codes.

Adoption of a fuel-specific code such as the VOLRES standard may also cause some political and institutional impacts in states where energy codes are presently fuel-blind. Most mandatory energy codes do not differentiate between energy sources, and this is becoming an increasingly common approach as states update their codes (NCSBCS 1985). Selection of appropriate fuel prices to use in ARES may also prove to be controversial, particularly if VOLRES is adopted on the basis of zones or regions within a state. While ARES is designed to create separate standards for different fuels in a given locale (to avoid giving any fuel preferential treatment), the resulting standards usually do not have identical requirements for energy conservation measures or associated life-cycle and construction costs. The cost differences may cause some change in the local market share held by a given fuel. This so-called "fuel switching" is actually the change in the heating fuels consumers are choosing for new homes.

Enforcement of the standard as part of local building codes could require different procedures than those typically used by most states for current energy codes (visual inspection and/or measurement). Compliance with the proposed standard is most easily verified if the energy conservation measure package generated by ARES is used as the code. If other compliance paths (energy budget or point system) are used, code enforcement officials may also need additional training and/or equipment (computers). However, the nature and extent of enforcement-related impacts would depend on the features of the proposed standard as adopted by state or local governments and the compliance paths that are permitted.

4.0 METHODOLOGY

This section provides a detailed description of the process used to assess the economic impacts of the VOLRES standard. The subsections begin with an overview of the analytical process. New residences are assumed to be configured as if ARES were used in the design of the building. The product of this design step, the building configurations, is the topic of the second subsection. This configuration is then used to calculate life-cycle costs from society's perspective, which is explained in Section 4.3. The results of this calculation are aggregated to a national total using information about different types of building and housing forecasts for each major region within the country; direct benefits (costs) of the standard that are the product of this aggregation procedure are explained in Section 4.4. The calculation of the total (direct plus indirect) benefits (costs), using an input-output table for the U.S. economy is explained in Section 4.5. Section 4.6 then examines the sensitivity analysis that was performed regarding changes in assumptions, primarily fuel price changes, changes in the discount rate, and changes in the time horizon. The final subsection details the source of the data used in the analysis.

4.1 OVERVIEW OF THE ANALYTICAL PROCESS

Figure 4.1 offers a flowchart diagram of the analytical process used in this study. Given values for the set of economic parameters, ARES generates a building configuration that meets the VOLRES standard at a minimum life-cycle cost for each building type (single-family, multi-family, and manufactured housing) for a given location. Values for several parameters for this analysis are used in ARES according to the recommendations of the ASHRAE committee for Special Project 53; other economic parameter values were selected for this study in consultation with DOE and the Office of Management and Budget.

A variety of locations is assessed for each building type. The fuel/equipment types considered in all locations include electric resistance, gas, and electric heat pump. Oil is also analyzed in Albany, New York, and Providence, Rhode Island, because it has a larger role in newly constructed

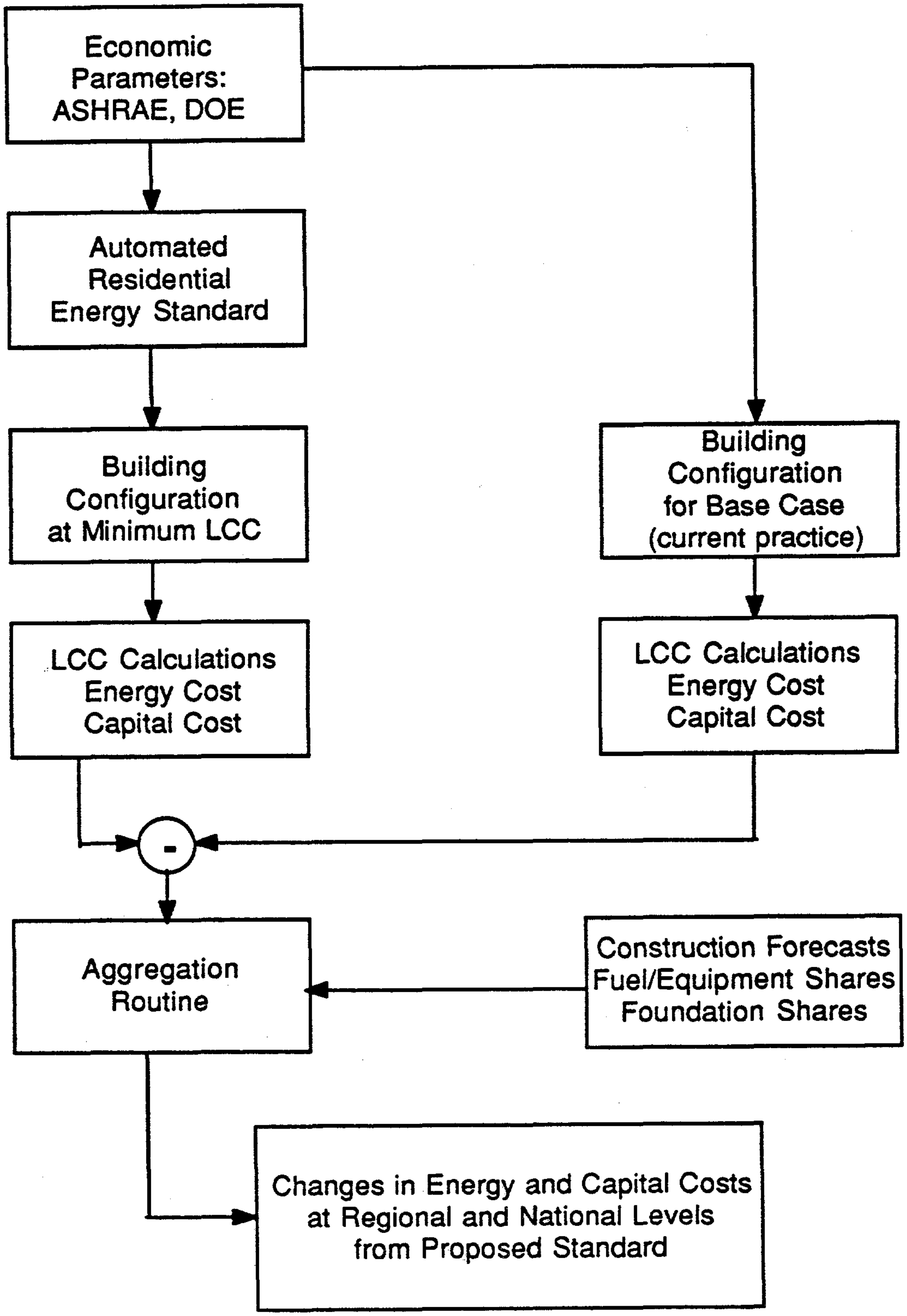

FIGURE 4.1. Overview of the Analytical Process

housing. For manufactured housing, LPG is also considered instead of heat pumps because of the prevalence of LPG use in manufactured housing.

The life-cycle cost of the ARES-generated building configuration is calculated from a societal perspective, as is that of the same building constructed according to current practice (determined by a survey of state code building requirements). This difference in life-cycle costs for capital and energy for each location, building type, and foundation type, represents the additional cost which the standard imposes. It is this difference in cost that is aggregated to regional and national totals, based on housing construction trends and their regional shifts, fuel/equipment preferences, and foundation types.

Once the direct impact of these changes in life-cycle cost has been aggregated to a national total, the indirect effects can be assessed. The method for assessing the indirect economic and employment impacts of the standard relies on the 1977 Input/Output (I/O) model of the U.S. economy. The difference between capital costs that would be incurred in the construction of the ARES-configured building and those of the buildings constructed according to current practice is introduced as changes in final demands for the I/O model to simulate the effect of the direct costs of the standard on the U.S. economy. Likewise, the difference in energy costs, allocated to the different fuels, is introduced as changes in final demand and the I/O model is again simulated to measure the effect of the energy savings due to the proposed standard. These changes are represented as increments or decrements in the output of all industry. The industry output, in turn, is factored by the labor-intensity of the corresponding industry to yield the change in employment that would result from the standard.

4.2 BUILDING CONFIGURATION USING ARES

The set of economic assumptions presented in Table 4.1 are introduced into the ARES software to determine the configuration of buildings in each of twelve locations. The twelve locations are presented in Table 4.2. The software relies upon a data base that contains site-specific information such as construction costs and weather data. With this site-specific information,

TABLE 4.1. Economic Parameters Used in the Economic Analysis

Parameter	Single- and Multi-Family Housing	Manufactured Housing
Inflation Rate	4% annually	4% annually
Mortgage Interest Rate	9% annually	12% annually
Points		1.500.0
Alternative Investment Rate	5.5% annually	5.5% annually
Income Tax Rate	21%	19%
Property Tax Rate	1%	1%
Down Payment Percentage	10%	10%
Loan Fee Percentage	3.3%	0
Term of Mortgage	30 years	15 years
Time Horizon	7 years	7 years

TABLE 4.2. Locations and Census Regions

Census Region	Location
Northeast	Albany, New York
	Providence, Rhode Island
South	Tampa, Florida
	Atlanta, Georgia
	Fort Worth, Texas
North Central	Minneapolis, Minnesota
West	Phoenix, Arizona
	Los Angeles, California
	Pasadena, California
	Santa Ana, California
	Denver, Colorado
	Seattle, Washington

ARES finds the combination of energy conservation measures that will minimize the consumer's life-cycle cost of providing energy for the residence.

The life-cycle costs of complying with the standard take into account the special circumstances of the typical consumer. Most people buying a house, for example, take out a mortgage, so that the major portion of the costs of the energy conservation measures is amortized over the life of the loan. On average, homeowners occupy a specific dwelling for only seven years. ARES' minimum life-cycle calculations, therefore, use a time horizon of only seven years and discount the initial costs as the mortgage is paid off. So the initial costs, from the consumers' perspective, include the down-payment and associated closing costs. The interest on the mortgage is tax deductible to the homeowner, so this is taken into account as well.

The life-cycle costs in ARES are evaluated from the perspective of the consumer, but these life-cycle costs are not suitable for society's perspective. Accordingly, the components of the building, as configured by ARES for the consumer's perspective, are used as a basis for calculating the life-cycle costs from society's perspective.

4.3 CALCULATION OF LIFE-CYCLE COSTS

The relevant life-cycle costs include three components: the initial cost of capital improvements, operation and maintenance costs, and fuel costs. By calculating the discounted present value of each of these components over an appropriate time horizon, the costs of the standard can be assessed.

The costs to the consumer will differ from society's costs for two major reasons: 1) the tax benefits that accrue to the homeowner; and 2) the amortizing of initial costs as the mortgage is paid off. From society's view, homeowner tax benefits are simply a transfer--either from non-homeowners to homeowners or, if the cost is financed by a deficit, through intergenerational transfers. The amortizing of initial costs, as done in the algorithm used in ARES, assumes that the consumer purchases the house with a down-payment and a loan. The costs of the energy conservation measure are incurred with each loan payment, and these are discounted costs. From society's point of view, the home and the energy conservation measure purchase arrangement is a transfer--a financial one; the cost to society is not reflected in the discounted mortgage payment, but rather in the resource use that occurs when the house is constructed. For these two major reasons the life-cycle costs are different for the homeowner and for society.

The effect of taking society's perspective rather than the consumers' is to increase the costs of the standard relative to the energy savings, but to augment the energy savings, albeit discounted, as the time horizon is extended. Since the resource use occurs when the house is built, the initial cost does not get discounted as it would if it were spread out over an amortization period. Society incurs the cost of the energy conservation measure at the time of installation; the costs are not discounted for society as they are for the consumer; therefore, the costs are higher for society. For the evaluation of the energy savings, from society's perspective, the appropriate time frame is not the average time that an individual resides in the home, but rather the economic life of the building. For this analysis, this time period was chosen to be 15 years. To avoid the necessity of predicting equipment replacement costs, the time period was not extended beyond this.

4.4 AGGREGATION OF DIRECT IMPACTS

The determination of direct impacts requires aggregation of the per-housing unit life-cycle costs to regional and national totals. The twelve sites used to represent the four Census regions are shown in Table 4.2. The difference between the life-cycle costs under the proposed standard and those under current practice are calculated for twelve locations for each building type, fuel/equipment type, and foundation type. The aggregation routine uses these incremental costs at each of these sites as prototypical of the difference in life-cycle costs for that region, so that the effects of the standard can be inferred using forecasted construction trends by region.

State-level housing construction forecasts were used to reflect anticipated shifts in construction growth trends within each region ("City's Share"), and to allocate residential housing construction between fuel/equipment preferences ("Fuel Type") and foundation types ("Foundation"). Each of these factors is used to calculate a weight to allocate the incremental per-unit housing costs appropriately, as follows:

WEIGHT = CITY'S SHARE * FOUNDATION * FUEL TYPE

This weight is then multiplied by the regional housing construction forecasts and the incremental life-cycle costs to calculate the total effect for the units in each location for each foundation type and fuel type. In addition, cooling costs are then multiplied by the share of new housing with air-conditioning in order to reflect the penetration of air-conditioning in the region. The effect for each location is then aggregated to regional and national totals.

Tables 4.3, 4.4, and 4.5 present the factors used to calculate the weights for single-family, multi-family and manufactured homes, respectively. For example, from the Albany row of Table 4.3, a single-family home built with gas heat on a slab foundation would have a weight equal to 0.05456 (=0.62*0.44*0.2); i.e., the incremental life-cycle costs and the discounted present value of energy savings constitute about 5.5 percent of the total costs and savings for single-family housing in the Northeast region. This 5.5 percent is then multiplied by the incremental capital costs and energy savings to provide an estimate of the net benefit (cost) for a single-family house in Albany. This product is then multiplied by the forecast housing starts for single-family housing in the Northeast region. When Albany and Providence are added together, a single-family housing estimate for the Northeast is obtained. This aggregation process was performed for each building type and aggregated to regional and national totals. (Section 4.7 offers detailed descriptions of the data and its sources for these factors.)

4.5 CALCULATION OF TOTAL IMPACTS

The direct impacts, obtained from the aggregation routine, are used to calculate the total (direct + indirect) impacts of adopting the standard. This calculation relies on the 1977 input-output structure of the U.S. economy as reported by the U.S. Department of Commerce (see Section 4.7 for data sources). The construction costs of imposing the standard were introduced into the vector of final demands and the output by industry was calculated. Similarly the energy savings implied by the aggregation routine were introduced into the vector of industry final demands via the bridge matrix by first estimating the final demand changes that result from an additional dollar of sales of one of the three fuels sold to consumers. This calculation relies on the familiar input-output identity:

TABLE 4.3. Regional Factors Used in Aggregation Process, Single-Family Housing

Census/City	City's Share	Fuel/Equipment Type				Foundation Type		Unheated Basement	Heated Basement	% with A/C
		Electricity	Gas	HP	Oil	Slab	Crawlspace			
Northeast										
Albany	0.62	0.15	0.44	0.16	0.25	0.20	0.09	0.39	0.26	0.43
Providence	0.38	0.15	0.44	0.16	0.25	0.20	0.09	0.39	0.26	0.43
South										
Tampa	0.30	0.21	0.31	0.48	-	0.64	0.20	0.14	0.02	0.91
Atlanta	0.30	0.21	0.31	0.48	-	0.64	0.20	0.14	0.02	0.91
Ft. Worth	0.30	0.21	0.31	0.48	-	0.64	0.20	0.14	0.02	0.91
North Central										
Minneapolis	1.00	0.08	0.82	0.10	-	0.12	0.12	0.41	0.35	0.62
West										
Phoenix	0.15	0.12	0.68	0.20	-	0.61	0.20	0.17	0.02	0.70
Los Angeles	0.19	0.12	0.68	0.20	-	0.61	0.20	0.17	0.02	0.60
Santa Ana	0.19	0.12	0.68	0.20	-	0.61	0.20	0.17	0.02	0.60
Pasadena	0.19	0.12	0.68	0.20	-	0.61	0.20	0.17	0.02	0.60
Denver	0.14	0.12	0.68	0.20	-	0.61	0.20	0.17	0.02	0.24
Seattle	0.12	0.12	0.68	0.20	-	0.61	0.20	0.17	0.02	0.24

TABLE 4.4. Regional Factors Used in Aggregation Process, Multi-Family Housing

Census/City	City's Share	Fuel/Equipment Type				Foundation Type		Unheated Basement	Heated Basement	% with A/C
		Electricity	Gas	HP	Oil	Slab	Crawlspace			
Northeast										
Albany	0.62	0.15	0.56	0.17	0.12	0.48	0.02	0.21	0.29	0.68
Providence	0.38	0.15	0.56	0.17	0.12	0.48	0.02	0.21	0.29	0.68
South										
Tampa	0.30	0.45	0.13	0.42	-	0.66	0.12	0.08	0.14	0.99
Atlanta	0.48	0.45	0.13	0.42	-	0.66	0.12	0.08	0.14	0.99
Ft. Worth	0.22	0.45	0.13	0.42	-	0.66	0.12	0.08	0.14	0.99
North Central										
Minneapolis	1.00	0.45	0.43	0.12	-	0.48	0.14	0.23	0.15	0.95
West										
Phoenix	0.15	0.27	0.53	0.20	-	0.70	0.16	0.06	0.08	0.97
Los Angeles	0.19	0.27	0.53	0.20	-	0.70	0.16	0.06	0.08	0.90
Santa Ana	0.19	0.27	0.53	0.20	-	0.70	0.16	0.06	0.08	0.90
Pasadena	0.19	0.27	0.53	0.20	-	0.70	0.16	0.06	0.08	0.90
Denver	0.14	0.27	0.53	0.20	-	0.70	0.16	0.06	0.08	0.24
Seattle	0.12	0.27	0.53	0.20	-	0.70	0.16	0.06	0.08	0.29

TABLE 4.5. Regional Factors Used in Aggregation Process, Manufactured Housing

Census/City	City's Share	Fuel/Equipment Type				Foundation Type		Unheated Basement	Heated Basement	% with A/C
		Electricity	Gas	LPG	Oil	Slab	Crawlspace			
Northeast										
Albany	0.62	0.04	0.23	0.07	0.66	-	1.00	-	-	0.36
Providence	0.38	0.04	0.23	0.07	0.66	-	1.00	-	-	0.36
South										
Tampa	0.30	0.34	0.31	0.35	-	-	1.00	-	-	0.78
Atlanta	0.48	0.34	0.31	0.35	-	-	1.00	-	-	0.78
Ft. Worth	0.22	0.34	0.31	0.35	-	-	1.00	-	-	0.78
North Central										
Minneapolis	1.00	0.13	0.55	0.32	-	-	1.00	-	-	0.62
West										
Phoenix	0.15	0.26	0.57	0.17	-	-	1.00	-	-	0.49
Los Angeles	0.19	0.26	0.57	0.17	-	-	1.00	-	-	0.49
Santa Ana	0.19	0.26	0.57	0.17	-	-	1.00	-	-	0.49
Pasadena	0.19	0.26	0.57	0.17	-	-	1.00	-	-	0.49
Denver	0.14	0.26	0.57	0.17	-	-	1.00	-	-	0.49
Seattle	0.12	0.26	0.57	0.17	-	-	1.00	-	-	0.49

$$X = (I-A)^{-1} F$$

where X = Output by industry
A = Input-output matrix
F = Final demands by industry
I = Identity matrix.

To estimate the construction impacts, the fraction of manufactured homes was first calculated (11.5 percent), then a $100 million dollar addition to final demand was distributed between manufactured and stick-built homes. This $100 million final demand vector was then premultiplied by the Leontief inverse, $(I-A)^{-1}$, to calculate the vector of industry outputs. This increase in construction brought about an increase in gross output of $197 million, with about $90 million in the housing construction industry and more than $11 million in manufactured housing.

The bridge matrix that allocates consumer expenditures to industry demand indicates that increases in consumer expenditures on electricity and natural gas increase the respective utilities, while an increase in fuel oil consumption increases the industry final demands of the petroleum refining industry primarily, but with slight additions to lumber and products, chemicals, and utilities. The evidence concerning the current housing stock suggests that about 30 percent of total fuel use is electricity, 55 percent is natural gas and the remaining 15 percent is fuel oil and propane. These allocations were distributed to industries according to the bridge matrix and normalized to $100 million. Then this final demand vector was premultiplied by the Leontief inverse to determine the industry output associated with changes in the use of fuels within residential homes. The results of this calculation indicate that $100 million of energy saved would reduce industry output by $212 million, with the bulk of that reduction accruing to the utility sectors that market the gas and electricity.

Employment impacts were determined by calculating the labor intensity (hours of employment per dollar of output) by industry corresponding to the vector X, then multiplying the estimated output for construction and fuel changes by these intensities. These changes in hours of work were then adjusted to reflect 1986 employment and hours, then translated into jobs by dividing the hours by 2080, the total number of hours in a 52-week, regular-shift year. The $100 million change in construction causes a change in employment of about 2760 jobs, while a $100 million change in fuel use brings about a change of 1950 jobs.

4.6 SENSITIVITY ANALYSIS

The ARES buildings configurations and the resulting life-cycle cost computations rely on the set of economic parameters presented in Table 4.1. The sensitivity of these results was tested over a range of the critical economic parameters in order to assess the validity of the conclusions. The economic parameters that were tested include fuel prices, the alternative investment rate, and the time horizon. The homeowners' life-cycle cost was also analyzed as part of the sensitivity analysis.

Only changes in fuel price were tested for every location and fuel/equipment type and aggregated to regional and national total. The large number of variable economic parameters limited the amount of sensitivity analysis performed for every prototype location and fuel/equipment type. However, by analyzing the difference between fuel costs (reported in Section 3.1.3) and cost changes that result from varying other parameters at specific sites, one can estimate the magnitude of change at the national level for other parameters. For the remaining parameters tested, several locations and fuel/equipment types were selected and the per-unit changes were then compared to the per-housing unit changes that occurred when changing the fuel price.

4.7 DATA

This section presents the data sources for the factors used in the aggregation routine. Each of the twelve locations are weighted according to the share of the region's construction growth that it will receive. Based on National Association of Home Builders' forecasts of single- and multi-family housing starts and their distribution across the states, the region's housing forecasts are allocated to the locations used in this analysis.[a] Manufactured housing forecasts were calculated to be twelve percent of private housing starts (as experienced between 1981-1986), from Industrial Outlook 1988.

The foundation type data for single-family housing came from the U.S. Census report entitled Characteristics of New Housing 1985. Over the 1983-1985 period, the average percentage of new housing with a foundation of "Slab," "Crawlspace," or "Full or Partial Basement" was calculated for each of the four Census regions. The "full or partial basement" category was further broken down into heated and unheated basement categories. The Energy Information Administration publication entitled Housing Characteristics 1984 provided the data about heated and unheated basements (in current stock). The foundation type data for multi-family housing came from an Oak Ridge National Laboratory publication (Christian 1987) that contains state-level data regarding the share of multi-family basements that are insulated and uninsulated. For manufactured housing, crawlspace was considered the foundation type in all cases.

The fuel/equipment type was factored in using data from The Residential and Commercial Buildings Data Book (Amols et al. 1988), compiled from Bureau of the Census' "Characteristics of New Housing, Construction Reports." The data cite the shares of electricity, gas, and oil for homes constructed in 1986 for single- and multi-family housing. By using data presented for equipment usage, the portion of electrical equipment that is heat pumps was also calculated. All totals were controlled in order to account for the small percentage of "other" fuels in each region.

Data revealing the amount of single- and multi-family housing that is air-conditioned also came from The Residential and Commercial Data Book. The single-family percentage represents the percentage of housing constructed in 1986 that has central air-conditioning. The multi-family housing data represent the percentage of housing built in 1986 that has air-conditioning

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(a) Personal Communication, 8/12/87, Bob Villaneuva, National Association of Homebuilders.

the share of housing with air-conditioning was adjusted on a location-by-location basis so that the locations have more realistic air-conditioning penetration rates; however, the West region's control total of 50 percent penetration was retained. For manufactured housing, the data present the share of current housing with air-conditioning by census region.

The input-output structure of the U.S. economy, used as the basis for determining the total impact of the standard, is described in the May 1984 Survey of Current Business, "The Input-Output Structure of the U.S. Economy, 1977" (DOC 1984). The Survey is a publication of the Bureau of Economic Analysis, U.S. Department of Commerce. The actual table used was the detailed, 537 industry/commodity table, aggregated to 130 sectors. These 130 sectors are, except for the detailed energy commodities, similar to the aggregation used by the U.S. Department of Energy's Energy Disaggregated Input-Output (EDIO) table. The bridging of consumer purchases to industry output was done according to Table B, "Input-Output Commodity Composition of Personal Consumption Expenditures", reported in the DOC (1984) publication cited above. The translation to employment was done using the U.S. Department of Labor hours-by-industry data to construct a measure of the labor intensity of industry (again aggregated to the EDIO level). The hours per dollar of compensation were deflated from the 1977 value to the 1986 value based on compensation of employee divided by employment adjusted by average weekly hours worked, then translating these hour values into jobs as explained above. Compensation, employment and average weekly hours were taken from Tables B-23, B-32 and B-41 respectively of the February 1988 Economic Report of the President.

APPENDIX A

DESCRIPTION OF HOUSING PROTOTYPES UNDER THE PROPOSED STANDARD

APPENDIX A

DESCRIPTION OF HOUSING PROTOTYPES UNDER THE PROPOSED STANDARD

This appendix contains a description of the housing prototypes and the other variables used in the analysis, including the considerations given to the selection of locations, fuel prices, and the economic parameters.

A.1 SELECTION OF THE CASE STUDY RESIDENCES

Over seventy case study homes were created for this analysis using the Automated Residential Energy Standard (ARES) software to determine levels of energy conservation measures that would meet the proposed voluntary standard. These case study homes cover three types of residential housing, up to five fuel/heating appliance specifications and ten locations. In addition, each site-built case study home's package of energy conservation measure included insulation requirements for four alternative foundations. Considerations used to select the residences to be studied included the following:

Building Prototypes. The ARES software produces standards for three types of residential structures: single-family site-built homes, multi-family site-built homes, and single-wide manufactured (mobile) homes. Each type is represented as a generic, relatively simple prototype, with set dimensions and features. Each site-built prototype also comes with several foundation options, while the manufactured home is modeled only on the crawl space foundations. Energy conservation measure packages generated by the standard show required insulation levels for each foundation type selected for consideration by the user. Tables A.1 and A.2 list the building types, their dimensions, and the foundation options that were studied in this analysis.

Case Study Locations. Twelve cities distributed across the continental United States were selected as locations where VOLRES would be compared to existing energy-efficiency-related building practices and requirements. These locations represent a range of heating and cooling degree day values

TABLE A.1. Prototype Residential Units

	House Type	Foundation Type
1)	Single-Family Residence	Crawl Space
2)	Single-Family Residence	Unconditioned Basement
3)	Single-Family Residence	Conditioned Basement
4)	Single-Family Residence	Slab
5)	Multi-Family Residence	Crawl Space
6)	Multi-Family Residence	Unconditioned Basement
7)	Multi-Family Residence	Conditioned Basement
8)	Multi-Family Residence	Slab
9)	Manufactured Home	Crawl Space

TABLE A.2. Residential Housing - Selected Unit Dependent Characteristics

Component	Single Family	Multi-Family	Manu. Home
Ceiling Square Feet	1540	600	902
Wall Square Feet	1328	640	1162
Floor Square Feet	1540	600	902
Slab Perimeter Linear Feet	166	40	NA
Basement Wall Perimeter Linear Feet	166	40	NA

that span the predominant climate conditions in the United States. Regions where new residential construction has been, and will be particularly heavy were slightly emphasized in the selection of the locations.

Fuels. The standards generated for VOLRES by the ARES software are specific to fuels and fuel/heating appliance applications selected by the user from among the five types provided in ARES. To limit the standard variations at each location somewhat, a VOLRES standard was developed for the two predominant heating fuels in each city. (When electricity was one of those fuels, however, there actually were three variations of the standard created, since ARES creates separate standards for electric forced air and electric heat pump appliances.) The predominant fuel types were also used in calculating life-cycle costs of the baseline residences. The two primary heating fuels were selected using data from The Residential and Commercial Buildings Databook (Amols et al. 1988) that showed the distribution by heating fuels of recently constructed new homes. In two locations (Albany and Providence), oil was considered as well as electricity and natural gas, because of its widespread use as a heating source.

A.2 SIMULATION OF ENERGY CONSERVATION MEASURE LEVELS IN THE CASE STUDY RESIDENCES

Generation of the energy conservation measure package with the ARES software requires the user to make a number of choices that tailor the standard to local conditions, prices and construction trends. The choices that were used to develop the proposed standard case study homes are listed below.

A.2.1 Fuel Prices

Prices used for selected fuels were current (1986) location-specific per unit prices obtained from published sources. The primary source of natural gas prices for each study location was the Annual Househeating Survey published by the American Gas Association (AGA 1986). Electricity prices were obtained from The Electrical World Directory of Electric Utilities, 1985-1986 (McGraw-Hill 1985). Fuel oil and LPG prices were obtained from the State Energy Price and Expenditure Report, 1985, published by the Energy Information Administration (DOE 1987). Sensitivity of ARES output to variations in fuel price was studied extensively. Table A.3 presents the fuel prices used in the economic analysis.

TABLE A.3. Fuel Prices

	($ per MMBtu) Electricity	Gas	LPG	Oil
Tampa, Florida	22.45	6.07	10.70	--
Phoenix, Arizona	25.65	5.71	10.25	--
Atlanta, Georgia	19.11	5.42	9.22	--
Seattle, Washington	12.40	5.47	8.46	--
Denver, Colorado	20.52	4.26	6.55	--
Minneapolis, Minnesota	18.17	5.27	7.79	--
Fort Worth, Texas	20.75	5.10	8.53	--
Pasadena, California	22.10	6.00	8.66	--
Santa Ana, California	22.10	6.00	8.66	--
Los Angeles, California	22.10	6.00	8.66	--
Albany, New York	20.08	7.64	11.12	8.07
Providence, Rhode Island	28.20	7.28	11.43	7.76

A.2.2 Construction Costs

ARES contains resident data bases with average energy conservation measure construction costs (1986 dollars) for eleven regions covering the continental United States. These costs are default values that can be modified by individual users of the software. For the purpose of this study, no changes were made to the default values, which were set by the ASHRAE technical evaluation committee.

A.2.3 Heating Appliance Efficiencies

ARES optimizes both envelop energy conservation measure features and space conditioning appliance efficiencies to minimize building life-cycle energy costs. Appliance efficiency values in ARES are not allowed to drop below the minimum efficiencies mandated in the National Appliance Energy Conservation Act (NAECA) of 1987 (42 USC 6201). However, the software can select higher efficiencies, if the life-cycle cost of the home can be lowered by doing so. NAECA minimum efficiencies become mandatory between 1990 and 1992 (the date varies by type of appliance) for new space conditioning equipment. These minimums were also used to develop the comparative life-cycle costs and energy use of the baseline (current code) prototypes.

A.2.4 Windows

Users of VOLRES can set the amount (window-to-floor-area ratio) and percent facing south (except in manufactured housing) of fenestration in the prototypes. Users can also limit the types of glazing that are to be considered in creating the standard. Modifying any of these items can result in changes to other energy conservation measure requirements. The case study (proposed standard and baseline) prototypes used the following parameters: 1) window area was set at 12 percent of floor area; 2) one-fourth of the window area was placed on the south-facing wall; and 3) ARES was not allowed to consider single pane/thermal break, triple pane/no thermal break, and reflective low E (low E-sun) glazing options for the windows. While those types of glazing are commercially available, they are not yet widely marketed for residential construction and are seldom used by builders (although low-E reflective glazing is becoming more popular in sunbelt states).(a)

A.2.5 Economic Parameters

ARES contains a file listing the economic parameters that guide its life-cycle cost calculations for energy conservation measures. In conjunction with other files and programming, the software generates the package of energy conservation measure components that represents minimized building life-cycle cost in any location. The user can edit the initial (default) values assigned to these economic parameters. A slightly different standard often results from such changes. For the purposes of this assessment, the default values for the economic parameters were used in single- and multi-family housing. The economic parameters used for the analysis of manufactured housing were changed in some cases to more accurately reflect manufactured home buyers' environment.

(a) Telephone conversation between Todd Taylor, PNL, and Steve Selkowitz, Lawrence Berkeley Laboratory, March 15, 1988.

APPENDIX B

DETAILED DATA AND SAMPLE ARES RUNS

APPENDIX B

DETAILED DATA AND SAMPLE ARES RUNS

This appendix contains detailed data used in the aggregation process of the economic analysis for all building types and all locations. Data included are housing forecasts, fuel shares, foundation type shares, the cities' share of regional growth, and the penetration of air-conditioning. Sample output runs from ARES are also included in this appendix.

Weights Used in Aggregation Process

	NE ALBANY-ELEC				NE ALBANY-GAS				NE ALBANY-HP/LPG			
REGIONAL FORECASTS (000's) (d)												
SF(a) -1988	196	196	196	196	196	196	196	196	196	196	196	196
1989	212	212	212	212	212	212	212	212	212	212	212	212
1990	229	229	229	229	229	229	229	229	229	229	229	229
1991	228	228	228	228	228	228	228	228	228	228	228	228
1992	226	226	226	226	226	226	226	226	226	226	226	226
1993	160	160	160	160	160	160	160	160	160	160	160	160
1994	148	148	148	148	148	148	148	148	148	148	148	148
1995	139	139	139	139	139	139	139	139	139	139	139	139
1996-2000	770	770	770	770	770	770	770	770	770	770	770	770
2001-2005	665	665	665	665	665	665	665	665	665	665	665	665
CITY'S SHARE	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
SF-FOUNDATION TYPE	0.20	0.09	0.39	0.32	0.20	0.09	0.39	0.32	0.20	0.09	0.39	0.32
SF-FUEL TYPE	0.15	0.15	0.15	0.15	0.44	0.44	0.44	0.44	0.16	0.16	0.16	0.16
SF-% WITH AC	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
MF(b) -1988	61	61	61	61	61	61	61	61	61	61	61	61
1989	54	54	54	54	54	54	54	54	54	54	54	54
1990	61	61	61	61	61	61	61	61	61	61	61	61
1991	63	63	63	63	63	63	63	63	63	63	63	63
1992	63	63	63	63	63	63	63	63	63	63	63	63
1993	42	42	42	42	42	42	42	42	42	42	42	42
1994	36	36	36	36	36	36	36	36	36	36	36	36
1995	33	33	33	33	33	33	33	33	33	33	33	33
1996-2000	190	190	190	190	190	190	190	190	190	190	190	190
2001-2005	125	125	125	125	125	125	125	125	125	125	125	125
CITY'S SHARE	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
MF-FOUNDATION TYPE	0.48	0.02	0.21	0.29	0.48	0.02	0.21	0.29	0.40	0.02	0.21	0.29
MF-FUEL TYPE	0.15	0.15	0.15	0.15	0.56	0.56	0.56	0.56	0.17	0.17	0.17	0.17
MF-% WITH AC	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
MH(c) -1988	35	35	35	35	35	35	35	35	35	35	35	35
1989	36	36	36	36	36	36	36	36	36	36	36	36
1990	40	40	40	40	40	40	40	40	40	40	40	40
1991	40	40	40	40	40	40	40	40	40	40	40	40
1992	39	39	39	39	39	39	39	39	39	39	39	39
1993	28	28	28	28	28	28	28	28	28	28	28	28
1994	25	25	25	25	25	25	25	25	25	25	25	25
1995	23	23	23	23	23	23	23	23	23	23	23	23
1996-2000	131	131	131	131	131	131	131	131	131	131	131	131
2001-2005	108	108	108	108	108	108	108	108	108	108	108	108
CITY'S SHARE	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.04	0.04	0.04	0.04	0.23	0.23	0.23	0.23	0.07	0.07	0.07	0.07
MH-% WITH AC	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

Weights Used in Aggregation Process (contd)

		NE				S				S			
		ALBANY-OIL				ATLANTA-ELEC				ATLANTA-GAS			
REGIONAL FORECASTS													
SF(a)	-1988	196	196	196	196	428	428	428	428	428	428	428	428
	1989	212	212	212	212	419	419	419	419	419	419	419	419
	1990	229	229	229	229	464	464	464	464	464	464	464	464
	1991	228	228	228	228	487	487	487	487	487	487	487	487
	1992	226	226	226	226	501	501	501	501	501	501	501	501
	1993	160	160	160	160	451	451	451	451	451	451	451	451
	1994	148	148	148	148	456	456	456	456	456	456	456	456
	1995	139	139	139	139	480	480	480	480	480	480	480	480
	1996-2000	770	770	770	770	2110	2110	2110	2110	2110	2110	2110	2110
	2001-2005	665	665	665	665	2055	2055	2055	2055	2055	2055	2055	2055
CITY'S SHARE		0.62	0.62	0.62	0.62	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
SF-FOUNDATION TYPE		0.20	0.09	0.39	0.32	0.64	0.20	0.14	0.02	0.64	0.20	0.14	0.02
SF-FUEL TYPE		0.25	0.25	0.25	0.25	0.21	0.21	0.21	0.21	0.31	0.31	0.31	0.31
SF-% WITH AC		0.43	0.43	0.43	0.43	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
MF(b)	-1988	61	61	61	61	143	143	143	143	143	143	143	143
	1989	54	54	54	54	145	145	145	145	145	145	145	145
	1990	61	61	61	61	162	162	162	162	162	162	162	162
	1991	63	63	63	63	169	169	169	169	169	169	169	169
	1992	63	63	63	63	178	178	178	178	178	178	178	178
	1993	42	42	42	42	171	171	171	171	171	171	171	171
	1994	36	36	36	36	168	168	168	168	168	168	168	168
	1995	33	33	33	33	163	163	163	163	163	163	163	163
	1996-2000	190	190	190	190	685	685	685	685	685	685	685	685
	2001-2005	125	125	125	125	565	565	565	565	565	565	565	565
CITY'S SHARE		0.62	0.62	0.62	0.62	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
MF-FOUNDATION TYPE		0.48	0.02	0.21	0.29	0.66	0.12	0.08	0.14	0.66	0.12	0.08	0.14
MF-FUEL TYPE		0.12	0.12	0.12	0.12	0.45	0.45	0.45	0.45	0.13	0.13	0.13	0.13
MF-% WITH AC		0.68	0.68	0.68	0.68	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
MH(c)	-1988	35	35	35	35	78	78	78	78	78	78	78	78
	1989	36	36	36	36	77	77	77	77	77	77	77	77
	1990	40	40	40	40	85	85	85	85	85	85	85	85
	1991	40	40	40	40	89	89	89	89	89	89	89	89
	1992	39	39	39	39	93	93	93	93	93	93	93	93
	1993	28	28	28	28	85	85	85	85	85	85	85	85
	1994	25	25	25	25	85	85	85	85	85	85	85	85
	1995	23	23	23	23	88	88	88	88	88	88	88	88
	1996-2000	131	131	131	131	381	381	381	381	381	381	381	381
	2001-2005	108	108	108	108	357	357	357	357	357	357	357	357
CITY'S SHARE		0.62	0.62	0.62	0.62	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
MH-FOUNDATION TYPE		0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE		0.66	0.66	0.66	0.66	0.34	0.34	0.34	0.34	0.31	0.31	0.31	0.31
MH-% WITH AC		0.36	0.36	0.36	0.36	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78

Weights Used in Aggregation Process (contd)

	S				W				W			
	ATLANTA-HP/LPG				DENVER-ELEC				DENVER-GAS			
REGIONAL FORECASTS												
SF(a) -1988	428	428	428	428	235	235	235	235	235	235	235	235
1989	419	419	419	419	220	220	220	220	220	220	220	220
1990	464	464	464	464	245	245	245	245	245	245	245	245
1991	487	487	487	487	254	254	254	254	254	254	254	254
1992	501	501	501	501	259	259	259	259	259	259	259	259
1993	451	451	451	451	294	294	294	294	294	294	294	294
1994	456	456	456	456	256	256	256	256	256	256	256	256
1995	480	480	480	480	236	236	236	236	236	236	236	236
1996-2000	2110	2110	2110	2110	1100	1100	1100	1100	1100	1100	1100	1100
2001-2005	2055	2055	2055	2055	1040	1040	1040	1040	1040	1040	1040	1040
CITY'S SHARE	0.48	0.48	0.48	0.48	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
SF-FOUNDATION TYPE	0.64	0.20	0.14	0.02	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02
SF-FUEL TYPE	0.48	0.48	0.48	0.48	0.12	0.12	0.12	0.12	0.68	0.68	0.68	0.68
SF-% WITH AC	0.91	0.91	0.91	0.91	0.2367	0.2367	0.2367	0.2367	0.2367	0.2367	0.2367	0.2367
MF(b) -1988	143	143	143	143	132	132	132	132	132	132	132	132
1989	145	145	145	145	137	137	137	137	137	137	137	137
1990	162	162	162	162	155	155	155	155	155	155	155	155
1991	169	169	169	169	164	164	164	164	164	164	164	164
1992	178	178	178	178	164	164	164	164	164	164	164	164
1993	171	171	171	171	171	171	171	171	171	171	171	171
1994	168	168	168	168	168	168	168	168	168	168	168	168
1995	163	163	163	163	163	163	163	163	163	163	163	163
1996-2000	685	685	685	685	1455	1455	1455	1455	1455	1455	1455	1455
2001-2005	565	565	565	565	590	590	590	590	590	590	590	590
CITY'S SHARE	0.48	0.48	0.48	0.48	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
MF-FOUNDATION TYPE	0.66	0.12	0.08	0.14	0.70	0.16	0.06	0.08	0.7	0.16	0.06	0.08
MF-FUEL TYPE	0.42	0.42	0.42	0.42	0.27	0.27	0.27	0.27	0.53	0.53	0.53	0.53
MF-% WITH AC	0.99	0.99	0.99	0.99	0.2441	0.2441	0.2441	0.2441	0.2441	0.2441	0.2441	0.2441
MH(c) -1988	78	78	78	78	50	50	50	50	50	50	50	50
1989	77	77	77	77	49	49	49	49	49	49	49	49
1990	85	85	85	85	55	55	55	55	55	55	55	55
1991	89	89	89	89	57	57	57	57	57	57	57	57
1992	93	93	93	93	58	58	58	58	58	58	58	58
1993	85	85	85	85	63	63	63	63	63	63	63	63
1994	85	85	85	85	58	58	58	58	58	58	58	58
1995	88	88	88	88	54	54	54	54	54	54	54	54
1996-2000	381	381	381	381	348	348	348	348	348	348	348	348
2001-2005	357	357	357	357	222	222	222	222	222	222	222	222
CITY'S SHARE	0.48	0.48	0.48	0.48	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.35	0.35	0.35	0.35	0.26	0.26	0.26	0.26	0.57	0.57	0.57	0.57
MH-% WITH AC	0.73	0.73	0.73	0.73	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Weights Used in Aggregation Process (contd)

		W				S				S			
		DENVER-HP/LPG				FT.WORTH-ELEC				FT.WORTH-GAS			
REGIONAL FORECASTS													
SF(a)	-1988	235	235	235	235	428	428	428	428	428	428	428	428
	1989	220	220	220	220	419	419	419	419	419	419	419	419
	1990	245	245	245	245	464	464	464	464	464	464	464	464
	1991	254	254	254	254	487	487	487	487	487	487	487	487
	1992	259	259	259	259	501	501	501	501	501	501	501	501
	1993	294	294	294	294	451	451	451	451	451	451	451	451
	1994	256	256	256	256	456	456	456	456	456	456	456	456
	1995	236	236	236	236	480	480	480	480	480	480	480	480
	1996-2000	1100	1100	1100	1100	2110	2110	2110	2110	2110	2110	2110	2110
	2001-2005	1040	1040	1040	1040	2055	2055	2055	2055	2055	2055	2055	2055
CITY'S SHARE		0.14	0.14	0.14	0.14	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
SF-FOUNDATION TYPE		0.61	0.20	0.17	0.02	0.64	0.20	0.14	0.02	0.64	0.20	0.14	0.02
SF-FUEL TYPE		0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.31	0.31	0.31	0.31
SF-% WITH AC		0.2367	0.2367	0.2367	0.2367	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
MF(b)	-1988	132	132	132	132	143	143	143	143	143	143	143	143
	1989	137	137	137	137	145	145	145	145	145	145	145	145
	1990	155	155	155	155	162	162	162	162	162	162	162	162
	1991	164	164	164	164	169	169	169	169	169	169	169	169
	1992	164	164	164	164	178	178	178	178	178	178	178	178
	1993	171	171	171	171	171	171	171	171	171	171	171	171
	1994	168	168	168	168	168	168	168	168	168	168	168	168
	1995	163	163	163	163	163	163	163	163	163	163	163	163
	1996-2000	1455	1455	1455	1455	685	685	685	685	685	685	685	685
	2001-2005	590	590	590	590	565	565	565	565	565	565	565	565
CITY'S SHARE		0.14	0.14	0.14	0.14	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
MF-FOUNDATION TYPE		0.7	0.16	0.06	0.08	0.66	0.12	0.08	0.14	0.66	0.12	0.08	0.14
MF-FUEL TYPE		0.2	0.2	0.2	0.2	0.45	0.45	0.45	0.45	0.13	0.13	0.13	0.13
MF-% WITH AC		0.2441	0.2441	0.2441	0.2441	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
MH(c)	-1988	50	50	50	50	78	78	78	78	78	78	78	78
	1989	49	49	49	49	77	77	77	77	77	77	77	77
	1990	55	55	55	55	85	85	85	85	85	85	85	85
	1991	57	57	57	57	89	89	89	89	89	89	89	89
	1992	58	58	58	58	93	93	93	93	93	93	93	93
	1993	63	63	63	63	85	85	85	85	85	85	85	85
	1994	58	58	58	58	85	85	85	85	85	85	85	85
	1995	54	54	54	54	88	88	88	88	88	88	88	88
	1996-2000	348	348	348	348	381	381	381	381	381	381	381	381
	2001-2005	222	222	222	222	357	357	357	357	357	357	357	357
CITY'S SHARE		0.14	0.14	0.14	0.14	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
MH-FOUNDATION TYPE		0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE		0.17	0.17	0.17	0.17	0.34	0.34	0.34	0.34	0.31	0.31	0.31	0.31
MH-% WITH AC		0.49	0.49	0.49	0.49	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78

Weights Used in Aggregation Process (contd)

	S				W				W			
	FT.WORTH-HP/LPG				LA-ELEC				LA-GAS			
REGIONAL FORECASTS												
SF(a) -1988	428	428	428	428	235	235	235	235	235	235	235	235
1989	419	419	419	419	220	220	220	220	220	220	220	220
1990	464	464	464	464	245	245	245	245	245	245	245	245
1991	487	487	487	487	254	254	254	254	254	254	254	254
1992	501	501	501	501	259	259	259	259	259	259	259	259
1993	451	451	451	451	294	294	294	294	294	294	294	294
1994	456	456	456	456	256	256	256	256	256	256	256	256
1995	480	480	480	480	236	236	236	236	236	236	236	236
1996-2000	2110	2110	2110	2110	1100	1100	1100	1100	1100	1100	1100	1100
2001-2005	2055	2055	2055	2055	1040	1040	1040	1040	1040	1040	1040	1040
CITY'S SHARE	0.22	0.22	0.22	0.22	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
SF-FOUNDATION TYPE	0.64	0.20	0.14	0.02	0.61	0.20	0.17	0,02	0.61	0.20	0.17	0.02
SF-FUEL TYPE	0.48	0.48	0.48	0.48	0.12	0.12	0.12	0.12	0.68	0.68	0.68	0.68
SF-% WITH AC	0.91	0.91	0.91	0.91	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
MF(b) -1988	143	143	143	143	132	132	132	132	132	132	132	132
1989	145	145	145	145	137	137	137	137	137	137	137	137
1990	162	162	162	162	155	155	155	155	155	155	155	155
1991	169	169	169	169	164	164	164	164	164	164	164	164
1992	178	178	178	178	164	164	164	164	164	164	164	164
1993	171	171	171	171	171	171	171	171	171	171	171	171
1994	168	168	168	168	168	168	168	168	168	168	168	168
1995	163	163	163	163	163	163	163	163	163	163	163	163
1996-2000	685	685	685	685	1455	1455	1455	1455	1455	1455	1455	1455
2001-2005	565	565	565	565	590	590	590	590	590	590	590	590
CITY'S SHARE	0.22	0.22	0.22	0.22	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
MF-FOUNDATION TYPE	0.66	0.12	0.08	0.14	0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08
MF-FUEL TYPE	0.42	0.42	0.42	0.42	0.27	0.27	0.27	0.27	0.53	0.53	0.53	0.53
MF-% WITH AC	0.99	0.99	0.99	0.99	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
MH(c) -1988	78	78	78	78	50	50	50	50	50	50	50	50
1989	77	77	77	77	49	49	49	49	49	49	49	49
1990	85	85	85	85	55	55	55	55	55	55	55	55
1991	89	89	89	89	57	57	57	57	57	57	57	57
1992	93	93	93	93	58	58	58	58	58	58	58	58
1993	85	85	85	85	63	63	63	63	63	63	63	63
1994	85	85	85	85	58	58	58	58	58	58	58	58
1995	83	83	83	83	54	54	54	54	54	54	54	54
1996-2000	381	381	381	381	348	348	348	348	348	348	348	348
2001-2005	357	357	357	357	222	222	222	222	222	222	222	222
CITY'S SHARE	0.22	0.22	0.22	0.22	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.35	0.35	0.35	0.35	0.26	0.26	0.26	0.26	0.57	0.57	0.57	0.57
MH-% WITH AC	0.78	0.78	0.78	0.78	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Weights Used in Aggregation Process (contd)

		W				MW				MW			
		LA-HP/LPG				MINN-ELEC				MINN-GAS			
REGIONAL FORECASTS													
SF(a)	-1988	235	235	235	235	255	255	255	255	255	255	255	255
	1989	220	220	220	220	242	242	242	242	242	242	242	242
	1990	245	245	245	245	254	254	254	254	254	254	254	254
	1991	254	254	254	254	257	257	257	257	257	257	257	257
	1992	259	259	259	259	249	249	249	249	249	249	249	249
	1993	294	294	294	294	158	158	158	158	158	158	158	158
	1994	256	256	256	256	144	144	144	144	144	144	144	144
	1995	236	236	236	236	137	137	137	137	137	137	137	137
	1996-2000	1100	1100	1100	1100	815	815	815	815	815	815	815	815
	2001-2005	1040	1040	1040	1040	685	685	685	685	685	685	685	685
CITY'S SHARE		0.19	0.19	0.19	0.19	1	1	1	1	1	1	1	1
SF-FOUNDATION TYPE		0.61	0.20	0.17	0.02	0.12	0.12	0.41	0.35	0.12	0.12	0.41	0.35
SF-FUEL TYPE		0.20	0.20	0.20	0.20	0.08	0.08	0.08	0.08	0.82	0.82	0.82	0.82
SF-% WITH AC		0.6	0.6	0.6	0.6	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
MF(b)	-1988	132	132	132	132	85	85	85	85	85	85	85	85
	1989	137	137	137	137	74	74	74	74	74	74	74	74
	1990	155	155	155	155	80	80	80	80	80	80	80	80
	1991	164	164	164	164	83	83	83	83	83	83	83	83
	1992	164	164	164	164	78	78	78	78	78	78	78	78
	1993	171	171	171	171	76	76	76	76	76	76	76	76
	1994	168	168	168	168	74	74	74	74	74	74	74	74
	1995	163	163	163	163	73	73	73	73	73	73	73	73
	1996-2000	1455	1455	1455	1455	355	355	355	355	355	355	355	355
	2001-2005	590	590	590	590	285	285	285	285	285	285	285	285
CITY'S SHARE		0.19	0.19	0.19	0.19	1	1	1	1	1	1	1	1
MF-FOUNDATION TYPE		0.7	0.16	0.06	0.08	0.43	0.14	0.23	0.15	0.48	0.14	0.23	0.15
MF-FUEL TYPE		0.2	0.2	0.2	0.2	0.45	0.45	0.45	0.45	0.43	0.43	0.43	0.43
MF-% WITH AC		0.9	0.9	0.9	0.9	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
MH(c)	-1988	50	50	50	50	46	46	46	46	46	46	46	46
	1989	49	49	49	49	43	43	43	43	43	43	43	43
	1990	55	55	55	55	46	46	46	46	46	46	46	46
	1991	57	57	57	57	46	46	46	46	46	46	46	46
	1992	58	58	58	58	45	45	45	45	45	45	45	45
	1993	63	63	63	63	32	32	32	32	32	32	32	32
	1994	58	58	58	58	30	30	30	30	30	30	30	30
	1995	54	54	54	54	29	29	29	29	29	29	29	29
	1996-2000	348	348	348	348	160	160	160	160	160	160	160	160
	2001-2005	222	222	222	222	132	132	132	132	132	132	132	132
CITY'S SHARE		0.19	0.19	0.19	0.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
MH-FOUNDATION TYPE		0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE		0.17	0.17	0.17	0.17	0.13	0.13	0.13	0.13	0.55	0.55	0.55	0.55
MH-% WITH AC		0.49	0.49	0.49	0.49	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62

Weights Used in Aggregation Process (contd)

	MW				W				W			
	MINN-HP/LPG				PASADENA-ELEC				PASADENA-GAS			
REGIONAL FORECASTS												
SF(a) -1988	255	255	255	255	235	235	235	235	235	235	235	235
1989	242	242	242	242	220	220	220	220	220	220	220	220
1990	254	254	254	254	245	245	245	245	245	245	245	245
1991	257	257	257	257	254	254	254	254	254	254	254	254
1992	249	249	249	249	259	259	259	259	259	259	259	259
1993	158	158	158	158	294	294	294	294	294	294	294	294
1994	144	144	144	144	256	256	256	256	256	256	256	256
1995	137	137	137	137	236	236	236	236	236	236	236	236
1996-2000	815	815	815	815	1100	1100	1100	1100	1100	1100	1100	1100
2001-2005	685	685	685	685	1040	1040	1040	1040	1040	1040	1040	1040
CITY'S SHARE	1	1	1	1	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
SF-FOUNDATION TYPE	0.12	0.12	0.41	0.35	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02
SF-FUEL TYPE	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.12	0.68	0.68	0.68	0.68
SF-% WITH AC	0.62	0.62	0.62	0.62	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
MF(b) -1988	85	85	85	85	132	132	132	132	132	132	132	132
1989	74	74	74	74	137	137	137	137	137	137	137	137
1990	80	80	80	80	155	155	155	155	155	155	155	155
1991	83	83	83	83	164	164	164	164	164	164	164	164
1992	78	78	78	78	164	164	164	164	164	164	164	164
1993	76	76	76	76	171	171	171	171	171	171	171	171
1994	74	74	74	74	168	168	168	168	168	168	168	168
1995	73	73	73	73	163	163	163	163	163	163	163	163
1996-2000	355	355	355	355	1455	1455	1455	1455	1455	1455	1455	1455
2001-2005	285	285	285	285	590	590	590	590	590	590	590	590
CITY'S SHARE	1	1	1	1	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
MF-FOUNDATION TYPE	0.48	0.14	0.23	0.15	0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08
MF-FUEL TYPE	0.12	0.12	0.12	0.12	0.27	0.27	0.27	0.27	0.53	0.53	0.53	0.53
MF-% WITH AC	0.95	0.95	0.95	0.95	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
MH(c) -1988	46	46	46	46	50	50	50	50	50	50	50	50
1989	43	43	43	43	49	49	49	49	49	49	49	49
1990	46	46	46	46	55	55	55	55	55	55	55	55
1991	46	46	46	46	57	57	57	57	57	57	57	57
1992	45	45	45	45	58	58	58	58	58	58	58	58
1993	32	32	32	32	63	63	63	63	63	63	63	63
1994	30	30	30	30	58	58	58	58	58	58	58	58
1995	29	29	29	29	54	54	54	54	54	54	54	54
1996-2000	160	160	160	160	348	348	348	348	348	348	348	348
2001-2005	132	132	132	132	222	222	222	222	222	222	222	222
CITY'S SHARE	1.00	1.00	1.00	1.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.32	0.32	0.32	0.32	0.26	0.26	0.26	0.26	0.57	0.57	0.57	0.57
MH-% WITH AC	0.62	0.62	0.62	0.62	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Weights Used in Aggregation Process (contd)

	W				W				W			
	PASADENA-HP/LPG				PHOENIX-ELEC				PHOENIX-GAS			
REGIONAL FORECASTS												
SF(a) -1988	235	235	235	235	235	235	235	235	235	235	235	235
1989	220	220	220	220	220	220	220	220	220	220	220	220
1990	245	245	245	245	245	245	245	245	245	245	245	245
1991	254	254	254	254	254	254	254	254	254	254	254	254
1992	259	259	259	259	259	259	259	259	259	259	259	259
1993	294	294	294	294	294	294	294	294	294	294	294	294
1994	256	256	256	256	256	256	256	256	256	256	256	256
1995	236	236	236	236	236	236	236	236	236	236	236	236
1996-2000	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
2001-2005	1040	1040	1040	1040	1040	1040	1040	1040	1040	1040	1040	1040
CITY'S SHARE	0.19	0.19	0.19	0.19	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
SF-FOUNDATION TYPE	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02
SF-FUEL TYPE	0.20	0.20	0.20	0.20	0.12	0.12	0.12	0.12	0.68	0.68	0.68	0.68
SF-% WITH AC	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
MF(b) -1988	132	132	132	132	132	132	132	132	132	132	132	132
1989	137	137	137	137	137	137	137	137	137	137	137	137
1990	155	155	155	155	155	155	155	155	155	155	155	155
1991	164	164	164	164	164	164	164	164	164	164	164	164
1992	164	164	164	164	164	164	164	164	164	164	164	164
1993	171	171	171	171	171	171	171	171	171	171	171	171
1994	168	168	168	168	168	168	168	168	168	168	168	168
1995	163	163	163	163	163	163	163	163	163	163	163	163
1996-2000	1455	1455	1455	1455	1455	1455	1455	1455	1455	1455	1455	1455
2001-2005	590	590	590	590	590	590	590	590	590	590	590	590
CITY'S SHARE	0.19	0.19	0.19	0.19	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
MF-FOUNDATION TYPE	0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08
MF-FUEL TYPE	0.2	0.2	0.2	0.2	0.27	0.27	0.27	0.27	0.53	0.53	0.53	0.53
MF-% WITH AC	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MH(c) -1988	50	50	50	50	50	50	50	50	50	50	50	50
1989	49	49	49	49	49	49	49	49	49	49	49	49
1990	55	55	55	55	55	55	55	55	55	55	55	55
1991	57	57	57	57	57	57	57	57	57	57	57	57
1992	58	58	58	58	58	58	58	58	58	58	58	58
1993	63	63	63	63	63	63	63	63	63	63	63	63
1994	58	58	58	58	58	58	58	58	58	58	58	58
1995	54	54	54	54	54	54	54	54	54	54	54	54
1996-2000	348	348	348	348	348	348	348	348	348	348	348	348
2001-2005	222	222	222	222	222	222	222	222	222	222	222	222
CITY'S SHARE	0.19	0.19	0.19	0.19	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.17	0.17	0.17	0.17	0.26	0.26	0.26	0.26	0.57	0.57	0.57	0.57
MH-% WITH AC	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

<u>Weights Used in Aggregation Process</u> (contd)

	W				NE				NE			
	PHOENIX-HP/LPG				PROVIDENCE-ELEC				PROVIDENCE-GAS			
REGIONAL FORECASTS												
SF(a) -1988	235	235	235	235	196	196	196	196	196	196	196	196
1989	220	220	220	220	212	212	212	212	212	212	212	212
1990	245	245	245	245	229	229	229	229	229	229	229	229
1991	254	254	254	254	228	228	228	228	228	228	228	228
1992	259	259	259	259	226	226	226	226	226	226	226	226
1993	294	294	294	294	160	160	160	160	160	160	160	160
1994	256	256	256	256	148	148	148	148	148	148	148	148
1995	236	236	236	236	139	139	139	139	139	139	139	139
1996-2000	1100	1100	1100	1100	770	770	770	770	770	770	770	770
2001-2005	1040	1040	1040	1040	665	665	665	665	665	665	665	665
CITY'S SHARE	0.15	0.15	0.15	0.15	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
SF-FOUNDATION TYPE	0.61	0.20	0.17	0.02	0.20	0.09	0.39	0.32	0.20	0.09	0.39	0.32
SF-FUEL TYPE	0.20	0.20	0.20	0.20	0.15	0.15	0.15	0.15	0.44	0.44	0.44	0.44
SF-% WITH AC	0.7	0.7	0.7	0.7	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
MF(b) -1988	132	132	132	132	61	61	61	61	61	61	61	61
1989	137	137	137	137	54	54	54	54	54	54	54	54
1990	155	155	155	155	61	61	61	61	61	61	61	61
1991	164	164	164	164	63	63	63	63	63	63	63	63
1992	164	164	164	164	63	63	63	63	63	63	63	63
1993	171	171	171	171	42	42	42	42	42	42	42	42
1994	168	168	168	168	36	36	36	36	36	36	36	36
1995	163	163	163	163	33	33	33	33	33	33	33	33
1996-2000	1455	1455	1455	1455	190	190	190	190	190	190	190	190
2001-2005	590	590	590	590	125	125	125	125	125	125	125	125
CITY'S SHARE	0.15	0.15	0.15	0.15	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
MF-FOUNDATION TYPE	0.7	0.16	0.06	0.08	0.48	0.02	0.21	0.29	0.48	0.02	0.21	0.29
MF-FUEL TYPE	0.2	0.2	0.2	0.2	0.15	0.15	0.15	0.15	0.56	0.56	0.56	0.56
MF-% WITH AC	1.0	1.0	1.0	1.0	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
MH(c) -1988	50	50	50	50	35	35	35	35	35	35	35	35
1989	49	49	49	49	36	36	36	36	36	36	36	36
1990	55	55	55	55	40	40	40	40	40	40	40	40
1991	57	57	57	57	40	40	40	40	40	40	40	40
1992	58	58	58	58	39	39	39	39	39	39	39	39
1993	63	63	63	63	28	28	28	28	28	28	28	28
1994	58	58	58	58	25	25	25	25	25	25	25	25
1995	54	54	54	54	23	23	23	23	23	23	23	23
1996-2000	348	348	348	348	131	131	131	131	131	131	131	131
2001-2005	222	222	222	222	108	108	108	108	108	108	108	108
CITY'S SHARE	0.15	0.15	0.15	0.15	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.17	0.17	0.17	0.17	0.04	0.04	0.04	0.04	0.23	0.23	0.23	0.23
MH-% WITH AC	0.49	0.49	0.49	0.49	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

Weights Used in Aggregation Process (contd)

	NE PROVIDENCE-HP/LPG				NE PROVIDENCE-OIL				W SANTA ANA-ELEC			
REGIONAL FORECASTS												
SF(a) -1988	196	196	196	196	196	196	196	196	235	235	235	235
1989	212	212	212	212	212	212	212	212	220	220	220	220
1990	229	229	229	229	229	229	229	229	245	245	245	245
1991	228	228	228	228	228	228	228	228	254	254	254	254
1992	226	226	226	226	226	226	226	226	259	259	259	259
1993	160	160	160	160	160	160	160	160	294	294	294	294
1994	148	148	148	148	148	148	148	148	256	256	256	256
1995	139	139	139	139	139	139	139	139	236	236	236	236
1996-2000	770	770	770	770	770	770	770	770	1100	1100	1100	1100
2001-2005	665	665	665	665	665	665	665	665	1040	1040	1040	1040
CITY'S SHARE	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.19	0.19	0.19	0.19
SF-FOUNDATION TYPE	0.20	0.09	0.39	0.32	0.20	0.09	0.39	0.32	0.61	0.20	0.17	0.02
SF-FUEL TYPE	0.16	0.16	0.16	0.16	0.25	0.25	0.25	0.25	0.12	0.12	0.12	0.12
SF-% WITH AC	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.5	0.5	0.5	0.5
MF(b) -1988	61	61	61	61	61	61	61	61	132	132	132	132
1989	54	54	54	54	54	54	54	54	137	137	137	137
1990	61	61	61	61	61	61	61	61	155	155	155	155
1991	63	63	63	63	63	63	63	63	164	164	164	164
1992	63	63	63	63	63	63	63	63	164	164	164	164
1993	42	42	42	42	42	42	42	42	171	171	171	171
1994	36	36	36	36	36	36	36	36	168	168	168	168
1995	33	33	33	33	33	33	33	33	163	163	163	163
1996-2000	190	190	190	190	190	190	190	190	1455	1455	1455	1455
2001-2005	125	125	125	125	125	125	125	125	590	590	590	590
CITY'S SHARE	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.19	0.19	0.19	0.19
MF-FOUNDATION TYPE	0.48	0.02	0.21	0.29	0.43	0.02	0.21	0.29	0.7	0.16	0.06	0.08
MF-FUEL TYPE	0.17	0.17	0.17	0.17	0.12	0.12	0.12	0.12	0.27	0.27	0.27	0.27
MF-% WITH AC	0.68	0.68	0.68	0.68	0.68	0.63	0.63	0.63	0.88	0.83	0.88	0.88
MH(c) -1988	35	35	35	35	35	35	35	35	50	50	50	50
1989	36	36	36	36	36	36	36	36	49	49	49	49
1990	40	40	40	40	40	40	40	40	55	55	55	55
1991	40	40	40	40	40	40	40	40	57	57	57	57
1992	39	39	39	39	39	39	39	39	58	58	58	58
1993	28	28	28	28	28	23	23	28	63	63	63	63
1994	25	25	25	25	25	25	25	25	58	58	58	58
1995	23	23	23	23	23	23	23	23	54	54	54	54
1996-2000	131	131	131	131	131	131	131	131	348	348	348	348
2001-2005	108	108	108	108	108	108	108	108	222	222	222	222
CITY'S SHARE	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.19	0.19	0.19	0.19
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.07	0.07	0.07	0.07	0.66	0.66	0.66	0.66	0.26	0.26	0.26	0.26
MH-% WITH AC	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.49	0.49	0.49	0.49

Weights Used in Aggregation Process (contd)

		W SANTA ANA-GAS				W SANTA ANA-HP/LPG				W SEATTLE-ELEC			
REGIONAL FORECASTS													
SF(a)	-1988	235	235	235	235	235	235	235	235	235	235	235	235
	1989	220	220	220	220	220	220	220	220	220	220	220	220
	1990	245	245	245	245	245	245	245	245	245	245	245	245
	1991	254	254	254	254	254	254	254	254	254	254	254	254
	1992	259	259	259	259	259	259	259	259	259	259	259	259
	1993	294	294	294	294	294	294	294	294	294	294	294	294
	1994	256	256	256	256	256	256	256	256	256	256	256	256
	1995	236	236	236	236	236	236	236	236	236	236	236	236
	1996-2000	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
	2001-2005	1040	1040	1040	1040	1040	1040	1040	1040	1040	1040	1040	1040
CITY'S SHARE		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.12	0.12	0.12	0.12
SF-FOUNDATION TYPE		0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02
SF-FUEL TYPE		0.68	0.68	0.68	0.68	0.20	0.20	0.20	0.20	0.12	0.12	0.12	0.12
SF-% WITH AC		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.235	0.235	0.235	0.235
MF(b)	-1988	132	132	132	132	132	132	132	132	132	132	132	132
	1989	137	137	137	137	137	137	137	137	137	137	137	137
	1990	155	155	155	155	155	155	155	155	155	155	155	155
	1991	164	164	164	164	164	164	164	164	164	164	164	164
	1992	164	164	164	164	164	164	164	164	164	164	164	164
	1993	171	171	171	171	171	171	171	171	171	171	171	171
	1994	168	168	168	168	168	168	168	168	168	168	168	168
	1995	163	163	163	163	163	163	163	163	163	163	163	163
	1996-2000	1455	1455	1455	1455	1455	1455	1455	1455	1455	1455	1455	1455
	2001-2005	590	590	590	590	590	590	590	590	590	590	590	590
CITY'S SHARE		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.12	0.12	0.12	0.12
MF-FOUNDATION TYPE		0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08
MF-FUEL TYPE		0.53	0.53	0.53	0.53	0.2	0.2	0.2	0.2	0.27	0.27	0.27	0.27
MF-% WITH AC		0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.29	0.29	0.29	0.29
MH(c)	-1988	50	50	50	50	50	50	50	50	50	50	50	50
	1989	49	49	49	49	49	49	49	49	49	49	49	49
	1990	55	55	55	55	55	55	55	55	55	55	55	55
	1991	57	57	57	57	57	57	57	57	57	57	57	57
	1992	58	58	58	58	58	58	58	58	58	58	58	58
	1993	63	63	63	63	63	63	63	63	63	63	63	63
	1994	58	58	58	58	58	58	58	58	58	58	58	58
	1995	54	54	54	54	54	54	54	54	54	54	54	54
	1996-2000	348	348	348	348	348	348	348	348	348	348	348	348
	2001-2005	222	222	222	222	222	222	222	222	222	222	222	222
CITY'S SHARE		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.12	0.12	0.12	0.12
MH-FOUNDATION TYPE		0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE		0.57	0.57	0.57	0.57	0.17	0.17	0.17	0.17	0.26	0.26	0.26	0.26
MH-% WITH AC		0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Weights Used in Aggregation Process (contd)

	W				W				S			
	SEATTLE-GAS				SEATTLE-HP/LPG				TAMPA-ELEC			
REGIONAL FORECASTS												
SF(a) -1988	235	235	235	235	235	235	235	235	428	428	428	428
1989	220	220	220	220	220	220	220	220	419	419	419	419
1990	245	245	245	245	245	245	245	245	464	464	464	464
1991	254	254	254	254	254	254	254	254	487	487	487	487
1992	259	259	259	259	259	259	259	259	501	501	501	501
1993	294	294	294	294	294	294	294	294	451	451	451	451
1994	256	256	256	256	256	256	256	256	456	456	456	456
1995	236	236	236	236	236	236	236	236	480	480	480	480
1996-2000	1100	1100	1100	1100	1100	1100	1100	1100	2110	2110	2110	2110
2001-2005	1040	1040	1040	1040	1040	1040	1040	1040	2055	2055	2055	2055
CITY'S SHARE	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.3	0.3	0.3	0.3
SF-FOUNDATION TYPE	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02	0.61	0.20	0.17	0.02
SF-FUEL TYPE	0.68	0.68	0.68	0.68	0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21
SF-% WITH AC	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.91	0.91	0.91	0.91
MF(b) -1988	132	132	132	132	132	132	132	132	143	143	143	143
1989	137	137	137	137	137	137	137	137	145	145	145	145
1990	155	155	155	155	155	155	155	155	162	162	162	162
1991	164	164	164	164	164	164	164	164	169	169	169	169
1992	164	164	164	164	164	164	164	164	178	178	178	178
1993	171	171	171	171	171	171	171	171	171	171	171	171
1994	168	168	168	168	168	168	168	168	168	168	168	168
1995	163	163	163	163	163	163	163	163	163	163	163	163
1996-2000	1455	1455	1455	1455	1455	1455	1455	1455	685	685	685	685
2001-2005	590	590	590	590	590	590	590	590	565	565	565	565
CITY'S SHARE	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.3	0.3	0.3	0.3
MF-FOUNDATION TYPE	0.7	0.16	0.06	0.08	0.7	0.16	0.06	0.08	0.66	0.12	0.08	0.14
MF-FUEL TYPE	0.53	0.53	0.53	0.53	0.2	0.2	0.2	0.2	0.45	0.45	0.45	0.45
MF-% WITH AC	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.99	0.99	0.99	0.99
MH(c) -1988	50	50	50	50	50	50	50	50	78	78	78	78
1989	49	49	49	49	49	49	49	49	77	77	77	77
1990	55	55	55	55	55	55	55	55	85	85	85	85
1991	57	57	57	57	57	57	57	57	89	89	89	89
1992	58	58	58	58	58	58	58	58	93	93	93	93
1993	63	63	63	63	63	63	63	63	85	85	85	85
1994	58	58	58	58	58	58	58	58	85	85	85	85
1995	54	54	54	54	54	54	54	54	88	88	88	88
1996-2000	348	348	348	348	348	348	348	348	381	381	381	381
2001-2005	222	222	222	222	222	222	222	222	357	357	357	357
CITY'S SHARE	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.30	0.30	0.30	0.30
MH-FOUNDATION TYPE	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE	0.57	0.57	0.57	0.57	0.17	0.17	0.17	0.17	0.34	0.34	0.34	0.34
MH-% WITH AC	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.78	0.78	0.78	0.78

Weights Used in Aggregation Process (contd)

		5 TAMPA-GAS				5 TAMPA-HP/LPG			
SF(a)	-1988	428	428	428	428	428	428	428	428
	1989	419	419	419	419	419	419	419	419
	1990	464	464	464	464	464	464	464	464
	1991	437	437	437	487	437	487	487	437
	1992	501	501	501	501	501	501	501	501
	1993	451	451	451	451	451	451	451	451
	1994	456	456	456	456	456	456	456	456
	1995	480	480	460	430	460	430	480	480
	1996-2000	2110	2110	2110	2110	2110	2110	2110	2110
	2001-2005	2055	2055	2055	2055	2055	2055	2055	2055
CITY'S SHARE		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SF-FOUNDATION TYPE		0.64	0.20	0.14	0.02	0.64	0.20	0.14	0.02
SF-FUEL TYPE		0.31	0.31	0.31	0.31	0.48	0.48	0.48	0.48
SF-% WITH AC		0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
MF(b)	-1988	143	143	143	143	143	143	143	143
	1989	145	145	145	145	145	145	145	145
	1990	162	162	162	162	162	162	162	162
	1991	169	169	169	169	169	169	169	169
	1992	178	178	178	178	178	178	178	178
	1993	171	171	171	171	171	171	171	171
	1994	168	168	168	168	168	168	168	168
	1995	163	163	163	163	163	163	163	163
	1996-2000	685	685	685	685	685	685	685	685
	2001-2005	565	565	565	565	565	565	565	565
CITY'S SHARE		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MF-FOUNDATION TYPE		0.66	0.12	0.03	0.14	0.66	0.12	0.08	0.14
MF-FUEL TYPE		0.13	0.13	0.13	0.13	0.42	0.42	0.42	0.42
MF-% WITH AC		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
MH(c)	-1988	78	78	78	78	78	78	78	78
	1989	77	77	77	77	77	77	77	77
	1990	85	85	85	85	85	85	85	85
	1991	89	89	89	89	89	89	89	89
	1992	93	93	93	93	93	93	93	93
	1993	85	85	65	85	85	85	85	85
	1994	85	85	85	85	85	85	85	85
	1995	38	88	88	88	88	88	83	88
	1996-2000	381	381	381	381	381	381	381	381
	2001-2005	357	357	357	357	357	357	357	357
CITY'S SHARE		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
MH-FOUNDATION TYPE		0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
MH-FUEL TYPE		0.31	0.31	0.31	0.31	0.35	0.35	0.35	0.35
MH-% WITH AC		0.78	0.78	0.78	0.78	0.73	0.78	0.78	0.78

(a) Single-Family
(b) Multi-Family
(c) Manufactured Housing
(d) Four columns represent foundation types: Slab, Crawlspace, Unheated Basement, Heated Basement.

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