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EXECUTIVE SUMMARY

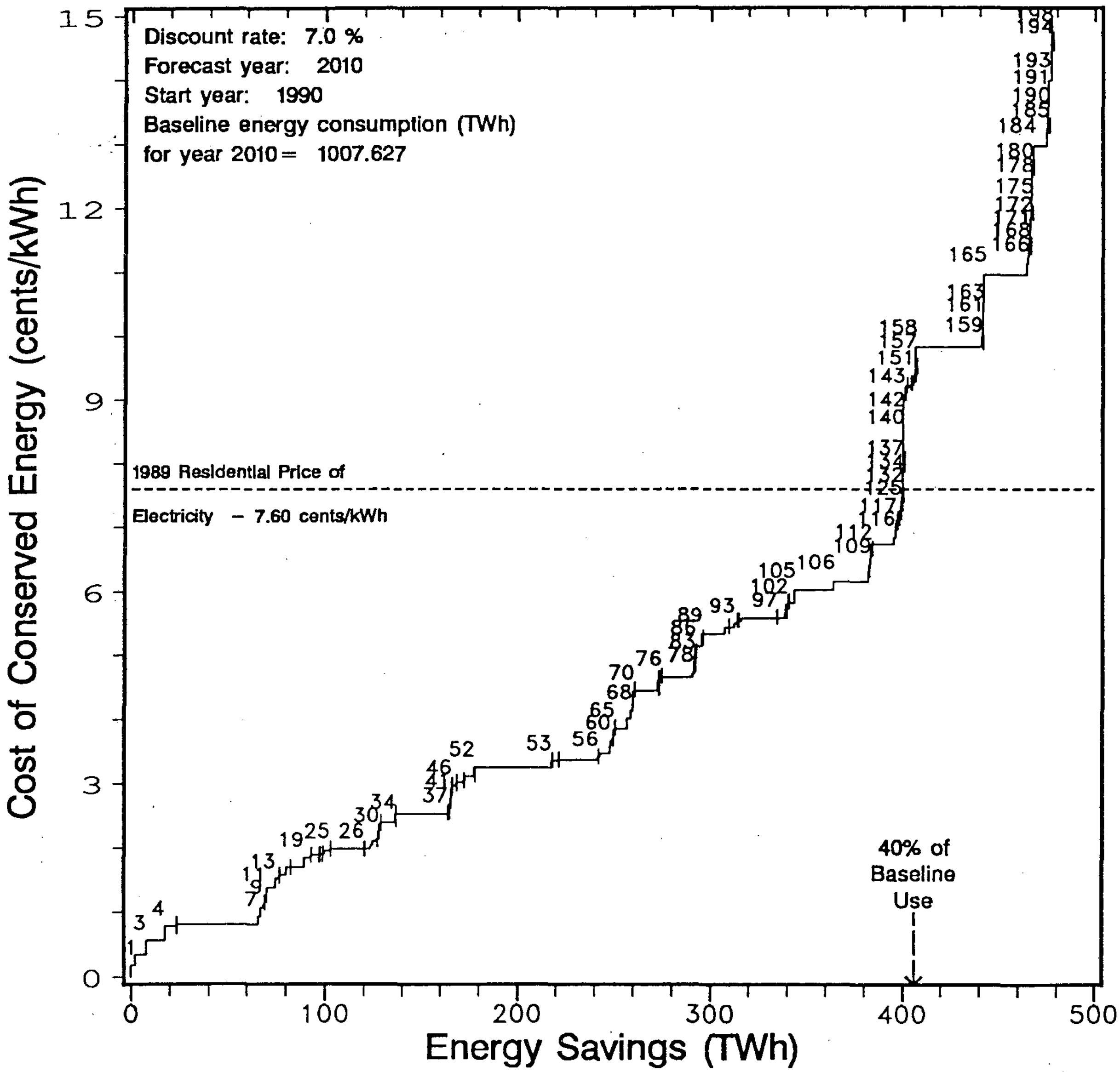
This report describes and documents an ongoing analysis of the technical potential for electricity efficiency improvements in the U.S. residential sector. Previous analyses have estimated the conservation potential for other countries, states, or individual utility service territories. As concern over greenhouse gas emissions has increased, interest has grown in estimates of conservation potential for the U.S. residential sector as a whole. Earlier estimates of U.S. conservation potential are either out of date or are less detailed than is desirable for engineering-economic estimates of the costs of reducing carbon emissions.

This study represents the most elaborate assessment to date of U.S. residential sector electricity efficiency improvements. It relies on regional disaggregation of input data, a state-of-the-art database of appliance efficiency and costs developed for the U.S. Department of Energy, and detailed analysis of thermal integrity measures in single-family dwellings. Fuel switching from electricity to direct use of natural gas has been included for water heaters, ranges, and clothes dryers. Advanced technologies (including "superwindows", spectrally-selective glazings, evacuated panels for refrigerators, and heat-pump water heaters) have been included based on engineering estimates of their costs and dates of availability.

Some promising efficiency technologies have been omitted because we lacked data, including thermal integrity improvements for new and existing multifamily buildings and mobile homes, integrated appliances, and advanced insulation technologies for new single-family homes. This study also does not include load management technologies (which may improve the overall efficiency of the electric utility system) or electrotechnologies that may increase the use of electricity but reduce primary energy consumption.

Efficiency improvements have been characterized in terms of their cost of conserved energy ($/kWh), for convenient comparison with the cost of competing electricity generating technologies. Figure ES-1 summarizes the results of this cost analysis. The total technical potential (without considering cost) is about 486 TWh, or about 48% of the frozen efficiency baseline. Total technical potential savings costing less than 7.6¢/kWh are 404 TWh/year by 2010, at an average cost of 3.4 ¢/kWh. If fully captured, savings costing less than 7.6¢/kWh would correspond to the output of 70-75 baseload (1000 MW) coal or nuclear plants.

Figure ES-1: Maximum Technical Potential in 2010

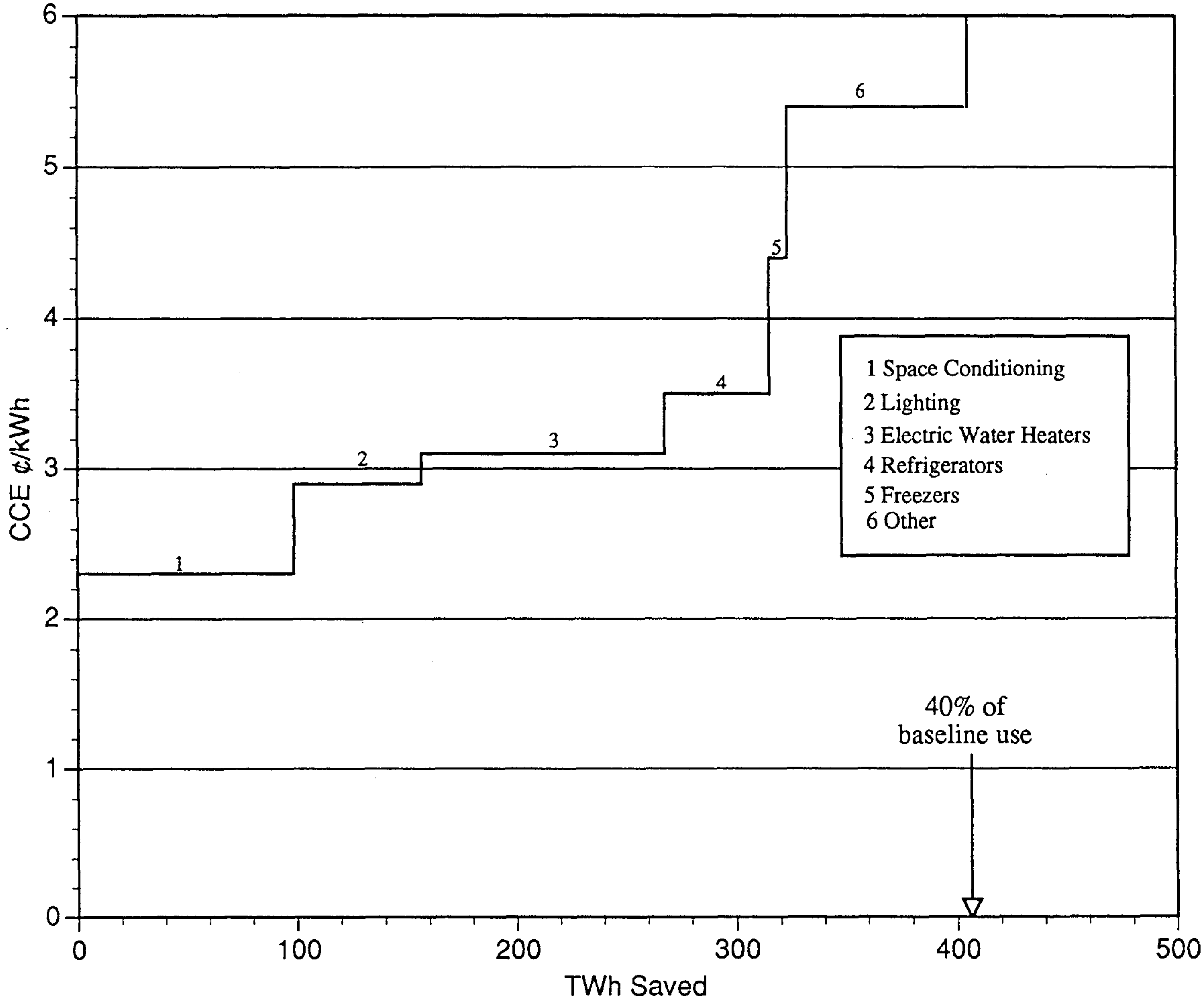


A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measures). The width of the step indicates the nationwide electricity savings from the measure and the height of the measure indicates the cost of conserved electricity. The end uses include space conditioning, water heating, refrigeration, lighting, and miscellaneous.

Figure ES-2 shows that electric water heating measures offer the largest potential savings (in absolute terms) for costs less than 7.6¢/kWh of any single end use (slightly more than 110 TWh, of which about 17 TWh, or roughly 15%, is attributable to fuel switching to natural gas). Savings from space conditioning are next most important in absolute terms, totalling about 100 TWh. Lighting measures save about 60 TWh, as do refrigerator and freezer measures together. In percentage terms (relative to each end-use category's baseline usage), water heating savings potential is the greatest (60%), followed by lighting (47%), refrigerators (39%), and space conditioning (31%).

Some of the technologies identified in this study will be adopted as the result of market forces, hence some of the efficiency improvements embodied in these technologies are reflected (either explicitly or implicitly) in government agencies' and utilities' business-as-usual projections of electricity demand. Nonetheless, our analysis shows that a significant potential exists to reduce residential electricity demand compared to projected demand in 2010.

Figure ES-2: Energy Savings and Costs by End-Use in 2010



Each segment of this curve shows the total electricity savings and the average cost of conserved energy for all measures in Figure ES-1 that cost less than 7.6¢/kWh (grouped by end use).

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I. INTRODUCTION

This study represents the most elaborate assessment to date of U.S. residential sector electricity efficiency improvements. Previous analyses (Bodlund et al. 1989, Geller et al. 1986, Hunn et al. 1986, Krause et al. 1987, Lovins 1987, Meier et al. 1983, Miller et al. 1989, NEEPC 1987, NPPC 1986, NPPC 1989, Usibelli et al. 1983, XENERGY 1990) have estimated the conservation potential for other countries, states, or individual utility service territories. As concern over greenhouse gas emissions has increased, interest has grown in estimates of conservation potential for the U.S. residential sector as a whole. The earliest detailed estimate of U.S. conservation potential is now out of date (SERI 1981), while more recent estimates (Carlsmith et al. 1990, EPRI 1990) are less detailed than is desirable for engineering-economic estimates of the costs of reducing carbon emissions.

In this paper, we first describe the methodology for creating supply curves of conserved energy, and then illustrate the subtleties of assessing the technical conservation potential. Next, we present the data and forecasts used in this assessment, including costs, baseline thermal characteristics, energy use, and energy savings. Finally, we present the main results and conclusions from the analysis, and discuss future work.

II. METHODOLOGY

The two essential elements of an analysis of future conservation potential are: 1) a database of measures for improving energy efficiency, including costs and energy savings for each measure, and 2) a detailed baseline forecast of typical future technologies that will be installed in the absence of policy action, including the number of devices, their cost, and their expected energy consumption. A supply curve analysis involves "implementing" the conservation options and calculating how that implementation would change the energy use in the baseline forecast.

Section II.A describes in general terms the concept of conservation supply curves. Section II.B presents the definitions and general assumptions used in this analysis. Section II.C describes the baseline frozen efficiency forecast, and Section II.D discusses the database of conservation measures.

A. Supply curves of conserved energy

Previous analyses have developed and used the concept of *supply curves of conserved energy* for assessing conservation potentials (Bodlund et al. 1989, Geller et al. 1986, Hunn et al. 1986, Krause et al. 1987, Lovins 1987, Meier et al. 1983, Miller et al. 1989, NEEPC 1987, NPPC 1986, NPPC 1989, Usibelli et al. 1983, XENERGY 1990) A supply curve of conserved energy is a graph that shows the amount of energy saved (TWh) on the x-axis and the cost of conserved energy or CCE (¢/kWh) on the y-axis.[1]

CCE is calculated using Equation (1):

$$\text{CCE (¢/kWh)} = \frac{\text{Capital Cost x } \dfrac{d}{(1-(1+d)^{-n})}}{\text{Annual Energy Savings}} \qquad (1)$$

[1]For more details see Meier et al. (1983).

where d is the discount rate (7%) and n is the lifetime of the conservation measure. The numerator in the right hand side of Equation 1 is the annualized cost of the conservation investment. Dividing annualized cost by annual energy savings yields the CCE, which can be compared to the busbar cost of a power plant.

Method of ranking conservation measures

To create the supply curve, conservation measures are ranked in order of increasing CCE. Determining this order is simple for efficiency measures that are independent. However, the ranking becomes complex when the energy saved by one conservation measure depends on the efficiency measures that have been implemented previously. For example, a typical supply curve might include conservation measures applied to a residential water heating system. The energy savings attributed to an improvement in the water heater's efficiency will depend on the amount of hot water demanded, which, in turn, will depend on the measures that have already been implemented (such as low-flow showerheads). Put another way, the sum of savings of each measure implemented alone will be greater than the two implemented together. If the interdependence of the measures is not taken into account, it is possible to "double-count" the energy savings.

A properly-constructed supply curve of conserved energy will avoid double-counting errors by using the following procedure:

(1) The CCE is calculated for all of the measures.

2) The cheapest (i.e., lowest CCE) measure is selected and "implemented", that is, the energy savings from the first measure are subtracted from the initial energy use.

3) The new energy use is used to recalculate the CCEs of the remaining measures. (In general, their CCEs will rise.)

4) The measure with the next lowest CCE is selected, and implemented.

5) The energy savings of the remaining measures are recalculated, and the measures are re-ranked.

This procedure is repeated until all the measures have been ranked (Meier 1982). For this project, the determination of the optimal sequence is performed exogenously, before the measures are entered in the supply curve program.[2]

Cost effectiveness

The CCE is, in most cases, independent of electricity price[3], and hence cannot by itself indicate whether a conservation measure is cost effective. By cost effective, we mean that the cost of investing in conservation is lower than the costs avoided by this investment.

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[2] We call this program ACCESS (this name is not an acronym).

[3]our characterization of fuel switching from electricity to direct use of natural gas includes the present valued cost of gas in the CCE (see below). This convention makes the CCE for fuel switching consistent with the CCEs for efficiency improvements, but it makes the CCE for fuel switching resources dependent on the price forecast for natural gas.

The assessment of cost effectiveness cannot be undertaken without specifying the perspective of the actors from whom it should be measured, such as the electric utility, a utility customer, or society as a whole (Krause and Eto 1988). We adopt the societal perspective here.[4]

The CCE is typically compared with the national average price of electric power to residential customers (7.6¢/kWh in 1989) as a rough gauge of cost effectiveness. This simple comparison can be misleading. In principle, the cost of a conservation measure should be compared to the *utility costs avoided* by that efficiency measure, which may or may not correspond to the *average price* of electricity.

We show the cost of electricity on the supply curves for rough comparisons, but emphasize that a consistent comparison between supply and demand-side resources requires using appropriate risk-based discount rates to calculate the busbar cost of new electric supply resources (Kahn 1988), the avoided capital costs of transmission and distribution (Orens 1989), the societal value of avoided pollutant emissions and other externalities (Chernick and Caverhill 1989, Hohmeyer 1988, Koomey 1990a, Ottinger et al. 1990), and the administrative, monitoring, and overhead costs of demand-side options (Berry 1989, Krause et al. 1989). Such a comparison should be undertaken as an extension of this paper. For further discussion of such comparisons, see Krause et al. (1991).

Our analysis uses a *real discount rate, without inflation,* which results in capital costs per kWh that are lower than those calculated using nominal discount rates including inflation and taxes. The omission of taxes does not affect the cost-effectiveness comparison as long as the conservation is assumed to be purchased entirely by the residential customer or expensed by the utility (the most common method for utility programs).

Frozen efficiency baseline

Our analysis begins with a *frozen efficiency baseline.* Such a forecast assumes that equipment and buildings existing in 1990 are not retrofit during the analysis period, and remain at constant efficiency until 2010 (or until they retire). New and replacement equipment and buildings are assumed to be installed at the efficiency level of new devices in 1990, but saturations are allowed to vary over the analysis period.[5] Average energy efficiency improves in the frozen efficiency case, because of replacement of existing structures and equipment with more efficient new devices. Appliance efficiency standards due to be implemented in 1992, 1993, and 1994 are represented as measures on the supply curve.

The LBL Residential Energy Model (LBL REM) is an end-use forecasting model that we use to estimate frozen efficiency case saturations and projected unit energy consumptions (UECs) for all non-space conditioning end-uses (see LBL REM (1991) and McMahon (1986)). Saturations for space conditioning end-uses are taken from US DOE

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[4]The discount rate we use (7% real) is probably high for a societal analysis, since the real rate of interest on long-term treasury notes averages 3-4% real. The real return on investment for electric utilities has averaged 5-7% real in the last decade (Koomey 1990b), and since utility resources would be avoided by our efficiency investments, we chose 7%. Reducing the discount rate to 3% would decrease the cost of conserved energy by 29%.

[5]Non-space conditioning saturations have been taken from LBL REM (1991) and vary over time. Space conditioning saturations do not vary in our analysis.

(1989a) and UECs for these end-uses are calculated directly from our building prototypes. LBL REM does not currently contain sufficient detail on space conditioning end-uses to use the saturations and UECs from its frozen efficiency case.

Technical conservation potential

This study estimates the *technical potential*, which is defined by Krause et al. (1987) as the amount of energy savings that could be achieved if all households install the most efficient devices, without considering lag times and other practical constraints associated with real-world programs. Level of service is kept constant in this analysis.

Achievable conservation potential

In practice, the technical potential is an upper limit to the amount of efficiency that can be captured by utilities. Markets will eventually capture part of this technical potential, though information barriers, capital constraints, risk aversion, bounded rationality, satisficing behavior, regulatory distortions, and other market failures prevent the market from capturing it all. Some of these market failures can be partially or totally overcome, which would allow some fraction of the technical potential to be captured by utility or government programs (Koomey 1990b).

To reflect utility program costs, the societal cost of conserved energy should be increased by 10 to 20% (Berry 1989, Krause et al. 1987, Nadel 1990, NPPC 1989).[6] We do not include this cost here, because we are estimating the technical potential. *However, analysts who use our technical potential estimates to derive achievable potential* ***must*** *include this cost.*

Summary

Figure 1, adopted from Krause et al. (1987), shows schematically how the frozen efficiency baseline compares to the technical potential case as well as to a hypothetical achievable potential case. Only the frozen efficiency baseline and technical potential cases are included in this analysis. The business as usual case with no additional policies represents what will happen given existing regulations and market forces (it includes appliance efficiency standards scheduled to take effect in 1992, 1993, and 1994, and the effect of exogenous changes in electricity prices).

B. Definitions and general assumptions

This section describes the major assumptions adopted for this analysis. For more details on terminology, assumptions, or calculational methods, see Appendix 10.

Discount rate and inflation

The discount rate is 7% real. All costs are expressed in constant 1989 dollars, net of inflation.

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[6]20% is a conservative number based on experience with current programs, while 10% implies some economies of scale and learning curve effects that would be captured by aggressive programs. Program costs for particular end-uses may be lower or higher than these crude averages (individual programs for specific end-uses may differ from these overall averages).

Figure 1: Relationship Between Frozen Efficiency and Maximum Technical Potential

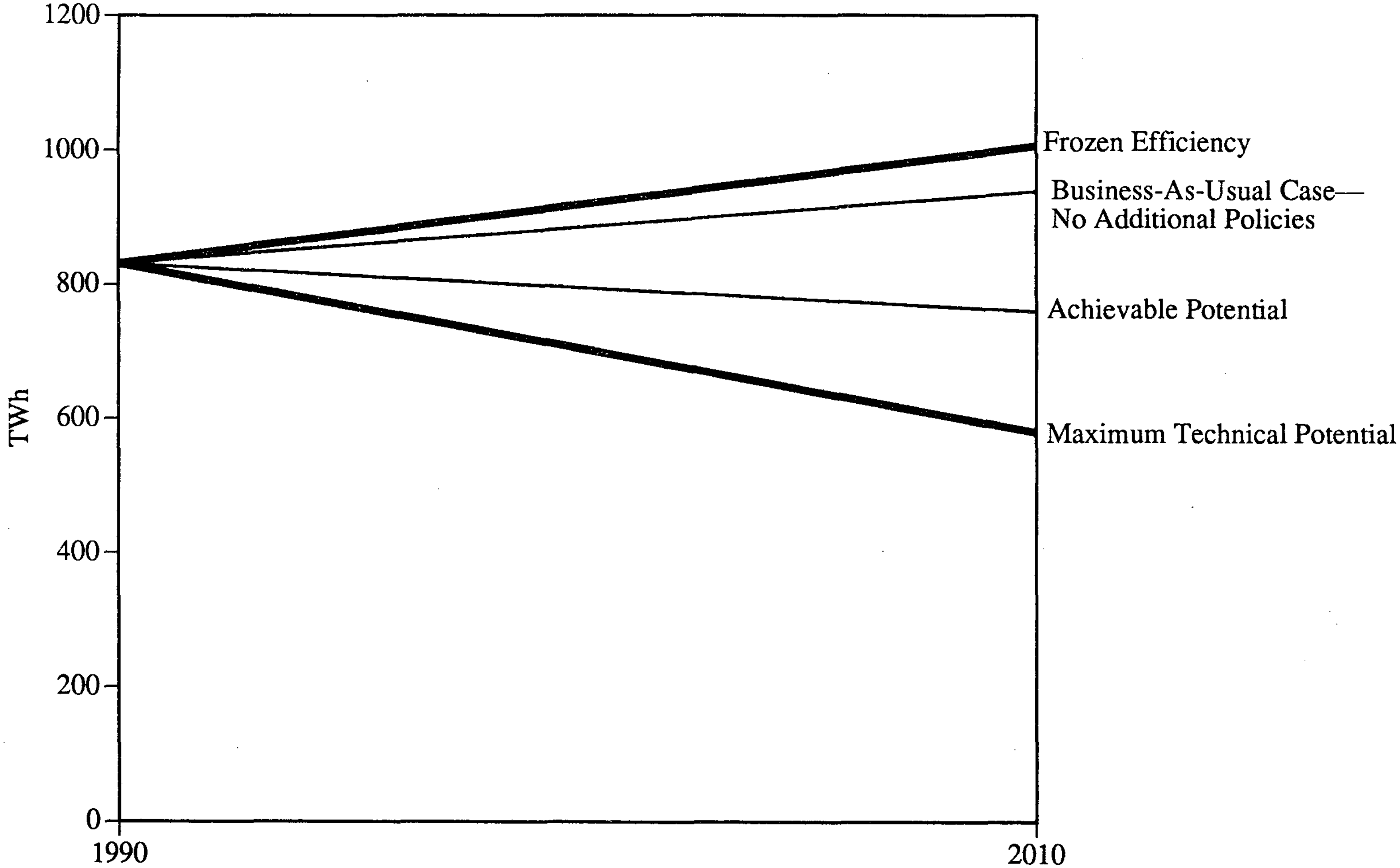


Figure adopted from Krause et al. (1987)

Analysis period

We consider the potential for energy efficiency improvements over the period 1990 to 2010. As longer time horizons are considered, potential savings increase but uncertainty about input parameters also increases.

Conservation costs

All costs are installed costs to the consumer. Space conditioning equipment and building shell improvement costs represent the cost of contractor installation. *No utility or government administrative costs are included.*

Retrofits and replacements

Shell retrofits are assumed to occur at a rate sufficient to retrofit all such shells by 2010. Replacement of existing equipment and appliances varies depending on the device lifetime. For an appliance with a ten year lifetime, 10% (1/10) of the equipment existing in 1990 is replaced each year. This replacement rate is linear, not exponential, and is only a crude approximation to actual retirement rates.

Technical potential

When calculating the technical potential for efficiency improvements, installation of conservation measures is affected solely by physical constraints. This convention becomes problematic when advanced technology options are considered that do not currently have substantial market shares and that would require major increases in production volume. For example, the logistic constraints involved in increasing production of heat pump water heaters are both physical and economic, and estimating how many could be produced is not solely a technical problem (see below). We attempt to account for these constraints by giving a *date of introduction* to advanced technologies.

Savings

Energy savings are calculated relative to the frozen efficiency baseline, assuming that level of service remains constant. Savings are measured at the customer's meter, and do not include the roughly 5-8% in avoided transmission and distribution losses from delivering the electricity. These losses must be included when comparing power plants to energy efficiency resources.

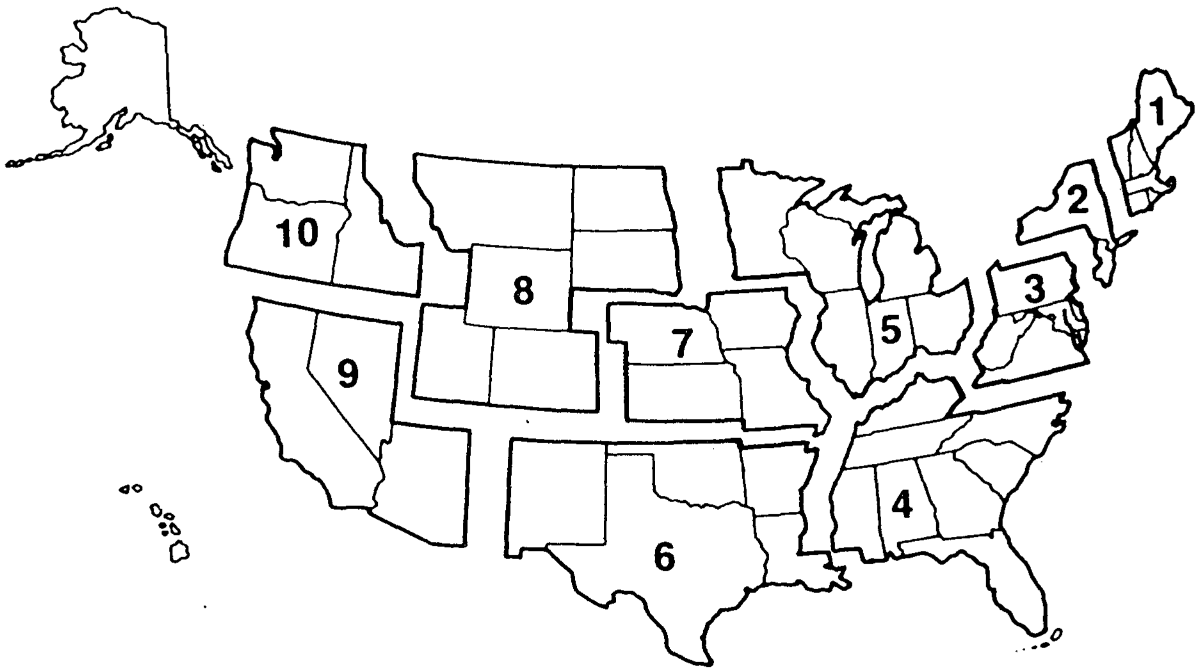
C. Frozen efficiency baseline forecast

Defining the frozen efficiency baseline estimate of energy consumption is a difficult but crucial exercise, because energy savings depend directly upon this baseline. If the baseline estimate is biased in one direction or another, the energy savings will be correspondingly affected The following section briefly describes the characteristics of our baseline forecast.

Regional disaggregation

We treat the U.S. as two distinct regions (north and south), but present the results for the U.S. as a whole. The south region is composed of the states in Federal (US DOE) regions 4, 6, and 9, while the north region is composed of the states in Federal regions 1, 2, 3, 5, 7, 8, and 10. **Figure 2** shows these regions.

Figure 2: Federal Regions



Region 1
New England
Connecticut (CT)
Maine (ME)
Massachusetts (MA)
New Hampshire (NH)
Rhode Island (RI)
Vermont (VT)

Region 2
New York/
New Jersey
New Jersey (NJ)
New York (NY)

Region 3
Mid Atlantic
Delaware (DE)
District of Columbia (DC)
Maryland (MD)
Pennsylvania (PA)
Virginia (VA)
West Virginia (WV)

Region 4
South Atlantic
Alabama (AL)
Florida (FL)
Georgia (GA)
Kentucky (KY)
Mississippi (MS)
North Carolina (NC)
South Carolina (SC)
Tennessee (TN)

Region 5
Midwest
Illinois (IL)
Indiana (IN)
Michigan (MI)
Minnesota (MN)
Ohio (OH)
Wisconsin (WI)

Region 6
Southwest
Arkansas (AR)
Louisiana (LA)
New Mexico (NM)
Oklahoma (OK)
Texas (TX)

Region 7
Central
Iowa (IA)
Kansas (KS)
Missouri (MO)
Nebraska (NE)

Region 8
North Central
Colorado (CO)
Montana (MT)
North Dakota (ND)
South Dakota (SD)
Utah (UT)
Wyoming (WY)

Region 9
West
Arizona (AZ)
California (CA)
Hawaii (HI)
Nevada (NV)

Region 10
Northwest
Alaska (AK)
Idaho (ID)
Oregon (OR)
Washington (WA)

South Region is defined as Federal Regions 4, 6, and 9.

North Region is defined as Federal Regions 1, 2, 3, 5, 7, 8, and 10

Housing starts and retirements

Table 1 shows housing starts and stocks for the U.S. as a whole, and **Tables 2 and 3** show housing units for the north and south regions, respectively. Single-family homes dominate the total, comprising about 67% of homes in the U.S. About two thirds of single/multi-family homes existing in 1990 will remain in 2010, while only one third of mobile homes existing in 1990 will remain in 2010 (due to their relatively short lifetimes). Annual percentage growth in single-family and multi-family homes is slightly higher in the south than in the north. Mobile homes are projected to grow more quickly in percentage terms than are single-family or multi-family homes, but this growth is exclusively in the southern region. Stocks and forecasts are from LBL REM (1991) and MHI (1989, 1990, 1991b)

Building and equipment lifetimes

Table 4 shows lifetimes for space conditioning equipment, appliances, and building shells. These lifetimes are used to estimate the rate of stock turnover of these devices, and to calculate the cost of conserved energy. Major appliances range in lifetime from 12 years for central air conditioners to 23 years for furnaces.

Weather

Estimates of space conditioning energy use rely on building energy simulation programs that use weather files for representative U.S. cities. We estimated the population-weighted average weather for the north and south regions of the U.S. using a climate averaging program (GLOM) developed at Lawrence Berkeley Laboratory (Andersson et al. 1986). GLOM revealed that Chicago, Illinois approximates average weather for the north, and Charleston, SC approximates the weather for the south.[7] In cases where weather files for these two cities were not available (e.g., when using data from Ritschard and Huang for multifamily prototypes), we used the next closest cities and adjusted space conditioning energy consumption by ratios of heating degree days and cooling degree days.

Thermal characteristics of buildings

Table 5 shows average shell characteristics of new and existing residential buildings, based on a variety of sources (Boghosian 1991, Koomey et al. 1991, Lee 1991, MHI 1991a, MHI 1991b, Mills 1984). When possible, characteristics have been compared to and made consistent with those found in the U.S. Department of Energy's Residential Energy Consumption Surveys (RECS) (US DOE 1984, US DOE 1989a). These characteristics are then input to our building energy simulation program (see Appendix 7 for the detailed input files to this program).

Floor area: Table 5 shows that average floor areas are uniformly larger for new buildings than for existing buildings.

Ceiling insulation: Average ceiling insulation levels range from R-17 to R-24 for existing single-family (SF) dwellings, and from R-25 to R-29 for new SF buildings. Ceiling insulation levels for existing mobile homes (MHs) are significantly lower than for

[7]Heating degree days for Chicago and Charleston (65 degrees F base) are 6125 and 2146, respectively. Cooling degree days (65 degrees F base) are 923 and 2077, respectively.

Table 1: Existing and forecasted housing units in the United States

in millions of units	*1990*	*1995*	*2000*	*2005*	*2010*	*Annual % growth 1990-2010*	*Total % growth 1990-2010*	*Average annual Δ units (x10^6) 1990-2010*	*Total Δ units (x10^6) 1990-2010*
Single-family total	*63.3*	*67.9*	*72.3*	*76.6*	*78.5*	1.1%	24.1%	0.76	15.23
Existing (1990)	63.3	61.0	58.6	56.0	53.3	-0.9%	-15.8%	-0.50	-10.01
New (post 1990)	0.0	6.9	13.7	20.6	25.2	N/A	N/A	1.26	25.24
Multi-family total	*26.5*	*28.4*	*30.3*	*32.1*	*32.9*	1.1%	24.1%	0.32	6.38
Existing (1990)	26.5	25.5	24.3	23.1	21.8	-1.0%	-17.6%	-0.23	-4.67
New (post 1990)	0.0	3.0	6.0	9.0	11.1	N/A	N/A	0.55	11.05
Mobile homes total	*4.2*	*4.6*	*5.1*	*5.8*	*6.5*	2.2%	55.3%	0.12	2.3
Existing (1990)	4.2	3.5	3.0	2.6	2.2	-3.2%	-47.8%	-0.10	-1.99
New (post 1990)	0.0	1.0	2.1	3.3	4.3	N/A	N/A	0.21	4.29
Total	94.0	100.9	107.7	114.5	117.9	1.1%	25.4%	1.20	23.91
As % of house type totals									
Single-family total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	90%	81%	73%	68%	-1.9%	-32.1%		
New (post 1990)	0%	10%	19%	27%	32%	N/A	N/A		
Multi-family total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	90%	80%	72%	66%	-2.0%	-33.6%		
New (post 1990)	0%	10%	20%	28%	34%	N/A	N/A		
Mobile homes total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	77%	59%	44%	34%	-5.3%	-66.4%		
New (post 1990)	0%	23%	41%	56%	66%	N/A	N/A		
As % of total units									
Single-family total	*67%*	*67%*	*67%*	*67%*	*67%*	-0.1%	-1.1%		
Existing (1990)	67%	60%	54%	49%	45%	-2.0%	-32.9%		
New (post 1990)	0%	7%	13%	18%	21%	N/A	N/A		
Multi-family total	*28%*	*28%*	*28%*	*28%*	*28%*	-0.1%	-1.1%		
Existing (1990)	28%	25%	23%	20%	19%	-2.1%	-34.3%		
New (post 1990)	0%	3%	6%	8%	9%	N/A	N/A		
Mobile homes total	*4%*	*5%*	*5%*	*5%*	*5%*	1.1%	23.8%		
Existing (1990)	4%	4%	3%	2%	2%	-4.3%	-58.4%		
New (post 1990)	0%	1%	2%	3%	4%	N/A	N/A		
Total	*100%*	*100%*	*100%*	*100%*	*100%*				

(1) Single family and multi family stocks are from LBL Residential Energy Model federal region projections of existing stock and additions.
(2) Mobile home 1990 stock is from MHI data for year-round occupied MHs with no permanent room attached (Census data treats MHs with permanent rooms as SF homes), updated to 1990 from 1989 using REM. We assume an exponential retirement rate of 3% per year, from MHI's average lifetime of 33.8 years. Of U.S. mobile homes existing in 1990, 42% are in the north and 58% in the south (MHI 1989).
(3) Mobile home additions are from REM national projections. We assume the fraction of additions in the north and south in 1989 (derived from MHI data) remain constant. 82% of new mobile homes are projected to be built in the south and 18% are projected to be built in the north.

Table 2: Existing and forecasted housing units in the north

in millions of units	*1990*	*1995*	*2000*	*2005*	*2010*	*Annual % growth 1990-2010*	*Total % growth 1990-2010*	*Average annual Δ units (x10^6) 1990-2010*	*Total Δ units (x10^6) 1990-2010*
Single-family total	*35.0*	*37.3*	*39.5*	*41.6*	*42.3*	1.0%	21.1%	0.37	7.36
Existing (1990)	35.0	33.7	32.4	31.0	29.5	-0.8%	-15.6%	-0.27	-5.47
New (post 1990)	0.0	3.6	7.1	10.6	12.8	N/A	N/A	0.64	12.83
Multi-family total	*16.6*	*17.6*	*18.7*	*19.7*	*20.0*	1.0%	21.0%	0.17	3.47
Existing (1990)	16.6	15.9	15.2	14.4	13.7	-1.0%	-17.4%	-0.14	-2.88
New (post 1990)	0.0	1.8	3.5	5.2	6.4	N/A	N/A	0.32	6.35
Mobile homes total	*1.8*	*1.7*	*1.6*	*1.7*	*1.7*	-0.2%	-4.6%	0.00	-0.08
Existing (1990)	1.8	1.5	1.3	1.1	0.9	-3.2%	-48.0%	-0.04	-0.84
New (post 1990)	0.0	0.2	0.4	0.6	0.8	N/A	N/A	0.04	0.76
Total	53.3	56.6	59.8	62.9	64.0	0.9%	20.2%	0.54	10.75
As % of house type totals									
Single-family total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	90%	82%	74%	70%	-1.8%	-30.3%		
New (post 1990)	0%	10%	18%	26%	30%	N/A	N/A		
Multi-family total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	90%	81%	73%	68%	-1.9%	-31.7%		
New (post 1990)	0%	10%	19%	27%	32%	N/A	N/A		
Mobile homes total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	89%	77%	65%	54%	-3.0%	-45.5%		
New (post 1990)	0%	11%	23%	35%	46%	N/A	N/A		
As % of total units									
Single-family total	*66%*	*66%*	*66%*	*66%*	*66%*	0.0%	0.7%		
Existing (1990)	66%	60%	54%	49%	46%	-1.8%	-29.8%		
New (post 1990)	0%	6%	12%	17%	20%	N/A	N/A		
Multi-family total	*31%*	*31%*	*31%*	*31%*	*31%*	0.0%	0.7%		
Existing (1990)	31%	28%	25%	23%	21%	-1.9%	-31.3%		
New (post 1990)	0%	3%	6%	8%	10%	N/A	N/A		
Mobile homes total	*3%*	*3%*	*3%*	*3%*	*3%*	-1.1%	-20.6%		
Existing (1990)	3%	3%	2%	2%	1%	-4.1%	-56.7%		
New (post 1990)	0%	0%	1%	1%	1%	N/A	N/A		
Total	*100%*	*100%*	*100%*	*100%*	*100%*				

(1) North is defined as Federal regions 1, 2, 3, 5, 7, 8, and 10.
(2) Single family and multi family stocks are from LBL Residential Energy Model federal region projections of existing stock and additions.
(3) Mobile home 1990 stock is from MHI data for year-round occupied MHs with no permanent room attached (Census data treats MHs with permanent rooms as SF homes), updated to 1990 from 1989 using REM. We assume an exponential retirement rate of 3% per year, from MHI's average lifetime of 33.8 years. Of U.S. mobile homes existing in 1990, 42% are in the north and 58% in the south (MHI 1989).
(4) Mobile home additions are from REM national projections. We assume the fraction of additions in the north and south in 1989 (derived from MHI data) remain constant. 82% of new mobile homes are projected to be built in the south and 18% are projected to be built in the north.

Table 3: Existing and forecasted housing units in the south

in millions of units	*1990*	*1995*	*2000*	*2005*	*2010*	*Annual % growth 1990-2010*	*Total % growth 1990-2010*	*Average annual Δ units (x10^6) 1990-2010*	*Total Δ units (x10^6) 1990-2010*
Single-family total	*28.3*	*30.6*	*32.8*	*35.0*	*36.2*	1.2%	27.8%	0.39	7.87
Existing (1990)	28.3	27.3	26.2	25.0	23.8	-0.9%	-16.0%	-0.23	-4.54
New (post 1990)	0.0	3.3	6.6	10.0	12.4	N/A	N/A	0.62	12.41
Multi-family total	*10.0*	*10.8*	*11.6*	*12.4*	*12.9*	1.3%	29.2%	0.15	2.91
Existing (1990)	10.0	9.6	9.1	8.7	8.2	-1.0%	-18.0%	-0.09	-1.79
New (post 1990)	0.0	1.2	2.5	3.8	4.7	N/A	N/A	0.24	4.7
Mobile homes total	*2.4*	*2.9*	*3.5*	*4.2*	*4.8*	3.5%	98.8%	0.12	2.38
Existing (1990)	2.4	2.1	1.8	1.5	1.3	-3.2%	-47.7%	-0.06	-1.15
New (post 1990)	0.0	0.9	1.8	2.7	3.5	N/A	N/A	0.18	3.53
Total	40.7	44.3	47.9	51.6	53.9	1.4%	32.3%	0.66	13.16
As % of house type totals									
Single-family total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	89%	80%	71%	66%	-2.1%	-34.3%		
New (post 1990)	0%	11%	20%	29%	34%	N/A	N/A		
Multi-family total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	89%	79%	70%	63%	-2.2%	-36.5%		
New (post 1990)	0%	11%	21%	30%	37%	N/A	N/A		
Mobile homes total	*100%*	*100%*	*100%*	*100%*	*100%*	0.0%	0.0%		
Existing (1990)	100%	70%	50%	36%	26%	-6.5%	-73.7%		
New (post 1990)	0%	30%	50%	64%	74%	N/A	N/A		
As % of total units									
Single-family total	*70%*	*69%*	*68%*	*68%*	*67%*	-0.2%	-3.4%		
Existing (1990)	70%	62%	55%	49%	44%	-2.2%	-36.5%		
New (post 1990)	0%	7%	14%	19%	23%	N/A	N/A		
Multi-family total	*24%*	*24%*	*24%*	*24%*	*24%*	-0.1%	-2.4%		
Existing (1990)	24%	22%	19%	17%	15%	-2.4%	-38.0%		
New (post 1990)	0%	3%	5%	7%	9%	N/A	N/A		
Mobile homes total	*6%*	*7%*	*7%*	*8%*	*9%*	2.1%	50.2%		
Existing (1990)	6%	5%	4%	3%	2%	-4.5%	-60.5%		
New (post 1990)	0%	2%	4%	5%	7%	N/A	N/A		
Total	*100%*	*100%*	*100%*	*100%*	*100%*				

(1) South is defined as Federal regions 4,6, and 9

(2) Single family and multi family stocks are from LBL Residential Energy Model federal region projections of existing stock and additions.

(3) Mobile home 1990 stock is from MHI data for year-round occupied MHs with no permanent room attached (Census data treats MHs with permanent rooms as SF homes), updated to 1990 from 1989 using REM. We assume an exponential retirement rate of 3% per year, from MHI's average lifetime of 33.8 years. Of U.S. mobile homes existing in 1990, 42% are in the north and 58% in the south (MHI 1989).

(4) Mobile home additions are from REM national projections. We assume the fraction of additions in the north and south in 1989 (derived from MHI data) remain constant. 82% of new mobile homes are projected to be built in the south and 18% are projected to be built in the north.

Table 4: Lifetimes of buildings, equipment, and shell measures

End use	*Average lifetime years*
Central space heating (electric)	23
Room air conditioners (RAC)	15
Central air conditioners (CAC)	12
Heat pump	14
Water heater (electric, gas)	13
Refrigerator	19
Freezer	21
Range/oven (electric, gas)	18
Dryer (electric, gas)	17
Lighting (2)	15
Dishwasher	12.6
Clothes washer	14.1
Miscellaneous	15
All building shell conservation measures	30
Single-family buildings	98
Multi-family buildings	89
Mobile homes	33.8

(1) source: LBL REM (1991), except for mobile homes, which are from MHI (1990)
(2) This is an artificial lifetime chosen for use in the ACCESS program. Actual equipment lifetimes are normalized to 15 years (see Appendix 6).

Table 5: Characteristics of baseline residential building prototypes

	Htg Type	Region	Floor area per unit square feet	Insulation levels Ceiling	Wall	Floor	Infiltration ACH	window layers
Existing single-family homes	elec res	North	1582	R-20.8	R-4.7	R-11	0.54	1.76
	elec res	South	1470	R-18	R-3.9	R-1.48, 2ft	0.71	1.53
	heat pump	North	1853	R-24	R-6.8	R-11	0.45	1.72
	heat pump	South	1784	R-21.5	R-6.2	R-1.68, 2ft	0.7	1.65
	non-elec	North	1550	R-21.1	R-2.1	R-11	0.62	1.79
	non-elec	South	1467	R-17.4	R-2.1	R-0.78, 2ft	0.72	1.44
New single-family homes	elec res	North	1856	R-29	R-15	R-15	0.4	2
	elec res	South	1894	R-28	R-10	R-3.8, 2ft	0.62	1.51
	heat pump	North	2222	R-28	R-14	R-13	0.4	1.87
	heat pump	South	1823	R-25	R-11	R-1.8, 2ft	0.63	1.69
	non-elec	North	2177	R-28	R-14	R-12	0.56	1.74
	non-elec	South	2071	R-25	R-12	R-1.9, 2ft	0.63	1.68
Multifamily								
Existing		North	1051	R-7	R-5			2
		South	945	R-4	R-2			1
New		North	1050	R-30	R-13			2
		South	968	R-21	R-12			2
Mobile homes								
Existing	elec res	North	1025	R-14.2	R-10.8	R-10.8	0.45	2
	elec res	South	940	R-10.8	R-10.8	R-6.8	0.56	1
	heat pump	North	800	R-14.2	R-10.8	R-10.8	0.45	2
	heat pump	South	1040	R-10.8	R-10.8	R-6.8	0.56	1
	non-elec	North	804	R-14.2	R-10.8	R-10.8	0.45	2
	non-elec	South	847	R-10.8	R-10.8	R-6.8	0.56	1
New		North	1195	R-26	R-18	R-14	0.36	2
		South	1195	R-20	R-12	R-10	0.45	1.26

(1) Building shell and infiltration characteristics for existing SF homes are from 1984 RECS (Boghosian 1991), updated to 1990 using the 1987 NAHB new home database (as summarized in Koomey et al. 1991). New SF home characteristics are from Koomey et al 1991.

(2) Floor insulation for the SF in the south is slab edge insulation to the R-value specified, to a depth of 2 feet. Floor insulation for SF existing in north is assumed to be R-11, as a conservatism. Floor conservation measures are only applied to unheated crawl spaces and basements for existing homes in the north.

(3) MF characteristics are averaged from Ritschard and Huang (1989), using 5 prototype buildings in Fort Worth for the south, and 4 prototypes in Chicago for the north. Ritschard and Huang do not consider prototypes for 1940s and 1950s buildings. We assume that 1940s buildings are the same as pre 1940s buildings, and that 1950s buildings are the same as 1960s buildings. Ritschard and Huang do not indicate the infiltration rates (in air changes per hour or ach) for their prototypes.

(4) Mobile home floor area is the national average for those sold in 1989, from Manufactured Housing Institute (MHI 1991b). MH infiltration rates are estimates from Allen Lee of Battelle PNL (personal communication, April 1991) of existing mobile homes in the Pacific Northwest. Lee's ACH of 0.4 was adjusted by the specific infiltration rate for our northern region in order to account for the difference in weather between Seattle and Chicago. We assumed that homes in the north and homes in Seattle would have the same specific leakage area. All other MH shell characteristics were obtained from Manufactured Housing Institute estimates of the most popular shell packages sold in 1990 by region (MHI 1991a).

Insulation levels for northern homes are uniformly higher than for southern homes.

Wall insulation: Just as for ceiling insulation, wall insulation in new buildings substantially exceeds that typically found in existing buildings. The wall insulation levels of structures in the north always equal or exceed those in the south.

Foundation characteristics: Other thermal integrity characteristics are amenable to averaging, while foundations are difficult to characterize because of the many different foundation types and methods of insulating them. Boghosian (1991) has attempted to overcome this problem using a "U" value per linear foot approach, but for simplicity, we have assumed that single family dwellings in the north have an unheated basement (with floor insulation of R-11, to be conservative), while SF dwellings in the south are slab homes. This assumption corresponds to the most commonly used foundations in homes in these regions.

Infiltration: Existing data on infiltration are poor. The infiltration rates used in this analysis were derived from Boghosian (1991), Koomey et al. (1991), and Lee (1991). Duct leakage, which can be substantial in centrally-conditioned homes (Brook 1991, Cummings et al. 1990), has not been included in the analysis due to lack of data. See the discussion below of *Improvements to the Analysis* (Part IV) for more explicit analysis of the potential effects of duct leakage.

Windows: Table 5 gives the average number of window panes for the building prototypes. Averaging the number of window panes in this manner will become a less and less reliable measure of window U-value as special coatings and noble-gas filled spaces between panes become commonplace. The estimates for SF buildings in Boghosian (1991) and Koomey et al. (1991) rely on data sources that do not distinguish windows by these special characteristics. No effort has been made to correct for this effect.

We have used the costs and thermal characteristics of triple pane windows and double pane low-emissivity windows interchangeably in this report. This assumption is probably conservative, since the cost of coatings is likely to decrease much faster than the costs of making a triple glazed window.

Space conditioning energy use

Tables 6 through 11 show space conditioning saturations, efficiencies, and unit energy consumptions (UECs) for existing and new single-family, multi-family, and mobile homes, respectively. Saturations for space conditioning equipment in existing homes are taken from US DOE (1989a). Saturations for new homes are from the same source, and represent a weighted average over all homes built 1980 to 1988, weighted using 1988 housing starts from Census (1990). Space conditioning UECs have been calculated using the batch version of PEAR (Program for the Energy Analysis of Residences), which is a residential building simulation model developed at Lawrence Berkeley Laboratory (EAP 1987). We have estimated the UECs and conservation potential separately for each combination of heating and cooling equipment, using the shell characteristics shown in Table 5 and equipment efficiencies from our national database (LBL 1990). Room air conditioner (RAC) UECs have been estimated from PEAR's central air conditioner (CAC) UECs by using regional ratios (adjusted to our north/south regions) of RAC UEC to CAC UEC from RCG/Hagler Bailly (1990).

Table 6: Heating and cooling of existing single-family buildings: saturations, efficiency, and electricity consumption

North Enduse Code	*Htg/Clg Type*	*% of all SF homes*	*Existing Htg/Clg Efficiency*	*Existing Htg UEC kWh/yr*	*Existing Clg UEC kWh/yr*	*Replacement Htg/Clg Efficiency*	*Replacement Htg UEC kWh/yr*	*Replacement Clg UEC kWh/yr*
ESNE	ER/ -	2%	100% / -	18311	0	100% / -	18311	0
ESNEC	ER/ CAC	2%	100% / 8.62 SEER	18311	1138	100% / 9.96 SEER	18311	985
ESNER	ER / RAC	2%	100% / 7.47 EER	18311	368	100% / 9.0 EER	18311	305
ESNHP	HP	3%	6.79 HSPF/ 8.59 SEER	9300	1176	7.24 HSPF/ 9.86 SEER	8722	1025
ESNG*	Gas-Other / -	38%	- / -	0	0	- / -	0	0
ESNGC*	Gas-Other / CAC	23%	- / 8.62 SEER	0	1162	- / 9.96 SEER	0	1006
ESNGR*	Gas-Other / RAC	29%	- / 7.47 EER	0	376	- / 9.0 EER	0	312
Total		100%						
South Enduse Code	*Htg/Clg Type*	*% of all SF homes*	*Existing Htg/Clg Efficiency*	*Existing Htg UEC kWh/yr*	*Existing Clg UEC kWh/yr*	*Replacement Htg/Clg Efficiency*	*Replacement Htg UEC kWh/yr*	*Replacement Clg UEC kWh/yr*
ESSE	ER/ -	3%	100% / -	8201	0	100% / -	8201	0
ESSEC	ER/ CAC	6%	100% / 8.62 SEER	8201	3739	100% / 9.96 SEER	8201	3236
ESSER	ER / RAC	3%	100% / 7.47 EER	8201	1325	100% / 9.0 EER	8201	1100
ESSHP	HP	8%	6.79 HSPF/ 8.59 SEER	4394	4077	7.24 HSPF/ 9.86 SEER	4121	3552
ESSG*	Gas-Other / -	33%	0	0	0	- / -	0	0
ESSGC*	Gas-Other / CAC	23%	- / 8.62 SEER	0	3842	- / 9.96 SEER	0	3325
ESSGR*	Gas-Other / RAC	24%	- / 7.47 EER	0	1362	- / 9.0 EER	0	1131
Total		100%						

* for baseline energy consumption only (no shell measures included). HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners

(1) All shell characteristics are from Boghosian, 1991 and are derived from RECS84 data updated to 1990 levels using the NAHB new home database created in Koomey et. al., 1991 (see Table 5 for more details). Due to time constraints, no foundation insulation measures for existing homes were included.

(2) Window area is assumed to be 10% of floor area.

(3) The saturations of heating/cooling types are from RECS87 Census region data converted to federal regions using 1980 Census state-by-state data.

(4) Equipment efficiencies are from LBL REM (1990 new unit and 1990 existing unit average efficiencies), based on extrapolation from 1987 ARI data.

(5) All UECs are from PEAR except for the room air conditioner UEC, which is assumed to be 34% of the PEAR-derived central air conditioner UEC. Room AC UEC was derived as a fraction of CAC UEC from utility data provided in RCG/Hagler Bailly Inc. (1990). All UECs for the north are based on a single story prototype home in Chicago, IL with unheated basement. All UECs for the south are based on a single story prototype home in Charleston, SC with slab foundation.

(6) Existing homes have two UECs. The "existing" UEC is calculated using the existing shell characteristics and the 1990 existing equipment efficiency from the LBL Residential Energy Model (LBL REM). The "replacement" UEC is calculated using the existing shell and the 1990 new unit efficiency from LBL REM.

(7) Furnace fan electricity use for non-electric furnaces is counted under the "Other" end-use category, and does not appear in this table.

(8) HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners

Table 7: Heating and cooling of new single-family buildings: saturations, efficiency, and electricity consumption

North Enduse Code	*Htg/Clg Type*	*% of all new SF homes*	*Htg/Clg Efficiency*	*Htg UEC kWh/yr*	*Clg UEC kWh/yr*
NSNE	ER/ -	7%	100%/ -	11809	0
NSNEC	ER/CAC	6%	100%/9.96 SEER	11809	964
NSNER	ER/RAC	2%	100%/9.0 EER	11809	299
NSNHP	HP/HP	17%	7.24 HSPF /9.86 SEER	6825	1048
NSNG*	Gas-Other / -	28%	- / -	0	0
NSNGC*	Gas-Other /CAC	31%	- /9.96 SEER	0	1042
NSNGR*	Gas-Other /RAC	9%	- /9.0 EER	0	323
Total		*100%*			
South* *Enduse Code	*Htg/Clg Type*	*% of all new SF homes*	*Htg/Clg Efficiency*	*Htg UEC kWh/yr*	*Clg UEC kWh/yr*
NSSE	ER/ -	5%	100%/ -	9114	0
NSSEC	ER/CAC	12%	100%/9.96 SEER	9114	3583
NSSER	ER/RAC	3%	100%/9.0 EER	9114	1218
NSSHP	HP/HP	26%	7.24 HSPF /9.86 SEER	3225	3408
NSSG*	Gas-Other / -	28%	- / -	0	0
NSSGC*	Gas-Other /CAC	20%	- /9.96 SEER	0	3576
NSSGR*	Gas-Other /RAC	7%	- /9.0 EER	0	1216
Total		*100%*			

* for baseline energy consumption only (no shell measures included). HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners

(1) All shell characteristics are from Koomey, et.al 1991. The characteristics were weighted by 1987 housing starts in the relevant federal regions.
(2) Window area is assumed to be 10% of floor area.
(3) The saturations of heating/cooling types are from RECS87 Census region data for homes built 1980-88, converted to federal regions using 1989 state-by-state housing start data from the 1990 Statistical Abstract of the United States.
(4) Equipment efficiencies are from LBL REM (1991) for 1990 new units (based on an extrapolation from 1987 ARI data).
(5) All new homes in the north are assumed to be two-story, basement foundation types, and in the south one-story, slab foundation types. These are the predominant configurations in these regions (from the NAHB new home database created in Koomey et.al., 1991).
(6) All UECs are from PEAR except for the room air conditioner UEC, which is assumed to be 34% of the PEAR-derived central air conditioner UEC. Room AC UEC was derived as a fraction of CAC UEC from utility data provided in RCG/Hagler Bailly Inc. 1990. Chicago weather was used for the northern prototype, and Charleston, SC weather for the southern prototype.
(7) Furnace fan electricity use for non-electric furnaces is counted as "miscellaneous energy" and does not appear in this table.
(8) HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners

Table 8: Heating and cooling of existing multi-family buildings: saturations, efficiency, and electricity consumption

North Enduse Code	*Htg/Clg Type*	*% of all SF homes*	*Existing Htg/Clg Efficiency*	*Existing Htg UEC kWh/yr*	*Existing Clg UEC kWh/yr*	*Replacement Htg/Clg Efficiency*	*Replacement Htg UEC kWh/yr*	*Replacement Clg UEC kWh/yr*
EANE	ER / -	5%	100% / -	11701	0	100% / -	11701	0
EANEC	ER / CAC	5%	100% / 8.62 SEER	11701	515	100% / 9.96 SEER	11701	446
EANER	ER / RAC	5%	100% / 7.47 EER	11701	160	100% / 9.0 EER	11701	138
EANHP	HP	2%	6.79 HSPF/ 8.59 SEER	5882	517	7.24 HSPF/ 9.86 SEER	5516	451
EANG	Gas-Other / -	42%	- / -	0	0	- / -	0	0
EANGC	Gas-Other / CAC	10%	- / 8.62 SEER	0	515	- / 9.96 SEER	0	446
EANGR	Gas-Other / RAC	32%	- / 7.47 EER	0	160	- / 9.0 EER	0	138
Total		*100%*						

South Enduse Code	*Htg/Clg Type*	*% of all SF homes*	*Existing Htg/Clg Efficiency*	*Existing Htg UEC kWh/yr*	*Existing Clg UEC kWh/yr*	*Replacement Htg/Clg Efficiency*	*Replacement Htg UEC kWh/yr*	*Replacement Clg UEC kWh/yr*
EASE	ER / -	13%	100% / -	3026	0	100% / -	3026	0
EASEC	ER / CAC	16%	100% / 8.62 SEER	3026	1366	100% / 9.96 SEER	3026	1182
EASER	ER / RAC	8%	100% / 7.47 EER	3026	424	100% / 9.0 EER	3026	367
EASHP	HP	7%	6.79 HSPF/ 8.59 SEER	1521	1371	7.24 HSPF/ 9.86 SEER	1427	1194
EASG	Gas-Other / -	29%	- / -	0	0	- / -	0	0
EASGC	Gas-Other / CAC	14%	- / 8.62 SEER	0	1366	- / 9.96 SEER	0	1182
EASGR	Gas-Other / RAC	14%	- / 7.47 EER	0	424	- / 9.0 EER	0	367
Total		*100%*						

(1) UECs were obtained from heating and cooling loads (Ritschard & Huang, 1989) for 5 prototype buildings of different vintage located in Chicago for the north, and Fort Worth for the south (Fort Worth weather adjusted to Charleston, SC weather using ratios of degree days). The vintages were weighted using data from RECS87 and the 1980 Census. Ritschard and Huang did not include prototypes for 1940s and 1950s buildings. 1940s buildings were assumed to have the same characteristics as pre-1940s buildings, and 1950s buildings were assumed to have the same characteristics as 1960s buildings.

(2) Equipment efficiencies are from LBL REM (1991) for 1990 new and existing units, based on extrapolation from 1987 ARI data.

(3) Existing homes have two UECs. The "existing" UEC is calculated using the existing shell characteristics and the 1990 existing equipment efficiency from the LBL Residential Energy Model (LBL REM). The "replacement" UEC is calculated using the existing shell but the 1990 new unit efficiency from LBL REM. Space conditioning equipment saturations are from RECS87 data. for multifamily homes and are weighted using 1980 Census MF home stocks.

(4) No shell efficiency measures are applied to multifamily buildings, only equipment efficiency measures.

(5) HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners

(6) Furnace fan electricity use for non-electric furnaces is counted as "miscellaneous energy" and does not appear in this table.

Table 9: Heating and cooling of new multi-family buildings: saturations, efficiency, and electricity consumption

North Enduse Code	*Htg/Clg Type*	*% of all new MF homes*	*Htg/Clg Efficiency*	*Htg UEC kWh/yr*	*Clg UEC kWh/yr*
NANE	ER / -	12%	100% / -	6768	0
NANEC	ER / CAC	20%	100% / 9.96 SEER	6768	412
NANER	ER / RAC	2%	100% / 9.0 EER	6768	128
NANHP	HP	3%	7.24 HSPF/ 9.86 SEER	3191	416
NANG	Gas-Other / -	23%	- / -	0	0
NANGC	Gas-Other / CAC	14%	- / 9.96 SEER	0	412
NANGR	Gas-Other / RAC	26%	- / 9.0 EER	0	128
Total		100%			
South ***Enduse Code***	***Htg/Clg Type***	***% of all new MF homes***	***Htg/Clg Efficiency***	***Htg UEC kWh/yr***	***Clg UEC kWh/yr***
NASE	ER / -	13%	100% / -	862	0
NASEC	ER / CAC	30%	100% / 9.96 SEER	862	945
NASER	ER / RAC	7%	100% / 9.0 EER	862	293
NASHP	HP	12%	7.24 HSPF/ 9.86 SEER	406	955
NASG	Gas-Other / -	14%	- / -	0	0
NASGC	Gas-Other / CAC	22%	- / 9.96 SEER	0	945
NASGR	Gas-Other / RAC	2%	- / 9.0 EER	0	293
Total		*100%*			

(1) Space conditioning equipment saturations are from RECS87 data for multifamily homes built 1980-88 and are weighted using 1988 new housing starts data from the Statistical Abstract of the United States 1990.
(2) UECs were obtained from heating and cooling loads (Ritschard & Huang, 1989) for 1980s vintage buildings located in Chicago for the north and Fort Worth for the south.
(Fort Worth weather adjusted to Charleston, SC weather using ratios of degree days).
(3) Equipment efficiencies are from LBL REM (1991) for 1990 new units, based on extrapolation from 1987 ARI data.
(4) No shell efficiency measures are applied to multifamily buildings, only equipment efficiency measures.
(5) HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners
(6) Furnace fan electricity use for non-electric furnaces is counted as "miscellaneous energy" and does not appear in this table.

Table 10: Heating and cooling of existing mobile homes: saturations, efficiency and electricity consumption

North Enduse Code	*Htg/Clg Type*	*% of all MHs*	*Existing Htg/Clg Efficiency*	*Existing Htg UEC*	*Existing Clg UEC*	*Replacement Htg/Clg Efficiency*	*Replacement Htg UEC*	*Replacement Clg UEC*
EMNE	ER / -	3%	100% / -	11188	0	100% / -	11188	0
EMNEC	ER / CAC	3%	100% / 8.62 SEER	11188	1542	100% / 9.96 SEER	11188	1334
EMNER	ER / RAC	4%	100% / 7.47 EER	11188	478	100% / 9.0 EER	11188	414
EMNHP	HP	1%	6.79 HSPF/ 8.59 SEER	5626	1544	7.24 HSPF/ 9.86 SEER	5276	1345
EMNG	Gas-Other / -	41%	- / -	0	0	- / -	0	0
EMNGC	Gas-Other / CAC	21%	- / 8.62 SEER	0	1429	- / 9.96 SEER	0	1236
EMNGR	Gas-Other / RAC	28%	- / 7.47 EER	0	443	- / 9.0 EER	0	383
Total		*100%*						
South Enduse Code	***Htg/Clg Type***	***% of all MHs***	***Existing Htg/Clg Efficiency***	***Existing Htg UEC***	***Existing Clg UEC***	***Replacement Htg/Clg Efficiency***	***Replacement Htg UEC***	***Replacement Clg UEC***
EMSE	ER / -	7%	100% / -	5800	0	100% / -	5800	0
EMSEC	ER / CAC	8%	100% / 8.62 SEER	5800	3065	100% / 9.96 SEER	5800	2653
EMSER	ER / RAC	12%	100% / 7.47 EER	5800	1042	100% / 9.0 EER	5800	902
EMSHP	HP	1%	6.79 HSPF/ 8.59 SEER	2964	3175	7.24 HSPF/ 9.86 SEER	2780	2766
EMSG	Gas-Other / -	27%	- / -	0	0	- / -	0	0
EMSGC	Gas-Other / CAC	10%	- / 8.62 SEER	0	2926	- / 9.96 SEER	0	532
EMSGR	Gas-Other / RAC	34%	- / 7.47 EER	0	995	- / 9.0 EER	0	861
Total		*100%*						

(1) Room air conditioner UEC is assumed to be 31% and 34% of corresponding CAC UEC in the north and south, respectively (from NERC regional utility data--RCG/Hagler-Bailly 1990).
(2) UECs were obtained from PEAR using a prototype one-story single family home with aluminum window sashes. The PEAR results for the north were adjusted from Cincinnati weather (the nearest city to Chicago with crawl space in the PEAR database) to Chicago weather using ratios of heating and cooling degree days. PEAR results in the south are based on Charleston, SC weather.
(3) Floor areas are from RECS 1987.
(4) All shell characteristics except for infiltration correspond to HUD Zone II minimum requirements (Mills 1984) for the north, and Zone I minimum requirements for the south. HUD Zones I and II are virtually identical geographically to our South and North regions, respectively.
(5) Infiltration rates are estimates from Allen Lee of Battelle PNL (personal communication, April 1991) of existing mobile homes in the Pacific Northwest. Lee's ACH of 0.5 was adjusted by the specific infiltration rate for our northern and southern regions in order to account for the difference in weather between Seattle and Chicago (or Charleston). We assumed that our prototype homes and homes in Seattle have the same specific leakage area.
(6) The saturations of homes in each space conditioning category are from RECS 87.
(7) No shell measures are applied to mobile homes, only equipment efficiency measures.
(8) HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners
(9) Furnace fan electricity use for non-electric furnaces is counted as "miscellaneous energy" and does not appear in this table.
(10) Equipment efficiencies are from LBL REM (1991) for 1990 new and existing units, based on extrapolation from 1987 ARI data.

Table 11: Heating and cooling of new mobile homes: saturations, efficiency, and electricity consumption					
North *Enduse Code*	*Htg/Clg Type*	*% of all Mobile homes*	*Htg/Clg Efficiency*	*Htg UEC kWh/yr*	*Clg UEC kWh/yr*
NMNE	ER / -	3%	100% / -	9603	0
NMNEC	ER / CAC	5%	100% / 9.96 SEER	9603	1307
NMNER	ER / RAC	6%	100% / 9.0 EER	9603	405
NMNHP	HP	0%	7.24 HSPF/ 9.86 SEER	4635	1244
NMNG	Gas-Other / -	36%	- / -	0	0
NMNGC	Gas-Other / CAC	24%	- / 9.96 SEER	0	1307
NMNGR	Gas-Other / RAC	27%	- / 9.0 EER	0	405
Total existing		101%			
South *Enduse Code*	*Htg/Clg Type*	*% of all Mobile homes*	*Htg/Clg Efficiency*	*Htg UEC kWh/yr*	*Clg UEC kWh/yr*
NMSE	ER / -	11%	100% / -	5161	0
NMSEC	ER / CAC	24%	100% / 9.96 SEER	5161	2716
NMSER	ER / RAC	19%	100% / 9.0 EER	5161	923
NMSHP	HP	2%	7.24 HSPF/ 9.86 SEER	2434	2740
NMSG	Gas-Other / -	14%	- / -	0	0
NMSGC	Gas-Other / CAC	15%	- / 9.96 SEER	0	2716
NMSGR	Gas-Other / RAC	15%	- / 9.0 EER	0	923
Total new		*100%*			

(1) Room air conditioner UEC is assumed to be 31% and 34% of corresponding CAC UEC in the north and south, respectively (from NERC regional utility data--RCG/Hagler-Bailly 1990).
(2) UECs were obtained from PEAR using a prototype one-story single family home with aluminum window sashes. The PEAR results for the north were adjusted from Cincinnati weather (the nearest city to Chicago with crawl space in the PEAR database) to Chicago weather using ratios of heating and cooling degree days. PEAR results in the south are based on Charleston, SC weather.
(3) Floor area is the national average for mobile homes sold in 1989, from MHI 1991b.
(4) Infiltration rates are estimates from Allen Lee of Battelle PNL (personal communication, April 1991) of existing mobile homes in the Pacific Northwest. Lee's ACH of 0.4 was adjusted by the specific infiltration rate for our northern and southern regions in order to account for the difference in weather between Seattle and Chicago (or Charleston). We assumed that our prototype homes and homes in Seattle have the same specific leakage area.
(5) All other shell characteristics were obtained from Manufactured Housing Institute estimates of the most popular shell packages sold in 1990 by region (MHI 1991a).
(6) The saturations of homes in each space conditioning category were for homes built 1980-88, from RECS 87.
(7) No shell measures are applied to mobile homes, only equipment efficiency measures.
(8) HP = heat pump; ER=electric resistance; CAC/RAC= central or room air conditioners
(9) Furnace fan electricity use for non-electric furnaces is counted as "miscellaneous energy" and does not appear in this table.
(10) Equipment efficiencies are from LBL REM (1991) for 1990 new units, based on extrapolation from 1987 ARI data.

Non-space conditioning end uses

Table 12 shows baseline saturations in 1990 and 2010, and the UECs for average appliances existing in 1990, and for the typical new appliance being installed in 1990.

Water heating: The UEC for electric water heaters reflects the 1990 standards, and includes the hot water used in dishwashers and clotheswashers. Energy savings from hot water reductions from the 1994 efficiency standards on laundry products are included as measures in the supply curve.

Refrigerators and Freezers: The top-mount auto-defrost refrigerator comprises about 2/3 of all refrigerators sold in the U.S. (LBL REM 1991), and this model is the one chosen to represent the conservation potential for all refrigerators. Freezers are assumed to be half upright manual defrost and half chest manual defrost. The frozen efficiency baseline includes the 1990 standards, but not the updated 1993 standards for these products (which are included as measures on the supply curve).

Lighting: The lighting end use includes both interior and exterior lighting. The baseline assumes all incandescent lighting with no controls. Saturations are an average from from the Residential Appliance Saturation Surveys (RASSs) from eight utilities. Energy consumption is estimated for a weighted-average of 4 house types from RECS (US DOE 1989a) housing stock: large single family, medium single family, small single family/mobile homes, and apartments. See Appendices 3 and 6 for more details.

Other: The Other end-use is comprised of various categories, such as TVs, electric ranges, clothes dryers, and Miscellaneous. The Miscellaneous category includes all electricity use that has not been disaggregated into an end-use. Only furnace fans, clotheswasher and dishwasher motors, and various other motors were distinguished within Miscellaneous. The rest of miscellaneous is not well specified, and more work is needed in this area (Rainer et al. 1990).

Baseline electricity use

Figures 3 and 4 show the breakdown of 1990 and 2010 U.S. residential electricity use, by end-use, based on the results of the supply curve model. Appendix 4 contains more detail on frozen efficiency end-use energy from ACCESS, and **Table 13** compares the LBL REM frozen efficiency forecast to that from ACCESS. Agreement is within 7.1% for total residential electricity consumption. This difference is caused principally by the base-year difference in space conditioning energy. The representation of space conditioning in LBL REM is not currently as detailed as that in the supply curve program, so the 13% difference between the forecasted baselines in 2010 is not a grave concern. As ACCESS's inputs become more closely integrated with those of LBL REM, we expect these differences to be reduced.

D. Conservation Measures

Once the baseline forecast has been established, the next step is to estimate the costs and energy savings for measures that reduce the baseline energy consumption.

Costs of measures

Space conditioning shell measures: Costs of space conditioning energy conservation measures are taken from Koomey et al (1991) for new single-family buildings and Boghosian (1991) for existing single-family buildings. In both cases, the costs were

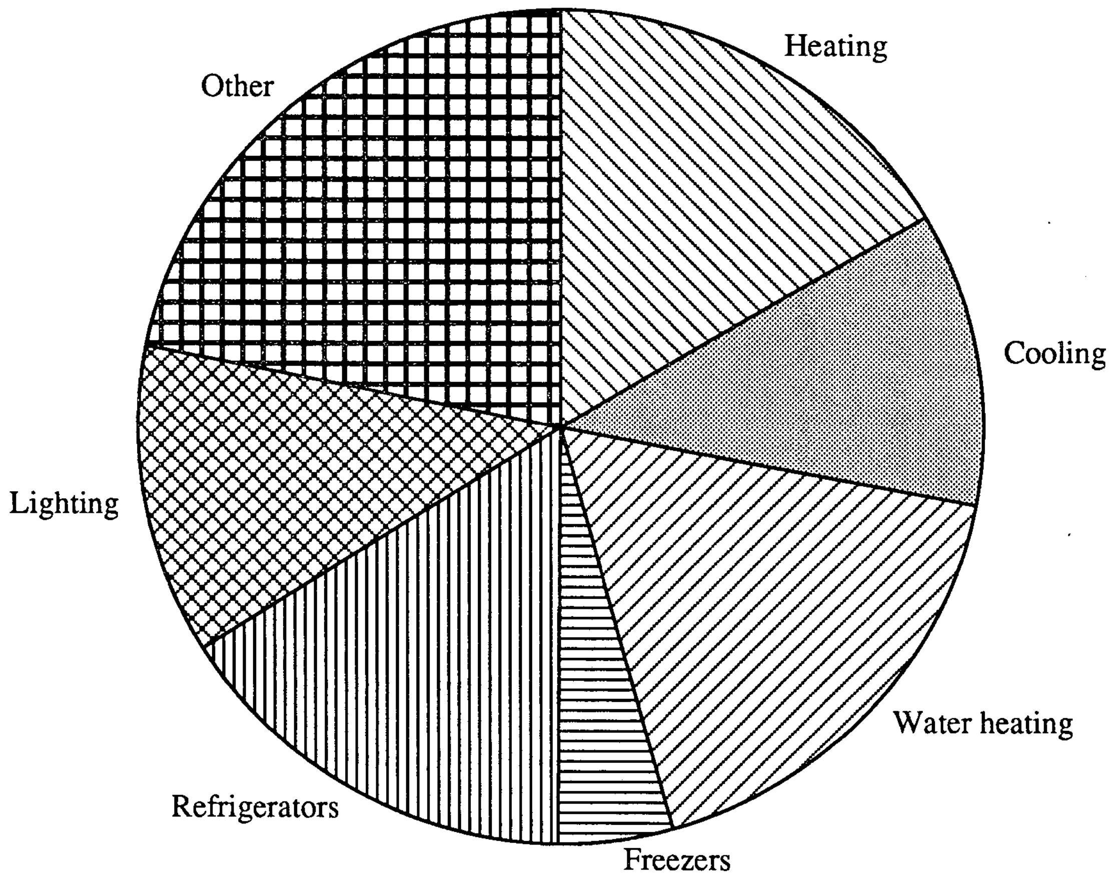
Table 12: Baseline saturations and unit energy consumption of non-space-conditioning appliances				
Appliance	*Average saturation of appliances existing in 1990*	*Average saturation of appliances in 2010*	*Average UEC of appliances existing in 1990*	*Average UEC of new appliances in 1990*
Black and white television sets, 13 inch (1)	37.0%	37.0%	50	50
Clothes Dryer electric	53.8%	59.4%	904	880
Color television sets 19-20 inch (1)	93.0%	92.0%	205	205
Elec. Water Heater	40.2%	44.5%	3850	3539
Electric Range	65.3%	75.2%	1010	944
Lighting (Indoor and Outdoor)	100.0%	100.0%	1060	1060
Freezer	35.7%	30.6%	1104	568
Miscellaneous electricity	100.0%	100.0%	559	559
Refrigerator	114.0%	115.6%	1226	893

(1) TV saturations are a weighted average of 31 national utilities' data and represent customer saturation, not appliance saturation. Customer saturation is the fraction of households having at least one appliance; appliance saturation reflects the number of appliances in each house and can therefore be greater than 100%. However, usage patterns of second and third TV sets are not well documented and we have ignored these additional units.

(2) All other appliance saturations are national averages from LBL REM (1991).

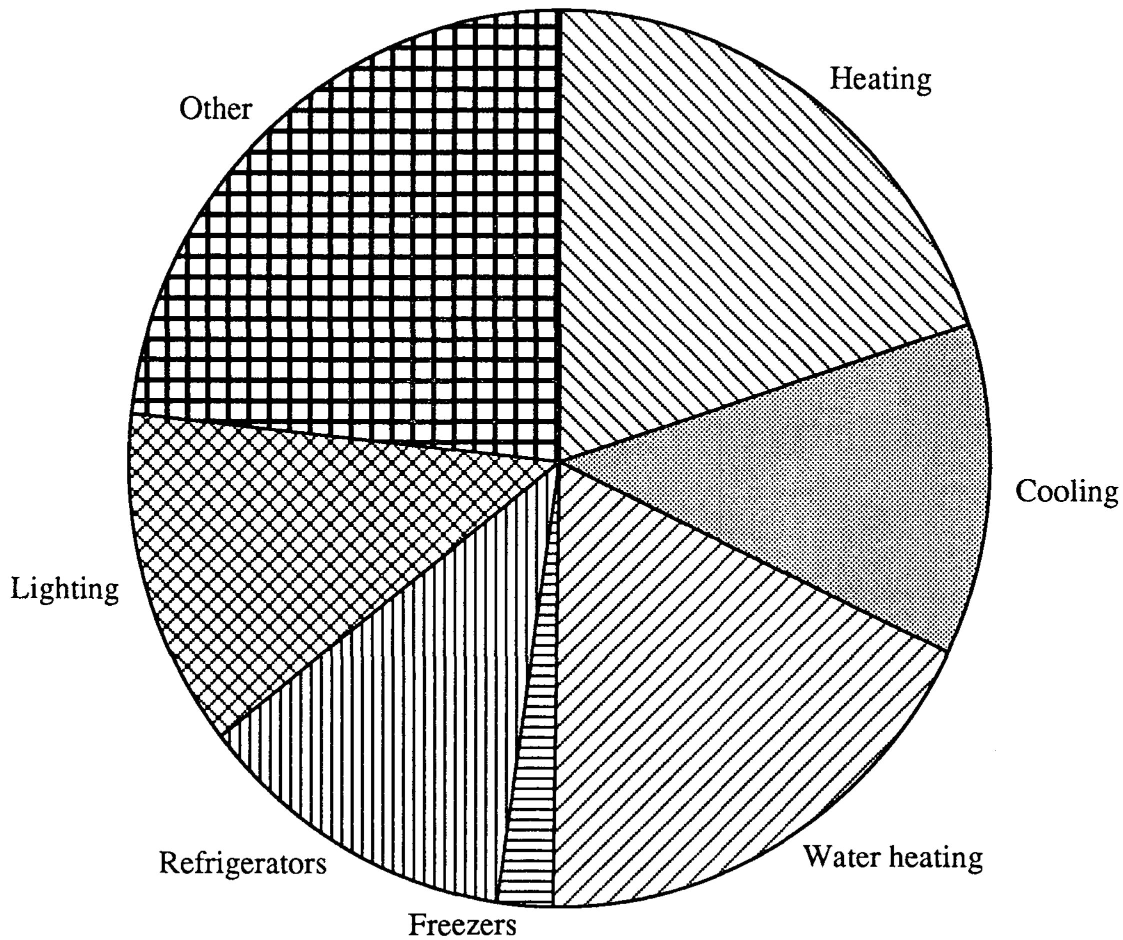
(3) UECs from LBL REM (1991), except for TVs (from US DOE 1988) and lighting (see Appendix 3 and Appendix 6 for details). UECs for new appliances reflect the 1990 standards (where applicable). Refrigerators and freezer UECs may not exactly match the LBL-REM weighted average over all units sold, as we have for these two end-uses represented all possible units sold with one or a two prototypes (see Appendix 3 for details). In these two cases, the prototype UECs are directly taken from LBL-REM (1991).

Figure 3: U.S. Residential Electricity Use 1990



Frozen efficiency baseline in 1990 = 828 TWh
Source: ACCESS (see Table 13 and Appendix 4)

Figure 4: U.S. Residential Electricity Use 2010 (Frozen Efficiency Baseline)



Frozen efficiency baseline in 2010 = 1008 TWh
Source: ACCESS (see Table 13 and Appendix 4)

Table 13: Comparison of ACCESS and LBL Residential Energy Model frozen efficiency forecasts						
	1990 ACCESS TWh	*1990 LBL REM TWh*	*1990 ACCESS/ LBL REM*	*2010 ACCESS TWh*	*2010 LBL REM TWh*	*2010 ACCESS/ LBL REM*
Space conditioning	232	253	*91.8%*	322	371	*86.9%*
Heating	137	149		201	231	
Cooling	95	104		121	140	
Water heating	146	146	*99.9%*	185	185	*100.2%*
Freezers	37	37	*100.5%*	21	21	*98.6%*
Refrigerators	132	132	*100.0%*	121	126	*95.8%*
Lighting	100	104	*96.5%*	124	132	*93.9%*
Other	181	181	*100.1%*	234	249	*93.9%*
Total	828	852	*97.2%*	1008	1085	*92.9%*

(1) The supply curve program (ACCESS) calculates space conditioning energy but does not separate it into heating and cooling. In this table, the relative amounts of heating and cooling from LBL REM (1991) are used to separate the supply curve's space conditioning energy into heating and cooling energy.

or by 1987 housing starts for existing and new buildings, respectively. See Appendices 2 and 3 for costs by measure.

Boghosian's documentation presents *total costs* (in million dollars) and *total savings* (in TWh) for efficiency measures in all existing homes, and does not present the cost or savings per measure per applicable home (Boghosian 1991). The costs and savings shown in Appendix 3 are averaged over all homes, since we could not easily derive the cost per measure per applicable home. *For this reason, the per unit measure costs and savings in Appendix 3 appear to be too low. These parameters are, however, correctly used to calculate the CCEs.*

The costs of window measures for existing buildings are based on the full cost of replacement, which assumes that the windows would not have been replaced anyway (Boghosian 1991). The long lifetime of windows makes this assumption roughly reasonable, though there is some window replacement that occurs as they break or as buildings are renovated. This assumption vastly overstates the CCE if windows are being replaced anyway, and this omission will be corrected in future work.

The costs of window improvements in new buildings are the incremental costs of improving efficiency beyond the prototype's base case assumption. Superwindows, which have an overall R-value (including frame effects) of R-5.5, are included for new buildings in the north. Spectrally selective glazings, which block the heating effects of ultraviolet and infrared radiation but do not affect visible transmissivity, are included for new homes in the south. Neither of these more advanced glazing technologies are included for existing buildings. This omission will be corrected in future updates to the supply curves.

Space conditioning equipment in multifamily buildings and mobile homes: The capital costs of space conditioning equipment in multifamily buildings and mobile homes have been adjusted using information from EPRI (1987) relating equipment capital costs to heating and cooling loads. We assume that each multifamily unit has its own space conditioning equipment. The 1987 RECS or Residential Energy Consumption Survey (US DOE 1989a) indicates that slightly more than 80% of all central air conditioners (CACs) in existing multifamily (MF) dwellings are individual units, and 94% of CACs in new MF units are individually owned (data for heat pumps are inconclusive due to small sample size). The assumption of all individual units makes the analysis conservative, since there are economies of scale in improving the efficiency of a single large unit instead of improving the efficiency of many small units. These homes usually have smaller loads per housing unit than the single-family homes upon which the absolute costs of equipment are based, and the costs of the equipment are adjusted accordingly.

Water heating: Water heating measures include savings from options affecting standby losses, conduction, and water flow rates, as well as hot water[8] savings from the 1994 standard on laundry products (clotheswashers and dishwashers). The baseline new water heater meets the 1990 standard. See Appendix 3 for more details.

The heat pump water heater (HPWH) is included in our technical potential analysis as an advanced option that is not available in large numbers until after 1995. The technology itself is currently available, and reliable, but early reliability problems and high initial costs have limited its use (Beckerman et al. 1990, EPRI 1984, Lerman 1988, Petrie

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[8]Motor savings from the Laundry product standards have been included as supply curve measures affecting the Other end use category.

and Peach 1988). We assume that the Electric Power Research Institute's "third generation" HPWHs, which are now being tested, become commercially available by 1993.

HPWHs can have a large effect on space conditioning loads if they are located in the conditioned space (they will increase space heating loads and decrease space cooling loads). They also do not perform well in cold climates, except if placed in unheated basements that do not become too cold in winter. We have assumed that all homes in our southern region would be eligible for HPWHs (taking advantage of the reduction in cooling load), and only 10% of the homes in the north (i.e., those homes with unheated basements) would be so eligible.

It is when discussing logistic considerations for advanced technologies like the HPWH that the limitations of the frozen efficiency/technical potential methodology become most apparent. There will be constraints in scaling up production of HPWHs that are both physical and economic. Economic constraints should in principle not be considered in a technical potential estimate, but in this case they are inextricably intertwined with the physical constraints. Current production of HPWHs is around 2000 units per year, but discussions with one of the larger manufacturers of these devices indicates that production could be increased to hundreds of thousands of units per year in a year or two, given sufficient demand (Shuford 1991).

We attempt to approximate the physical constraints in scaling up HPWH production by assuming that only half of eligible electric water heaters (EWHs) sold in the 1995-2000 period (that are not switched to natural gas) are converted to heat pumps. During the period 1995-2000, 50% of electric water heaters sold in the South (after fuel switching is accounted for) are converted to HPWHs, and 5% of EWHs sold in the North are converted to HPWHs. After 2000, we assume that all eligible EWHs sold during this period are converted to HPWHs.

The purchase cost of HPWHs would decrease if production were increased by a substantial amount, due to economies of scale (Chan 1991). For refrigerators, the rule of thumb is that consumer cost will decrease by about 10% if production of a particular model is doubled. For fluorescent ballasts, consumer cost will decrease 20-30% if manufacturing output is increased by a factor of ten.[9] Since the number of HPWHs sold in our technical potential case increases by a factor of 500 to 1000 over current levels, it is plausible to argue that consumer costs will decrease by at least 20% compared to current prices. We chose to reduce consumer cost by 20% as a conservative estimate.

Energy savings from HPWHs vary from 30% to 70%, with more recent higher efficiency models tending towards the higher savings number. EPRI (1984) reviewed 45 utility field tests of savings from HPWHs in all regions of the U.S., and found that savings averaged roughly 50%. The EPRI third generation HPWHs are expected to save 60-65%, but we assumed 50% savings to be conservative. See Appendix 3 for details on costs and energy savings.

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[9]Refrigerators are much more similar to HPWHs than are ballasts, but the large increase in production that we forecast (by factors of 500 to 1000) make our 20% cost reduction conservative. Shuford (1991) estimates that such a large production increase would reduce the capital cost of the third generation HPWHs to 50% of their cost at the time when the devices are first introduced in 1992 or 1993.

Refrigerators and Freezers: Costs for efficiency improvements in refrigeration equipment have been calculated assuming that chlorofluorocarbon (CFC) refrigerants and blowing agents *are unavailable* throughout the analysis period, using costs from US DOE (1988, 1989b).

Lighting: Costs of lighting equipment are shown in Appendix 6, and are taken from Grainger (1990), Real Goods (1990) and EFI (1990).

Laundry products: Costs for efficiency improvements of clothes washers, clothes dryers, and dishwashers are taken from US DOE (1990b). The CCEs for shifting to horizontal axis clothes washers depend on whether heat pump water heaters are assumed to be implemented first (there are separate measures for each of the possible cases).

Heat pump (HP) dryers are assumed to saturate the electric dryer market after the year 2000. Prototypes of both HP dryers and microwave dryers have been tested successfully, but most development work is currently being devoted to microwave dryers. HP dryers save more energy and have a lower CCE than microwave dryers, so we chose them for our technical potential case. Changes in current research and development funding would have to occur for HP dryers to become commercial, which is why the measure is delayed until the year 2000.

Other Non space-conditioning end-uses: Costs of other non space-conditioning energy conservation measures are taken from LBL (1990), LBL REM (1991), McMahon (1986), US DOE (1988, 1989b, 1990b), Perlman (1987), and Goldstein et al. (1990), and from other references listed in Appendix 3. For costs by measure see Appendix 2.

Fuel switching measures: The CCEs for gas fuel-switching measures include the present-valued cost of the natural gas used to run the appliance, using the gas price projections in the Reference case from the U.S. Department of Energy's Annual Energy Outlook (US DOE 1990a). This approach was adopted because the cost of delivering service equivalent to an electric appliance includes both the capital cost of switching and the cost for non-electric fuel.

Fuel switching from electricity to direct use of natural gas results in an increase in gas use. **Table 14** shows this increased use, along with the measure codes, CCEs,the number of units switched, and the electricity savings for each appliance. The total increase in gas use if all three of these fuel switching measures are fully implemented is about 5% of the US DOE's estimate of *residential* natural gas use in 2010 (4.7 Quadrillion Btus, from US DOE (1991)).

Appliances are only switched in homes that have gas hookups in the home already, but have an *electric* water heater, clothes dryer, or range (based on the saturations contained in the Residential Appliance Saturation Surveys for the utilities shown in Appendix 9). No switching of electric space heating to gas was included, because almost all houses with gas service already have gas space heat. Further fuel switching (including switching electric furnaces to gas) may be possible in areas to which gas lines could be inexpensively extended. Assessing this potential would require significant additional analysis, but the large electricity savings possible in each house (see Tables 6 to 11) make this option worthy of further study.

Table 14: Electricity savings, increased gas use, and cost of fuel switching to natural gas

	Units	*Electric range to gas range*	*Electric water heater to gas WH*	*Electric dryer to gas dryer*
Measure code		ERNG02	EWH08	CD-E03
Cost of conserved energy	¢/kWh	6.2	4.7	6.1
Applicable fraction	%	22%	8.5%	36%
Per unit natural gas use	therms/unit/yr	47.7	159.5	34.9
Units switched by 2010	millions	19.4	4.7	25.0
Total additional gas use (in 2010)	TBtus/yr	93	75	87
Electricity savings	kWh/unit/yr	944	3539	807
Total electricity savings (in 2010)	TWh/yr	18	17	20

(1) Cost of conserved energy includes the present-valued cost of the natural gas use assuming the residential gas price forecast in US DOE 1990a, levelized using a 7% real discount rate.
(2) Applicable fraction calculated using data from residential appliance saturation surveys from utilities listed in Appendix 9. It represents the fraction of all electric appliances purchased in a given year that can be switched to natural gas.
(3) Per unit gas use from LBL REM (1991).

Energy savings

For space conditioning in new and existing single-family buildings, energy savings for specific measures are calculated using the batch version of PEAR and Chicago or Charleston weather sites (see Appendix 8 for details on the space conditioning analysis). The exceptions to this rule are the estimates of energy saved from "superwindows" and from spectrally-selective glazings, which are calculated using a beta-test version of an LBL model (RESFEN 1.0) for estimating heating and cooling energy use associated with various window technologies (Sullivan 1991). Interactions between space conditioning equipment efficiency and shell measures are correctly accounted for. See Appendix 3 for details.

Energy savings for *appliances and space conditioning equipment* in multifamily buildings and mobile homes have been included in our analysis. Unfortunately, there was insufficient data to model space conditioning energy savings *from shell measures* in these buildings. Some measured data on energy savings from retrofits of fuel-heated multifamily buildings were available (Cohen et al. 1991, Goldman et al. 1988), but data on electrically heated buildings are largely confined to the Northwestern U.S. (in a climate quite different than that of the U.S. average). NPPC (NPPC 1986, NPPC 1989) has estimated the conservation potential for multi-family buildings in the Northwest, but no comparable analysis exists for the U.S. Judkoff (1991, 1990) and Baylon et al. (1990) have analyzed savings for mobile homes for particular regions of the country, but not for the U.S. as a whole.

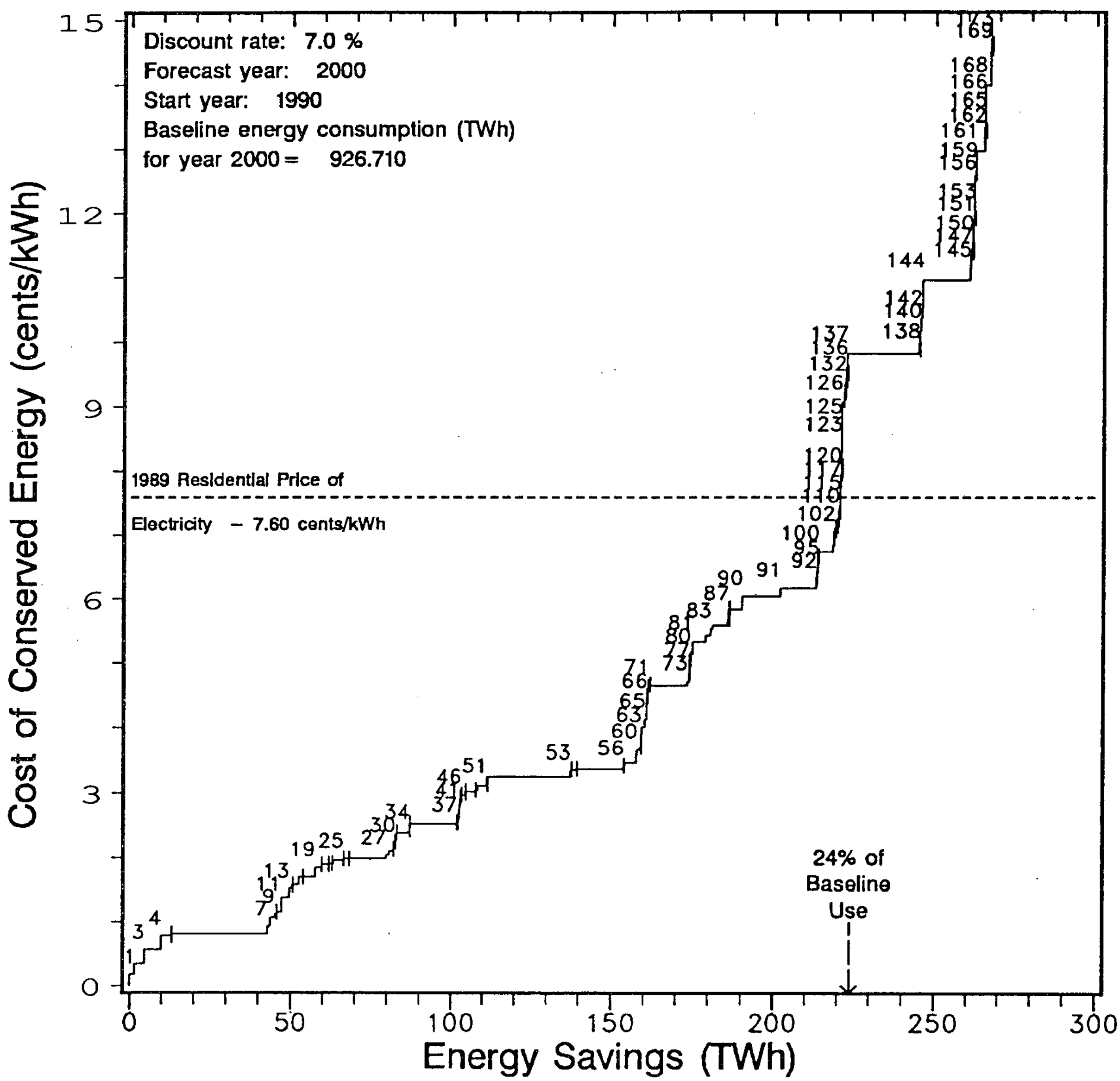
Multifamily space conditioning electricity comprises about 7% of the frozen efficiency baseline in 2010, and mobile home space conditioning electricity comprises about 2% of this baseline. To the extent that additional energy savings could be achieved using MF and mobile home space conditioning shell measures, the savings from our analysis are conservative. Savings from shell measures comparable to those found in single-family homes (roughly 10-15% of the SF frozen efficiency baseline at a cost of less than 7.6¢/kWh) would yield an additional 10 to 15 TWh of energy savings from MF and MH space conditioning shell measures.

Energy savings for appliances were taken from our national database (see LBL (1990) and Appendix 3 for more details). No attempt was made to correct for changes in space conditioning loads due to changes in the energy use of non-space conditioning appliances located in the conditioned space.

III. RESULTS

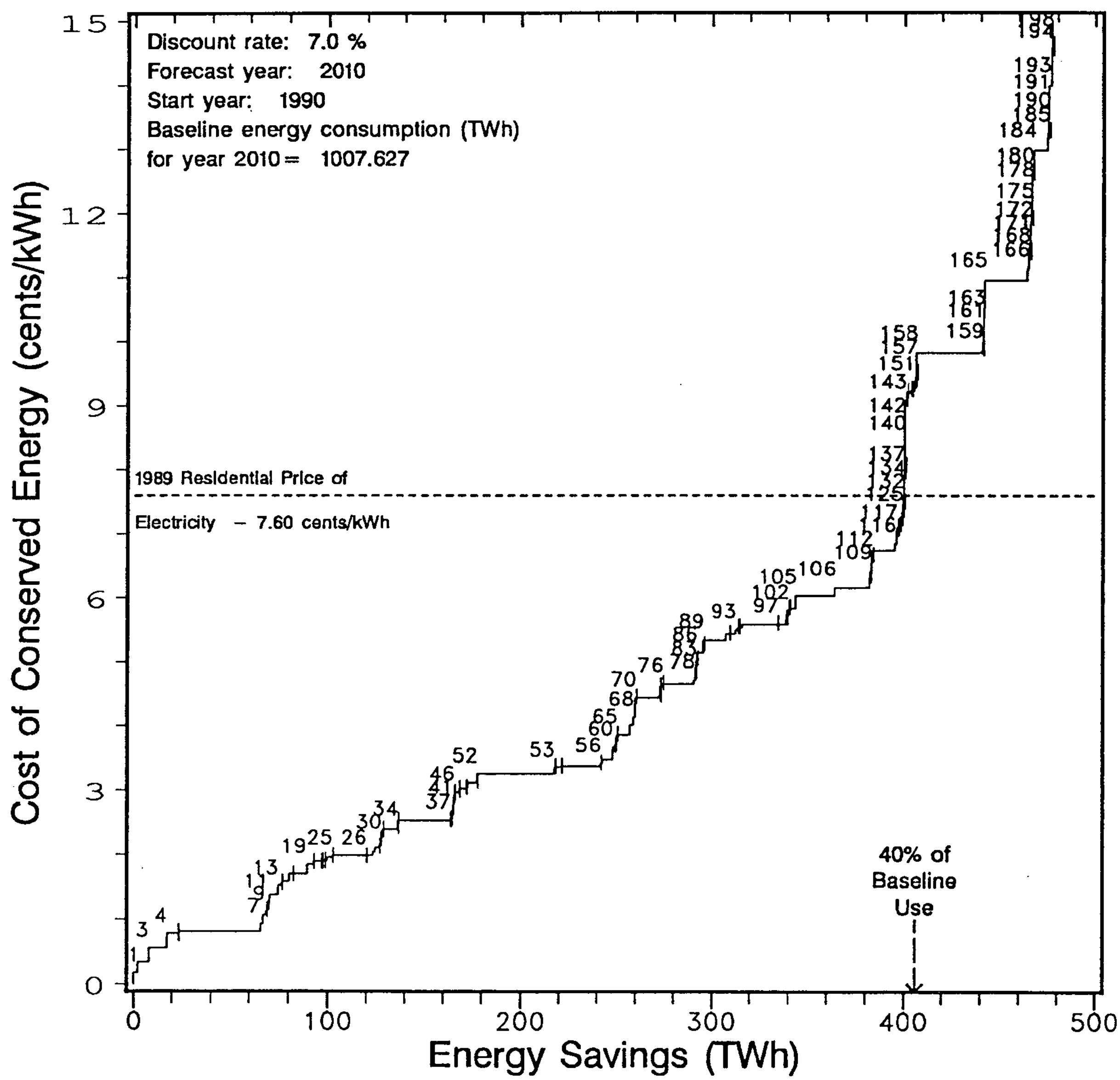
Figure 5 shows a supply curve of conserved energy for the U.S. residential sector in 2000, and **Figure 6** shows the supply curve for 2010. Appendices 2a and 2b contain details on the measures that make up the supply curve in these two years. The total technical potential in 2010 (without considering cost) is about 486 TWh, or about 48% of the frozen efficiency baseline. The technical potential in 2000 and 2010 for energy savings costing less than 7.6¢/kWh is about 24% and 41% of each year's baseline use, respectively. The potential corresponds to 250 TWh in 2000 and 404 TWh in 2010,

Figure 5: Maximum Technical Potential in 2000



A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measures). The width of the step indicates the nationwide electricity savings from the measure and the height of the measure indicates the cost of conserved electricity. The end uses include space conditioning, water heating, refrigeration, lighting, and miscellaneous.

Figure 6: Maximum Technical Potential in 2010



A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measures). The width of the step indicates the nationwide electricity savings from the measure and the height of the measure indicates the cost of conserved electricity. The end uses include space conditioning, water heating, refrigeration, lighting, and miscellaneous.

implying a technical potential for energy savings of 70-75 baseload 1000 MW power plants by 2010.[10]

Figure 7 indicates that electric water heating measures offer the largest potential savings (in absolute terms) for costs less than 7.6¢/kWh of any single end use (slightly more than 110 TWh, of which about 17 TWh, or roughly 15%, is attributable to fuel switching to natural gas). Space conditioning measures are next most important in absolute terms, saving about 100 TWh. Lighting measures save about 60 TWh, as do refrigerator and freezer measures together. In percentage terms (relative to each end-use category's baseline usage), water heating savings potential is the greatest (60%), followed by lighting (47%), refrigerators (39%), and space conditioning (31%).

Table 15 presents a summary of residential electricity use and savings by geographic region. The number of households in the Southern region is projected to grow more quickly than in the Northern region, but the total number of households in 2010 is still larger in the North than in the South. Total electricity use is slightly larger in the North in both 1990 and 2010, but *space conditioning* electricity use is split almost exactly equally between the two regions in 1990 and is slightly larger in the South by 2010. Total electricity *savings* costing less than 7.6¢/kWh are slightly larger in the South, while space conditioning savings are larger by a factor of 1.7 to 1. This substantial difference is caused by the larger number of new homes in the South (because efficiency improvements are cheaper in new homes), the cost effectiveness of spectrally selective glazings, and the prevalence of air conditioning in the South.

Table 16 displays a breakdown of the energy savings and costs of appliance standards implemented 1992-1994. Annual expected savings from these standards in 2010 are roughly 47 TWh/year, or about 5% of the frozen efficiency baseline. Of the 410 TWh of technical potential savings costing less than 7.6¢/kWh, about 12% (or five percent relative to the frozen efficiency baseline) are accounted for by the post-1990 standards.

IV. IMPROVEMENTS TO THE ANALYSIS: FUTURE WORK

In creating the database of conservation measures, we frequently were forced to make compromises because of data limitations, weaknesses in computer tools, or resource constraints. On balance, we believe that correcting for data omissions and methodological limitations would *increase* the energy savings and *decrease* the cost of conserved energy, so in that sense our analysis is conservative. This section describes some of the limitations of this analysis, and presents our "wish list" for improving the conservation supply curves. As we continue to update the supply curves on a regular basis, many of these limitations will be corrected.

A. Multifamily and mobile home building-shell-related energy savings

The frozen efficiency baseline includes space conditioning energy use in multifamily buildings and mobile homes. We do not include building shell measures for these end-uses, because of an inability to easily simulate mobile home and multifamily building space conditioning energy use, and uncertainty about the costs of improving

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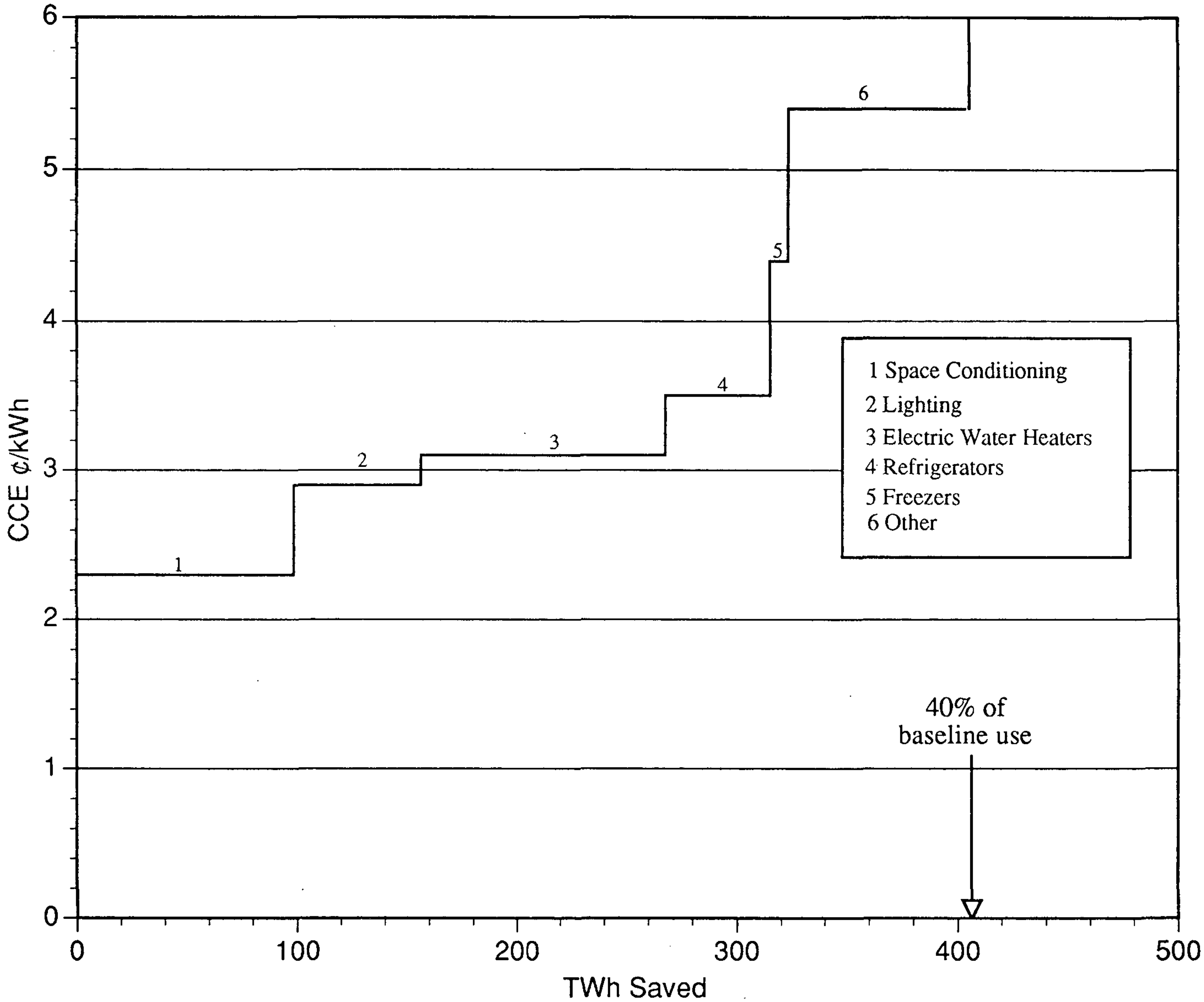
[10]This crude comparison is presented here only to establish the order of magnitude. More accurate calculations would account for the time at which conservation measures save energy relative to the utility system peak demand, and relate these "load shape characteristics" to baseload, intermediate and peaking supply resources. See Koomey et al 1990 for more details.

Figure 7: Energy Savings and Costs by End-Use in 2010



Each segment of this curve shows the total electricity savings and the average cost of conserved energy for all measures in Figure 5 that cost less than 7.6¢/kWh (grouped by end use).

Table 15: Residential electricity use and savings potential by geographic region			
	North	South	Total
Number of Households 1990 (millions)	53.3	40.7	94.0
Percentage of Total	*56.7%*	*43.3%*	*100%*
Number of Households 2010 (millions)	64.0	53.9	117.9
Percentage of Total	*54.3%*	*45.7%*	*100%*
TOTAL RESIDENTIAL ELECTRICITY CONSUMPTION			
Total 1990 (TWh)*	455	373	828
Percentage of Total	*55.0%*	*45.0%*	*100%*
Total Frozen Efficiency Baseline Electricity Use 2010 (TWh)*	529	479	1008
Percentage of Total	*52.5%*	*47.5%*	*100%*
Total Savings Potential in 2010 for CCE ≤ 7.6 ¢/kWh (TWh) **	190	214	404
Percentage of Total Savings Potential	*47.1%*	*52.9%*	*100%*
Energy Savings Potential as a Percentage of Total Frozen Efficiency Energy Use in 2010	35.9%	44.6%	40:1%
SPACE CONDITIONING ELECTRICITY CONSUMPTION			
Total Space Conditioning (SC) 1990 (TWh)	117	115	232
Percentage of Total SC Use	*50.6%*	*49.4%*	*100%*
Total Space Conditioning Electricity Use Frozen Efficiency Baseline 2010 (TWh)	157	166	322
Percentage of Total SC Use	*48.6%*	*51.4%*	*100%*
Space Conditioning Savings Potential in 2010 for CCE ≤ 7.6 ¢/kWh (TWh)	36.6	62.1	98.7
Percentage of Total Savings Potential	*37.1%*	*62.9%*	*100%*
Space Conditioning Savings Potential as a Percentage of Total Frozen Efficiency Space Conditioning Energy Use in 2010	23.4%	37.5%	30.6%

(1) All non-space-conditioning electricity use is assumed to be proportional to the number of households in the Northern and Southern regions.

(2) Five-sixths of the electricity savings from heat pump water heaters accrue in the South, and 1/6 in the North (see text and Appendix 3 for explanation). Otherwise, all non-space-conditioning energy savings are assumed to be proportional to the number of households in the Northern and Southern regions.

Table 16: Savings in 2010 from post-1990 appliance efficiency standards affecting electric end-uses					
Appliance	House Type	Year of Standard	Cost of Conserved Energy ¢/kWh	Savings in 2010 TWh/yr	Savings in 2010 % of 2010 baseline
Central Air Conditioner (CAC)	SF	1992	5.6	1.96	0.2%
	MF	1992	8.7	0.37	0.0%
	MH	1992	5.0	0.25	0.0%
	All	*1992*	*6.0*	*2.58*	0.3%
Heat Pump (HP)	SF	1992	2.6	2.64	0.3%
	MF	1992	4.0	0.34	0.0%
	MH	1992	2.8	0.02	0.0%
	All	*1992*	*2.8*	*3.01*	0.3%
Refrigerator	*All*	*1993*	*2.4*	*27.52*	2.7%
Freezer	*All*	*1993*	*3.4*	*3.42*	0.3%
Clothes dryer	*All*	*1994*	*3.1*	*5.08*	0.5%
Clothes washer	*All*	*1994*	*2.1*	*3.39*	0.3%
Dishwasher	*All*	*1994*	*0.2*	*2.14*	0.2%
Total from Standards				47.14	4.7%
Total less than 7.6¢/kWh				46.39	4.6%

(1) CAC and HP savings calculated using prototypes defined in Table 5.
(2) Electricity savings costing less than 7.6¢/kWh in the supply curves in Figures 5 and 6 include the roughly 47 TWh savings from appliance standards.
(3) Standards for CACs/HPs are assumed to be the first measure in all shell packages for housetypes with this equipment (for purposes of calculating energy consumption). They are ranked in the supply curve by CCE, and do not always come in below 7.6¢/kWh. However, 98% of the savings cost less than 7.6¢/kWh.
(3) In single-family homes, we switch all CACs w/electric furnaces to HPs. Savings from the standards for the CACs in single-family homes that are switched to HPs are not included in the savings in this Table. Similarly, savings from the HP standards for the switched CAC units were not included (the CACs are switched directly to the most cost-effective HP). These 'lost' savings are on the order of 0.5 TWh in 2010.

existing mobile home thermal integrity. Savings from improvements in space conditioning equipment *are* included for these end-uses.

Some research has been done on this topic, which should be extended to the national level. Space conditioning energy savings in existing mobile homes have been estimated for Colorado weather from Judkoff (1991, 1990). Savings in new mobile homes have been estimated for the Northwest by Baylon et al. (1990). Multifamily costs and energy savings have been estimated by the Northwest Power Planning Council (NPPC 1986, NPPC 1989), while space conditioning loads for prototypes all over the U.S. have been estimated by Ritschard and Huang (1989).

B. Shell measures for existing and new homes

Existing single-family buildings: Advanced window options (such as superwindows and spectrally-selective glazing) have not been included for these buildings, and they should be. Costs of window replacement should be calculated for two cases: (1) assuming that the window would be replaced anyway, and estimating the incremental cost of upgrading the window, and (2) assuming that the window would not be replaced anyway. Estimates of the natural retrofit rate (i.e. because of breakage or window age) are currently being obtained from window and renovation trade associations.

New single-family buildings: all wall insulation levels higher than R-19 are assumed in our analysis to be reached using exterior sheathing, which is relatively expensive. Mass--producible advanced wall technologies for new buildings, including I-beam construction (used in Sweden--(Andrews 1990b, Schipper et al. 1985)), steel frame construction (Johnson and Liebeler 1991), foam blocks (Gilmore 1987), or solid-core foam walls may reduce the costs of achieving higher insulation values in walls.

Advances in windows are proceeding at a pace more characteristic of the computer industry than the generally more sedate building industry. Cheaper coatings and noble gas fillings are becoming the norm, and the goal of producing a window that would yield a net heat gain facing any direction on any northern U.S. house (R-8, including frame effects) is now within reach (Bakke 1990, Feder 1990, Gilmore 1986, Jones 1990, Warner 1990). New technologies on the horizon include chromogenic glazings that allow electronic control of window transmissivity (Moore 1987, Selkowitz and Lampert 1989) and innovative heat recovery schemes using controlled window infiltration (Pop Sci 1989).

Ventilation with heat recovery (which replaces uncontrolled infiltration as a means of preserving indoor air quality) is a technology that has matured in the past decade and is used widely in the Northwest (Lubliner and Young 1990). It has not been included in our conservation potential estimates. Both whole-house and room units are available (Cons. Rpts. 1985). Use of a tightly sealed shell with mechanical ventilation can achieve substantial further reductions in heating load due to infiltration, at a small cost in additional energy to operate the ventilation (Feustel et al. 1987).[11] Early results with these devices were mixed (Fisk and Turiel 1983, Turiel et al. 1983), but further experience has proved their reliability.

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[11] Ventilation with heat recovery may also help to achieve capital cost savings in the heating system--see section IV. C

C. Capital cost savings for advanced shell measures

Substantial improvements in shell efficiency can result in capital cost savings for space conditioning equipment. In the limiting case for space heating, the furnace can be eliminated altogether, and replaced with a larger water heater, as has been done by Bigelow Homes near Chicago (Andrews 1990a, Donovan 1988). Assessing these potential capital cost savings requires a whole-system analysis approach much more complicated than the one used in this study. EPRI (1987) has taken the first steps towards systematizing such an analysis.

D. Window orientation/passive solar features/landscaping

Few data exist about window orientation in new homes, but simple calculations suggest that using shading (awnings, trellises, shade screens, thermal curtains, or overhangs) and allocating more windows to the south and west side of northern houses (and more to the northern side of houses in the south) can reap substantial energy savings benefits. In the absence of data, our analysis assumed that window area is spread equally on all four walls, and that there are overhangs on all windows.

No other passive solar options are considered here, in spite of the potential energy savings available from these options (Kahn 1991), because costs for these improvements are more difficult to estimate than for simple changes in insulation levels. Both energy savings and costs of passive solar buildings are dependent on the complete building design and not just on the characteristics of the components.

Many analyses suggest that landscaping can have major effects on energy use (Huang et al. 1990, Meier 1991), but little information is available on the applicability of such measures to new and existing homes. Data are needed on the number of trees now planted around houses, the kind of trees typically planted, and the window orientation. More research is needed on these issues to assess the potential for reducing energy use using landscaping.

E. Internal loads

Changes in space conditioning loads due to improvements in appliance efficiency are not included in the supply curve analysis. In general, improvements in appliance efficiency will increase heating loads and decrease cooling loads. The LBL residential energy model (LBL REM) does keep track of these interactions, and as LBL REM and the supply curve model become more closely integrated, we expect to include these effects. The importance of heat pump water heaters and dryers in the technical potential case make a detailed assessment of the effects of internal loads imperative.

F. Infiltration

The data on baseline infiltration in both new and existing buildings of all types are based on small sample sizes that are heavily weighted towards buildings in California and the Northwest (CEC 1990, Kolb and Baylon 1989, Modera 1986, Sherman et al. 1984). Many local government agencies and non-profit organizations perform pressurization tests using blower doors to measure infiltration rates and perform retrofits of houses in their region. These data have never been compiled in a systematic format for the U.S. as a whole, but such a compilation is urgently needed for national-level policy analyses. Measuring *savings* from specific infiltration reduction measures are also needed, because the available measured data are scanty and inconclusive (Butterfield 1989, Schlegel 1990).

G. Duct leakage

Duct leakage, which can be substantial in centrally-conditioned homes (Brook 1991), has not been included in the analysis. Modera's (1991) latest unpublished results on the effect of duct leakage on furnace and central air conditioning efficiency indicate that the nominal efficiency of furnaces should be multiplied by a factor of 0.65 to calculate actual efficiency of heat delivery, while the comparable number for cooling is 0.66. This huge correction factor indicates that the importance of duct leakage has traditionally been underestimated in conservation potential analyses. We will include this correction factor in future updates of the supply curves whenever Modera's detailed work is published. RECS (US DOE 1989a) indicates that 70-80% of all existing U.S. houses have ducts, so this issue is potentially an important one. Omitting this factor represents a conservatism, in the face of uncertainty about current data and about the effects of recent changes in duct sealing practice.

H. Long-term fuel switching to homes near gas supply

We consider fuel switching in homes that already have gas service, but do not assess the potential for extending gas mains into areas that are close to the existing distribution system, or for ensuring that as many new developments as possible have gas service. In the long-term, such fuel switching could in many cases be cost effective, especially where electric space heating and water heating are switched to gas simultaneously. A more comprehensive study is needed to assess the size and cost-effectiveness of this additional fuel-switching potential.

I. Integrated appliances and advanced appliances

No attempt has been made to include the potential energy savings from integrated appliances that combine the functions of space conditioning and water heating, or those of televisions and video cassette recorders.

Ground-source heat pumps, which are extremely efficient compared to air-source models, have not been included in our technical potential estimates. Solar water heaters and solar pool heaters are not included, though these are cost effective in some applications. Gas-fired air conditioners are currently in use for commercial applications, and may yield additional cost-effective fuel switching potential in residential space conditioning by the mid-1990s.

J. Treatment of appliance standards

Appliance standards implemented after 1990 (e.g. the 1993 refrigerator/freezer standards) have been treated in this study as having a positive cost to society (relative to the 1990 standard). This cost is used to rank the standard in the supply curve.[12] A *utility* considering programs to increase the efficiency of refrigerators would "receive" these energy savings at zero cost, even though the *customer* would have to pay something for them. Care must therefore be used in extrapolating these national results to specific utility service territories.

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[12]These standards are always the first measures "implemented" regardless of CCE, even though the measures are shown on the grand supply curve ranked by CCE. This convention ensures that all energy savings for improving efficiency beyond the appliance standards are calculated correctly.

K. Lighting end-use

Lighting has been characterized in a relatively detailed fashion, considering that the available data are somewhat scanty. We expect some of these data to change as we accumulate more information in conjunction with LBL's analysis of possible lighting efficiency standards. Technical improvements and cost reductions for compact fluorescent lamps, partly influenced by utility incentive programs, will be assessed in more detail.

L. Miscellaneous end-uses

More investigation is needed into the components of and the savings from the Miscellaneous end-use category. In particular, pool heaters, furnace fans for non-electric furnaces, computers, VCRs, and other high saturation electronic devices need more careful study.

M. Load shape characteristics

Once measured or calculated, load shape characteristics for each measure (as represented in simplest form by *conservation load factors* (Koomey et al. 1990) or in more comprehensive fashion by average monthly or weekly load shapes) could be included as fields in each record of ACCESS's database. This addition would improve the program's usefulness in least-cost utility planning analyses, because it would allow more accurate characterization of the coincident load savings attributable to the efficiency resources.

N. Additional data needs

Improved data are needed on the costs of switching to heat pumps (HPs) in existing homes with electric resistance (ER) heating and central air conditioner (CAC) cooling. We assumed that $600 would suffice to pay for retrofitting and reoptimizing the ventilation system, and that a standard HP would cost an additional $100 over the cost of a standard CAC. Since the lifetime of the CAC is 12 years and the lifetime of baseboard heaters is roughly twice that, we assumed that HPs would be installed at the rate of retirement of baseboard heaters, thus avoiding the costs associated with early retirement of equipment. Further research is needed to test the accuracy of these assumptions, although the measure is so cost effective that even a several-fold increase in capital cost would keep the CCE below 7.6¢/kWh in all cases.

Information on the costs of fuel switching for water heaters, ranges, and dryers is often anecdotal. These costs are site-specific, and we know little about the extent of constraints on fuel switching and on the cost penalties imposed by such constraints.

V. CONCLUSIONS

This analysis has demonstrated that there are significant, cost-effective energy efficiency resources available in the U.S. residential sector. The technical potential for energy savings in the U.S. residential sector by 2010 is roughly equivalent to 70-75 1000-MW power plants, at an average cost of conserved energy of 3.4¢/kWh (using only those efficiency resources costing less than 7.6¢/kWh). These savings represent about 40% of the frozen efficiency baseline. If conservation resources up to 14¢/kWh are considered, the total technical potential is about 48% of the frozen efficiency baseline. Potentially large efficiency resources have not been included in the analysis due to lack of data or lack of resources, including building shell improvements for mobile homes and multifamily buildings, expansion of the gas supply network, landscaping and passive solar techniques, and advanced space conditioning shell technologies for new homes.

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APPENDIX 1: END-USE CODES

This appendix contains the codes for each conservation measure, for easy reference when analyzing the options shown in Appendices 2-3. The first two pages contain all the end-use codes, and the third page contains a graphical representation of the space conditioning codes that will aid comprehension.

USA-ELEC
END USES AND CODES

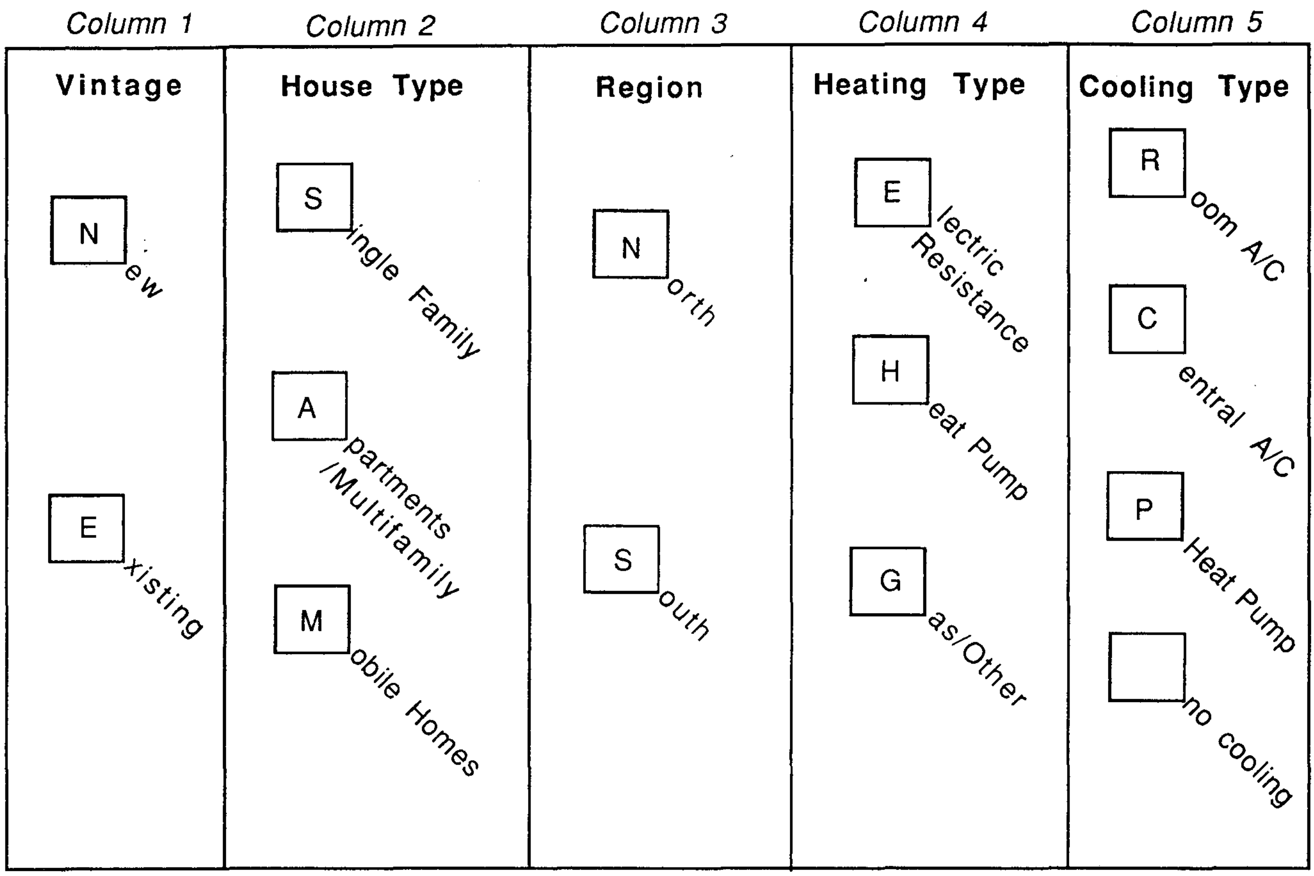
CODE	NAME
BWTV	Black and white television sets, 13 inch
CD-E	Clothes Dryer electric
CTV	Color television sets 19-20 inch
EANE	Existing multi family w/o cooling, North
EANEC	Existing MF w/ CAC, North
EANER	Existing MF w/ RAC, North
EANGC	Existing MF w/ non-elec htg & CAC, North
EANGR	Existing MF w/ non-elec htg & RAC, North
EANHP	Existing MF w/ heat pump, North
EASE	Existing multi family w/o cooling, South
EASEC	Existing MF w/ CAC, South
EASER	Existing MF w/ RAC, South
EASGC	Existing MF w/ non-elec htg & CAC, South
EASGR	Existing MF w/ non-elec htg & RAC, South
EASHP	Existing MF w/ heat pump, South
EMNE	Existing mobile homes w/o cooling, North
EMNEC	Existing MH w/ CAC, North
EMNER	Existing MH w/ RAC, North
EMNGC	Existing MH w/ non-elec htg & CAC, North
EMNGR	Existing MH w/ non-elec htg & RAC, North
EMNHP	Existing MH w/ heat pump, North
EMSE	Existing mobile homes w/o cooling, South
EMSEC	Existing MH w/ CAC, South
EMSER	Existing MH w/ RAC, South
EMSGC	Existing MH w/ non-elec htg & CAC, South
EMSGR	Existing MH w/ non-elec htg & RAC, South
EMSHP	Existing MH w/ heat pump, South
ERNG	Electric Range
ESNE	Existing SF homes w/o cooling, North
ESNEC	Existing SF w/ CAC, North
ESNER	Existing SF w/ RAC, North
ESNGC	Existing SF w/ non-elec htg & CAC, North
ESNGR	Existing SF w/ non-elec htg & RAC, North
ESNHP	Existing SF w/ heat pump, North
ESSE	Existing SF homes w/o cooling, South
ESSEC	Existing SF w/ CAC, South
ESSER	Existing SF w/ RAC, South
ESSGC	Existing SF w/ non-elec htg & CAC, South
ESSGR	Existing SF w/ non-elec htg & RAC, South
ESSHP	Existing SF w/ heat pump, South
EWH	Elec. Water Heater
FRZR	Manual defrost freezer
LTG	Lighting (Indoor and Outdoor)
MISE	Miscellaneous electricity
NANE	New multi family w/o cooling, North
NANEC	New multi family w/ CAC, North

NANER	New multi family w/ RAC, North
NANGC	New MF w/ non-elec htg & CAC, North
NANGR	New MF w/ non-elec htg & RAC, North
NANHP	New multi family w/ heat pump, North
NASE	New multi family w/o cooling, South
NASEC	New multi family w/ CAC, South
NASER	New multi family w/ RAC, South
NASGC	New MF w/ non-elec htg & CAC, South
NASGR	New MF w/ non-elec htg & RAC, South
NASHP	New multi family w/ heat pump, South
NMNE	New mobile homes w/o cooling, North
NMNEC	New mobile homes w/ CAC, North
NMNER	New mobile homes w/ RAC, North
NMNGC	New MH w/ non-elec htg & CAC, North
NMNGR	New MH w/ non-elec htg & RAC, North
NMNHP	New mobile homes w/ heat pump, North
NMSE	New mobile homes w/o cooling, South
NMSEC	New mobile homes w/ CAC, South
NMSER	New mobile homes w/ RAC, South
NMSGC	New MH w/ non-elec htg & CAC, South
NMSGR	New MH w/ non-elec htg & RAC, South
NMSHP	New mobile homes w/ heat pump, South
NSNE	New single family homes w/o cooling, North
NSNEC	New SF electric furnace, CAC homes in North
NSNER	New SF electric furnace homes with room AC, North
NSNGC	New SF non-electrically heated homes w/ CAC, North
NSNGR	New SF non-electrically heated homes w/ RAC, North
NSNHP	New single family homes w heat pumps, North
NSSE	New single family homes w/o cooling, South
NSSEC	New SF electric furnace, CAC homes in South
NSSER	New SF electric furnace homes with room AC, South
NSSGC	New SF non-electrically heated homes w/ CAC, South
NSSGR	New SF non-electrically heated homes w/ RAC, South
NSSHP	New single family homes w heat pumps, South
REF	Refrigerator

LIST OF ACRONYMS

AC Air conditioning
CAC Central air conditioning
RAC Room air conditioning
SF Single family home
MF Multi family
MH Mobile home

Figure A-1: End Use Codes for Space Conditioning



(1) New Homes are defined as those built after 1990

APPENDIX 2a: CONSERVATION MEASURE DATABASE 2000

This appendix contains the conservation measures that are plotted in Figure 5, ranked in order of Cost of Conserved Energy (CCE). The CCE represents technology cost—no program costs are included. Applicable stock represents the number of appliances or building shells to which the measure can be applied from 1990 to 2000. All costs from sources in Appendix 3 have been converted to 1989$.

Grand Supply Curve - Year 2000Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	EWH01	Improve clotheswasher to 1994 standard	1	45	0.2	1.52	1.52	33993
2	NSNEC01	Switch elec furnace to HP in new SF homes, North	222	7298	0.3	3.16	4.67	432
3	NSSEC01	Switch elec furnace to HP in new SF homes, South	322	6456	0.6	5.09	9.76	789
4	ESNEC01	Switch elec furn to HP in existing North SF	822	11853	0.8	3.44	13.20	290
5	ESNHP02	Improve ceiling insulation in ESF HP homes, North	7	72	0.8	0.03	13.23	460
6	EWH02	Reduce hot water consumption	50	873	0.8	29.68	42.91	33993
7	ESNER01	Improve shell in ESF ER/RAC homes, North	274	2374	0.9	0.79	43.70	332
8	ESNHP03	Improve HP in ESF HP homes, North	151	1598	1.1	1.47	45.17	919
9	ESNHP01	Improve HP to 92 std in ESF HP homes, North	71	719	1.1	0.66	45.83	919
10	EANHP02	Improve HP beyond 92 std in EMF HP homes, North	104	1028	1.2	1.33	47.15	1291
11	ESSHP02	Improve ceiling insulation in ESF HP homes, South	5	31	1.3	0.03	47.19	1027
12	NSSGC02	Spectrally selective windows, NSF non-elec, South	311	1813	1.4	2.43	49.61	1339
13	NSSER01	Shell improvement in new SF homes w/ ER/RAC, South	1061	5624	1.5	0.95	50.56	169
14	EMNHP02	Improve HP beyond 1992 standard in North EMH	159	1150	1.6	0.01	50.58	13
15	NSNER01	Shell improvement in new SF homes w/ ER/RAC, North	631	3231	1.6	0.25	50.83	78
16	NSSE01	Shell improvement in new SF homes w/ ER/-, South	1061	5424	1.6	1.77	52.60	327
17	ESNE01	Improve shell in ESF ER/- homes, North	754	3583	1.7	1.22	53.82	340
18	ESSEC01	Switch elec furn to HP in existing South SF	869	5805	1.7	3.83	57.65	659
19	NSSHP02	Improve HP beyond 1992 standard in South SF homes	183	1122	1.9	1.93	59.57	1716
20	NSSEC02	Improved shell in new SF homes w/ ER/CAC, South	682	2910	1.9	2.29	61.87	789
21	NANHP02	Improve HP beyond 92 std in NMF HP homes, North	104	623	1.9	0.06	61.93	94
22	MISE03	Improve dishwasher motor to 1994 standard	4	23	1.9	0.80	62.73	34347
23	NSNER02	Shell improvement in new SF homes w/ ER/RAC, North	1095	4639	1.9	0.36	63.09	77
24	ESSHP03	Improve HP in ESF HP homes, South	292	1693	2.0	3.48	66.57	2055
25	NSNHP03	Improve HP beyond 1992 standard in North SF homes	241	1379	2.0	1.63	68.20	1184
26	LTG01	Timer & Photocell (outdoor)	27	151	2.0	11.53	79.73	76328
27	ESSER01	Improve shell in ESF ER/RAC homes, South	444	1757	2.0	0.78	80.51	446
28	EWH03	Improve dishwasher to 1994 standard	8	45	2.1	1.53	82.04	33993
29	ESSE01	Improve shell in ESF ER/- homes, South	451	1712	2.1	0.61	82.64	354
30	EMSHP02	Improve HP beyond 1992 standard in South EMH	192	981	2.2	0.02	82.66	17

Grand Supply Curve - Year 2000Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Cumulative TWh	Applicable Stock 10^3
31	NSNHP01	Improve HP to 1992 standard in North SF homes	71	243	2.4	0.29	82.95	1184
32	NMSHP02	Improve HP beyond 1992 standard in South NMH	192	917	2.4	0.03	82.98	35
33	NSSHP03	Improved shell in new SF homes w/ HP, South	711	2398	2.4	4.12	87.10	1716
34	NSSGR01	Increase condenser rows in RAC, NSF non-elec, Sth	12	54	2.4	0.02	87.12	435
35	EMSHP01	Improve HP to 92 std in EMH HP homes, South	55	251	2.5	0.00	87.12	17
36	REF01	Improve refrigerator to 1993 standard	53	203	2.5	14.83	101.95	72978
37	NSNEC02	Triple glazed windows in new SF homes, North	223	707	2.6	0.31	102.26	432
38	EASHP02	Improve HP beyond 92 std in EMF HP homes, South	104	462	2.6	0.28	102.54	612
39	ESNEC02	Improve shell in ESF ER/CAC homes, North	274	842	2.6	0.31	102.85	363
40	NMSHP01	Improve HP to 92 std in NMH HP homes, South	57	239	2.7	0.01	102.86	35
41	ESNHP04	Improve shell in ESF HP homes, North	121	353	2.8	0.16	103.02	460
42	NSSER02	Increase condenser rows of RAC in elec NSF, South	12	45	2.9	0.01	103.03	169
43	NMSGR01	Improve RAC in NMH non-elec homes, Sth	10	41	2.9	0.01	103.04	262
44	NMSER01	Improve RAC in NMH elec htd homes, Sth	10	41	2.9	0.01	103.05	332
45	EANHP01	Improve HP to 92 std in EMF HP homes, North	49	190	2.9	0.25	103.30	1291
46	NSNHP02	Triple glazed windows in new SF homes w/HP, North	311	1188	3.0	1.41	104.70	1184
47	EMSER01	Improve RAC in EMH elec htd homes, Sth	10	40	3.0	0.01	104.71	210
48	CTV01	Efficient color TV set	8	34	3.0	3.14	107.85	92278
49	ESSHP01	Improve HP to 92 std in ESF HP homes, South	86	321	3.1	0.66	108.51	2055
50	CD-E01	Improve clothes dryer to 1994 NAECA standard	22	73	3.1	2.99	111.50	40959
51	EMSGR01	Improve RAC in EMH non-elec homes, Sth	10	38	3.1	0.02	111.52	594
52	LTG02	Compact Fluorescent Lamps	102	342	3.3	26.10	137.62	76328
53	ESNHP05	Improve HP in ESF HP homes, North	90	305	3.4	0.28	137.90	919
54	FRZR01	Improve freezer to 1993 DOE standard	37	100	3.4	1.55	139.46	15543
55	EWH04	Reduce standby losses	120	425	3.4	14.45	153.90	33993
56	NSSHP01	Improve HP to 1992 standard in South SF homes	86	285	3.4	0.49	154.39	1716
57	MISE02	Upgrade furnace fan efficiency	48	150	3.5	3.43	157.83	22898
58	ESSER02	Improve room AC in ESF homes, South	15	47	3.5	0.04	157.87	891
59	ESNEC03	Switch to improved HP in North ESF homes	90	285	3.6	0.08	157.95	290
60	ESSGC01	Improve CAC to 1992 std in ESF non-elec homes, Sth	50	171	3.7	1.05	159.00	6128

Grand Supply Curve - Year 2000Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
61	NSSER04	Shell improvement in NSF ER/RAC homes, Sth (>1995)	530	1152	3.7	0.10	159.10	84
62	NSSGC01	Improve CAC to 1992 std in NSF non-elec homes, Sth	50	169	3.7	0.23	159.32	1339
63	EANHP03	Improve HP(2) in EMF HP homes, North	62	179	3.9	0.23	159.55	1291
64	ESNER02	Improve window, ceil & wall in ESF homes, North	1354	2718	4.0	0.90	160.46	332
65	ESSHP04	Improve shell in ESF HP homes, South	304	593	4.2	0.61	161.07	1027
66	EMNHP01	Improve HP to 92 std in EMH HP homes, North	93	238	4.5	0.00	161.07	13
67	NMSGC01	Improve CAC to 1992 std in new non-elec MH, South	50	140	4.5	0.04	161.10	262
68	NMSEC01	Improve CAC to 1992 std in new elec htd MH, South	50	140	4.5	0.06	161.16	419
69	EMSEC01	Improve CAC to 1992 std in EMH elec htd homes, Sth	50	136	4.6	0.02	161.18	140
70	ESSEC02	Improve shell in ESF ER/CAC homes, South	444	776	4.6	0.64	161.82	824
71	NANHP01	Improve HP to 92 std in NMF HP homes, North	49	119	4.7	0.01	161.83	94
72	EWH08	Replace electric water heater with gas	1380	3539	4.7	11.77	173.60	3325
73	ESNE02	Improve window, ceil & wall in ESF homes, North	859	1469	4.7	0.50	174.10	340
74	EMSGC01	Improve CAC to 1992 std in EMH non-elec homes, Sth	50	130	4.8	0.02	174.12	175
75	EASHP01	Improve HP to 92 std in EMF HP homes, South	49	115	4.9	0.07	174.19	612
76	NASHP02	Improve HP beyond 92 std in NMF HP homes, South	104	244	4.9	0.07	174.27	296
77	BWTV01	Efficient black and white TV set	1	3	4.9	0.10	174.37	39890
78	NSNEC03	Improve HP in North single-family	190	430	5.0	0.19	174.55	432
79	ESNHP06	Improve ceiling in ESF HP homes, North	3	5	5.1	0.00	174.55	460
80	FRZR02	Evacuated panels for freezer (post 1995)	74	132	5.2	0.88	175.44	6697
81	REF02	Evacuated Panels for refrigerator (post 1995)	62	113	5.4	4.10	179.53	36250
82	EWH07	Horizontal axis clotheswasher w/ EWH (1995-2000)	137	285	5.5	1.38	180.92	4855
83	MISE07	Horiz axis clthswshr w/EWH (motor svgs) 1995-2000	32	65	5.6	0.66	181.58	10263
84	EWH05	Heat pump water heater (1995-2000)	504	1076	5.6	4.64	186.22	4315
85	EASGC01	Improve CAC to 1992 std in EMF non-elec homes, Sth	28	61	5.7	0.08	186.30	1287
86	EASEC01	Improve CAC to 1992 std in EMF elec htd homes, Sth	28	61	5.7	0.09	186.39	1479
87	EMNHP03	Improve HP(2) in North EMH	95	185	5.8	0.00	186.40	13
88	NSNEC04	Wall to R-19 in new SF homes, North	186	257	5.9	0.11	186.51	432
89	ESSGC02	Improve CAC in South ESF non-elec homes w/ CAC	309	664	5.9	4.07	190.58	6128
90	CD-E03	Switch electric clothesdryer to gas	480	807	6.1	11.90	202.48	14745

Grand Supply Curve - Year 2000Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
91	ERNG02	Switch from electric to gas range	590	944	6.2	11.05	213.52	11710
92	NSSER03	Ceiling to R-30 in NSF ER/RAC homes, Sth (pre-'95)	57	73	6.3	0.01	213.54	169
93	NSNER03	Wall to R-27, ceil to R-49 in new SF homes, North	1355	1725	6.4	0.27	213.80	155
94	NSNHP04	Wall to R-19 in new SF homes w/ HP, North	267	335	6.5	0.40	214.20	1184
95	EMNER01	Improve RAC in EMH elec htd homes, Nth	10	19	6.5	0.00	214.20	51
96	NSSE02	Ceiling to R-30 in new SF homes w/ ER/-, South	57	70	6.6	0.02	214.22	327
97	NANHP03	Improve HP(2) in NMF HP homes, North	62	106	6.7	0.01	214.23	94
98	NMNER01	Improve RAC in NMH elec htd homes, Nth	10	18	6.7	0.00	214.23	23
99	NMNGR01	Improve RAC in NMH non-elec htd homes, Nth	10	18	6.7	0.00	214.24	102
100	ERNG01	Induction cooktop and improved oven (post-1995)	171	250	6.8	4.47	218.71	17894
101	NSNHP07	Superwindows in NSF HP homes, N (post-95)	556	655	6.9	0.38	219.09	588
102	EMNGR01	Improve RAC in EMH non-elec homes, Nth	10	17	7.1	0.01	219.10	354
103	ESNER03	R-30 floor in ESF ER/RAC homes, North	1297	1482	7.1	0.18	219.28	123
104	NASGC01	Improve CAC to 1992 std in NMF non-elec homes, Sth	28	49	7.1	0.03	219.31	538
105	NASEC01	Improve CAC to 1992 std in NMF elec htd homes, Sth	28	49	7.1	0.04	219.34	738
106	ESNE03	R-30 floor in ESF ER/- homes, North	1297	1471	7.1	0.50	219.84	340
107	NSSEC03	Wall to R-19 in new SF homes, South	379	429	7.2	0.34	220.18	789
108	NMSGC02	Improve CAC beyond 1992 std in NMH non-elec homes,	309	537	7.3	0.14	220.32	262
109	NMSEC02	Improve CAC beyond 1992 std in NMH elec htd homes,	309	537	7.3	0.23	220.55	419
110	NSSE03	Superwindows in NSF homes w/ ER/-, South(post-'95)	473	521	7.4	0.09	220.63	164
111	EASER01	Improve RAC in EMF elec htd homes, Sth	10	16	7.4	0.01	220.65	703
112	EASGR01	Improve RAC in EMF non-elec homes, Sth	10	16	7.4	0.02	220.67	1232
113	EMSEC02	Improve CAC beyond 1992 std in EMH elec htd homes,	309	525	7.4	0.07	220.74	140
114	ESSER03	Improve ceiling in ESF ER/RAC homes, South	410	443	7.5	0.20	220.94	446
115	ESNE04	Improve ceiling in ESF homes, North	14	15	7.6	0.01	220.94	340
116	ESSEC03	Switch to improved HP in South ESF homes	109	162	7.7	0.11	221.05	659
117	EMSGC02	Improve CAC beyond 1992 std in EMH non-elec homes,	309	501	7.8	0.09	221.14	175
118	EMNEC01	Improve CAC to 1992 std in EMH elec htd homes, Nth	43	69	7.9	0.00	221.14	38
119	NASHP01	Improve HP to 92 std in NMF HP homes, South	49	70	8.0	0.02	221.16	296
120	ESSE02	Improve ceiling in ESF ER/- homes, South	403	409	8.0	0.14	221.30	354

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Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
121	NMNEC01	Improve CAC to 1992 std in new elec htd MH, North	43	67	8.1	0.00	221.31	19
122	NMNGC01	Improve CAC to 1992 std in new non-elec MH, North	43	67	8.1	0.01	221.31	91
123	EMNGC01	Improve CAC to 1992 std in EMH non-elec homes, Nth	43	64	8.5	0.02	221.33	266
124	NSNER04	Ceiling to R-60 in new SF homes w/ ER/RAC, North	148	139	8.6	0.02	221.35	155
125	NSNE04	Ceiling to R-60 in new SF homes w/ ER/-, North	148	138	8.7	0.07	221.42	476
126	EASGC02	Improve CAC beyond 1992 std in EMF non-elec homes,	169	234	9.1	0.30	221.72	1287
127	EASEC02	Improve CAC beyond 1992 std in EMF elec htd homes,	169	234	9.1	0.35	222.06	1479
128	NASGR01	Improve RAC in NMF non-elec homes, Sth	10	13	9.2	0.00	222.06	52
129	NASER01	Improve RAC in NMF elec htd homes, Sth	10	13	9.2	0.00	222.06	167
130	EWH06	Horizontal axis clotheswasher w/ HPWH (1995-2000)	116	143	9.2	0.26	222.32	1798
131	MISE04	Horiz axis clthswshr w/HPWH (motor svgs) 1995-2000	53	65	9.3	0.25	222.57	3801
132	NSNEC06	Floor to R-30 in new SF homes, North	223	192	9.4	0.08	222.65	432
133	ESSEC04	Switch to improved HP in South ESF homes	330	399	9.4	0.26	222.91	659
134	NSSEC04	Improve HP in South new SF ER/CAC homes	90	108	9.5	0.09	223.00	789
135	ESSHP05	Improve ceiling in ESF HP homes, South	2	2	9.5	0.00	223.00	1027
136	NSNHP05	R-30 floor in new SF homes w/ HP, N (<'95)	311	261	9.7	0.16	223.16	596
137	LTG03	Compact Fluorescent Fixtures	263	293	9.9	22.36	245.52	76328
138	ESNEC04	Improve ceiling insulation in ESF homes, North	480	393	9.9	0.14	245.66	363
139	NSNGC01	Improve CAC to 1992 std in NSF non-elec homes, Nth	43	54	10.0	0.12	245.78	2196
140	EANHP04	Improve HP(3) in EMF HP homes, North	228	254	10.2	0.33	246.11	1291
141	EMSHP03	Improve HP(2) in South EMH	114	127	10.3	0.00	246.11	17
142	ESNGC01	Improve CAC to 1992 std in ESF non-elec homes, Nth	43	52	10.4	0.40	246.51	7600
143	ESNHP07	Improve ceiling in ESF HP homes, North	555	425	10.6	0.20	246.70	460
144	MISE01	Improve miscellaneous appliance motor efficiency	190	190	11.0	14.50	261.20	76328
145	NSNHP08	R-30 floor in new SF homes w/ HP, N (>'95)	311	226	11.2	0.27	261.47	1184
146	NMSHP03	Improve HP(2) in South NMH	114	115	11.3	0.00	261.47	35
147	NASGC02	Improve CAC beyond 1992 std in NMF non-elec homes,	169	187	11.4	0.10	261.57	538
148	NASEC02	Improve CAC beyond 1992 std in NMF elec htd homes,	169	187	11.4	0.14	261.71	738
149	EASHP03	Improve HP(2) in EMF HP homes, South	62	62	11.4	0.04	261.75	612
150	NSSGC03	Improve CAC in South new SF non-elec homes w/ CAC	309	336	11.6	0.45	262.20	1339

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Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
151	NSSER05	Ceiling to R-38 in new SF homes w/ ER/RAC, South	322	219	11.9	0.04	262.24	169
152	NSSHP04	Improve HP in South new SF HP homes	109	104	11.9	0.18	262.42	1716
153	EMNHP04	Improve HP(3) in North EMH	347	327	12.1	0.00	262.42	13
154	ESNER04	Improve windows in ESF homes, North	316	210	12.2	0.07	262.49	332
155	ESNE05	Improve windows in ESF homes, North	316	209	12.2	0.07	262.56	340
156	NSNEC07	Ceiling to R-30 in new SF homes, North	19	12	12.5	0.01	262.57	432
157	NSNHP06	R-30 ceiling in new SF homes w/ HP, N(<'95)	44	29	12.6	0.02	262.58	596
158	NSSHP05	Wall to R-19 in new SF homes w/ HP, South	328	210	12.6	0.36	262.94	1716
159	NSSE04	Ceiling to R-38 in new SF homes w/ ER/-, South	322	205	12.7	0.07	263.01	327
160	ESSER04	Improve windows in ESF ER/RAC homes, South	425	269	12.8	0.12	263.13	446
161	REF03	Two-Compressor System for refrigerator (post 1995)	93	69	13.0	2.50	265.63	36250
162	EMSHP04	Improve HP(3) in South EMH	419	360	13.3	0.01	265.64	17
163	ESSE03	Improve windows in ESF ER/- homes, South	425	259	13.3	0.09	265.73	354
164	ESSER05	Improve wall in ESF ER/RAC homes, South	325	197	13.4	0.09	265.82	446
165	NSNGR01	Increase condenser rows in RAC in NSF non-elec, N	15	14	13.5	0.01	265.83	663
166	ESSE04	Improve wall in ESF ER/- homes, South	325	191	13.8	0.07	265.89	354
167	NMSHP04	Improve HP(3) in South NMH	419	344	13.9	0.01	265.91	35
168	ESSGC03	Improve CAC(2) in ESF non-elec homes w/ CAC, South	293	263	14.0	1.61	267.52	6128
169	EANEC01	Improve CAC to 1992 std in EMF elec htd homes, Nth	27	23	14.6	0.02	267.54	850
170	EANGC01	Improve CAC to 1992 std in EMF elec htd homes, Nth	27	23	14.6	0.04	267.57	1579
171	ESNHP08	Improve windows in ESF HP homes, North	298	165	14.6	0.08	267.65	460
172	NSNHP09	R-30 ceiling in new SF homes w/ HP, N(>'95)	44	25	14.6	0.03	267.68	1184
173	ESNEC05	Improve window & wall in ESF homes, North	646	355	14.8	0.13	267.81	363
174	EASHP04	Improve HP(3) in EMF HP homes, South	228	164	15.8	0.10	267.91	612
175	NANGC01	Improve CAC to 1992 std in NMF elec htd homes, Nth	27	21	16.0	0.01	267.92	504
176	NANEC01	Improve CAC to 1992 std in NMF elec htd homes, Nth	27	21	16.0	0.01	267.93	679
177	NSNGC02	Improve CAC in North NSF non-elec homes w/ CAC	264	208	16.0	0.46	268.39	2196
178	NANHP04	Improve HP(3) in NMF HP homes, North	228	161	16.1	0.02	268.41	94
179	ESNGC02	Improve CAC in North ESF non-elec homes w/ CAC	264	201	16.5	1.53	269.93	7600
180	ESSEC05	Improve ceiling insulation in ESF homes, South	403	187	17.5	0.15	270.09	824

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Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
181	NSSGR02	Increase condenser area of RAC, NSF non-elec, Sth	87	54	17.7	0.02	270.11	435
182	ESSHP06	Improve windows in ESF HP homes, South	360	135	21.6	0.14	270.25	1027
183	NASHP03	Improve HP(2) in NMF HP homes, South	62	26	26.9	0.01	270.26	296
184	NSSGC04	Improve CAC(2) in NSF non-elec homes w/ CAC, South	293	133	27.8	0.18	270.43	1339
185	NSNGC03	Improve CAC(2) in North NSF non-elec homes w/ CAC	250	82	38.4	0.18	270.61	2196

APPENDIX 2b: CONSERVATION MEASURE DATABASE 2010

This appendix contains the conservation measures that are plotted in Figure 6, ranked in order of Cost of Conserved Energy (CCE). The CCE represents technology cost—no program costs are included. Applicable stock represents the number of or building shells to which the measure can be applied from 1990 to the end of the analysis period.

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Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	EWH01	Improve clotheswasher to 1994 standard	1	45	0.2	2.14	2.14	47969
2	NSNEC01	Switch elec furnace to HP in new SF homes, North	222	7298	0.3	5.72	7.86	784
3	NSSEC01	Switch elec furnace to HP in new SF homes, South	322	6456	0.6	9.58	17.44	1484
4	ESNEC01	Switch elec furn to HP in existing North SF	822	11853	0.8	7.83	25.27	661
5	ESNHP02	Improve ceiling insulation in ESF HP homes, North	7	72	0.8	0.06	25.33	838
6	EWH02	Reduce hot water consumption	50	873	0.8	41.88	67.21	47969
7	ESNER01	Improve shell in ESF ER/RAC homes, North	274	2374	0.9	1.44	68.65	605
8	ESNHP03	Improve HP in ESF HP homes, North	151	1598	1.1	1.34	69.99	838
9	ESNHP01	Improve HP to 92 std in ESF HP homes, North	71	719	1.1	0.60	70.59	838
10	EANHP02	Improve HP beyond 92 std in EMF HP homes, North	104	1028	1.2	1.19	71.78	1162
11	ESSHP02	Improve ceiling insulation in ESF HP homes, South	5	31	1.3	0.06	71.84	1865
12	NSSGC02	Spectrally selective windows, NSF non-elec, South	311	1813	1.4	4.57	76.41	2519
13	NSSER01	Shell improvement in new SF homes w/ ER/RAC, South	1061	5624	1.5	1.79	78.19	318
14	EMNHP02	Improve HP beyond 1992 standard in North EMH	159	1150	1.6	0.01	78.20	9
15	NSNER01	Shell improvement in new SF homes w/ ER/RAC, North	631	3231	1.6	0.25	78.46	78
16	NSSE01	Shell improvement in new SF homes w/ ER/-, South	1061	5424	1.6	3.34	81.79	616
17	ESNE01	Improve shell in ESF ER/- homes, North	754	3583	1.7	2.22	84.01	619
18	ESSEC01	Switch elec furn to HP in existing South SF	869	5805	1.7	8.69	92.70	1496
19	NSSHP02	Improve HP beyond 1992 standard in South SF homes	183	1122	1.9	3.62	96.32	3230
20	NSSEC02	Improved shell in new SF homes w/ ER/CAC, South	682	2910	1.9	4.32	100.64	1484
21	NANHP02	Improve HP beyond 92 std in NMF HP homes, North	104	623	1.9	0.11	100.75	171
22	MISE03	Improve dishwasher motor to 1994 standard	4	23	1.9	1.23	101.98	52729
23	NSNER02	Shell improvement in new SF homes w/ ER/RAC, North	1095	4639	1.9	0.94	102.93	203
24	ESSHP03	Improve HP in ESF HP homes, South	292	1693	2.0	3.16	106.08	1865
25	LTG01	Timer & Photocell (outdoor)	27	151	2.0	17.69	123.78	117175
26	NSNHP03	Improve HP beyond 1992 standard in North SF homes	241	1379	2.0	2.96	126.74	2147
27	ESSER01	Improve shell in ESF ER/RAC homes, South	444	1757	2.0	1.42	128.16	809
28	EWH03	Improve dishwasher to 1994 standard	8	45	2.1	2.16	130.32	47969
29	ESSE01	Improve shell in ESF ER/- homes, South	451	1712	2.1	1.10	131.42	642
30	EMSHP02	Improve HP beyond 1992 standard in South EMH	192	981	2.2	0.01	131.43	13

Supply Curve - Year 2010 Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
31	NSNHP01	Improve HP to 1992 standard in North SF homes	71	243	2.4	0.52	131.95	2147
32	NMSHP02	Improve HP beyond 1992 standard in South NMH	192	917	2.4	0.06	132.02	71
33	NSSHP03	Improved shell in new SF homes w/ HP, South	711	2398	2.4	7.75	139.76	3230
34	NSSGR01	Increase condenser rows in RAC, NSF non-elec, Sth	12	54	2.4	0.04	139.81	819
35	EMSHP01	Improve HP to 92 std in EMH HP homes, South	55	251	2.5	0.00	139.81	13
36	REF01	Improve refrigerator to 1993 standard	53	203	2.5	27.52	167.33	135449
37	NSNEC02	Triple glazed windows in new SF homes, North	223	707	2.6	0.55	167.89	784
38	EASHP02	Improve HP beyond 92 std in EMF HP homes, South	104	462	2.6	0.25	168.14	548
39	ESNEC02	Improve shell in ESF ER/CAC homes, North	274	842	2.6	0.56	168.70	661
40	NMSHP01	Improve HP to 92 std in NMH HP homes, South	57	239	2.7	0.02	168.71	71
41	ESNHP04	Improve shell in ESF HP homes, North	121	353	2.8	0.30	169.01	838
42	NSSER02	Increase condenser rows of RAC in elec NSF, South	12	45	2.9	0.01	169.02	318
43	NMSGR01	Improve RAC in NMH non-elec homes, Sth	10	41	2.9	0.02	169.04	529
44	NMSER01	Improve RAC in NMH elec htd homes, Sth	10	41	2.9	0.03	169.07	670
45	EANHP01	Improve HP to 92 std in EMF HP homes, North	49	190	2.9	0.22	169.29	1162
46	NSNHP02	Triple glazed windows in new SF homes w/HP, North	311	1188	3.0	2.55	171.84	2147
47	EMSER01	Improve RAC in EMH elec htd homes, Sth	10	40	3.0	0.01	171.85	151
48	CTV01	Efficient color TV set	8	34	3.0	3.71	175.55	108973
49	ESSHP01	Improve HP to 92 std in ESF HP homes, South	86	321	3.1	0.60	176.15	1865
50	CD-E01	Improve clothes dryer to 1994 NAECA standard	22	73	3.1	5.08	181.23	69599
51	EMSGR01	Improve RAC in EMH non-elec homes, Sth	10	38	3.1	0.02	181.25	429
52	LTG02	Compact Fluorescent Lamps	102	342	3.3	40.07	221.32	117175
53	ESNHP05	Improve HP in ESF HP homes, North	90	305	3.4	0.26	221.58	838
54	FRZR01	Improve freezer to 1993 DOE standard	37	100	3.4	3.42	225.00	34248
55	EWH04	Reduce standby losses	120	425	3.4	20.39	245.38	47969
56	NSSHP01	Improve HP to 1992 standard in South SF homes	86	285	3.4	0.92	246.31	3230
57	MISE02	Upgrade furnace fan efficiency	48	150	3.5	5.27	251.58	35153
58	ESSER02	Improve room AC in ESF homes, South	15	47	3.5	0.04	251.62	809
59	ESNEC03	Switch to improved HP in North ESF homes	90	285	3.6	0.19	251.80	661
60	ESSGC01	Improve CAC to 1992 std in ESF non-elec homes, Sth	50	171	3.7	0.95	252.76	5562

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Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
61	NSSER07	Increase condenser area of RAC in elec NSF, South	20	59	3.7	0.01	252.76	149
62	NSSER04	Shell improvement in NSF ER/RAC homes, Sth (>1995)	530	1152	3.7	0.27	253.03	233
63	NSSGC01	Improve CAC to 1992 std in NSF non-elec homes, Sth	50	169	3.7	0.43	253.46	2519
64	FRZR03	5.3 EER compressor for freezer (post-2000)	10	25	3.8	0.47	253.93	18705
65	REF12	Recycle refrigerator condenser heat (post-2000)	40	100	3.9	6.81	260.74	68137
66	EANHP03	Improve HP(2) in EMF HP homes, North	62	179	3.9	0.21	260.95	1162
67	ESNER02	Improve window, ceil & wall in ESF homes, North	1354	2718	4.0	1.64	262.59	605
68	ESSHP04	Improve shell in ESF HP homes, South	304	593	4.2	1.11	263.70	1865
69	NSSGR03	Variable speed RAC, NSF non-elec, South (>2000)	67	173	4.3	0.07	263.76	384
70	EMNHP01	Improve HP to 92 std in EMH HP homes, North	93	238	4.5	0.00	263.77	9
71	CD-E02	Heat pump dryer	230	525	4.5	12.63	276.40	24068
72	NMSGC01	Improve CAC to 1992 std in new non-elec MH, South	50	140	4.5	0.07	276.47	529
73	NMSEC01	Improve CAC to 1992 std in new elec htd MH, South	50	140	4.5	0.12	276.59	846
74	EMSEC01	Improve CAC to 1992 std in EMH elec htd homes, Sth	50	136	4.6	0.01	276.61	101
75	ESSEC02	Improve shell in ESF ER/CAC homes, South	444	776	4.6	1.16	277.77	1496
76	NANHP01	Improve HP to 92 std in NMF HP homes, North	49	119	4.7	0.02	277.79	171
77	EWH08	Replace electric water heater with gas	1380	3539	4.7	16.61	294.40	4693
78	ESNE02	Improve window, ceil & wall in ESF homes, North	859	1469	4.7	0.91	295.31	619
79	NSSGR04	Increase condenser area of RAC, non-elec NSF, Sth	20	46	4.8	0.02	295.32	384
80	EMSGC01	Improve CAC to 1992 std in EMH non-elec homes, Sth	50	130	4.8	0.02	295.34	126
81	EASHP01	Improve HP to 92 std in EMF HP homes, South	49	115	4.9	0.06	295.40	548
82	NASHP02	Improve HP beyond 92 std in NMF HP homes, South	104	244	4.9	0.14	295.54	564
83	BWTV01	Efficient black and white TV set	1	3	4.9	0.11	295.65	43355
84	NSNEC03	Improve HP in North single-family	190	430	5.0	0.34	295.99	784
85	ESNHP06	Improve ceiling in ESF HP homes, North	3	5	5.1	0.00	295.99	838
86	FRZR02	Evacuated panels for freezer (post 1995)	74	132	5.2	3.35	299.34	25402
87	NMSGR02	Improve RAC(2) in NMH non-elec homes, Sth(post2000	56	132	5.3	0.04	299.38	267
88	NMSER02	Improve RAC(2) in NMH elec htd homes, Sth(post2000	56	132	5.3	0.04	299.42	338
89	REF02	Evacuated Panels for refrigerator (post 1995)	62	113	5.4	11.80	311.22	104387
90	EMSER02	Improve RAC(2) in EMH elec htd homes, Sth(post2000	56	129	5.4	0.01	311.23	58

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Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
91	EWH07	Horizontal axis clotheswasher w/ EWH (1995-2000)	137	285	5.5	1.38	312.61	4855
92	EWH10	Horizontal axis clotheswasher w/ EWH(post-2000)	137	285	5.5	3.55	316.16	12473
93	REF13	Raise refrig compressor EER to 5.3 (post 2000)	10	18	5.5	1.23	317.39	68137
94	MISE07	Horiz axis clthswshr w/EWH (motor svgs) 1995-2000	32	65	5.6	0.66	318.05	10263
95	MISE05	Horiz axis clthswshr w/EWH (motor svgs) post-2000	32	65	5.6	1.64	319.69	25315
96	EWH08	Heat pump water heater (post-2000)	504	1076	5.6	18.41	338.09	17106
97	EWH05	Heat pump water heater (1995-2000)	504	1076	5.6	4.64	342.74	4315
98	EMSGR02	Improve RAC(2) in EMH non-elec homes, Sth(post2000	56	123	5.7	0.02	342.76	165
99	EASGC01	Improve CAC to 1992 std in EMF non-elec homes, Sth	28	61	5.7	0.07	342.83	1152
100	EASEC01	Improve CAC to 1992 std in EMF elec htd homes, Sth	28	61	5.7	0.08	342.91	1324
101	FRZR04	Freezer condenser gas heat	31	50	5.8	0.94	343.84	18705
102	EMNHP03	Improve HP(2) in North EMH	95	185	5.8	0.00	343.85	9
103	NSNEC04	Wall to R-19 in new SF homes, North	186	257	5.9	0.20	344.05	784
104	ESSGC02	Improve CAC in South ESF non-elec homes w/ CAC	309	664	5.9	3.69	347.74	5562
105	CD-E03	Switch electric clothesdryer to gas	480	807	6.1	20.22	367.96	25056
106	ERNG02	Switch from electric to gas range	590	944	6.2	18.29	386.25	19384
107	NSSER03	Ceiling to R-30 in NSF ER/RAC homes, Sth (pre-'95)	57	73	6.3	0.02	386.27	318
108	NSNER03	Wall to R-27, ceil to R-49 in new SF homes, North	1355	1725	6.4	0.48	386.76	281
109	NSNHP04	Wall to R-19 in new SF homes w/ HP, North	267	335	6.5	0.72	387.48	2147
110	EMNER01	Improve RAC in EMH elec htd homes, Nth	10	19	6.5	0.00	387.48	37
111	NSSE02	Ceiling to R-30 in new SF homes w/ ER/-, South	57	70	6.6	0.04	387.52	616
112	NANHP03	Improve HP(2) in NMF HP homes, North	62	106	6.7	0.02	387.54	171
113	NMNER01	Improve RAC in NMH elec htd homes, Nth	10	18	6.7	0.00	387.54	46
114	NMNGR01	Improve RAC in NMH non-elec htd homes, Nth	10	18	6.7	0.00	387.54	206
115	ERNG01	Induction cooktop and improved oven (post-1995)	171	250	6.8	11.78	399.32	47110
116	NSNHP07	Superwindows in NSF HP homes, N (post-95)	556	655	6.9	1.02	400.33	1551
117	EMNGR01	Improve RAC in EMH non-elec homes, Nth	10	17	7.1	0.00	400.34	256
118	ESNER03	R-30 floor in ESF ER/RAC homes, North	1297	1482	7.1	0.33	400.67	224
119	NASGC01	Improve CAC to 1992 std in NMF non-elec homes, Sth	28	49	7.1	0.05	400.72	1023
120	NASEC01	Improve CAC to 1992 std in NMF elec htd homes, Sth	28	49	7.1	0.07	400.79	1405

Supply Curve - Year 2010 Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
121	ESNE03	R-30 floor in ESF ER/- homes, North	1297	1471	7.1	0.91	401.70	619
122	NSSEC03	Wall to R-19 in new SF homes, South	379	429	7.2	0.64	402.34	1484
123	NMSGC02	Improve CAC beyond 1992 std in NMH non-elec homes,	309	537	7.3	0.28	402.62	529
124	NMSEC02	Improve CAC beyond 1992 std in NMH elec htd homes,	309	537	7.3	0.45	403.08	846
125	NSSE03	Superwindows in NSF homes w/ ER/-, South(post-'95)	473	521	7.4	0.24	403.31	452
126	EASER01	Improve RAC in EMF elec htd homes, Sth	10	16	7.4	0.01	403.32	629
127	EASGR01	Improve RAC in EMF non-elec homes, Sth	10	16	7.4	0.02	403.34	1103
128	EMSEC02	Improve CAC beyond 1992 std in EMH elec htd homes,	309	525	7.4	0.05	403.39	101
129	ESSER03	Improve ceiling in ESF ER/RAC homes, South	410	443	7.5	0.36	403.75	809
130	EASGC03	Variable speed CAC compressor, EMF g/o homes, Sth	105	176	7.5	0.02	403.77	135
131	EASEC03	Variable speed CAC compressor, EMF elec homes, Sth	105	176	7.5	0.03	403.80	155
132	ESNE04	Improve ceiling in ESF homes, North	14	15	7.6	0.01	403.81	619
133	ESSEC03	Switch to improved HP in South ESF homes	109	162	7.7	0.24	404.05	1496
134	EMSGC02	Improve CAC beyond 1992 std in EMH non-elec homes,	309	501	7.8	0.06	404.12	126
135	EMNEC01	Improve CAC to 1992 std in EMH elec htd homes, Nth	43	69	7.9	0.00	404.12	27
136	NASHP01	Improve HP to 92 std in NMF HP homes, South	49	70	8.0	0.04	404.16	564
137	ESSE02	Improve ceiling in ESF ER/- homes, South	403	409	8.0	0.26	404.42	642
138	NMNEC01	Improve CAC to 1992 std in new elec htd MH, North	43	67	8.1	0.00	404.42	38
139	NMNGC01	Improve CAC to 1992 std in new non-elec MH, North	43	67	8.1	0.01	404.44	183
140	EMNGC01	Improve CAC to 1992 std in EMH non-elec homes, Nth	43	64	8.5	0.01	404.45	192
141	NSNER04	Ceiling to R-60 in new SF homes w/ ER/RAC, North	148	139	8.6	0.04	404.49	281
142	NSNE04	Ceiling to R-60 in new SF homes w/ ER/-, North	148	138	8.7	0.12	404.61	864
143	EASGC02	Improve CAC beyond 1992 std in EMF non-elec homes,	169	234	9.1	0.30	404.91	1287
144	EASEC02	Improve CAC beyond 1992 std in EMF elec htd homes,	169	234	9.1	0.35	405.25	1479
145	NASGR01	Improve RAC in NMF non-elec homes, Sth	10	13	9.2	0.00	405.25	99
146	NASER01	Improve RAC in NMF elec htd homes, Sth	10	13	9.2	0.00	405.26	318
147	EWH06	Horizontal axis clotheswasher w/ HPWH (1995-2000)	116	143	9.2	0.26	405.51	1798
148	EWH09	Horizontal axis clotheswasher w/HPWH(post-2000)	116	143	9.2	1.98	407.49	13898
149	MISE04	Horiz axis clthswshr w/HPWH (motor svgs) 1995-2000	53	65	9.3	0.25	407.74	3801
150	MISE06	Horiz axis clthswshr w/HPWH (motor svgs) post-2000	53	65	9.3	1.82	409.56	28209

Supply Curve - Year 2010 Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
151	NASGC03	Variable speed CAC compressor, NMF g/o homes, Sth	105	141	9.4	0.07	409.63	485
152	NASEC03	Variable speed CAC compressor, NMF elec homes, Sth	105	141	9.4	0.09	409.72	666
153	NSNEC06	Floor to R-30 in new SF homes, North	223	192	9.4	0.15	409.88	784
154	ESSEC04	Switch to improved HP in South ESF homes	330	399	9.4	0.60	410.47	1496
155	NSSEC04	Improve HP in South new SF ER/CAC homes	90	108	9.5	0.16	410.63	1484
156	ESSHP05	Improve ceiling in ESF HP homes, South	2	2	9.5	0.00	410.64	1865
157	NSNHP05	R-30 floor in new SF homes w/ HP, N (<'95)	311	261	9.7	0.16	410.79	596
158	LTG03	Compact Fluorescent Fixtures	263	293	9.9	34.33	445.12	117175
159	ESNEC04	Improve ceiling insulation in ESF homes, North	480	393	9.9	0.26	445.38	661
160	NSNGC01	Improve CAC to 1992 std in NSF non-elec homes, Nth	43	54	10.0	0.22	445.60	3982
161	EANHP04	Improve HP(3) in EMF HP homes, North	228	254	10.2	0.30	445.89	1162
162	EMSHP03	Improve HP(2) in South EMH	114	127	10.3	0.00	445.90	13
163	ESNGC01	Improve CAC to 1992 std in ESF non-elec homes, Nth	43	52	10.4	0.36	446.26	6925
164	ESNHP07	Improve ceiling in ESF HP homes, North	555	425	10.6	0.36	446.61	838
165	MISE01	Improve miscellaneous appliance motor efficiency	190	190	11.0	22.26	468.87	117175
166	NSNHP08	R-30 floor in new SF homes w/ HP, N (>'95)	311	226	11.2	0.48	469.36	2147
167	NMSHP03	Improve HP(2) in South NMH	114	115	11.3	0.01	469.37	71
168	NASGC02	Improve CAC beyond 1992 std in NMF non-elec homes,	169	187	11.4	0.10	469.47	538
169	NASEC02	Improve CAC beyond 1992 std in NMF elec htd homes,	169	187	11.4	0.14	469.61	738
170	EASHP03	Improve HP(2) in EMF HP homes, South	62	62	11.4	0.03	469.64	548
171	NSSGC03	Improve CAC in South new SF non-elec homes w/ CAC	309	336	11.6	0.85	470.49	2519
172	EMNER02	Improve RAC(2) in EMH elec htd homes, Nth(post2000	56	59	11.8	0.00	470.49	14
173	NSSER05	Ceiling to R-38 in new SF homes w/ ER/RAC, South	322	219	11.9	0.07	470.56	318
174	NSSHP04	Improve HP in South new SF HP homes	109	104	11.9	0.34	470.89	3230
175	EMNHP04	Improve HP(3) in North EMH	347	327	12.1	0.00	470.90	9
176	ESNER04	Improve windows in ESF homes, North	316	210	12.2	0.13	471.02	605
177	ESNE05	Improve windows in ESF homes, North	316	209	12.2	0.13	471.15	619
178	NSSER06	Variable speed RAC in south NSF homes (post-2000)	67	59	12.4	0.01	471.16	149
179	NSNEC07	Ceiling to R-30 in new SF homes, North	19	12	12.5	0.01	471.17	784
180	NSNHP06	R-30 ceiling in new SF homes w/ HP, N(<'95)	44	29	12.6	0.02	471.19	596

Supply Curve - Year 2010 Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
181	NSSHP05	Wall to R-19 in new SF homes w/ HP, South	328	210	12.6	0.68	471.87	3230
182	NSSE04	Ceiling to R-38 in new SF homes w/ ER/-, South	322	205	12.7	0.13	471.99	616
183	ESSER04	Improve windows in ESF ER/RAC homes, South	425	269	12.8	0.22	472.21	809
184	REF03	Two-Compressor System for refrigerator (post 1995)	93	69	13.0	7.20	479.41	104387
185	EMSHP04	Improve HP(3) in South EMH	419	360	13.3	0.00	479.42	13
186	ESSE03	Improve windows in ESF ER/- homes, South	425	259	13.3	0.17	479.58	642
187	EASER02	Improve RAC(2) in EMF elec htd homes, Sth(post2000	56	53	13.3	0.00	479.59	74
188	EASGR02	Improve RAC(2) in EMF non-elec homes, Sth(post2000	56	53	13.3	0.01	479.59	129
189	ESSER05	Improve wall in ESF ER/RAC homes, South	325	197	13.4	0.16	479.75	809
190	NSNGR01	Increase condenser rows in RAC in NSF non-elec, N	15	14	13.5	0.02	479.77	1202
191	ESSE04	Improve wall in ESF ER/- homes, South	325	191	13.8	0.12	479.89	642
192	NMSHP04	Improve HP(3) in South NMH	419	344	13.9	0.02	479.92	71
193	ESSGC03	Improve CAC(2) in ESF non-elec homes w/ CAC, South	293	263	14.0	1.46	481.38	5562
194	EANEC01	Improve CAC to 1992 std in EMF elec htd homes, Nth	27	23	14.6	0.02	481.40	765
195	EANGC01	Improve CAC to 1992 std in EMF elec htd homes, Nth	27	23	14.6	0.03	481.43	1421
196	ESNHP08	Improve windows in ESF HP homes, North	298	165	14.6	0.14	481.57	838
197	NSNHP09	R-30 ceiling in new SF homes w/ HP, N(>'95)	44	25	14.6	0.05	481.62	2147
198	ESNEC05	Improve window & wall in ESF homes, North	646	355	14.8	0.23	481.86	661
199	EASHP04	Improve HP(3) in EMF HP homes, South	228	164	15.8	0.09	481.95	548
200	NANGC01	Improve CAC to 1992 std in NMF elec htd homes, Nth	27	21	16.0	0.02	481.97	919
201	NANEC01	Improve CAC to 1992 std in NMF elec htd homes, Nth	27	21	16.0	0.03	481.99	1239
202	NSNGC02	Improve CAC in North NSF non-elec homes w/ CAC	264	208	16.0	0.83	482.82	3982
203	NANHP04	Improve HP(3) in NMF HP homes, North	228	161	16.1	0.03	482.85	171
204	ESNGC02	Improve CAC in North ESF non-elec homes w/ CAC	264	201	16.5	1.39	484.24	6925
205	NASGR02	Improve RAC(2) in NMF non-elec homes, Sth(post2000	56	42	16.6	0.00	484.24	47
206	NASER02	Improve RAC(2) in NMF elec htd homes, Sth(post2000	56	42	16.6	0.01	484.25	151
207	ESSEC05	Improve ceiling insulation in ESF homes, South	403	187	17.5	0.28	484.53	1496
208	NSSGR02	Increase condenser area of RAC, NSF non-elec, Sth	87	54	17.7	0.02	484.55	435
209	NSNGR02	Variable speed RAC, NSF non-elec, North (>2000)	83	46	19.8	0.02	484.58	539
210	ESSHP06	Improve windows in ESF HP homes, South	360	135	21.6	0.25	484.83	1865

Supply Curve - Year 2010 Maximum Technical Potential

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
211	NSNGR03	Increase condenser area of RAC, NSF non-elec, Nth	26	12	23.8	0.01	484.83	539
212	NASHP03	Improve HP(2) in NMF HP homes, South	62	26	26.9	0.01	484.85	564
213	NSSGC04	Improve CAC(2) in NSF non-elec homes w/ CAC, South	293	133	27.8	0.34	485.18	2519
214	NSNGC03	Improve CAC(2) in North NSF non-elec homes w/ CAC	250	82	38.4	0.33	485.51	3982

APPENDIX 3: COMMENTS ON CONSERVATION MEASURES

The following detailed tables document the sources and methods used to derive the energy savings numbers in our national database. The first three pages (Figures A.3.1-A.3.3) show graphical depictions of the most complicated end-uses (ranges, dryers, and water heaters). They show baseline unit energy consumptions (UECs) at the top, and the UECs and eligible fractions for each branch in the supply curve for these end-uses.

References

References to Koomey 1991 should read Koomey et al. 1991.

References to RECS 87 are to US DOE 1989a (US DOE, U.S. Department of Energy. 1989a. *Residential Energy Consumption Survey: Housing Characteristics 1987.* EIA, Energy Information Administration. DOE/EIA-0314(87). May 1989)

References to PEAR are to EAP 1987 (EAP, Energy Analysis Program. 1987. *Program for Energy Analysis of Residences (PEAR 2.1): User's Manual.* Lawrence Berkeley Laboratory. PUB-610. March 1987.)

References to LBL's Appliance Energy Conservation database are to LBL. 1990. *Appliance Energy Conservation Database.* Lawrence Berkeley Laboratory. September 1990.

Explanation of abbreviations and terms

UEC = unit energy consumption (baseline unit)

UES = unit energy savings for a single measure, assuming all preceding measures have already been implemented.

incremental cost = the added cost of improving the efficiency of an appliance or building over the preceding measure. For all end-uses except existing buildings, this parameter is defined as the cost per applicable building (or device). The costs shell measures in existing buildings are taken from a source that did not show the cost per applicable building, so the incremental cost in this case is averaged over ALL existing buildings, and hence appears lower in absolute terms than would be expected. See text for more explanation.

lifetime = life of measure or device, in years

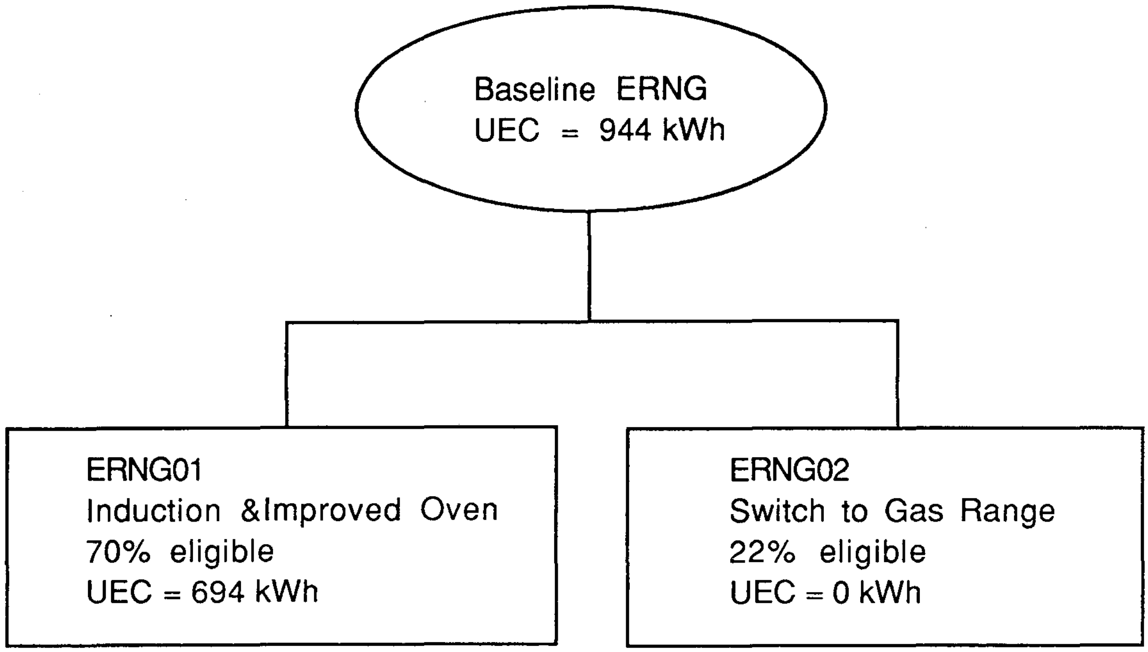
% of stock applicable = the percentage of all homes or appliances in an endpuse to which the measure can be applied

preceding measure = those measures implemented before implementing the measure under consideration

Consumer price index conversion factors used in ACCESS:

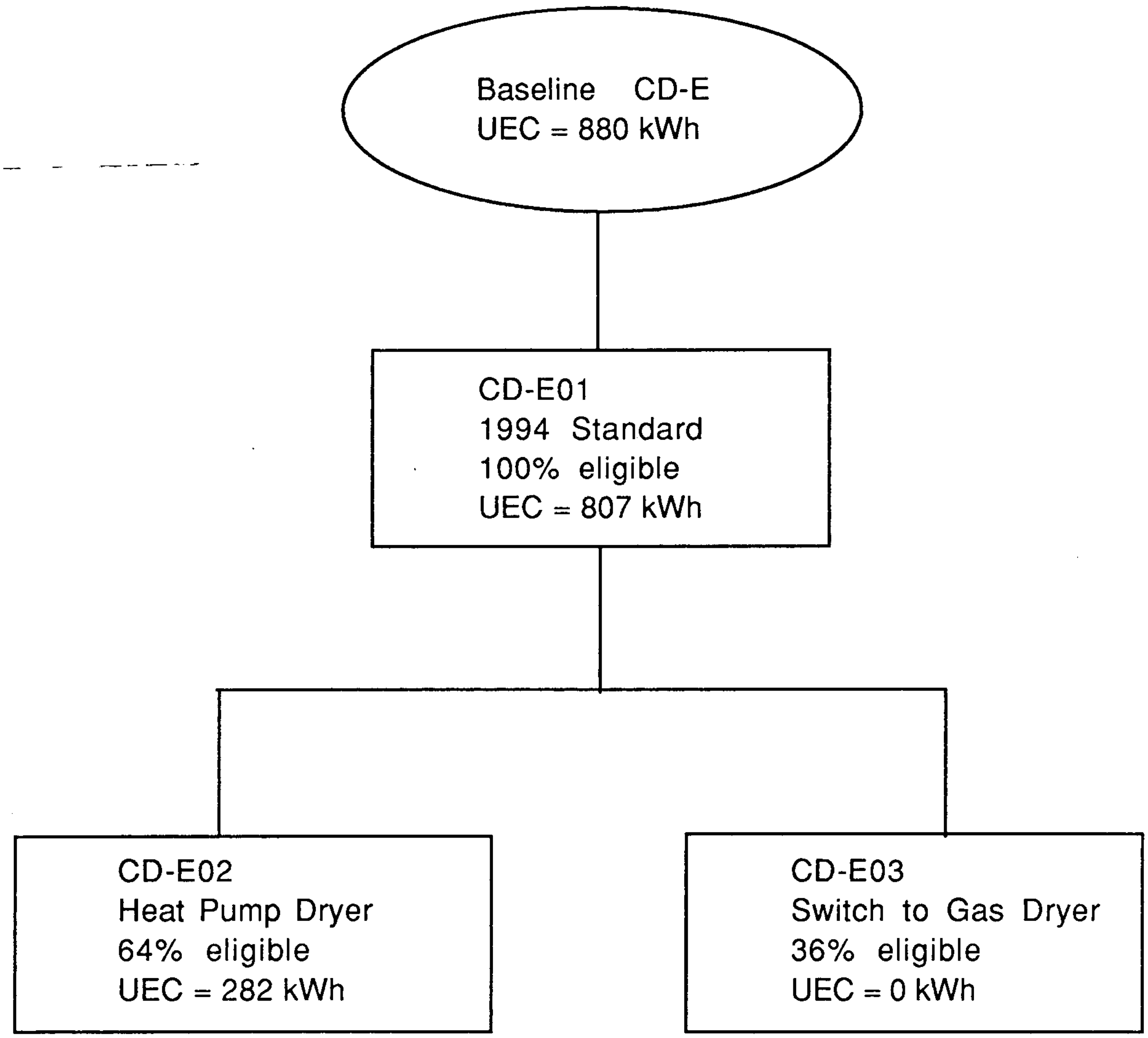
To convert from	to	factor =
1983 $	1989$	1.24
1984 $		1.19
1985 $		1.15
1986 $		1.13
1987 $		1.09
1988 $		1.05
1989 $		1.00
1990 $		0.95

Figure A-3.1: ELECTRIC RANGE



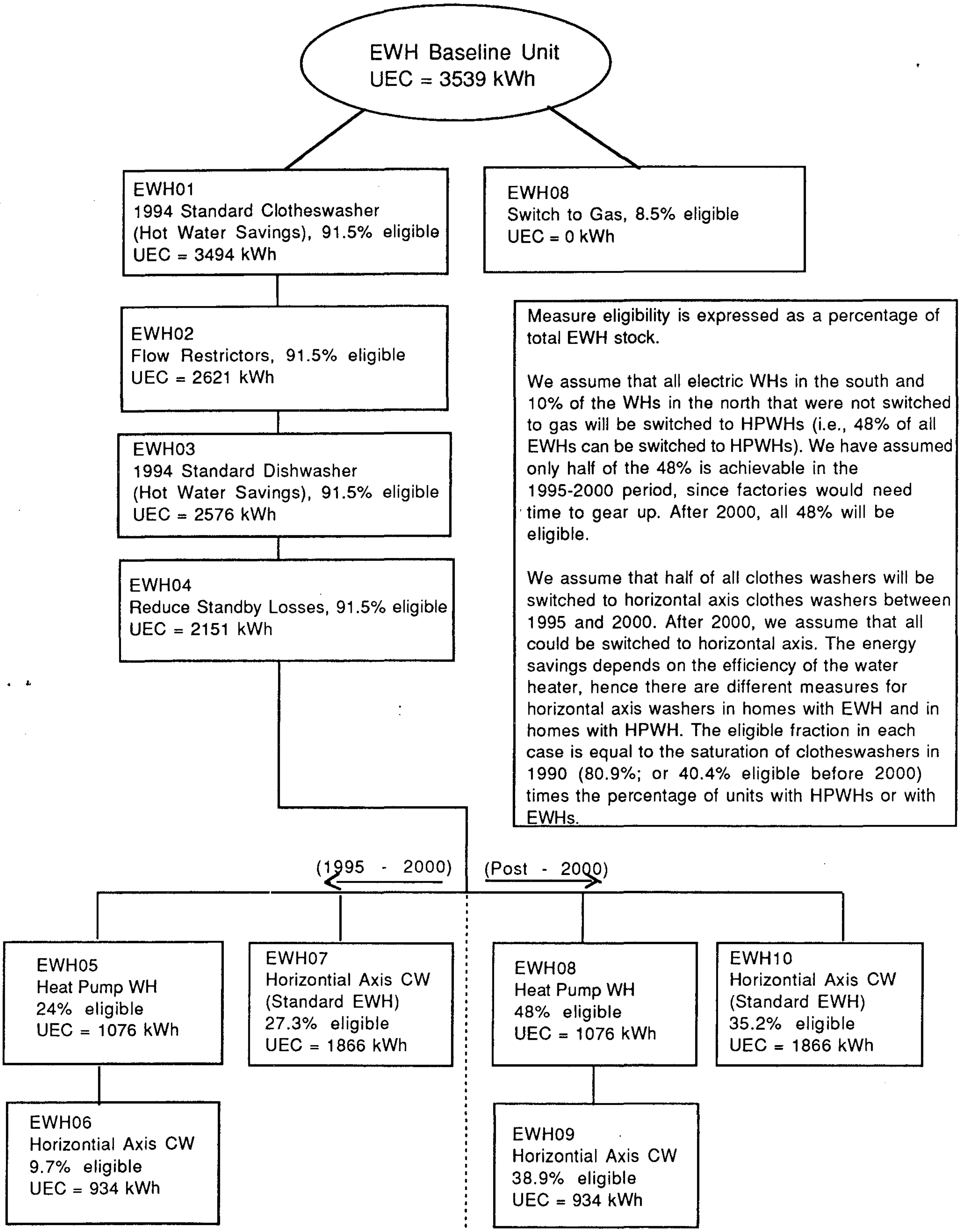
Measure eligibility is expressed as a percentage of total electric range stock.

Figure A-3.2: ELECTRIC CLOTHES DRYER



Measure eligibility is expressed as a percentage of total electric clothes dryer stock.

Figure A-3.3 : ELECTRIC WATER HEATER



END USE: BWTV Black and white television sets, 13 inch

1990 UEC: 50 kWh
Lifetime (yrs): 6
Fuel Type: electric

Lifetime reflects high turnover to color sets, not necessarily engineering life. Baseline model has mechanical tuning, white picture - 28 W, black picture - 17 W. From LBL's compilation of utility RASSes, we found that 37% of homes have at least one B&W TV set. We assumed 6 viewing hours per household per day, which may be comprised of 1 set on for 6 hrs or 2 sets on for 3 hrs each, and so on.

Source: US DOE, November 1988

Efficient black and white TV set
BWTV01
new measure
measure active between 1990 and 2010
Incremental Cost: $1 in 1988$
UES: 2.5 kWh
Lifetime (yrs): 6
% of stock applicable: 100%

Measure includes replacing surge protection resistor + additional output taps on the power supply. Screen power is reduced 5% by this measure.

Source: US DOE, November 1988

Preceding Measure: none

END USE: CD-E Clothes Dryer electric

1990 UEC: 880 kWh
Lifetime (yrs): 17
Fuel Type: electric

Electric dryer (weighted average of standard 5.9 cu.ft. dryer, compact 120V and compact 240 V dryers). UEC is the average new unit UEC bought in 1990 (from LBL-REM). The average energy factor is 2.76 (from US DOE 1990).

Source: LBL-REM

Improve clothes dryer to 1994 NAECA standard
CD-E01
new measure
measure active between 1990 and 2010
Incremental Cost: $21 in 1988$
UES: 73.0 kWh
Lifetime (yrs): 17
% of stock applicable: 100%

Improve clothes dryer to 1994 standard efficiency. Energy savings and cost are from US DOE 1990. Cost assumes a retail markup factor of 1.46 (from LBL-MIM).

Source: US DOE 1990.

Preceding Measure: none

Heat pump dryer
CD-E02
new measure
measure active between 2000 and 2010
Incremental Cost: $219 in 1988$
UES: 524.9 kWh
Lifetime (yrs): 17
% of stock applicable: 64%

Heat pump dryers are assumed to be widely available after 2000 (heat pump dryers have now been succesfully developed and tested). We assume all dryers not switched to gas, or 64% of the stock, are replaced with the HP dryer. Cost and energy savings are from US DOE 1990 and are incremental from the 1994 standard. Heat pump dryer energy factor is 8.61 lbs/kWh (weighted average of compact and standard size dryers).

Source: US DOE 1990.

Preceding Measure: CD-E01

Switch electric clothesdryer to gas
CD-E03
new measure/fuel switching
Yearly Gas Use: 34.9
measure active between 1990 and 2010
Incremental Cost: $480 in 1989$
UES: 807.0 kWh
Lifetime (yrs): 17
% of stock applicable: 36%

About 36% of U.S. elec. clothes dryer stock is found in homes having gas service. This measure involves replacing the electric clothesdryer with a comparable gas unit. The cost includes a gas line extension and the incremental cost of a gas dryer (at a total of $250) plus $230 for the present valued cost of gas over the 17-year lifetime (derived from the 1990 Annual Energy Outlook). Energy savings assume the 1994 standard measure has been implemented first and represent the entire UEC of the electric unit. The gas unit will use about 35 therms (REM 1990 new unit UEC).

Source: Investigations by C. Atkinson, Aug 1990

Preceding Measure: CD-E01

END USE: CTV Color television sets 19-20 inch

1990 UEC: 205 kWh
Lifetime (yrs): 11
Fuel Type: electric

Baseline model has electronic tuning, standby power of 4.4 W, white picture - 100W, black picture - 60 W. From LBL's compilation of utility RASSes, 93% of homes have at least one color TV set. We assume that the average daily number of viewing hours per household is 6. (This is similar to the Nielsen research findings of 7 hrs in 1986, and can be interpreted as one set on for 6 hrs or 2 sets on for 3 hrs each, etc.).

Source: US DOE, November 1988

Efficient color TV set
CTV01
new measure
measure active between 1990 and 2010
Incremental Cost: $7 in 1988$
UES: 34.0 kWh
Lifetime (yrs): 11
% of stock applicable: 100%

Measures include reducing standby power to 2W, reducing white/black screen power by 5% (93W/55W), plus increase efficiency of display (91W/53W).

Source: US DOE, November 1988

Preceding Measure: none.

END USE: EANEC Existing MF w/ CAC, North

1990 UEC: 12147 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing multi family with electric furnaces and central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from multifamily heating and cooling loads for Chicago (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in EMF elec htd homes, Nth

EANEC01

new measure

measure active between 1990 and 2010

Incremental Cost: $27 in 1989$

UES: 23.0 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing electrically heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.62 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the north is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

END USE: EANGC Existing MF w/ non-elec htg & CAC, North

1990 UEC: 446 kWh

Lifetime (yrs): 30

Fuel Type: electric

Existing non-electrically heated multi family with central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from multifamily heating and cooling loads for Chicago (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in EMF elec htd homes, Nth

EANGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $27 in 1989$
UES: 23.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing electrically heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.62 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the north is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

END USE: EANHP Existing MF w/ heat pump, North

1990 UEC: 5967 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing multi family with heat pumps in the North. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UECs are derived from multifamily heating and cooling loads for Chicago (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve HP to 92 std in EMF HP homes, North

EANHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $49 in 1989$
UES: 190.1 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in existing multi family buildings in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the north is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

Improve HP beyond 92 std in EMF HP homes, North

EANHP02
new measure
measure active between 1990 and 2010
Incremental Cost: $104 in 1989$
UES: 1027.6 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.06 HSPF, 13.03 SEER from LBL-REM's average 1992 new unit efficiency. Applies to existing multi family buildings in the North. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EANHP01

Improve HP(2) in EMF HP homes, North
EANHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $62 in 1989$
UES: 179.4 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.43 HSPF, 13.28 SEER. Applies to existing multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EANHP02

Improve HP(3) in EMF HP homes, North
EANHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $228 in 1989$
UES: 254.4 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.93 HSPF, 15.14 SEER. Applies to new multi family buildings in the North. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the north is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EANHP03

END USE: EASEC Existing MF w/ CAC, South

1990 UEC: 4209 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing multi family with electric furnaces and central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from multifamily heating and cooling loads for Fort Worth (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in EMF elec htd homes, Sth
EASEC01

new measure
measure active between 1990 and 2010
Incremental Cost: $28 in 1989$
UES: 61.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing electrically heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.64 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

Improve CAC beyond 1992 std in EMF elec htd homes,

EASEC02
new measure
measure active between 1990 and 2000
Incremental Cost: $169 in 1989$
UES: 233.7 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in existing electrically heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.64 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit. This measure makes way in the year 2000 for the more cost-effective variable speed compressor unit, assumed to become available in 2000.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EASEC01

Variable speed CAC compressor, EMF elec homes, Sth

EASEC03
new measure
measure active between 2000 and 2010
Incremental Cost: $105 in 1989$
UES: 176.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed compressor improves average new unit CAC efficiency to 12.48 SEER from 10.5 SEER (1992 new unit) in existing electrically heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.64 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EASEC01

END USE: EASER Existing MF w/ RAC, South

1990 UEC: 3393 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing multi family with electric furnaces and room AC in the South. Furnace efficiency is assumed to be 100%. Cooling UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are derived from multifamily heating and cooling loads for Fort Worth (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve RAC in EMF elec htd homes, Sth
EASER01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 16.4 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in existing electrically heated multi family homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in EMF elec htd homes, Sth(post2000
EASER02
new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 52.6 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to existing electrically heated multi family homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EASER01

END USE: EASGC Existing MF w/ non-elec htg & CAC, South

1990 UEC: 1182 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing non-electrically heated multi family with central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from multifamily heating and cooling loads for Fort Worth (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in EMF non-elec homes, Sth
EASGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $28 in 1989$
UES: 61.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing gas heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.64 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

Improve CAC beyond 1992 std in EMF non-elec homes,

EASGC02
new measure
measure active between 1990 and 2000
Incremental Cost: $169 in 1989$
UES: 233.7 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in existing gas/other heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.64 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EASGC01

Variable speed CAC compressor, EMF g/o homes, Sth

EASGC03
new measure
measure active between 2000 and 2010
Incremental Cost: $105 in 1989$
UES: 176.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed compressor improves average new unit CAC efficiency to 12.48 SEER from 10.5 SEER (1992 new unit) in existing gas/other heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.64 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EASGC01

END USE: EASGR Existing MF w/ non-elec htg & RAC, South

1990 UEC: 367 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing non-electrically heated multi family with room AC in the South. Cooling UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are derived from multifamily heating and cooling loads for Fort Worth (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve RAC in EMF non-elec homes, Sth
EASGR01

new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 16.4 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in existing gas/other heated multi family homes in the South. Measure involves increasing condenser rows. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in EMF non-elec homes, Sth(post2000
EASGR02

new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 52.6 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to existing gas/other heated multi family homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EASGR01

END USE: EASHP Existing MF w/ heat pump, South

1990 UEC: 2621 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing multi family with heat pumps in the South. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UECs are derived from multifamily heating and cooling loads for Fort Worth (Ritschard 1989). Ritschard's MF vintage categories were weighted by RECS87 data to obtain an average UEC for existing MF units. The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of total MF stock in this htg/clg category is from RECS87 data.

Source: Ritschard 1989 and RECS87.

Improve HP to 92 std in EMF HP homes, South
EASHP01

new measure
measure active between 1990 and 2010
Incremental Cost: $49 in 1989$
UES: 114.9 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in new multi family buildings in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

Improve HP beyond 92 std in EMF HP homes, South

EASHP02

new measure

measure active between 1990 and 2010

Incremental Cost: $104 in 1989$

UES: 462.3 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Improve average new unit HP efficiency to 9.06 HSPF, 13.03 SEER from LBL-REM's average 1992 new unit efficiency. Applies to existing multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EASHP01

Improve HP(2) in EMF HP homes, South

EASHP03

new measure

measure active between 1990 and 2010

Incremental Cost: $62 in 1989$

UES: 61.8 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Improve average new unit HP efficiency to 9.43 HSPF, 13.28 SEER. Applies to existing multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EASHP02

Improve HP(3) In EMF HP homes, South
EASHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $228 in 1989$
UES: 164.1 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.93 HSPF, 15.14 SEER. Applies to existing multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: EASHP03

END USE: EMNEC Existing MH w/ CAC, North
1990 UEC: 12522 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing mobile homes with electric furnaces and central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics correspond to minimum HUD code requirement for Zone II (Mills, 1984). Insulation values for the north (HUD Zone II) are: R-14 ceiling, R-11 wall, R-11 floor, and double glazing. Home was modelled as a 1-story, 1025 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson et al 1986). The floor area is from RECS87 data for existing mobile homes with ER in the north. Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve CAC to 1992 std in EMH elec htd homes, Nth

EMNEC01

new measure

measure active between 1990 and 2010

Incremental Cost: $43 in 1989$

UES: 69.0 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing electrically heated mobile homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 35 kBtu/hr capacity.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: EMNER Existing MH w/ RAC, North

1990 UEC: 11602 kWh

Lifetime (yrs): 30

Fuel Type: electric

Existing mobile homes with electric furnaces and room AC in the North. Furnace efficiency is assumed to be 100%. Room AC UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). Central AC UEC is from PEAR runs using baseline shell characteristics correspond to minimum HUD code requirement for Zone II (Mills, 1984). Insulation values for the north (HUD Zone II) are: R-14 ceiling, R-11 wall, R-11 floor, and double glazing. Home was modelled as a 1-story, 1025 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson et al 1986). The floor area is from RECS87 data for existing mobile homes with ER in the north. Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve RAC in EMH elec htd homes, Nth

EMNER01

new measure

measure active between 1990 and 2010

Incremental Cost: $10 in 1989$

UES: 18.5 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in existing electrically heated mobile homes in the North. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in EMH elec htd homes, Nth(post2000

EMNER02

new measure

measure active between 2000 and 2010

Incremental Cost: $56 in 1989$

UES: 59.3 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to existing electrically heated mobile homes in the North. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMNER01

END USE: EMNGC Existing MH w/ non-elec htg & CAC, North

1990 UEC: 1236 kWh

Lifetime (yrs): 30

Fuel Type: electric

Existing non-electrically heated mobile homes with central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics correspond to minimum HUD code requirement for Zone II (Mills, 1984). Insulation values for the north (HUD Zone II) are: R-14 ceiling, R-11 wall, R-11 floor, and double glazing. Home was modelled as a 1-story, 804 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson et al 1986). The floor area is from RECS87 data for existing mobile homes with ER in the north. Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve CAC to 1992 std in EMH non-elec homes, Nth

EMNGC01

new measure

measure active between 1990 and 2010

Incremental Cost: $43 in 1989$

UES: 64.0 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing gas heated mobile homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 35 kBtu/hr capacity.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: EMNGR Existing MH w/ non-elec htg & RAC, North

1990 UEC: 383 kWh

Lifetime (yrs): 30

Fuel Type: electric

Existing non-electrically heated mobile homes with room AC in the North. Room AC UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). Central AC UEC is from PEAR runs using baseline shell characteristics correspond to minimum HUD code requirement for Zone II (Mills, 1984). Insulation values for the north (HUD Zone II) are: R-14 ceiling, R-11 wall, R-11 floor, and double glazing. Home was modelled as a 1-story, 804 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson et al 1986). The floor area is from RECS87 data for existing mobile homes with ER in the north. Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve RAC In EMH non-elec homes, Nth

EMNGR01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 17.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in existing non-electrically heated mobile homes in the North. Measure involves increasing condenser rows. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: EMNHP Existing MH w/ heat pump, North

1990 UEC: 6622 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing mobile homes with heat pumps in the North. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics correspond to minimum HUD code requirement for Zone II (Mills, 1984). Insulation values for the north (HUD Zone II) are: R-14 ceiling, R-11 wall, R-11 floor, and double glazing. Home was modelled as a 1-story, 800 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson et al 1986). The floor area is from RECS87 data for existing mobile homes with ER in the north. Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve HP to 92 std in EMH HP homes, North

EMNHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $93 in 1989$
UES: 237.6 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in existing mobile homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database for a peak cooling capacity of 35 kBtu/hr and is adjusted by a scaling factor equal to the ratio of the mobile home UEC to the single family UEC for this combination of heating and cooling types. The scaling factor in this case is 1.3.

Source: Cost from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Improve HP beyond 1992 standard in North EMH

EMNHP02
new measure
measure active between 1990 and 2010
Incremental Cost: $151 in 1988$
UES: 1150.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.06 and SEER = 13.03 from LBL-REM's 1992 average new unit efficiency.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMNHP01

Improve HP(2) in North EMH

EMNHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $90 in 1988$
UES: 185.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.43 and SEER = 13.28.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMNHP02

Improve HP(3) in North EMH
EMNHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $330 in 1988$
UES: 327.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.93 and SEER = 15.14.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMNHP03

END USE: EMSEC Existing MH w/ CAC, South
1990 UEC: 8452 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing mobile homes with electric furnaces and central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics corresponding to minimum HUD code requirement for Zone I (Mills, 1984). Insulation values for the south (HUD Zone I) are: R-11 ceiling, R-11 wall, R-7 floor, and single glazing. Home was modelled as a 1-story, 940 sqft home with crawl space foundation in Charleston. The floor area is from RECS87 data for existing mobile homes with ER in the south. Infiltration rate is assumed to be 0.56 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve CAC to 1992 std in EMH elec htd homes, Sth
EMSEC01
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1989$
UES: 136.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing electrically heated mobile homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 41 kBtu/hr capacity and is increased over LBL's Conservation database 35kBtu cost by a factor of 17%. Factor was derived from EPRI TAG 1987 cost versus capacity curve.

Source: Energy savings from PEAR. Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC beyond 1992 std in EMH elec htd homes,

EMSEC02

new measure

measure active between 1990 and 2010

Incremental Cost: $309 in 1989$

UES: 524.5 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in existing electrically heated mobile homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 41 kBtu/hr capacity in the south and is 17% higher than LBL's Conservation database cost for a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve).

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSEC01

END USE: EMSER Existing MH w/ RAC, South

1990 UEC: 6702 kWh

Lifetime (yrs): 30

Fuel Type: electric

Existing mobile homes with electric furnaces and room AC in the South. Furnace efficiency is assumed to be 100%. Room AC UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). Central AC UEC is from PEAR runs using baseline shell characteristics corresponding to minimum HUD code requirement for Zone I (Mills, 1984). Insulation values for the south (HUD Zone I) are: R-11 ceiling, R-11 wall, R-7 floor, and single glazing. Home was modelled as a 1-story, 940 sqft home with crawl space foundation in Charleston. The floor area is from RECS87 data for existing mobile homes with ER in the south. Infiltration rate is assumed to be 0.56 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve RAC in EMH elec htd homes, Sth

EMSER01

new measure

measure active between 1990 and 2010

Incremental Cost: $10 in 1989$

UES: 40.2 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in existing electrically heated mobile homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in EMH elec htd homes, Sth(post2000

EMSER02
new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 129.3 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to existing electrically heated mobile homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSER01

END USE: EMSGC Existing MH w/ non-elec htg & CAC, South

1990 UEC: 2532 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing non-electrically heated mobile homes with central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics corresponding to minimum HUD code requirement for Zone I (Mills, 1984). Insulation values for the south (HUD Zone I) are: R-11 ceiling, R-11 wall, R-7 floor, and single glazing. Home was modelled as a 1-story, 847 sqft home with crawl space foundation in Charleston. The floor area is from RECS87 data for existing mobile homes with ER in the south. Infiltration rate is assumed to be 0.56 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve CAC to 1992 std in EMH non-elec homes, Sth

EMSGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1989$
UES: 130.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing gas heated mobile homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 41 kBtu/hr capacity and is increased over LBL's Conservation database 35kBtu cost by a factor of 17%. Factor was derived from EPRI TAG 1987 cost versus capacity curve.

Source: Energy savings from PEAR. Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC beyond 1992 std in EMH non-elec homes,

EMSGC02
new measure
measure active between 1990 and 2010
Incremental Cost: $309 in 1989$
UES: 500.6 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in existing gas/other heated mobile homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 41 kBtu/hr capacity in the south and is 17% higher than LBL's Conservation database cost for a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve).

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSGC01

END USE: EMSGR Existing MH w/ non-elec htg & RAC, South

1990 UEC: 861 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing non-electrically heated mobile homes with room AC in the South. Room AC UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). Central AC UEC is from PEAR runs using baseline shell characteristics corresponding to minimum HUD code requirement for Zone I (Mills, 1984). Insulation values for the south (HUD Zone I) are: R-11 ceiling, R-11 wall, R-7 floor, and single glazing. Home was modelled as a 1-story, 1025 sqft home with crawl space foundation in Charleston. The floor area is from RECS87 data for existing mobile homes with ER in the south. Infiltration rate is assumed to be 0.56 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve RAC in EMH non-elec homes, Sth

EMSGR01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 38.4 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in existing non-electrically heated mobile homes in the South. Measure involves increasing condenser rows. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in EMH non-elec homes, Sth(post2000

EMSGR02

new measure

measure active between 2000 and 2010

Incremental Cost: $56 in 1989$

UES: 123.4 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to existing electrically heated mobile homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSGR01

END USE: EMSHP Existing MH w/ heat pump, South

1990 UEC: 5545 kWh

Lifetime (yrs): 30

Fuel Type: electric

Existing mobile homes with heat pumps in the South. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics corresponding to minimum HUD code requirement for Zone I (Mills, 1984). Insulation values for the south (HUD Zone I) are: R-11 ceiling, R-11 wall, R-7 floor, and single glazing. Home was modelled as a 1-story, 1040 sqft home with crawl space foundation in Charleston. The floor area is from RECS87 data for existing mobile homes with ER in the south. Infiltration rate is assumed to be 0.56 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987. Mills 1984.

Improve HP to 92 std in EMH HP homes, South

EMSHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $55 in 1989$
UES: 250.6 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in existing mobile homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database for a peak cooling capacity of 35 kBtu/hr and is adjusted by a scaling factor equal to the ratio of the mobile home UEC to the single family UEC for this combination of heating and cooling types. The scaling factor in this case is 0.8.

Source: Cost from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Improve HP beyond 1992 standard in South EMH

EMSHP02
new measure
measure active between 1990 and 2010
Incremental Cost: $183 in 1988$
UES: 981.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.06 and SEER = 13.03 from LBL-REM's 1992 average new unit efficiency. Cost assumes a 41 kBtu/hr capacity in the south and includes a 21% increase over the cost of a 35 kBtu/hr unit derived from EPRI TAG 1987 cost versus capacity table.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSHP01

Improve HP(2) in South EMH

EMSHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $109 in 1988$
UES: 127.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.43 and SEER = 13.28. Cost assumes a 41 kBtu/hr capacity in the south and includes a 21% increase over the cost of a 35 kBtu/hr unit derived from EPRI TAG 1987 cost versus capacity table.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSHP02

Improve HP(3) in South EMH
EMSHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $399 in 1988$
UES: 360.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.93 and SEER = 15.14. Cost assumes a 41 kBtu/hr capacity in the south and includes a 21% increase over the cost of a 35 kBtu/hr unit derived from EPRI TAG 1987 cost versus capacity table.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: EMSHP03

END USE: ERNG Electric Range
1990 UEC: 944 kWh
Lifetime (yrs): 18
Fuel Type: electric

Baseline UEC is LBL-REM forecast for 1990 new units. It is probably high because it does not yet take into account the widespread use of microwave ovens.

Source: US DOE, November 1989

Induction cooktop and improved oven (post-1995)
ERNG01
new measure
measure active between 1995 and 2010
Incremental Cost: $180 in 1990$
UES: 250.0 kWh
Lifetime (yrs): 18
% of stock applicable: 70%

Measure includes induction heaters on cooktop and an adjustable-size, convection oven. Induction heaters are shown to save over 50% compared to standard electric coils. We assume that only two out of the four burners are switched to induction. Adjustable-size oven + convection saves 30%, but accounts for only 15% of total range use. We assume these technologies could become widely available by 1995 and that they would be applied to almost all of the electric ranges remaining after fuel-switching.

Source: LBL engineering estimates.

Preceding Measure: none

Switch from electric to gas range
ERNG02
new measure/fuel switching
Yearly Gas Use: 47.8
measure active between 1990 and 2010
Incremental Cost: $590 in 1989$
UES: 943.5 kWh
Lifetime (yrs): 18
% of stock applicable: 22%

Electric savings represent the UEC of the replaced electric unit. The gas unit will use about 48 therms (REM 1990 new unit UEC). 22% of homes with electric ranges have gas service(from LBL's compilation of utility RASS data), and we assume that all of these homes will switch to gas dryers. The cost includes $300 for the additional first cost of the gas unit compared to an electric, plus gas line extension and flues; and $290 for the present valued cost of buying natural gas over the range's 15-year lifetime.

Source: RASS data, and Meier et al, 1983.

Preceding Measure: none

END USE: ESNE Existing SF homes w/o cooling, North
1990 UEC: 18311 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing single family homes with electric furnaces and no cooling in the North. The furnace is set back at night and has 100% efficiency. UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for north ER homes are: R-20.8 ceiling, R-4.7 wall, 0.54 ACH, and 1.8 window layers. The prototype is a 1-story, 1582 sqft home with unheated basement in Chicago. We diverge from Boghosian's data only in foundation insulation. For the sake of simplicity, we assumed R-11 insulation in the floors and no foundation insulation. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve shell in ESF ER/- homes, North
ESNE01
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $754 in 1989$
UES: 3583.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.41, increasing average wall insulation to R-6.15, adding R-19 to all insulated ceilings, and adding R-30 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: none

Improve window, ceil & wall in ESF homes, North
ESNE02
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $859 in 1989$
UES: 1469.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves increasing average wall insulation to R-8.4, adding R-30 to all insulated ceilings, and adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNE01

R-30 floor in ESF ER/- homes, North
ESNE03
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $1297 in 1989$
UES: 1471.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves increasing average floor insulation to R-30. The cost of the measure is assumed to be the same as the cost for insulating crawl spaces. The measure is applicable only to homes with crawlspaces (15%) or unheated basements (22%), or 37% of all northern ER homes. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNE02

Improve ceiling in ESF homes, North
ESNE04
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $14 in 1989$
UES: 15.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves insulating all non-insulated ceilings to R-49. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNE03

Improve windows in ESF homes, North
ESNE05
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $316 in 1989$
UES: 209.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves replacing all single-glazed windows with double-glazed, low-e, argon-filled units. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNE04

END USE: ESNEC Existing SF w/ CAC, North
1990 UEC: 19296 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing SF homes with electric furnaces and central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). The furnace is set back at night and has 100% efficiency. UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for north ER homes are: R-20.8 ceiling, R-4.7 wall, 0.54 ACH, and 1.8 window layers. The prototype is a 1-story, 1582 sqft home with unheated basement in Chicago. We diverge from Boghosian's data only in foundation insulation. For the sake of simplicity, we assumed R-11 insulation in the floors and no foundation insulation. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Switch elec furn to HP in existing North SF

ESNEC01

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $822 in 1989$

UES: 11853.0 kWh

replacement rate:4%/year

Lifetime (yrs): 14

% of stock applicable: 100%

Switch the electric furnace and central air conditioner to a heat pump having HSPF of 9.06 and SEER of 13.03. All homes with CAC and electric furnaces are switched. There is virtually no difference in cost between a standard heat pump and a CAC/electric heating system (EPRI, 1987). Measure cost includes $222 for the cost of this HP over a 1990 standard HP (from LBL's AEC Database) plus $600 for changes in ducting and controls. The average lifetimes of CAC and electric furnaces are 12 and 23 years, respectively. We assumed that the furnace and CAC were installed at the same time, hence every 24 years both will retire approximately simultaneously. Our retrofit rate is thus 1/24, or 4%, per year.

Source: PEAR for energy savings, costs from LBL's Energy Conservation Database, J McMahon, revised Sep 1990.

Preceding Measure: none

Improve shell in ESF ER/CAC homes, North

ESNEC02

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $274 in 1989$

UES: 842.2 kWh

replacement rate:5%/year

Lifetime (yrs): 30

% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.41, increasing average wall insulation to R-6.15, and insulating all non-insulated ceilings to R-30. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNEC01

Switch to improved HP in North ESF homes
ESNEC03

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $90 in 1989$
UES: 285.2 kWh
replacement rate:4%/year
Lifetime (yrs): 14
% of stock applicable: 100%

Switch all ER/CAC homes to an improved efficiency heat pump (HSPF 9.5 and SEER 13.3). Replacement rate is assumed to be 4% per year (see measure ESNEC01).

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: ESNEC02

Improve ceiling insulation in ESF homes, North
ESNEC04

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $480 in 1989$
UES: 392.8 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-19 to all insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNEC03

Improve window & wall in ESF homes, North
ESNEC05

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $646 in 1989$
UES: 354.5 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves increasing average wall insulation to R-8.4 and adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNEC04

END USE: ESNER Existing SF w/ RAC, North

1990 UEC: 18616 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing SF homes with electric furnaces and room AC in the North. Cooling UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). The furnace is set back at night and has 100% efficiency. UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for north ER homes are: R-20.8 ceiling, R-4.7 wall, 0.54 ACH, and 1.8 window layers. The prototype is a 1-story, 1582 sqft home with unheated basement in Chicago. We diverge from Boghosian's data only in foundation insulation. For the sake of simplicity, we assumed R-11 insulation in the floors and no foundation insulation. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve shell in ESF ER/RAC homes, North

ESNER01
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $274 in 1989$
UES: 2374.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.41, increasing average wall insulation to R-6.15, and adding R-30 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: none

Improve window, ceil & wall in ESF homes, North

ESNER02
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $1354 in 1989$
UES: 2718.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves increasing average wall insulation to R-8.4, adding R-30 to all insulated ceilings, adding R-49 to all non-insulated ceilings, and adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNER01

R-30 floor in ESF ER/RAC homes, North
ESNER03
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $1297 in 1989$
UES: 1482.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 37%

This measure involves increasing average floor insulation to R-30. The cost of the measure is assumed to be the same as the cost for insulating crawl spaces. The measure is applicable only to homes with crawlspaces (15%) or unheated basements (22%), or 37% of all northern ER homes. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNER02

Improve windows in ESF homes, North
ESNER04
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $316 in 1989$
UES: 210.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves replacing all single-glazed windows with double-glazed, low-e, argon-filled units. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNER03

END USE: ESNGC Existing SF w/ non-elec htg & CAC, North

1990 UEC: 1006 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing non-electrically heated SF homes with central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for north fuel-heated homes are: R-21 ceiling, R-2.1 wall, 0.62 ACH, and 1.8 window layers. The prototype is a 1-story, 1550 sqft home with unheated basement in Chicago. We diverge from Boghosian's data only in foundation insulation. For the sake of simplicity, we assumed R-11 insulation in the floors and no foundation insulation. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve CAC to 1992 std in ESF non-elec homes, Nth

ESNGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $43 in 1989$
UES: 52.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing single family gas/other heated homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 35 kBtu/hr capacity unit.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC in North ESF non-elec homes w/ CAC

ESNGC02
new measure
measure active between 1990 and 2010
Incremental Cost: $264 in 1989$
UES: 201.0 kWh
Lifetime (yrs): 12
% of stock applicable: .100%

Improve the central air conditioner efficiency to 13.3 SEER. Cost assumes a 35 kBtu/hr capacity unit.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSNGC01

END USE: ESNHP Existing SF w/ heat pump, North

1990 UEC: 9747 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing SF homes with heat pumps in the North. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for north HP homes are: R-24 ceiling, R-6.8 wall, 0.45 ACH, and 1.7 window layers. The prototype is a 1-story, 1853 sqft home with unheated basement in Chicago. We diverge from Boghosian's data only in foundation insulation. For the sake of simplicity, we assumed R-11 insulation in the floors and no foundation insulation. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve HP to 92 std in ESF HP homes, North

ESNHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $71 in 1989$
UES: 719.3 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in existing single family homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost assumes a 35 kBtu/hr capacity.

Source: Cost from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Improve ceiling insulation in ESF HP homes, North

ESNHP02
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $7 in 1989$
UES: 71.6 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-19 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNHP01

Improve HP in ESF HP homes, North
ESNHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $151 in 1989$
UES: 1598.1 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump from LBL-REM's 1992 average new unit efficiency to 9.06 HSPF, 13.03 SEER. Cost assumes a 35 kBtu/hr capacity.

Source: Cost and efficiency from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: ESNHP02

Improve shell in ESF HP homes, North
ESNHP04
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $121 in 1989$
UES: 353.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.42 and increasing average wall insulation to R-8.49. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNHP03

Improve HP in ESF HP homes, North
ESNHP05
new measure
measure active between 1990 and 2010
Incremental Cost: $90 in 1989$
UES: 304.9 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to 9.5 HSPF, 13.3 SEER.

Source: Cost and efficiency from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: ESNHP04

Improve ceiling in ESF HP homes, North
ESNHP06

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $3 in 1989$
UES: 4.8 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-30 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNHP05

Improve ceiling in ESF HP homes, North
ESNHP07

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $555 in 1989$
UES: 425.1 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-30 to all insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNHP06

Improve windows in ESF HP homes, North
ESNHP08

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $298 in 1989$
UES: 165.4 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESNHP07

END USE: ESSE Existing SF homes w/o cooling, South

1990 UEC: 8201 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing single family homes with electric furnaces and no cooling in the South. The furnace is set back at night and has 100% efficiency. UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for south ER homes are: R-18 ceiling, R-3.9 wall, U-0.95 foundation, 0.71 ACH, and 1.5 window layers. The prototype is a 1-story, 1470 sqft home with slab foundation in Charleston. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve shell in ESF ER/- homes, South
ESSE01

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $451 in 1989$
UES: 1712.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.46, increasing average wall insulation to R-6.45, and adding R-30 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: none

Improve ceiling in ESF ER/- homes, South
ESSE02

retrofit measure
measure active between 1990 and 2010
Incremental Cost: $403 in 1989$
UES: 409.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-19 to all insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSE01

Improve windows in ESF ER/- homes, South
ESSE03
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $425 in 1989$
UES: 259.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSE02

Improve wall in ESF ER/- homes, South
ESSE04
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $325 in 1989$
UES: 191.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure improves wall insulation to R-8.3. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSE03

END USE: ESSEC Existing SF w/ CAC, South
1990 UEC: 11436 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing SF homes with electric furnaces and central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). The furnace is set back at night and has 100% efficiency. UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for south ER homes are: R-18 ceiling, R-3.9 wall, U-0.95 foundation, 0.71 ACH, and 1.5 window layers. The prototype is a 1-story, 1470 sqft home with slab foundation in Charleston. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Switch elec furn to HP in existing South SF

ESSEC01

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $869 in 1989$

UES: 5805.0 kWh

replacement rate:4%/year

Lifetime (yrs): 14

% of stock applicable: 100%

Switch the electric resistance heater and central air conditioner to a heat pump having HSPF of 9.06 and SEER of 13.03. All homes with CAC and electric furnaces are switched. There is virtually no difference in cost between a standard heat pump and a CAC/electric heating system (EPRI, 1987). Measure cost includes $269 for the cost of this HP over a 1990 standard HP (from LBL's AEC Database, adjusted by 21% to account for greater size of unit) plus $600 for changes in ducting and controls. The average lifetimes of CAC and electric furnaces are 12 and 23 years, respectively. We assumed that the furnace and CAC were installed at the same time, hence every 24 years both will retire approximately simultaneously. Our retrofit rate is thus 1/24, or 4%, per year.

Source: PEAR for energy savings, costs from LBL's Energy Conservation Database, J McMahon, revised Sep 1990. EPRI TAG 1987

Preceding Measure: none

Improve shell in ESF ER/CAC homes, South

ESSEC02

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $444 in 1989$

UES: 776.2 kWh

replacement rate:5%/year

Lifetime (yrs): 30

% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.46, increasing average wall insulation to R-6.45, and insulating all non-insulated ceilings to R-30. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSEC01

Switch to improved HP in South ESF homes

ESSEC03

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $109 in 1989$

UES: 162.2 kWh

replacement rate:4%/year

Lifetime (yrs): 14

% of stock applicable: 100%

Switch all ER/CAC homes to an improved efficiency heat pump (HSPF 9.5 and SEER 13.3). Cost assumes a unit capacity of 41 kBtu/hr and is adjusted by 21% over the LBL Appliance Database cost for a 35 kBtu/hr unit. Price increase was determined from EPRI TAG 1987 cost vs. capacity curves for heat pumps. Replacement rate is assumed to be 4%/year (see measure ESSEC02 description).

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: ESSEC02

Switch to improved HP in South ESF homes

ESSEC04

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $330 in 1989$

UES: 399.0 kWh

replacement rate:4%/year

Lifetime (yrs): 14

% of stock applicable: 100%

Switch all ER/CAC homes to an improved efficiency heat pump (HSPF 9.93 and SEER 15.14). Cost assumes a unit capacity of 41 kBtu/hr and is adjusted by 21% over the LBL Appliance Database cost for a 35 kBtu/hr unit. Price increase was determined from EPRI TAG 1987 cost vs. capacity curves for heat pumps. Replacement rate is assumed to be 4%/year (see measure ESSEC02 description).

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: ESSEC03

Improve ceiling insulation in ESF homes, South

ESSEC05

retrofit measure

measure active between 1990 and 2010

Incremental Cost: $403 in 1989$

UES: 186.8 kWh

replacement rate:5%/year

Lifetime (yrs): 30

% of stock applicable: 100%

This measure involves adding R-19 to all insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSEC04

END USE: ESSER Existing SF w/ RAC, South

1990 UEC: 9301 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing SF homes with electric furnaces and room AC in the South. Cooling UEC is assumed to be 34% of the central AC UEC (RCG/Hagler, Bailly, 1990). The furnace is set back at night and has 100% efficiency. UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for south ER homes are: R-18 ceiling, R-3.9 wall, U-0.95 foundation, 0.71 ACH, and 1.5 window layers. The prototype is a 1-story, 1470 sqft home with slab foundation in Charleston. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve shell in ESF ER/RAC homes, South
ESSER01
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $444 in 1989$
UES: 1757.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.46, increasing average wall insulation to R-6.45, and adding R-19 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: none

Improve room AC in ESF homes, South
ESSER02
new measure
measure active between 1990 and 2010
Incremental Cost: $15 in 1989$
UES: 46.5 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser rows, improving RAC efficiency to 9.42 EER.

Source: Savings and cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: ESSER01

Improve ceiling in ESF ER/RAC homes, South
ESSER03
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $410 in 1989$
UES: 443.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-19 to all insulated ceilings, and insulating all non-insulated ceilings to R-30. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSER02

Improve windows in ESF ER/RAC homes, South
ESSER04
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $425 in 1989$
UES: 269.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSER03

Improve wall in ESF ER/RAC homes, South
ESSER05
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $325 in 1989$
UES: 196.5 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure improves wall insulation to R-8.3. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT RE-FLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSER04

END USE: ESSGC Existing SF w/ non-elec htg & CAC, South

1990 UEC: 3325 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing non-electrically heated SF homes with central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for south ER homes are: R-17 ceiling, R-2.1 wall, U-1.05 foundation, 0.72 ACH, and 1.4 window layers. The prototype is a 1-story, 1467 sqft home with slab foundation in Charleston. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve CAC to 1992 std in ESF non-elec homes, Sth
ESSGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1989$
UES: 171.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in existing single family gas/other heated homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 41 kBtu/hr capacity and is increased over LBL's Conservation database 35kBtu cost by a factor of 17%. Factor was derived from EPRI TAG 1987 cost versus capacity curve.

Source: Energy savings from PEAR. Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC in South ESF non-elec homes w/ CAC
ESSGC02
new measure
measure active between 1990 and 2010
Incremental Cost: $309 in 1989$
UES: 664.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve the central air conditioner efficiency to 13.3 SEER. Cost assumes a 41 kBtu/hr unit capacity.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990, modified by EPRI TAG 1987 factor.

Preceding Measure: ESSGC01

Improve CAC(2) in ESF non-elec homes w/ CAC, South

ESSGC03
new measure
measure active between 1990 and 2010
Incremental Cost: $293 in 1989$
UES: 263.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve the central air conditioner efficiency to 14.87 SEER from 13.3 SEER. Cost assumes a 41 kBtu/hr capacity.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990, adjusted by EPRI TAG 1987 factor.

Preceding Measure: ESSGC02

END USE: ESSHP Existing SF w/ heat pump, South

1990 UEC: 7672 kWh
Lifetime (yrs): 30
Fuel Type: electric

Existing SF homes with heat pumps in the South. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UEC is from PEAR runs using baseline shell characteristics derived from RECS84 and updated to 1990 levels (Boghosian, 1991). Insulation values for south HP homes are: R-21 ceiling, R-6.2 wall, U-0.92 foundation, 0.7 ACH, and 1.6 window layers. The prototype is a 1-story, 1784 sqft home with slab foundation in Charleston. The fraction of SF stock in this category is from RECS87.

Source: Boghosian, 1991 and RECS 1987.

Improve HP to 92 std in ESF HP homes, South

ESSHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $86 in 1989$
UES: 320.5 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in existing single family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. The heat pump capacity is assumed to be 41 kBtu/hr (from EPRI TAG 1987 estimates of peak cooling load). The cost is 21% greater than the northern, 35 kBtu unit cost. The price increase factor was determined using EPRI TAG cost vs. capacity curves.

Source: Cost from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Improve ceiling insulation in ESF HP homes, South
ESSHP02
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $5 in 1989$
UES: 30.8 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-19 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSHP01

Improve HP in ESF HP homes, South
ESSHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $292 in 1989$
UES: 1693.2 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump from LBL-REM's 1992 average new unit efficiency to 9.5 HSPF, 13.3 SEER. Cost assumes 41 kBtu/hr capacity and is adjusted for this capacity as discussed above (see measure ESSHP01 description).

Source: Cost and efficiency from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: ESSHP02

Improve shell in ESF HP homes, South
ESSHP04
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $304 in 1989$
UES: 593.0 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

Shell improvements are from Boghosian, 1991 and include: decreasing the infiltration rate to 0.48 and increasing average wall insulation to R-7.95. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: measures and costs from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSHP03

Improve ceiling in ESF HP homes, South
ESSHP05
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $2 in 1989$
UES: 1.7 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding R-30 to all non-insulated ceilings. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSHP04

Improve windows in ESF HP homes, South
ESSHP06
retrofit measure
measure active between 1990 and 2010
Incremental Cost: $360 in 1989$
UES: 135.1 kWh
replacement rate:5%/year
Lifetime (yrs): 30
% of stock applicable: 100%

This measure involves adding single-glazed storm windows to all single-glazed windows. COST AND ENERGY SAVINGS ARE AVERAGES OVER ALL EXISTING HOMES OF THIS FUEL TYPE AND DO NOT REFLECT THE ACTUAL COST PER APPLICABLE HOUSE.

Source: Measure and cost from Boghosian, 1991. Energy savings from PEAR.

Preceding Measure: ESSHP05

END USE: EWH Elec. Water Heater
1990 UEC: 3539 kWh
Lifetime (yrs): 13
Fuel Type: electric

UEC is average 1990 new unit UEC (from LBL-REM) & includes the hot water consumption of dishwashers and clothes washers. The energy use of the washer motors is included in the MISE (miscellaneous) enduse UEC.

Source: US DOE, November 1989

Improve clotheswasher to 1994 standard

EWH01

new measure

measure active between 1990 and 2010

Incremental Cost: $1 in 1987$

UES: 44.6 kWh

Lifetime (yrs): 14

% of stock applicable: 92%

Measure includes the hot water energy savings due to the 1994 clotheswasher standard. The saturation of clotheswashers in all housing types in 1990 is 80.9% (LBL-REM). The cost and energy savings are from a recent LBL-REM run with the 1994 standards. The absolute savings (55kWh) and cost ($0.80) were multiplied by the saturation in order to apply this measure to all homes. The applicable fraction (91.5%) reflects the fact that 8.5% of the EWHs have switched to gas WHs. The savings and cost are weighted averages over the two types of clotheswashers (standard and compact). The standard does not improve motor efficiency.

Source: LBL-REM

Preceding Measure: None.

Reduce hot water consumption

EWH02

new measure

measure active between 1990 and 2010

Incremental Cost: $50 in 1989$

UES: 873.0 kWh

Lifetime (yrs): 10

% of stock applicable: 92%

Install faucet aerators and low-flow showerheads in 91.5% of all homes with electric WHs (8.5% have been switched to gas WHs). Energy savings and assumptions are from Krause et al., 1987. Energy savings for the aerators assumes that faucets account for 30% of the total water heater UEC and that the aerator reduces flow by two-thirds. One third of the homes are assumed to have aerators already. Savings were proportioned from Krause's 175 kWh to reflect our baseline (3539 kWh compared to Krause's 4000 kWh). Savings becomes 155 kWh. The cost assumes 5 aerators per household at $2 each. We assume 2 low-flow showerheads per home at a cost of $20 each. Flow is reduced from 4.8 gpm to 2.0 gpm. The savings, when scaled to our baseline, are 718 kWh (20%). The savings assume that 10% of the households already have such showerheads.

Source: Krause et al. 1987, pp 4-9 - 4-11. Costs are LBL estimates.

Preceding Measure: EWH01

Improve dishwasher to 1994 standard
EWH03
new measure
measure active between 1990 and 2010
Incremental Cost: $7 in 1988$
UES: 45.0 kWh
Lifetime (yrs): 13
% of stock applicable: 92%

Measure includes the hot water energy savings due to the 1994 dishwasher standard. The saturation of dishwashers in all housing types in 1990 is 49% (LBL-REM). The cost is from US DOE 1990; we assume a retail markup of 1.46 (from LBL-MIM). The cost of this measure (hot water savings from the standard) is apportioned from the total cost (which also includes motor improvements) according to the respective energy savings due to motor efficiency and water use reduction. The savings and cost are weighted averages over the two major types of dishwashers -- standard and standard with water heating booster. The absolute savings (91.9 kWh) and cost ($15.1) were multiplied by the saturation in order to apply this measure to all homes. The applicable fraction (91.5%) reflects the fact that 8.5% of the EWHs have switched to gas WHs.

Source: US DOE 1990, LBL-REM and LBL-MIM.

Preceding Measure: EWH02.

Reduce standby losses
EWH04
new measure
measure active between 1990 and 2010
Incremental Cost: $120 in 1989$
UES: 425.0 kWh
Lifetime (yrs): 13
% of stock applicable: 92%

Replace retired and new standard water heaters with units having highly insulated tanks and heat traps. Measure includes polyurethane foam sides, top and bottom cavity plus a 50 mm pad underneath the tank. Saves about 320 kWh/yr more in standby losses than the standard 3" fiberglass tank insulation at a cost between $60 and $120 (Perlman 1987). We have assumed a $90 incremental cost for the insulation. A pair of square plastic heat traps plus short lengths of insulation on the pipes is also added. The traps plus pipe insulation reduced standby losses by 160 kWh/yr in preliminary tests (Perlman 1987). Copper heat traps plus pipe insulation have been shown to reduce standby losses by an average of 105 kWh/yr (Perlman 1987). We have conservatively assumed 105 kWh would be saved. Net savings for this measure is thus 425 kWh. We have assumed $30 for the cost of the heat traps and pipe insulation. Measure applies to 91.5% of the EWHs (remaining 8.5% have switched to gas water heaters).

Source: Perlman 1987.

Preceding Measure: EWH03

Heat pump water heater (1995-2000)
EWH05
new measure
measure active between 1995 and 2000
Incremental Cost: $530 in 1990$
UES: 1076.0 kWh
Lifetime (yrs): 13
% of stock applicable: 24%

Savings and cost are based on the third-generation heat pump water heater now being developed for EPRI by Crispaire of Atlanta. We assume that all electric WHs in the south could be switched to HPWHs, since reduction in cooling load would compensate for any increase in heating load due to the HPWH. We assume that 10% of the WHs in the north are located in unheated basements and could thus be switched. The total eligible fraction is 51.6% in the south plus 4.8% in the north (RECS87). We have assumed only half of the 56.4% is achievable in the 1995-2000 period, since factories would need time to gear up. After subtracting the units that will be switched to gas WHs (assuming distribution in N and S is proportional to EWH population), the eligible fraction is 24%. Under these assumptions, about 1 million HPWHs will be sold each year - a 500 fold increase over today's production volume. We assume a 20% reduction in capital costs would accompany the increased volume (from discussions with Terry Chan of LBL). Installed cost of the HPWH should be about $800 in 1992 (Shuford, 1991). Assuming $130 for installation, the capital cost after 20% reduction is $670*0.8= $536. Installed cost is then $536+$130 = $666. The unit mounts onto a standard tank; we have added $200 for the tank (Petrie 1988, p.3). Basecase unit cost is $200 for the tank/heater plus $130 installation (Lerman 1988). Incremental cost is $866-$330 = $536. The third-generation unit is expected to have a COP of 3.4 and real energy savings of 60-65% (Shuford 1991) but we have conservatively assumed 50% energy savings. Previous utility field tests have documented real energy savings of 50% on average for 45 utilities throughout the U.S. (EPRI 1984) for less efficient WHs.

Source: Shuford 1991; EPRI 1984. Cost reduction factor for increased production volume from discussions with Terry Chan of LBL's Appliance Standards Group, June 1991.

Preceding Measure: EWH04

Horizontal axis clotheswasher w/ HPWH (1995-2000)

EWH06

new measure

measure active between 1995 and 2000

Incremental Cost: $110 in 1988$

UES: 142.5 kWh

Lifetime (yrs): 14

% of stock applicable: 10%

Horizontal axis clothes washers are widely used in Europe, but not in the U.S. We assume a lead time of 5 years is necessary for them to become widely available here. In the 1995-2000 period, we assume that half of the clotheswashers sold could be horizontal axis. The eligible fraction is thus 0.5*0.81, or 0.405, where 0.81 is the saturation of clotheswashers from LBL-REM. This measure applies only to homes that will be switched to HPWHs (24% of all homes between 1995 & 2000). The eligible fraction is thus 0.405*24 = 9.7%. The energy savings and cost are incremental from the 1994 standard and are from US DOE 1990. We assumed a COP of 2.0 for the HPWH, thus the savings from US DOE 1990 were halved to reflect the more efficient water heater. The total cost of the measure is $160 (assuming a retail markup of 1.46 from LBL-MIM) and has been apportioned according to energy savings in motor use (listed as a MISE enduse measure, cost = $50) and in hot water use.

Source: LBL-REM, US DOE 1990, LBL-MIM.

Preceding Measure: EWH05

Horizontal axis clotheswasher w/ EWH (1995-2000)

EWH07

new measure

measure active between 1995 and 2000

Incremental Cost: $130 in 1988$

UES: 285.0 kWh

Lifetime (yrs): 14

% of stock applicable: 27%

Horizontal axis clothes washers are widely used in Europe, but not in the U.S. We assume a lead time of 5 years is necessary for them to become widely available here. In the 1995-2000 period, we assume that half of the clotheswashers sold could be horizontal axis. The eligible fraction is thus 0.5*0.81, or 0.405, where 0.81 is the saturation of clotheswashers from LBL-REM. This measure applies only to homes that will NOT be switched to HPWHs or gas WHs (67.5% of all homes between 1995 & 2000). The eligible fraction is thus 0.405*67.5 = 27.3%. The energy savings and cost are incremental from the 1994 standard and are from US DOE 1990. The total cost of the measure is $160 (assuming a retail markup of 1.46 from LBL-MIM) and has been apportioned according to energy savings in motor use (listed as a MISE enduse measure, cost = $30) and in hot water use. The water use portion of the cost is $130.

Source: LBL-REM, US DOE 1990, LBL-MIM.

Preceding Measure: EWH04

Replace electric water heater with gas
EWH08
new measure/fuel switching
Yearly Gas Use: 159.5
measure active between 1990 and 2010
Incremental Cost: $1380 in 1989$
UES: 3539.0 kWh
Lifetime (yrs): 13
% of stock applicable: 9%

LBL's compilation of utility surveys indicates that about 8.5% of homes with electric water heaters have gas service, and we switch the electric water heaters in these homes to gas water heaters. We switch these units first, thus the electricity savings is equivalent to the baseline UEC of 3539 kWh. Gas use increases by 159.5 Th (LBL-REM, 1990 new unit). The incremental cost of $1380 includes $100 for the added cost of a gas water heater over an electric one; plus $300 for a gas line extension, power vent, and/or flue where necessary; plus $980 for the levelized price of gas over the 15-year lifetime of the appliance.

Source: LBL investigations, LBL-REM and utility RASSes.

Preceding Measure: none

Horizontal axis clotheswasher w/HPWH(post-2000)
EWH09
new measure
measure active between 2000 and 2010
Incremental Cost: $110 in 1988$
UES: 142.5 kWh
Lifetime (yrs): 14
% of stock applicable: 39%

Horizontal axis clothes washers are widely used in Europe, but not in the U.S. We assume a lead time of 5 years is necessary for them to become widely available here. After the year 2000, we assume that all of the clotheswashers sold could be horizontal axis. The eligible fraction is thus 0.81 (the saturation of clotheswashers from LBL-REM) times the percentage of units that are switched to HPWHs (48%), or 38.9%. (This measure applies only to homes that are switched to HPWHs). The energy savings and cost are incremental from the 1994 standard and are from US DOE 1990. We have assumed a COP of 2.0 for the HPWH and have halved the savings from US DOE 1990 to reflect a more efficient water heater. The total cost of the measure is $160 (assuming a retail markup of 1.46 from LBL-MIM) and has been apportioned according to energy savings in motor use (listed as a MISE enduse measure, cost = $50) and in hot water use. The water use portion of the cost is $110.

Source: LBL-REM, US DOE 1990, LBL-MIM.

Preceding Measure: EWH08

Horizontal axis clotheswasher w/ EWH(post-2000)

EWH10

new measure

measure active between 2000 and 2010

Incremental Cost: $130 in 1988$

UES: 285.0 kWh

Lifetime (yrs): 14

% of stock applicable: 35%

Horizontal axis clothes washers are widely used in Europe, but not in the U.S. We assume a lead time of 5 years is necessary for them to become widely available here. After the year 2000, we assume that all of the clotheswashers sold could be horizontal axis. The eligible fraction is thus 0.81 (the saturation of clotheswashers from LBL-REM) times the percentage of units that are not switched to HPWHs or gas WHs (43.5%), or 35.2%. (This measure applies only to homes that are NOT switched to HPWHs or gas WHs). The energy savings and cost are incremental from the 1994 standard and are from US DOE 1990. The total cost of the measure is $160 (assuming a retail markup of 1.46 from LBL-MIM) and has been apportioned according to energy savings in motor use (listed as a MISE enduse measure, cost = $30) and in hot water use. The water use portion of the cost is $130.

Source: LBL-REM, US DOE 1990, LBL-MIM.

Preceding Measure: EWH04

END USE: FRZR Manual defrost freezer

1990 UEC: 568 kWh

Lifetime (yrs): 21

Fuel Type: electric

Total freezer stock is approximated as 50% upright manual defrost, 50% chest manual defrost. Baseline UEC represents a weighted average of the 1990 NAECA standards for chest and upright manual defrost freezers (upright automatic defrost freezers are a small fraction of the freezer stock and were not included, resulting in a 4% lower overall average UEC than REM's). Savings and costs are weight-averaged in the same manner. Baseline and measures assume no CFCs.

Source: LBL-REM

Improve freezer to 1993 DOE standard
FRZR01
new measure
measure active between 1990 and 2010
Incremental Cost: $34 in 1987$
UES: 99.8 kWh
Lifetime (yrs): 21
% of stock applicable: 100%

1993 standard upgrade measures include: - 5.05 EER compressor - 2.5" side, bottom and door insulation (foam) Cost assumes a retail markup factor of 1.7, from LBL-MIM.

Source: US DOE Nov 1989

Preceding Measure: none

Evacuated panels for freezer (post 1995)
FRZR02
new measure
measure active between 1995 and 2010
Incremental Cost: $68 in 1987$
UES: 132.0 kWh
Lifetime (yrs): 21
% of stock applicable: 100%

Estimated cost is for powder-filled panels. Assumes a 1.7 retail markup factor (from LBL-MIM).

Source: US DOE Nov 1989

Preceding Measure: FRZR01

5.3 EER compressor for freezer (post-2000)
FRZR03
new measure
measure active between 2000 and 2010
Incremental Cost: $11 in 1990$
UES: 25.0 kWh
Lifetime (yrs): 21
% of stock applicable: 100%

Based on technology likely to be available by the year 2000.

Source: LBL engineering estimates.

Preceding Measure: FRZR02

Freezer condenser gas heat
FRZR04
new measure
measure active between 2000 and 2010
Incremental Cost: $33 in 1990$
UES: 50.0 kWh
Lifetime (yrs): 21
% of stock applicable: 100%

Energy savings and cost are best predictions of post-2000 technology.

Source: LBL engineering estimates.

Preceding Measure: FRZR03

END USE: LTG Lighting (Indoor and Outdoor)
1990 UEC: 1060 kWh
Lifetime (yrs): 15
Fuel Type: electric

Incandescent lights, no controls. Indoor lights on 3-5 hrs/day; outdoor on 6 hrs/day SF, 12 hrs apt. Weighted average of large, medium, small singlefamily/mobile home, and apartments, from RECS 1987 housing stock. Baseline cost (present value, 15 years) = $307.20.Assumes $0.75 per incandescent lamp. Vacation periods are assumed to lower the amount of time the indoor lamps are used per year to 85% or 95% (see Appendix for full details). Exterior lamps are assumed to be on year-round.

Source: Barbara Atkinson, LBL Principal Research Associate. Cost from retail stores. Saturations and hourly usage data from 8 utilities' RASSes (see Appendix for details).

Timer & Photocell (outdoor)
LTG01
new measure
measure active between 1990 and 2010
Incremental Cost: $29 in 1990$
UES: 151.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

For single family and mobile homes, the average number of hours outdoor lights are on is decreased from 6 hours to 3 hours. In the basecase, we assume 35% leave the lights on more than 3 hours/day and do not already have a timer. The basecase also assumes that 50% of all apartment units leave exterior lights on more than 6 hrs/day. The average operation of these lamps is reduced from 12 to 6 hrs/day. Each timer and photocell is assumed to be shared by an average of 4 apartment units. Cost data are from Grainger's General Catalog. Saturations are from eight utilities' RASSes. For details of calculations, see Lighting Appendix.

Source: Barbara Atkinson and Grainger's General Catalog, No.377, 1990.

Preceding Measure: none

Compact Fluorescent Lamps
LTG02
new measure
measure active between 1990 and 2010
Incremental Cost: $107 in 1990$
UES: 342.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Compact Fluorescent Screw-In Retrofit where applicable without fixture change (interior: 30% of 100 W fixtures, 50% of 75 W, 60% of 60 W; exterior: 50% of large and medium single family, 25% of small/mobile homes and apts.) Where not applicable, energy-saving incandescents. These include krypton lamps indoors and halogen lamps outdoors. Cost data are from Energy Federation Inc catalog, Massachusetts, March 1990. Lifetimes and wattages are from various manufacturers' catalogs. Saturations are estimated by LBL Principal Research Associate Barbara Atkinson. For details of calculations, see Lighting Appendix.

Source: Barbara Atkinson, LBL Principal Research Associate; Energy Federation Inc catalog, MA, March 1990; manufacturers' catalogs.

Preceding Measure: LTG01

Compact Fluorescent Fixtures
LTG03
new measure
measure active between 1990 and 2010
Incremental Cost: $277 in 1990$
UES: 293.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Compact fluorescent fixture retrofits, interior and exterior, for remaining incandescents that could not be retrofit with screw-in fluorescents. Cost data are from Energy Federation Inc catalog, MA, March 1990 and Real Goods' Alternative Energy Sourcebook catalog, CA, 1990. For details of the calculation of savings and costs, see the Lighting Appendix.

Source: Barbara Atkinson; Energy Federation, Inc., MA, March 1990 catalog; and Real Goods' Alternative Energy Sourcebook catalog, 1990.

Preceding Measure: LTG02

END USE: MISE Miscellaneous electricity

1990 UEC: 559 kWh
Lifetime (yrs): 15
Fuel Type: electric

Miscellaneous includes clotheswasher and dishwasher motor electricity use, but excludes television set use (TV sets are treated separately). Baseline UEC is from REM, adjusted to meet our definition of the enduse (i.e., REM defines miscellaneous as including TVs but excluding washing appliance motors). Both enduses are intended to be catch-alls for electricity use that does not fall under one of the defined enduse categories.

Source: LBL-REM

Improve miscellaneous appliance motor efficiency
MISE01
new measure
measure active between 1990 and 2010
Incremental Cost: $200 in 1990$
UES: 190.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

This includes motor improvements for pumps, ceiling fans, pool pumps, vacuum cleaners, etc. Excludes furnace fan and laundry motor improvements.

Source: LBL engineering estimates.

Preceding Measure: None

Upgrade furnace fan efficiency
MISE02
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1990$
UES: 150.0 kWh
Lifetime (yrs): 15
% of stock applicable: 30%

This assumes installation of variable speed furnace fan and hood fan. It also assumes a 2-stage gas burner. Carrier claims that its variable speed units cut electricity use by 80% due to greatly reduced air movement rates and benefits from cubic law. Rainer, et.al.1990 estimates furnace fan UEC as 500 kWh (national average). Our estimate of 30% savings (150kWh) is thus conservative.

Source: Rainer, et al 1990 and LBL engineering estimates.

Preceding Measure: none

Improve dishwasher motor to 1994 standard

MISE03

new measure

measure active between 1990 and 2010

Incremental Cost: $4 in 1990$

UES: 23.4 kWh

Lifetime (yrs): 13

% of stock applicable: 45%

This is the weighted average savings over the two major types of dishwashers (standard and standard with water heating booster). The total cost of the 1994 standard is apportioned according to the respective savings in water heating energy and motor energy. The saturation of dishwashers is 49% of the total housing stock in 1990 (LBL-REM). However, 8.5% of all electric water heaters are switched to gas, thus the eligible fraction of dishwashers in homes with EWHs becomes 44.8%. Manufacturer's cost from US DOE 1990 was multiplied by LBL-MIM's retail markup for dishwashers of 1.46.

Source: US DOE 1990 LBL-MIM and LBL-REM.

Preceding Measure: None

Horiz axis clthswshr w/HPWH (motor svgs) 1995-2000

MISE04

new measure

measure active between 1995 and 2000

Incremental Cost: $50 in 1988$

UES: 64.6 kWh

Lifetime (yrs): 14

% of stock applicable: 10%

Motor energy savings due to the horizontal axis clotheswasher. Between 1995 and 2000, only half of the eligible stock (80.9% of all homes have clotheswashers (LBL-REM)) will go to horizontal axis. After 2000, we assume greater availability of these units in the U.S. and will switch all eligible units to horizontal axis. Since 8.5% of all electric water heaters are switched to gas WHs, only 91.5% of EWHs are eligible for this measure; eligible fraction is then 0.915*(0.809/2) = 37%. This measure applies only where the EWH has been switched to a HPWH, thus the eligible fraction is lowered again to 9.7% (see description of EWH06 for details). Energy savings and cost for the motor are from US DOE 1990, p.3-23. Both assume the 1994 standard comes first. The cost assumes a 1.46 retail markup (LBL-MIM) and is apportioned to both an EWH measure and this measure according to the respective energy savings in hot water consumption and in motor use.

Source: US DOE 1990 LBL-MIM and LBL-REM.

Preceding Measure: none

Horiz axis clthswshr w/EWH (motor svgs) post-2000
MISE05
new measure
measure active between 2000 and 2010
Incremental Cost: $30 in 1988$
UES: 64.6 kWh
Lifetime (yrs): 14
% of stock applicable: 35%

Motor energy savings due to the horizontal axis clotheswasher. Between 1995 and 2000, only half of the eligible stock (80.9% of all homes have clotheswashers (LBL-REM)) will go to horizontal axis. After 2000, we assume greater availability of these units in the U.S. and will switch all eligible units to horizontal axis. Since 8.5% of all electric water heaters are switched to gas WHs, only 91.5% of EWHs are eligible for this measure; eligible fraction is then 0.915*0.809 = 74%. This measure applies only where the EWH has not been switched to a HPWH, thus the eligible fraction is lowered again to 35.2% (see description of EWH10 for details). Energy savings and cost for the motor are from US DOE 1990, p.3-23. Both assume the 1994 standard comes first. The cost assumes a 1.46 retail markup (LBL-MIM) and is apportioned to both an EWH measure and this measure according to the respective energy savings in hot water consumption and in motor use.

Source: US DOE 1990 LBL-MIM and LBL-REM.

Preceding Measure: none

Horiz axis clthswshr w/HPWH (motor svgs) post-2000
MISE06
new measure
measure active between 2000 and 2010
Incremental Cost: $50 in 1988$
UES: 64.6 kWh
Lifetime (yrs): 14
% of stock applicable: 39%

Motor energy savings due to the horizontal axis clotheswasher. Between 1995 and 2000, only half of the eligible stock (80.9% of all homes have clotheswashers (LBL-REM)) will go to horizontal axis. After 2000, we assume greater availability of these units in the U.S. and will switch all eligible units to horizontal axis. Since 8.5% of all electric water heaters are switched to gas WHs, only 91.5% of EWHs are eligible for this measure; eligible fraction is then 0.915*0.809 = 74%. This measure applies only where the EWH has been switched to a HPWH, thus the eligible fraction is lowered again to 38.9% (see description of EWH09 for details). Energy savings and cost for the motor are from US DOE 1990, p.3-23. Both assume the 1994 standard comes first. The cost assumes a 1.46 retail markup (LBL-MIM) and is apportioned to both an EWH measure and this measure according to the respective energy savings in hot water consumption and in motor use.

Source: US DOE 1990 LBL-MIM and LBL-REM.

Preceding Measure: none

Horiz axis clthswshr w/EWH (motor svgs) 1995-2000

MISE07

new measure

measure active between 1995 and 2000

Incremental Cost: $30 in 1988$

UES: 64.6 kWh

Lifetime (yrs): 14

% of stock applicable: 27%

Motor energy savings due to the horizontal axis clotheswasher. Between 1995 and 2000, only half of the eligible stock (80.9% of all homes have clotheswashers (LBL-REM)) will go to horizontal axis. After 2000, we assume greater availability of these units in the U.S. and will switch all eligible units to horizontal axis. Since 8.5% of all electric water heaters are switched to gas WHs, only 91.5% of EWHs are eligible for this measure; eligible fraction is then 0.915*(0.809/2) = 37%. This measure applies only where the EWH has not been switched to a HPWH, thus the eligible fraction is lowered again to 27.3% (see description of EWH07 for details). Energy savings and cost for the motor are from US DOE 1990, p.3-23. Both assume the 1994 standard comes first. The cost assumes a 1.46 retail markup (LBL-MIM) and is apportioned to both an EWH measure and this measure according to the respective energy savings in hot water consumption and in motor use.

Source: US DOE 1990 LBL-MIM and LBL-REM.

Preceding Measure: none

END USE: NANEC New multi family w/ CAC, North

1990 UEC: 7180 kWh

Lifetime (yrs): 30

Fuel Type: electric

New multi family with electric furnaces and central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from heating and cooling loads for Chicago mulitfamily homes built in the 1980's (Ritschard 1989). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in NMF elec htd homes, Nth

NANEC01
new measure
measure active between 1990 and 2010
Incremental Cost: $27 in 1989$
UES: 21.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new electrically heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 12 kBtu/hr capacity (average peak load for Chicago apartments, from Ritschard 1989) and is 62% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: NANGC New MF w/ non-elec htg & CAC, North

1990 UEC: 412 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated multi family with central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from heating and cooling loads for Chicago mulitfamily homes built in the 1980's (Ritschard 1989). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in NMF elec htd homes, Nth

NANGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $27 in 1989$
UES: 21.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new electrically heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 12 kBtu/hr capacity (average peak load for Chicago apartments, from Ritschard 1989) and is 62% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: NANHP New multi family w/ heat pump, North

1990 UEC: 3606 kWh
Lifetime (yrs): 30
Fuel Type: electric

New multi family with heat pumps in the North. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UECs are derived from heating and cooling loads for Chicago mulitfamily homes built in the 1980's (Ritschard 1989). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve HP to 92 std in NMF HP homes, North

NANHP01

new measure

measure active between 1990 and 2010

Incremental Cost: $49 in 1989$

UES: 119.4 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in new multi family buildings in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the north is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

Improve HP beyond 92 std in NMF HP homes, North

NANHP02

new measure

measure active between 1990 and 2010

Incremental Cost: $104 in 1989$

UES: 622.8 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Improve average new unit HP efficiency to 9.06 HSPF, 13.03 SEER from LBL-REM's average 1992 new unit efficiency. Applies to new multi family buildings in the North. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: NANHP01

Improve HP(2) in NMF HP homes, North
NANHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $62 in 1989$
UES: 106.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.43 HSPF, 13.28 SEER. Applies to new multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: NANHP02

Improve HP(3) in NMF HP homes, North
NANHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $228 in 1989$
UES: 161.3 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.93 HSPF, 15.14 SEER. Applies to new multi family buildings in the North. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 12 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: NANHP03

END USE: NASEC New multi family w/ CAC, South

1990 UEC: 1807 kWh
Lifetime (yrs): 30
Fuel Type: electric

New multi family with electric furnaces and central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from heating and cooling loads for Fort Worth mulitfamily homes built in the 1980's (Ritschard 1989). The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in NMF elec htd homes, Sth

NASEC01
new measure
measure active between 1990 and 2010
Incremental Cost: $28 in 1989$
UES: 49.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new electrically heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 14 kBtu/hr capacity (average peak load for Fort Worth aparments, from Ritschard 1989) and is 64% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC beyond 1992 std in NMF elec htd homes,

NASEC02

new measure

measure active between 1990 and 2000

Incremental Cost: $169 in 1989$

UES: 186.8 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in new electrically heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 14 kBtu/hr capacity (average peak load for Fort Worth apartments, from Ritschard 1989) and is 64% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). This measure makes way in the year 2000 for the more cost-effective variable speed compressor unit, assumed to become available in 2000.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NASEC01

Variable speed CAC compressor, NMF elec homes, Sth

NASEC03

new measure

measure active between 2000 and 2010

Incremental Cost: $105 in 1989$

UES: 140.8 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Variable speed compressor improves average new unit CAC efficiency to 12.48 SEER from 10.5 SEER (1992 new unit) in new electrically heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 14 kBtu/hr capacity (average peak load for Fort Worth aparments, from Ritschard 1989) and is 64% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). This measure is assumed to be available beginning in the year 2000.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NASEC01

END USE: NASER New multi family w/ RAC, South

1990 UEC: 1155 kWh
Lifetime (yrs): 30
Fuel Type: electric

New multi family with electric furnaces and room AC in the South. Furnace efficiency is assumed to be 100%. Cooling UEC is assumed to be 34% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are derived from heating and cooling loads for Fort Worth mulitfamily homes built in the 1980's (Ritschard 1989). The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve RAC in NMF elec htd homes, Sth
NASER01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 13.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in new electrically heated multi family homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in NMF elec htd homes, Sth(post2000
NASER02
new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 42.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to new electrically heated multi family homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NASER01

END USE: NASGC New MF w/ non-elec htg & CAC, South

1990 UEC: 945 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated multi family with central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are derived from heating and cooling loads for Fort Worth mulitfamily homes built in the 1980's (Ritschard 1989). The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve CAC to 1992 std in NMF non-elec homes, Sth

NASGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $28 in 1989$
UES: 49.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new gas heated multi family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 14 kBtu/hr capacity (average peak load for Fort Worth aparments, from Ritschard 1989) and is 64% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC beyond 1992 std in NMF non-elec homes,

NASGC02

new measure

measure active between 1990 and 2000

Incremental Cost: $169 in 1989$

UES: 186.8 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in new gas/other heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 14 kBtu/hr capacity (average peak load for Fort Worth aparments, from Ritschard 1989) and is 64% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). This measure makes way in the year 2000 for the more cost-effective variable speed compressor unit, assumed to become available in 2000.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NASGC01

Variable speed CAC compressor, NMF g/o homes, Sth

NASGC03

new measure

measure active between 2000 and 2010

Incremental Cost: $105 in 1989$

UES: 140.8 kWh

Lifetime (yrs): 12

% of stock applicable: 100%

Variable speed compressor improves average new unit CAC efficiency to 12.48 SEER from 10.5 SEER (1992 new unit) in new gas/other heated multi family homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 14 kBtu/hr capacity (average peak load for Fort Worth aparments, from Ritschard 1989) and is 64% of LBL's Conservation database cost of a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve). This measure is assumed to be available beginning in the year 2000.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NASGC01

END USE: NASGR New MF w/ non-elec htg & RAC, South

1990 UEC: 293 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated multi family with room AC in the South. Cooling UEC is assumed to be 34% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are derived from heating and cooling loads for Fort Worth mulitfamily homes built in the 1980's (Ritschard 1989). The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve RAC in NMF non-elec homes, Sth
NASGR01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 13.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in new gas/other heated multi family homes in the South. Measure involves increasing condenser rows. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in NMF non-elec homes, Sth(post2000
NASGR02
new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 42.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to new gas/other heated multi family homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NASGR01

END USE: NASHP New multi family w/ heat pump, South

1990 UEC: 1361 kWh
Lifetime (yrs): 30
Fuel Type: electric

New multi family with heat pumps in the South. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UECs are derived from heating and cooling loads for Fort Worth mulitfamily homes built in the 1980's (Ritschard 1989). The Fort Worth UECs were adjusted to Charleston weather using heating and cooling degree day ratios (Andersson, et al 1986). Efficiency of space conditioning equipment is from LBL-REM. The fraction of all new MF units in this htg/clg category is from RECS87 data for MF homes built in the 1980's.

Source: Ritschard 1989 and RECS87.

Improve HP to 92 std in NMF HP homes, South

NASHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $49 in 1989$
UES: 70.2 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in new multi family buildings in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: none

Improve HP beyond 92 std in NMF HP homes, South

NASHP02
new measure
measure active between 1990 and 2010
Incremental Cost: $104 in 1989$
UES: 243.7 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.06 HSPF, 13.03 SEER from LBL-REM's average 1992 new unit efficiency. Applies to new multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: NASHP01

Improve HP(2) in NMF HP homes, South

NASHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $62 in 1989$
UES: 26.3 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 9.43 HSPF, 13.28 SEER. Applies to new multi family buildings in the South. Cost is from LBL's Energy Conservation Database, scaled down by a factor of 0.69 to account for the smaller capacity (The database cost is for a 35 kBtu/hr peak cooling capacity, whereas the peak load for apartments in the south is about 14 kBtu/hr, from Ritschard 1989). The cost factor was derived from an EPRI TAG 1987 cost-capacity curve for the smallest HP available (23 kBtu/hr) compared to the 35 kBtu unit.

Source: LBL's Energy Conservation Database, Sep 1990. EPRI TAG 1987.

Preceding Measure: NASHP02

END USE: NMNEC New mobile homes w/ CAC, North

1990 UEC: 10910 kWh
Lifetime (yrs): 30
Fuel Type: electric

New mobile homes with electric furnaces and central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the north are: R-26 ceiling, R-18 wall, R-14 floor, and double glazing. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson, et al. 1986). The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.36 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve CAC to 1992 std in new elec htd MH, North
NMNEC01
new measure
measure active between 1990 and 2010
Incremental Cost: $43 in 1989$
UES: 67.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new electrically heated mobile homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 35 kBtu/hr capacity.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: NMNER New mobile homes w/ RAC, North

1990 UEC: 10008 kWh
Lifetime (yrs): 30
Fuel Type: electric

New mobile homes with electric furnaces and room AC in the North. Furnace efficiency is assumed to be 100%. Cooling UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the north are: R-26 ceiling, R-18 wall, R-14 floor, and double glazing. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using degree days (Andersson et al 1986). Floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.36 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve RAC in NMH elec htd homes, Nth
NMNER01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 18.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in new electrically heated mobile homes in the North. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: NMNGC New MH w/ non-elec htg & CAC, North

1990 UEC: 1307 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated mobile homes with central AC in the North. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the north are: R-26 ceiling, R-18 wall, R-14 floor, and double glazing. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson, et al. 1986). The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.36 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve CAC to 1992 std in new non-elec MH, North

NMNGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $43 in 1989$
UES: 67.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new gas heated mobile homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 35 kBtu/hr capacity.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: NMNGR New MH w/ non-elec htg & RAC, North

1990 UEC: 405 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated mobile homes with room AC in the North. Cooling UEC is assumed to be 31% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the north are: R-26 ceiling, R-18 wall, R-14 floor, and double glazing. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Cincinnati (closest city to Chicago in PEAR database having crawl). UECs were adjusted to Chicago weather using heating and cooling degree days (Andersson, et al. 1986). The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.36 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve RAC in NMH non-elec htd homes, Nth
NMNGR01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 18.1 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in new electrically heated mobile homes in the North. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

END USE: NMSEC New mobile homes w/ CAC, South

1990 UEC: 7877 kWh
Lifetime (yrs): 30
Fuel Type: electric

New mobile homes with electric furnaces and central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the south are: R-20 ceiling, R-12 wall, R-10 floor, and 1.26 window layers. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Charleston. The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source:. MHI, 1991a and 1990. RECS 1987.

Improve CAC to 1992 std in new elec htd MH, South

NMSEC01
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1989$
UES: 140.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new electrically heated mobile homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 41 kBtu/hr capacity and is increased over LBL's Conservation database 35kBtu cost by a factor of 17%. Factor was derived from EPRI TAG 1987 cost versus capacity curve.

Source: Energy savings from PEAR. Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC beyond 1992 std in NMH elec htd homes,
NMSEC02
new measure
measure active between 1990 and 2010
Incremental Cost: $309 in 1989$
UES: 536.9 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in new electrically heated mobile homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 41 kBtu/hr capacity in the south and is 17% higher than LBL's Conservation database cost for a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve).

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSEC01

END USE: NMSER New mobile homes w/ RAC, South
1990 UEC: 6084 kWh
Lifetime (yrs): 30
Fuel Type: electric

New mobile homes with electric furnaces and room AC in the South. Furnace efficiency is assumed to be 100%. Cooling UEC is assumed to be 34% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the south are: R-20 ceiling, R-12 wall, R-10 floor, and 1.26 window layers. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Charleston. The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve RAC in NMH elec htd homes, Sth
NMSER01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 41.2 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in new electrically heated mobile homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Measure involves increasing condenser rows. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in NMH elec htd homes, Sth(post2000

NMSER02
new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 132.3 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to new electrically heated mobile homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSER01

END USE: NMSGC New MH w/ non-elec htg & CAC, South

1990 UEC: 2716 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated mobile homes with central AC in the South. Furnace efficiency is assumed to be 100%. CAC efficiency is 9.96 SEER (REM 1990 new unit). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the south are: R-20 ceiling, R-12 wall, R-10 floor, and 1.26 window layers. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Charleston. The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve CAC to 1992 std in new non-elec MH, South

NMSGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1989$
UES: 140.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new gas heated mobile homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 41 kBtu/hr capacity and is increased over LBL's Conservation database 35kBtu cost by a factor of 17%. Factor was derived from EPRI TAG 1987 cost versus capacity curve.

Source: Energy savings from PEAR. Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC beyond 1992 std in NMH non-elec homes,

NMSGC02
new measure
measure active between 1990 and 2010
Incremental Cost: $309 in 1989$
UES: 536.9 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 13.3 SEER from 10.5 SEER in new gas/other heated mobile homes in the South. Energy savings calculated from the efficiencies. Cost assumes a 41 kBtu/hr capacity in the south and is 17% higher than LBL's Conservation database cost for a 35kBtu unit (percentage derived from EPRI TAG 1987 CAC cost versus capacity curve).

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSGC01

END USE: NMSGR New MH w/ non-elec htg & RAC, South

1990 UEC: 923 kWh
Lifetime (yrs): 30
Fuel Type: electric

New non-electrically heated mobile homes with room AC in the South. Cooling UEC is assumed to be 34% of the central AC UEC (RCG/Hagler, Bailly, 1990). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the south are: R-20 ceiling, R-12 wall, R-10 floor, and 1.26 window layers. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Charleston. The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve RAC in NMH non-elec homes, Sth
NMSGR01
new measure
measure active between 1990 and 2010
Incremental Cost: $10 in 1989$
UES: 41.2 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit RAC efficiency to 9.42 SEER from the 1990 baseline (9.0 SEER) in new gas/other heated mobile homes in the South. Measure involves increasing condenser rows. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database. Energy savings calculated from the change in efficiency.

Source: Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve RAC(2) in NMH non-elec homes, Sth(post2000
NMSGR02
new measure
measure active between 2000 and 2010
Incremental Cost: $56 in 1989$
UES: 132.3 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Variable speed unit assumed to be available after 2000. Energy savings is from LBL's Conservation Database 1990 and represents a 15% savings over the 9.42 SEER unit. Applies to new gas/other heated mobile homes in the South. Cost assumes an 8 kBtu/hr capacity and is from LBL's Appliance Energy Conservation Database.

Source: LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSGR01

END USE: NMSHP New mobile homes w/ heat pump, South

1990 UEC: 5174 kWh
Lifetime (yrs): 30
Fuel Type: electric

New mobile homes with heat pumps in the South. Heat pump efficiency is 9.86 SEER and 7.24 HSPF (REM 1990 new unit). UECs are from PEAR runs using baseline shell characteristics from the Manufactured Housing Institute's Survey of Retailers, 1991. The shells are representative of the most popular packages sold currently. Average insulation values for the south are: R-20 ceiling, R-12 wall, R-10 floor, and 1.26 window layers. Home was modelled as a 1-story, 1195 sqft home with crawl space foundation in Charleston. The floor area is nationwide average sold in 1989 (from MHI Quick Facts, 1990/91). Infiltration rate is assumed to be 0.45 ACH. Fraction of total MH stock in this category is from RECS87.

Source: MHI, 1991a and 1990. RECS 1987.

Improve HP to 92 std in NMH HP homes, South

NMSHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $57 in 1989$
UES: 238.8 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in new mobile homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost is from LBL's Energy Conservation Database for a peak cooling capacity of 35 kBtu/hr and is adjusted by a scaling factor equal to the ratio of the mobile home UEC to the single family UEC for this combination of heating and cooling types. The scaling factor in this case is 1.2.

Source: Cost from LBL's Energy Conservation Database, Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Improve HP beyond 1992 standard in South NMH

NMSHP02
new measure
measure active between 1990 and 2010
Incremental Cost: $183 in 1988$
UES: 917.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.06 and SEER = 13.03 from LBL-REM's 1992 average new unit efficiency. Cost assumes a 41 kBtu/hr capacity in the south and includes a 21% increase over the cost of a 35 kBtu/hr unit derived from EPRI TAG 1987 cost versus capacity table.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSHP01

Improve HP(2) in South NMH

NMSHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $109 in 1988$
UES: 115.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.43 and SEER = 13.28. Cost assumes a 41 kBtu/hr capacity in the south and includes a 21% increase over the cost of a 35 kBtu/hr unit derived from EPRI TAG 1987 cost versus capacity table.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSHP02

Improve HP(3) in South NMH

NMSHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $399 in 1988$
UES: 344.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.93 and SEER = 15.14. Cost assumes a 41 kBtu/hr capacity in the south and includes a 21% increase over the cost of a 35 kBtu/hr unit derived from EPRI TAG 1987 cost versus capacity table.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NMSHP03

END USE: NSNE New single family homes w/o cooling, North

1990 UEC: 11809 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with electric furnaces and no cooling in the North. Furnace efficiency is assumed to be 100%. UEC is from PEAR runs using baseline shell characteristics from NAHB 1987 data: R-29 ceiling, R-15 wall and floor, and double glazing. House prototype is 2-story basement, 1856 sqft of floor area. Infiltration rate is 0.4 ACH.

Source: Koomey et al. 1991 and LBL-REM.

Ceiling to R-60 in new SF homes w/ ER/-, North
NSNE04

new measure
measure active between 1990 and 2010
Incremental Cost: $148 in 1989$
UES: 137.5 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-60 in new SF Northern homes with electric resistance heating and no cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNE02

END USE: NSNEC New SF electric furnace, CAC homes in North

1990 UEC: 12773 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with electric furnaces and central air conditioners. Efficiency of the furnace is assumed to be 100%; CAC efficiency is 1990 new unit efficiency from REM (9.96 SEER). UECs for heating and cooling were obtained from PEAR runs using baseline shell characteristics derived from NAHB 1987 data. Insulation levels are: R-29 ceiling, R-15 wall and floor, and double glazed windows. Infiltration rate is assumed to be 0.4 ACH. House prototype is a 2-story basement with 1856 sq ft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Switch elec furnace to HP in new SF homes, North
NSNEC01
new measure
measure active between 1990 and 2010
Incremental Cost: $222 in 1989$
UES: 7297.6 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Switch the electric resistance heater and central air conditioner to a heat pump having HSPF of 8.83 and SEER of 10.96. All homes with CAC and electric furnaces are "switched" to heat pumps. Even though there is virtually no difference in the cost of a standard heat pump and the cost of a CAC/electric heating system (EPRI, 1987), we have added $100 to the cost of the measure to be conservative. The remaining $122 is the incremental cost of the efficient HP over the 1990 standard new unit (7.24 HSPF, 9.86 SEER) cost. The efficient HP cost is from LBL's Appliance Energy Conservation Database by Jim McMahon, revised September 1990.

Source: PEAR for energy savings, costs from EPRI 1987 and LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Triple glazed windows in new SF homes, North
NSNEC02
new measure
measure active between 1990 and 2010
Incremental Cost: $223 in 1989$
UES: 707.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNEC01

Improve HP in North single-family
NSNEC03
new measure
measure active between 1990 and 2010
Incremental Cost: $190 in 1989$
UES: 430.0 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve the heat pump efficiency to HSPF 9.5 and SEER 13.3 from HSPF 8.83, SEER 10.96.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSNEC02

Wall to R-19 in new SF homes, North
NSNEC04
new measure
measure active between 1990 and 2010
Incremental Cost: $186 in 1989$
UES: 256.7 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNEC03

Floor to R-30 in new SF homes, North
NSNEC06
new measure
measure active between 1990 and 2010
Incremental Cost: $223 in 1989$
UES: 191.9 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNEC05

Ceiling to R-30 in new SF homes, North
NSNEC07
new measure
measure active between 1990 and 2010
Incremental Cost: $19 in 1989$
UES: 12.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNEC05

END USE: NSNER New SF electric furnace homes with room AC, North

1990 UEC: 12108 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with electric furnaces and room air conditioners in the North. Efficiency of the furnace is assumed to be 100%; RAC efficiency is 9.0 EER (REM 1990 new unit average). UECs for heating and (central) cooling were obtained from PEAR runs using baseline shell characteristics derived from NAHB 1987 data. Insulation levels are: R-29 ceiling, R-15 wall and floor, and double glazed windows. The baseline RAC UEC is assumed to be 31% of the calculated UEC for central AC. This figure is from a compilation of utility data in the Northern region (RCG/Hagler, Bailly, 1990). For cost of RAC improvement measures, an average of 1.5 room AC units per house was assumed. The number of room AC units per house was derived from RECS 87 data for our southern region (Census regions were reaggregated and weighted by housing starts). Infiltration rate is assumed to be 0.4 ACH.

Source: Koomey et al. 1991 and LBL-REM.

Shell improvement in new SF homes w/ ER/RAC, North
NSNER01

new measure
measure active between 1990 and 1995
Incremental Cost: $631 in 1989$
UES: 3231.4 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Measure includes increasing wall insulation to R-19 and floor to R-30, plus triple glazed windows in homes built prior to 1995.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: none

Shell improvement in new SF homes w/ ER/RAC, North
NSNER02
new measure
measure active between 1995 and 2010
Incremental Cost: $1095 in 1989$
UES: 4638.7 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Measure includes increasing wall insulation to R-19 and floor to R-30, plus superwindows in homes built after 1995. Superwindows are double-paned with 2 transparent, low-E films suspended in between the panes. Shading coefficient of the window is 0.52, R-value in the middle is 8.1 and the overall R-value is 5.5. Their transmissivity is 62%. The energy savings were calculated using percentage changes in heating and cooling loads from the RESFEN 1.0 computer program (LBL, 1991). Current costs are now $5 per sq ft of window area. Costs are assumed to drop to $2.50 per sq ft in 1995, based on personal communication with Dariush Arasteh (LBL staff scientist), 1991. Southwall Technologies provided window characteristics and RESFEN provided the energy savings for superwindows.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNER01

Wall to R-27, ceil to R-49 in new SF homes, North
NSNER03
new measure
measure active between 1990 and 2010
Incremental Cost: $1355 in 1989$
UES: 1725.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-49 and wall insulation to R-27 in new SF Northern homes with electric resistance heating and room AC cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNER02

Ceiling to R-60 in new SF homes w/ ER/RAC, North
NSNER04
new measure
measure active between 1990 and 2010
Incremental Cost: $148 in 1989$
UES: 139.2 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-60 in new SF Northern homes with electric resistance heating and room AC cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNER02

END USE: NSNGC New SF non-electrically heated homes w/ CAC, North

1990 UEC: 1042 kWh
Lifetime (yrs): 30
Fuel Type: electric

Cooling in new single family houses with non-electric heating and central air conditioners. CAC efficiency is 1990 new unit efficiency from REM (9.96 SEER). UEC for cooling was obtained from PEAR run using baseline shell characteristics derived from NAHB 1987 data. Insulation levels are: R-28 ceiling, R-14 wall, R-12 floor, and 1.74 window layers. Infiltration rate is assumed to be 0.4 ACH. Prototype is a 2-story basement home with 2177 sq ft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Improve CAC to 1992 std in NSF non-elec homes, Nth
NSNGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $43 in 1989$
UES: 54.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new single family gas heated homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve CAC in North NSF non-elec homes w/ CAC
NSNGC02
new measure
measure active between 1990 and 2010
Incremental Cost: $264 in 1989$
UES: 208.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve the central air conditioner efficiency to 13.3 SEER.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSNGC01

Improve CAC(2) in North NSF non-elec homes w/ CAC
NSNGC03

new measure
measure active between 1990 and 2010
Incremental Cost: $250 in 1989$
UES: 82.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve the central air conditioner efficiency to 14.87 SEER from 13.3 SEER.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSNGC02

END USE: NSNGR New SF non-electrically heated homes w/ RAC, North

1990 UEC: 323 kWh
Lifetime (yrs): 30
Fuel Type: electric

Cooling in new single family houses with non-electric heating and room air conditioners. Baseline RAC efficiency is 9.0 EER (REM 1990 new unit average). UEC for cooling is assumed to be 31% of the calculated CAC UEC (from regional utility data compiled by RCG/Hagler, Bailly, 1990). For cost calculations, an average of 1.5 room AC units per house is assumed (from RECS 87 regional data). Insulation levels are: R-28 ceiling, R-14 wall, R-12 floor, and 1.74 window layers. Infiltration rate is assumed to be 0.4 ACH. Prototype is 2-story basement home with 2177 sq ft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Increase condenser rows in RAC in NSF non-elec, N
NSNGR01

new measure
measure active between 1990 and 2010
Incremental Cost: $15 in 1989$
UES: 14.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Increase condenser rows in room AC units in new SF Northern homes with gas/other heating and room AC cooling. Efficiency is improved to 9.42 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Variable speed RAC, NSF non-elec, North (>2000)
NSNGR02
new measure
measure active between 2000 and 2010
Incremental Cost: $83 in 1989$
UES: 46.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Variable speed RAC is assumed to be available after 2000. For homes with gas/other heating and room AC cooling.

Source: Cost and energy savings from LBL's Appliance Energy Conservation Database, revised Sep 1990.

Preceding Measure: NSNGR01

Increase condenser area of RAC, NSF non-elec, Nth
NSNGR03
new measure
measure active between 2000 and 2010
Incremental Cost: $26 in 1989$
UES: 12.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser area of room AC units in new SF Northern homes built after 2000 with gas/other heating and room AC cooling. Efficiency is improved to 9.88 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised Sep 1990. Energy savings from PEAR.

Preceding Measure: NSNGR02

END USE: NSNHP New single family homes w heat pumps, North
1990 UEC: 7873 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with heat pumps in the North. Heat pump efficiency is 9.86 SEER, 7.24 HSPF (1990 new unit, from REM). UEC is from PEAR runs using baseline shell characteristics from NAHB 1987 data: R-28 ceiling, R-14 wall, R-13 floor, and 1.87 window layers. House prototype is 2-story basementwith 2222 sqft of floor area. Infiltration rate is 0.4 ACH.

Source: Koomey et al. 1991 and LBL-REM.

Improve HP to 1992 standard in North SF homes
NSNHP01
new measure
measure active between 1990 and 2010
Incremental Cost: $71 in 1989$
UES: 242.9 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in new single family homes in the North. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought.

Source: Energy savings from PEAR. Cost from LBL's Appliance Energy Conservation Database, Sep 1990.

Preceding Measure: none

Triple glazed windows in new SF homes w/HP, North
NSNHP02
new measure
measure active between 1990 and 2010
Incremental Cost: $311 in 1989$
UES: 1188.4 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Install triple glazed windows in new SF homes in the north with heat pumps.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NNHP01

Improve HP beyond 1992 standard in North SF homes
NSNHP03
new measure
measure active between 1990 and 2010
Incremental Cost: $241 in 1989$
UES: 1379.1 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.5 and SEER = 13.3 from LBL-REM's 1992 average new unit efficiency.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSNHP02

Wall to R-19 in new SF homes w/ HP, North
NSNHP04

new measure
measure active between 1990 and 2010
Incremental Cost: $267 in 1989$
UES: 334.8 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Increase wall insulation to R-19 in new single family heat pump homes in the North.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNHP03

R-30 floor in new SF homes w/ HP, N (<'95)
NSNHP05

new measure
measure active between 1990 and 1995
Incremental Cost: $311 in 1989$
UES: 261.1 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Increase floor insulation to R-30 in new SF homes built before 1995 with heat pumps in the north.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNHP04

R-30 ceiling in new SF homes w/ HP, N(<'95)
NSNHP06

new measure
measure active between 1990 and 1995
Incremental Cost: $44 in 1989$
UES: 28.5 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Increase ceiling insulation to R-30 in new SF homes built before 1995 in the north with heat pumps.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNHP05

Superwindows in NSF HP homes, N (post-95)
NSNHP07
new measure
measure active between 1995 and 2010
Incremental Cost: $556 in 1989$
UES: 654.6 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Superwindows in homes built after 1995. Superwindows are double-paned with 2 transparent, low-E films suspended in between the panes. Shading coefficient of the window is 0.52, R-value in the middle is 8.1 and the overall R-value is 5.5. Their transmissivity is 62%. The energy savings were calculated using percentage changes in heating and cooling loads from the RESFEN 1.0 computer program (LBL, 1991). Current costs are now $5 per sq ft of window area over triple glazing. Costs are assumed to drop to $2.50 per sq ft over triple in 1995, based on personal communication with Dariush Arasteh (LBL staff scientist), 1991. Southwall Technologies provided window characteristics and RESFEN provided the energy savings for superwindows.

Source: Costs from Koomey, 1991. Energy savings from PEAR. RESFEN for superwindow savings.

Preceding Measure: NSNHP05

R-30 floor in new SF homes w/ HP, N (>'95)
NSNHP08
new measure
measure active between 1990 and 2010
Incremental Cost: $311 in 1989$
UES: 225.5 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

R-30 floor in homes built after 1995.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNHP07

R-30 ceiling in new SF homes w/ HP, N(>'95)
NSNHP09
new measure
measure active between 1990 and 2010
Incremental Cost: $44 in 1989$
UES: 24.6 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

R-30 ceiling in homes built after 1995.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSNHP08

END USE: NSSE New single family homes w/o cooling, South

1990 UEC: 9114 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with electric furnaces and no cooling in the South. Furnace efficiency is assumed to be 100%. UEC is from PEAR runs using baseline shell characteristics from NAHB 1987 data: R-28 ceiling, R-10 wall, R-3.8 to 2ft foundation, and 1.51 window layers. House prototype is 1-story slab with 1894 sqft of floor area. Infiltration rate is 0.62 ACH (from NAHB 87).

Source: Koomey et al. 1991 and LBL-REM.

Shell improvement in new SF homes w/ ER/-, South
NSSE01
new measure
measure active between 1990 and 2010
Incremental Cost: $1061 in 1989$
UES: 5424.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Measure includes increasing wall insulation to R-19 and floor to R-5 (2 ft deep), plus triple glazed windows and 0.4 ACH infiltration rate in homes built prior to 1995.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: none

Ceiling to R-30 in new SF homes w/ ER/-, South
NSSE02
new measure
measure active between 1990 and 2010
Incremental Cost: $57 in 1989$
UES: 70.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-30 in new SF Southern homes with electric resistance heating and no cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSE01

Superwindows in NSF homes w/ ER/-, South(post-'95)
NSSE03
new measure
measure active between 1995 and 2010
Incremental Cost: $473 in 1989$
UES: 521.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Superwindows in homes built after 1995. Superwindows are double-paned with 2 transparent, low-E films suspended in between the panes. Shading coefficient of the window is 0.52, R-value in the middle is 8.1 and the overall R-value is 5.5. Their transmissivity is 62%. The energy savings were calculated using percentage changes in heating and cooling loads from the RESFEN 1.0 computer program (LBL, 1991). Current costs are now $5 per sq ft of window area. Costs are assumed to drop to $2.50 per sq ft in 1995, based on personal communication with Dariush Arasteh (LBL staff scientist), 1991. Southwall Technologies provided window characteristics and RESFEN provided the energy savings for superwindows.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSE02

Ceiling to R-38 in new SF homes w/ ER/-, South
NSSE04
new measure
measure active between 1990 and 2010
Incremental Cost: $322 in 1989$
UES: 205.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-38 in new SF Southern homes with electric resistance heating and no cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSE03

END USE: NSSEC New SF electric furnace, CAC homes in South
1990 UEC: 12697 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with electric furnaces and central air conditioners. Efficiency of the furnace is assumed to be 100%; CAC efficiency is 1990 new unit efficiency from REM (9.96 SEER). UECs for heating and cooling were obtained from PEAR runs using baseline shell characteristics derived from NAHB 1987 data. Insulation levels are: R-28 ceiling, R-10 wall, R-3.8 to 2ft foundation, 1.51 window layers, and 0.62 ACH. House prototype is a 1-story slab with 1894 sq ft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Switch elec furnace to HP in new SF homes, South

NSSEC01

new measure

measure active between 1990 and 2010

Incremental Cost: $322 in 1989$

UES: 6456.1 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Switch the electric resistance heater and central air conditioner to a heat pump having HSPF of 9.06 and SEER of 13.3. All homes with CAC and electric furnaces are "switched" to heat pumps. Even though there is virtually no difference in the cost of a standard heat pump and the cost of a CAC/electric heating system (EPRI, 1987), we have added $100 to the cost of the measure to be conservative. The remaining $222 is the incremental cost of the efficient HP above the 1990 average new unit (7.24 HSPF, 9.86 SEER) cost. The efficient HP cost is from LBL's Appliance Energy Conservation Database by Jim McMahon, revised September 1990.

Source: PEAR for energy savings, costs from EPRI 1987 and LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improved shell in new SF homes w/ ER/CAC, South

NSSEC02

new measure

measure active between 1990 and 2010

Incremental Cost: $682 in 1989$

UES: 2909.9 kWh

Lifetime (yrs): 30

% of stock applicable: 100%

Measure includes spectrally selective windows, 0.4 ACH infiltration rate and R-5, 2 ft foundation insulation in new SF homes in the South with ER heating and CAC. Spectrally selective windows cost the same as double pane, low E, argon filled windows, have the same U value but a shading coefficient of 0.5, according to LBL staff scientist Dariush Arasteh. Energy savings for the spectrally selective windows were determined as a fraction of the double to triple pane savings using RESFEN 1.0.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSEC01

Wall to R-19 in new SF homes, South
NSSEC03

new measure
measure active between 1990 and 2010
Incremental Cost: $379 in 1989$
UES: 428.9 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Increase wall insulation to R-19 in new single family homes with ER/CAC in the south.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSEC02

Improve HP in South new SF ER/CAC homes
NSSEC04

new measure
measure active between 1990 and 2010
Incremental Cost: $90 in 1989$
UES: 108.1 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve the heat pump efficiency to HSPF 9.5 and SEER 13.3 from HSPF 9.5, SEER 13.3.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSSEC03

END USE: NSSER New SF electric furnace homes with room AC, South

1990 UEC: 10333 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with electric furnaces and room air conditioners in the South. Prototype is 1-story slab w/ 1894 sq ft. Furnace efficiency is assumed to be 100%; RAC efficiency is 9.0 EER (REM 1990 new unit average). UECs for heating and (central) cooling were obtained from PEAR runs using baseline shell characteristics derived from NAHB 1987 data. Insulation levels are: R-28 ceiling, R-10 wall, R-3.8 to 2ft foundation, 0.62 ACH, and 1.51 window layers. The baseline RAC UEC is assumed to be 34% of the calculated UEC for central AC (from a compilation of utility data in the Southern region (RCG/Hagler, Bailly, 1990)). For cost of RAC improvement measures, an average of 1.2 room AC units per house was assumed. The number of room AC units per house was derived from RECS 87 data for our southern region (Census regions were reaggregated and weighted by housing starts).

Source: Koomey et al. 1991 and LBL-REM.

Shell improvement in new SF homes w/ ER/RAC, South
NSSER01

new measure
measure active between 1990 and 2010
Incremental Cost: $1061 in 1989$
UES: 5623.9 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Measure includes increasing wall insulation to R-19 and floor to R-30, plus triple glazed windows and reducing infiltration rate to 0.4 ACH.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: none

Increase condenser rows of RAC in elec NSF, South
NSSER02

new measure
measure active between 1990 and 2010
Incremental Cost: $12 in 1989$
UES: 45.4 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser rows of all room AC units in new single family homes in the south with RAC. This measure improves efficiency to 9.42 EER from the 1990 standard efficiency of 9.0 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised September 1990. Energy savings from PEAR.

Preceding Measure: NSSER01

Ceiling to R-30 in NSF ER/RAC homes, Sth (pre-'95)
NSSER03

new measure
measure active between 1990 and 2010
Incremental Cost: $57 in 1989$
UES: 72.9 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-30 in new SF Southern homes built prior to 1995 with electric resistance heating and room AC cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSER02

Shell improvement in NSF ER/RAC homes, Sth (>1995)
NSSER04
new measure
measure active between 1995 and 2010
Incremental Cost: $530 in 1989$
UES: 1151.6 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Measure includes increasing ceiling insulation to R-30 plus superwindows in homes built after 1995. Superwindows are double-paned with 2 transparent, low-E films suspended in between the panes. Shading coefficient of the window is 0.52, R-value in the middle is 8.1 and the overall R-value is 5.5. Their transmissivity is 62%. The energy savings were calculated using percentage changes in heating and cooling loads from the RESFEN 1.0 computer program (LBL, 1991). Current costs are now $5 per sq ft of window area. Costs are assumed to drop to $2.50 per sq ft in 1995, based on personal communication with Dariush Arasteh (LBL staff scientist), 1991. Southwall Technologies provided window characteristics and RESFEN provided the energy savings for superwindows.

Source: Costs from Koomey et al, 1991b. Energy savings from PEAR.

Preceding Measure: NSSER02

Ceiling to R-38 in new SF homes w/ ER/RAC, South
NSSER05
new measure
measure active between 1990 and 2010
Incremental Cost: $322 in 1989$
UES: 219.4 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Improves ceiling insulation to R-38 in new SF Southern homes with electric resistance heating and room AC cooling.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSER03 (before 1995); NSSER04 (after 1995).

Variable speed RAC in south NSF homes (post-2000)
NSSER06
new measure
measure active between 2000 and 2010
Incremental Cost: $67 in 1989$
UES: 59.4 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Variable speed room AC are expected to be available in 2000. This measure does not change the efficiency, but decreases consumption. Energy savings and cost are from LBL's Appliance Energy Conservation Database, revised September 1990.

Source: Cost & energy savings from LBL's Appliance Energy Conservation Database, revised September 1990.

Preceding Measure: NSSER05

Increase condenser area of RAC in elec NSF, South

NSSER07
new measure
measure active between 2000 and 2010
Incremental Cost: $20 in 1989$
UES: 59.4 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser area of all room AC units in new single family homes in the south with RAC. This measure improves efficiency to 9.88 EER from the variable speed RAC efficiency of 9.0 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised September 1990. Energy savings from PEAR.

Preceding Measure: NSSER06

END USE: NSSGC New SF non-electrically heated homes w/ CAC, South

1990 UEC: 3576 kWh
Lifetime (yrs): 30
Fuel Type: electric

Cooling in new single family houses with non-electric heating and central air conditioners. CAC efficiency is 1990 new unit efficiency from REM (9.96 SEER). UECs for cooling was obtained from PEAR run using baseline shell characteristics derived from NAHB 1987 data. Insulation levels are: R-25 ceiling, R-12 wall, R-1.9 to 2ft foundation, 1.68 window layers, and 0.63 ACH. House prototype is a 1-story slab with 2071 sq ft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Improve CAC to 1992 std in NSF non-elec homes, Sth

NSSGC01
new measure
measure active between 1990 and 2010
Incremental Cost: $50 in 1989$
UES: 169.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve average new unit CAC efficiency to 10.5 SEER in new single family gas heated homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard (10.0 SEER), reflecting the above-standard units that are bought. Cost assumes a 41 kBtu/hr capacity and is increased over LBL's Conservation database 35kBtu cost by a factor of 17%. Factor was derived from EPRI TAG 1987 cost versus capacity curve.

Source: Energy savings from PEAR. Cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Spectrally selective windows, NSF non-elec, South

NSSGC02
new measure
measure active between 1990 and 2010
Incremental Cost: $311 in 1989$
UES: 1813.0 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Measure places spectrally selective windows in new SF homes in the South with gas heating and CAC. Spectrally selective windows cost the same as double pane, low E, argon filled windows, have the same U value but a shading coefficient of 0.5, according to LBL staff scientist Dariush Arasteh. Energy savings for the spectrally selective windows were determined as a fraction of the double to triple pane savings using RESFEN 1.0.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSGC01

Improve CAC in South new SF non-elec homes w/ CAC

NSSGC03
new measure
measure active between 1990 and 2010
Incremental Cost: $309 in 1989$
UES: 336.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve the central air conditioner efficiency to 13.3 SEER. Cost assumes a 41 kBtu/hr unit capacity.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSSGC02

Improve CAC(2) in NSF non-elec homes w/ CAC, South

NSSGC04
new measure
measure active between 1990 and 2010
Incremental Cost: $293 in 1989$
UES: 133.0 kWh
Lifetime (yrs): 12
% of stock applicable: 100%

Improve the central air conditioner efficiency to 14.87 SEER from 13.3 SEER. Cost assumes a 41 kBtu/hr capacity.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSSGC03

END USE: NSSGR New SF non-electrically heated homes w/ RAC, South

1990 UEC: 1216 kWh
Lifetime (yrs): 30
Fuel Type: electric

Cooling in new single family houses with non-electric heating and room air conditioners. RAC efficiency is 9.0 EER (REM 1990 new unit average). UEC for cooling is assumed to be 34% of the calculated CAC UEC (from regional utility data compiled by RCG/Hagler, Bailly, 1990). For cost calculations, an average of 1.2 room AC units per house is assumed (from RECS 87 regional data). Insulation levels are: R-25 ceiling, R-12 wall, R-1.9 to 2ft foundation, and 1.68 window layers, and 0.63 ACH. House prototype is a 1-story slab with 2071 sq ft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Increase condenser rows in RAC, NSF non-elec, Sth
NSSGR01
new measure
measure active between 1990 and 2010
Incremental Cost: $12 in 1989$
UES: 54.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser rows in room AC units in new SF Southern homes with gas/other heating and room AC cooling. Efficiency is improved to 9.42 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised Sep 1990. Energy savings from PEAR.

Preceding Measure: none

Increase condenser area of RAC, NSF non-elec, Sth
NSSGR02
new measure
measure active between 1990 and 2000
Incremental Cost: $87 in 1989$
UES: 54.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser area of room AC units in new SF Southern homes built before 2000 with gas/other heating and room AC cooling. Efficiency is improved to 9.88 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised Sep 1990. Energy savings from PEAR.

Preceding Measure: NSSGR01

Variable speed RAC, NSF non-elec, South (>2000)
NSSGR03
new measure
measure active between 2000 and 2010
Incremental Cost: $67 in 1989$
UES: 173.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Variable speed RAC is assumed to be available after 2000. For homes with gas/other heating and room AC cooling.

Source: Cost and energy savings from LBL's Appliance Energy Conservation Database, revised Sep 1990.

Preceding Measure: NSSGR02

Increase condenser area of RAC, non-elec NSF, Sth
NSSGR04
new measure
measure active between 2000 and 2010
Incremental Cost: $20 in 1989$
UES: 46.0 kWh
Lifetime (yrs): 15
% of stock applicable: 100%

Increase condenser area of room AC units in new SF Southern homes built after 2000 with gas/other heating and room AC cooling. Efficiency is improved to 9.88 EER.

Source: Cost from LBL's Appliance Energy Conservation Database, revised Sep 1990. Energy savings from PEAR.

Preceding Measure: NSSGR03

END USE: NSSHP New single family homes w heat pumps, South
1990 UEC: 6634 kWh
Lifetime (yrs): 30
Fuel Type: electric

New single family houses with heat pumps in the South. Heat pump efficiency is 9.86 SEER, 7.24 HSPF (1990 new unit, from REM). UEC is from PEAR runs using baseline shell characteristics from NAHB 1987 data: R-25 ceiling, R-11 wall, R-1.8 to 2ft foundation, 1.69 window layers, and 0.63 ACH infiltration rate. House prototype is 1-story slab with 1823 sqft of floor area.

Source: Koomey et al. 1991 and LBL-REM.

Improve HP to 1992 standard in South SF homes

NSSHP01

new measure

measure active between 1990 and 2010

Incremental Cost: $86 in 1989$

UES: 285.4 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Improve average new unit HP efficiency to 7.46 HSPF, 10.5 SEER in new single family homes in the South. This efficiency represents LBL-REM's prediction of the average new unit efficiency in 1992, after the standard is operative. It is higher than the standard, reflecting the above-standard units that are bought. Cost assumes a 41 kBtu unit capacity, derived from EPRI TAG 1987 design cooling loads for southeastern cities. A 17% cost increase over the 35 kBtu capacity unit was derived from EPRI TAG cost vs. peak output curves and applied to the cost in LBL's Conservation Database.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: none

Improve HP beyond 1992 standard in South SF homes

NSSHP02

new measure

measure active between 1990 and 2010

Incremental Cost: $183 in 1989$

UES: 1122.1 kWh

Lifetime (yrs): 14

% of stock applicable: 100%

Improve heat pump to HSPF = 9.06 and SEER = 13.03 from LBL-REM's 1992 average new unit efficiency. Cost assumes a 41 kBtu/hr unit capacity.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSSHP01

Improved shell in new SF homes w/ HP, South

NSSHP03

new measure

measure active between 1990 and 2010

Incremental Cost: $711 in 1989$

UES: 2397.8 kWh

Lifetime (yrs): 30

% of stock applicable: 100%

Measure includes spectrally selective windows, 0.4 ACH infiltration rate and R-5, 2 ft foundation insulation in new SF homes in the South with ER heating and CAC. Spectrally selective windows cost the same as double pane, low E, argon filled windows, have the same U value but a shading coefficient of 0.5, according to LBL staff scientist Dariush Arasteh. Energy savings for the spectrally selective windows were determined as a fraction of the double to triple pane savings using RESFEN 1.0.

Source: Costs from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSHP02

Improve HP in South new SF HP homes
NSSHP04
new measure
measure active between 1990 and 2010
Incremental Cost: $109 in 1989$
UES: 104.1 kWh
Lifetime (yrs): 14
% of stock applicable: 100%

Improve heat pump to HSPF = 9.5 and SEER = 13.3. Cost assumes a 41 kBtu/unit capacity.

Source: PEAR for energy savings, cost from LBL's Energy Conservation Database, Sep 1990.

Preceding Measure: NSSHP03

Wall to R-19 in new SF homes w/ HP, South
NSSHP05
new measure
measure active between 1990 and 2010
Incremental Cost: $328 in 1989$
UES: 210.4 kWh
Lifetime (yrs): 30
% of stock applicable: 100%

Increase wall insulation to R-19 in new single family heat pump homes in the South.

Source: Cost from Koomey, 1991. Energy savings from PEAR.

Preceding Measure: NSSHP04

END USE: REF Refrigerator
1990 UEC: 893 kWh
Lifetime (yrs): 19
Fuel Type: electric

We model the entire refrigerator stock as top mount automatic defrost, which accounts for 73% of the stock (LBL-REM). The baseline UEC is the 1990 standard for top mount AD refrigerators, from LBL-REM. Cost and energy savings for the measures assume a unit without CFCs. Actual REM 1990 new unit UEC (a weighted average over all models sold) is 927.8 kWh, or 4% higher.

Source: LBL-REM

Improve refrigerator to 1993 standard
REF01
new measure
measure active between 1990 and 2010
Incremental Cost: $49 in 1987$
UES: 203.2 kWh
Lifetime (yrs): 19
% of stock applicable: 100%

1993 standard includes enhanced heat transfer, foam door, 5.05 EER compressor, 2" door insulation, efficient fans, 3"/2.7" side and 3.0" back insulation. Assumes the unit has no CFCs. Cost assumes a 1.7 retail markup factor (from LBL-MIM).

Source: US DOE Nov 1989

Preceding Measure: none

Evacuated Panels for refrigerator (post 1995)
REF02
new measure
measure active between 1995 and 2010
Incremental Cost: $57 in 1987$
UES: 113.0 kWh
Lifetime (yrs): 19
% of stock applicable: 100%

Evacuated powder filled panels, assumed to be available after 1995.

Source: US DOE Nov 1989

Preceding Measure: REF01 (1993 standard)

Two-Compressor System for refrigerator (post 1995)
REF03
new measure
measure active between 1995 and 2010
Incremental Cost: $85 in 1987$
UES: 69.0 kWh
Lifetime (yrs): 19
% of stock applicable: 100%

Source: US DOE Nov 1989

Preceding Measure: REF02 (evac panels)

Recycle refrigerator condenser heat (post-2000)

REF12

new measure

measure active between 2000 and 2010

Incremental Cost: $40 in 1989$

UES: 100.0 kWh

Lifetime (yrs): 19

% of stock applicable: 100%

Energy savings are based on saving the electricity use of anti-sweat heaters, which account for 11% of the baseline energy use (947 kWh), or about 100 kWh, by recycling condenser heat. The cost is an estimate of the cost of adding thin tubing to carry the recycled heat around the perimeter of the refrigerator. Costs and savings are not yet available for this measure, which is assumed to become commercially available by the year 2000.

Source: US DOE Nov 1989 and conversations with Ike Turiel of LBL's Appliance Standards Group

Preceding Measure: REF03

Raise refrig compressor EER to 5.3 (post 2000)

REF13

new measure

measure active between 2000 and 2010

Incremental Cost: $9 in 1987$

UES: 18.0 kWh

Lifetime (yrs): 19

% of stock applicable: 100%

The compressor accounts for 75% of baseline energy use, and is estimated to account for 70% of the more efficient refrigerator's consumption. An improvement of 0.25/5.05 EER, or 5%, in the compressor will save 5% of 70% of the previous measure's UEC. This amounts to an energy savings of about 18 kWh. The incremental cost represents the cost of making the same improvement in a refrigerator with CFCs, from USDOE 1989. The costs should be approximately the same for a refrigerator without CFCs (Ike Turiel). The manufacturer cost has been multiplied by a retail cost factor of 1.7 from LBL-MIM.

Source: US DOE Nov 1989 and conversations with Ike Turiel of LBL's Appliance Standards Group, May 1991.

Preceding Measure: REF12

APPENDIX 4: END-USE ENERGY IN FROZEN EFFICIENCY CASE

This appendix contains the detailed breakdown of end-use energy in the frozen efficiency case, for 1990, 2000, and 2010, taken from ACCESS. All numbers are in TWh/year.

FROZEN EFFICIENCY CONSUMPTION IN 1990

CATEGORY	ENDUSE CODE	ENERGY
Lighting		
	LTG	100.11
	total	100.11
Other		
	BWTV	1.73
	CD-E	45.89
	CTV	18.01
	ERNG	62.32
	MISE	52.80
	total	180.74
Refrigeration		
	FRZR	37.23
	REF	132.02
	total	169.24
Space Conditioning		
	EANE	9.49
	EANEC	11.32
	EANER	16.29
	EANGC	0.89
	EANGR	1.46
	EANHP	9.00
	EASE	3.98
	EASEC	7.09
	EASER	2.65
	EASGC	1.92
	EASGR	0.57
	EASHP	1.93
	EMNE	0.59
	EMNEC	0.67
	EMNER	0.82
	EMNGC	0.52
	EMNGR	0.22
	EMNHP	0.13
	EMSE	0.98
	EMSEC	1.71
	EMSER	1.98
	EMSGC	0.71
	EMSGR	0.82
	EMSHP	0.15
	ESNE	13.44
	ESNEC	15.23
	ESNER	13.39
	ESNGC	9.54
	ESNGR	3.82
	ESNHP	10.40
	ESSE	6.27
	ESSEC	21.28
	ESSER	9.18
	ESSGC	25.45
	ESSGR	9.11
	ESSHP	18.82
	total	231.81
Water Heating		
	EWH	146.18
	total	146.18

Total for all enduses: 828.091 TWh

FROZEN EFFICIENCY CONSUMPTION IN 2000

CATEGORY	ENDUSE CODE	ENERGY
Lighting		
	LTG	114.28
	total	114.28
Other		
	BWTV	1.97
	CD-E	54.94
	CTV	20.55
	ERNG	77.92
	MISE	60.27
	total	215.65
Refrigeration		
	FRZR	28.33
	REF	127.72
	total	156.05
Space Conditioning		
	EANE	8.71
	EANEC	10.33
	EANER	14.92
	EANGC	0.70
	EANGR	1.16
	EANHP	7.70
	EASE	3.65
	EASEC	6.22
	EASER	2.39
	EASGC	1.52
	EASGR	0.45
	EASHP	1.60
	EMNE	0.42
	EMNEC	0.48
	EMNER	0.59
	EMNGC	0.33
	EMNGR	0.14
	EMNHP	0.08
	EMSE	0.71
	EMSEC	1.18
	EMSER	1.40
	EMSGC	0.44
	EMSGR	0.51
	EMSHP	0.10
	ESNE	12.45
	ESNEC	13.99
	ESNER	12.35
	ESNGC	7.64
	ESNGR	2.94
	ESNHP	8.96
	ESSE	5.80
	ESSEC	18.85
	ESSER	8.29
	ESSGC	20.37
	ESSGR	6.99
	ESSHP	15.77
	NANE	2.86
	NANEC	4.88
	NANER	0.53
	NANGC	0.21
	NANGR	0.12
	NANHP	0.34
	NASE	0.28
	NASEC	1.33
	NASER	0.19
	NASGC	0.51
	NASGR	0.02
	NASHP	0.40
	NMNE	0.11
	NMNEC	0.21
	NMNER	0.23
	NMNGC	0.12
	NMNGR	0.04
	NMSE	0.99
	NMSEC	3.30
	NMSER	2.02
	NMSGC	0.71
	NMSGR	0.24
	NMSHP	0.18
	NSNE	5.62
	NSNEC	5.52
	NSNER	1.88
	NSNGC	2.29
	NSNGR	0.21
	NSNHP	9.32
	NSSE	2.98
	NSSEC	10.01
	NSSER	1.74
	NSSGC	4.79
	NSSGR	0.53
	NSSHP	11.39
	total	276.23
Water Heating		
	EWH	164.50
	total	164.50

Total for all enduses: 926.710 TWh

FROZEN EFFICIENCY CONSUMPTION IN 2010

CATEGORY	ENDUSE CODE	ENERGY
Lighting		
	LTG	124.21
	total	124.21
Other		
	BWTV	2.15
	CD-E	61.25
	CTV	22.34
	ERNG	83.13
	MISE	65.50
	total	234.37
Refrigeration		
	FRZR	21.24
	REF	120.98
	total	142.22
Space Conditioning		
	EANE	7.84
	EANEC	9.30
	EANER	13.43
	EANGC	0.63
	EANGR	1.04
	EANHP	6.93
	EASE	3.26
	EASEC	5.57
	EASER	2.14
	EASGC	1.36
	EASGR	0.40
	EASHP	1.44
	EMNE	0.31
	EMNEC	0.34
	EMNER	0.42
	EMNGC	0.24
	EMNGR	0.10
	EMNHP	0.06
	EMSE	0.51
	EMSEC	0.85
	EMSER	1.01
	EMSGC	0.32
	EMSGR	0.37
	EMSHP	0.07
	ESNE	11.34
	ESNEC	12.75
	ESNER	11.26
	ESNGC	6.96
	ESNGR	2.68
	ESNHP	8.16
	ESSE	5.27
	ESSEC	17.11
	ESSER	7.52
	ESSGC	18.49
	ESSGR	6.35
	ESSHP	14.31
	NANE	5.21
	NANEC	8.90
	NANER	0.96
	NANGC	0.38
	NANGR	0.21
	NANHP	0.62
	NASE	0.53
	NASEC	2.54
	NASER	0.37
	NASGC	0.97
	NASGR	0.03
	NASHP	0.77
	NMNE	0.22
	NMNEC	0.42
	NMNER	0.46
	NMNGC	0.24
	NMNGR	0.08
	NMSE	2.00
	NMSEC	6.67
	NMSER	4.08
	NMSGC	1.44
	NMSGR	0.49
	NMSHP	0.36
	NSNE	10.20
	NSNEC	10.01
	NSNER	3.40
	NSNGC	4.15
	NSNGR	0.39
	NSNHP	16.90
	NSSE	5.61
	NSSEC	18.85
	NSSER	3.28
	NSSGC	9.01
	NSSGR	1.00
	NSSHP	21.43
	total	322.31
Water Heating		
	EWH	184.53
	total	184.53

Total for all enduses: 1007.627 TWh

APPENDIX 5: CONSERVATION SUPPLY CURVES BY END-USE CATEGORY

This appendix contains the supply curves and measure tables by end-use category, from which the grand supply curves (Figures 5 and 6) are created. The end uses are:

Space conditioning

Refrigeration

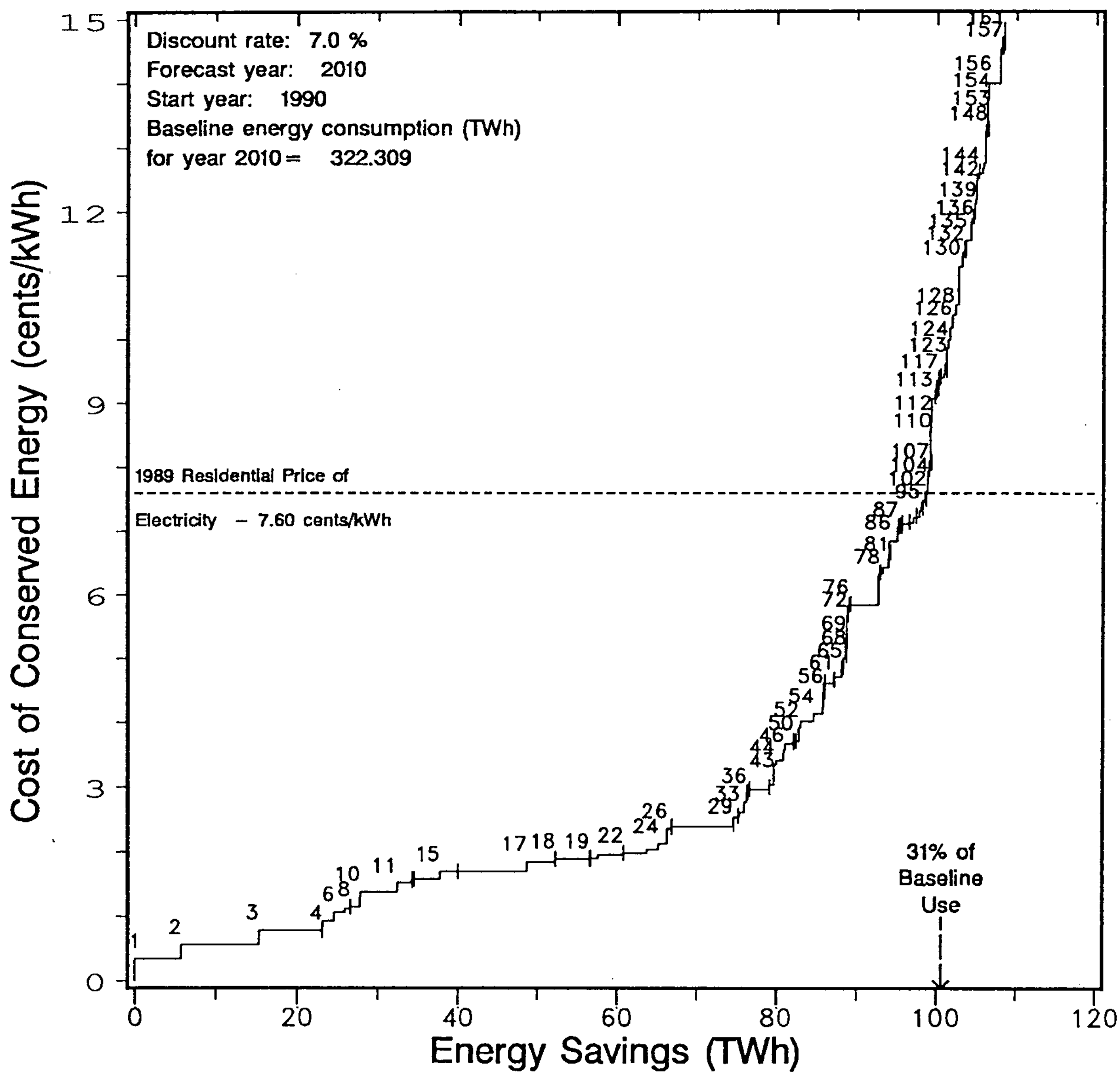
Water heating

Lighting

Other

As before, the CCE represents technology cost--no program costs are included. Applicable stock represents the number of appliances or building shells to which the measure can be applied from 1990 to the end of the analysis period.

Year 2010 MTP for Space Conditioning



A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measur es). The width of the step indicates the nationwide electricity savings fro m the measure and the height of the measure indicates the cost of conserve d electricity.

Year 2010 MTP for Space Conditioning

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	NSNEC01	Switch elec furnace to HP in new SF homes, North	222	7298	0.3	5.72	5.72	784
2	NSSEC01	Switch elec furnace to HP in new SF homes, South	322	6456	0.6	9.58	15.30	1484
3	ESNEC01	Switch elec furn to HP in existing North SF	822	11853	0.8	7.83	23.13	661
4	ESNHP02	Improve ceiling insulation in ESF HP homes, North	7	72	0.8	0.06	23.19	838
5	ESNER01	Improve shell in ESF ER/RAC homes, North	274	2374	0.9	1.44	24.63	605
6	ESNHP03	Improve HP in ESF HP homes, North	151	1598	1.1	1.34	25.97	838
7	ESNHP01	Improve HP to 92 std in ESF HP homes, North	71	719	1.1	0.60	26.57	838
8	EANHP02	Improve HP beyond 92 std in EMF HP homes, North	104	1028	1.2	1.19	27.76	1162
9	ESSHP02	Improve ceiling insulation in ESF HP homes, South	5	31	1.3	0.06	27.82	1865
10	NSSGC02	Spectrally selective windows, NSF non-elec, South	311	1813	1.4	4.57	32.39	2519
11	NSSER01	Shell improvement in new SF homes w/ ER/RAC, South	1061	5624	1.5	1.79	34.18	318
12	EMNHP02	Improve HP beyond 1992 standard in North EMH	159	1150	1.6	0.01	34.19	9
13	NSNER01	Shell improvement in new SF homes w/ ER/RAC, North	631	3231	1.6	0.25	34.44	78
14	NSSE01	Shell improvement in new SF homes w/ ER/-, South	1061	5424	1.6	3.34	37.78	616
15	ESNE01	Improve shell in ESF ER/- homes, North	754	3583	1.7	2.22	40.00	619
16	ESSEC01	Switch elec furn to HP in existing South SF	869	5805	1.7	8.69	48.68	1496
17	NSSHP02	Improve HP beyond 1992 standard in South SF homes	183	1122	1.9	3.62	52.31	3230
18	NSSEC02	Improved shell in new SF homes w/ ER/CAC, South	682	2910	1.9	4.32	56.63	1484
19	NANHP02	Improve HP beyond 92 std in NMF HP homes, North	104	623	1.9	0.11	56.73	171
20	NSNER02	Shell improvement in new SF homes w/ ER/RAC, North	1095	4639	1.9	0.94	57.68	203
21	ESSHP03	Improve HP in ESF HP homes, South	292	1693	2.0	3.16	60.83	1865
22	NSNHP03	Improve HP beyond 1992 standard in North SF homes	241	1379	2.0	2.96	63.79	2147
23	ESSER01	Improve shell in ESF ER/RAC homes, South	444	1757	2.0	1.42	65.21	809
24	ESSE01	Improve shell in ESF ER/- homes, South	451	1712	2.1	1.10	66.31	642
25	EMSHP02	Improve HP beyond 1992 standard in South EMH	192	981	2.2	0.01	66.33	13
26	NSNHP01	Improve HP to 1992 standard in North SF homes	71	243	2.4	0.52	66.85	2147
27	NMSHP02	Improve HP beyond 1992 standard in South NMH	192	917	2.4	0.06	66.91	71
28	NSSHP03	Improved shell in new SF homes w/ HP, South	711	2398	2.4	7.75	74.66	3230
29	NSSGR01	Increase condenser rows in RAC, NSF non-elec, Sth	12	54	2.4	0.04	74.70	819
30	EMSHP01	Improve HP to 92 std in EMH HP homes, South	55	251	2.5	0.00	74.71	13

Year 2010 MTP for Space Conditioning

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
31	NSNEC02	Triple glazed windows in new SF homes, North	223	707	2.6	0.55	75.26	784
32	EASHP02	Improve HP beyond 92 std in EMF HP homes, South	104	462	2.6	0.25	75.51	548
33	ESNEC02	Improve shell in ESF ER/CAC homes, North	274	842	2.6	0.56	76.07	661
34	NMSHP01	Improve HP to 92 std in NMH HP homes, South	57	239	2.7	0.02	76.09	71
35	ESNHP04	Improve shell in ESF HP homes, North	121	353	2.8	0.30	76.38	838
36	NSSER02	Increase condenser rows of RAC in elec NSF, South	12	45	2.9	0.01	76.40	318
37	NMSGR01	Improve RAC in NMH non-elec homes, Sth	10	41	2.9	0.02	76.42	529
38	NMSER01	Improve RAC in NMH elec htd homes, Sth	10	41	2.9	0.03	76.45	670
39	EANHP01	Improve HP to 92 std in EMF HP homes, North	49	190	2.9	0.22	76.67	1162
40	NSNHP02	Triple glazed windows in new SF homes w/HP, North	311	1188	3.0	2.55	79.22	2147
41	EMSER01	Improve RAC in EMH elec htd homes, Sth	10	40	3.0	0.01	79.22	151
42	ESSHP01	Improve HP to 92 std in ESF HP homes, South	86	321	3.1	0.60	79.82	1865
43	EMSGR01	Improve RAC in EMH non-elec homes, Sth	10	38	3.1	0.02	79.84	429
44	ESNHP05	Improve HP in ESF HP homes, North	90	305	3.4	0.26	80.09	838
45	NSSHP01	Improve HP to 1992 standard in South SF homes	86	285	3.4	0.92	81.02	3230
46	ESSER02	Improve room AC in ESF homes, South	15	47	3.5	0.04	81.05	809
47	ESNEC03	Switch to improved HP in North ESF homes	90	285	3.6	0.19	81.24	661
48	ESSGC01	Improve CAC to 1992 std in ESF non-elec homes, Sth	50	171	3.7	0.95	82.19	5562
49	NSSER07	Increase condenser area of RAC in elec NSF, South	20	59	3.7	0.01	82.20	149
50	NSSER04	Shell improvement in NSF ER/RAC homes, Sth (>1995)	530	1152	3.7	0.27	82.47	233
51	NSSGC01	Improve CAC to 1992 std in NSF non-elec homes, Sth	50	169	3.7	0.43	82.90	2519
52	EANHP03	Improve HP(2) in EMF HP homes, North	62	179	3.9	0.21	83.10	1162
53	ESNER02	Improve window, ceil & wall in ESF homes, North	1354	2718	4.0	1.64	84.75	605
54	ESSHP04	Improve shell in ESF HP homes, South	304	593	4.2	1.11	85.85	1865
55	NSSGR03	Variable speed RAC, NSF non-elec, South (>2000)	67	173	4.3	0.07	85.92	384
56	EMNHP01	Improve HP to 92 std in EMH HP homes, North	93	238	4.5	0.00	85.92	9
57	NMSGC01	Improve CAC to 1992 std in new non-elec MH, South	50	140	4.5	0.07	86.00	529
58	NMSEC01	Improve CAC to 1992 std in new elec htd MH, South	50	140	4.5	0.12	86.11	846
59	EMSEC01	Improve CAC to 1992 std in EMH elec htd homes, Sth	50	136	4.6	0.01	86.13	101
60	ESSEC02	Improve shell in ESF ER/CAC homes, South	444	776	4.6	1.16	87.29	1496

Year 2010 MTP for Space Conditioning

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
61	NANHP01	Improve HP to 92 std in NMF HP homes, North	49	119	4.7	0.02	87.31	171
62	ESNE02	Improve window, ceil & wall in ESF homes, North	859	1469	4.7	0.91	88.22	619
63	NSSGR04	Increase condenser area of RAC, non-elec NSF, Sth	20	46	4.8	0.02	88.24	384
64	EMSGC01	Improve CAC to 1992 std in EMH non-elec homes, Sth	50	130	4.8	0.02	88.25	126
65	EASHP01	Improve HP to 92 std in EMF HP homes, South	49	115	4.9	0.06	88.32	548
66	NASHP02	Improve HP beyond 92 std in NMF HP homes, South	104	244	4.9	0.14	88.45	564
67	NSNEC03	Improve HP in North single-family	190	430	5.0	0.34	88.79	784
68	ESNHP06	Improve ceiling in ESF HP homes, North	3	5	5.1	0.00	88.80	838
69	NMSGR02	Improve RAC(2) in NMH non-elec homes, Sth(post2000	56	132	5.3	0.04	88.83	267
70	NMSER02	Improve RAC(2) in NMH elec htd homes, Sth(post2000	56	132	5.3	0.04	88.88	338
71	EMSER02	Improve RAC(2) in EMH elec htd homes, Sth(post2000	56	129	5.4	0.01	88.88	58
72	EMSGR02	Improve RAC(2) in EMH non-elec homes, Sth(post2000	56	123	5.7	0.02	88.90	165
73	EASGC01	Improve CAC to 1992 std in EMF non-elec homes, Sth	28	61	5.7	0.07	88.97	1152
74	EASEC01	Improve CAC to 1992 std in EMF elec htd homes, Sth	28	61	5.7	0.08	89.05	1324
75	EMNHP03	Improve HP(2) in North EMH	95	185	5.8	0.00	89.06	9
76	NSNEC04	Wall to R-19 in new SF homes, North	186	257	5.9	0.20	89.26	784
77	ESSGC02	Improve CAC in South ESF non-elec homes w/ CAC	309	664	5.9	3.69	92.95	5562
78	NSSER03	Ceiling to R-30 in NSF ER/RAC homes, Sth (pre-'95)	57	73	6.3	0.02	92.97	318
79	NSNER03	Wall to R-27, ceil to R-49 in new SF homes, North	1355	1725	6.4	0.48	93.46	281
80	NSNHP04	Wall to R-19 in new SF homes w/ HP, North	267	335	6.5	0.72	94.18	2147
81	EMNER01	Improve RAC in EMH elec htd homes, Nth	10	19	6.5	0.00	94.18	37
82	NSSE02	Ceiling to R-30 in new SF homes w/ ER/-, South	57	70	6.6	0.04	94.22	616
83	NANHP03	Improve HP(2) in NMF HP homes, North	62	106	6.7	0.02	94.24	171
84	NMNER01	Improve RAC in NMH elec htd homes, Nth	10	18	6.7	0.00	94.24	46
85	NMNGR01	Improve RAC in NMH non-elec htd homes, Nth	10	18	6.7	0.00	94.24	206
86	NSNHP07	Superwindows in NSF HP homes, N (post-95)	556	655	6.9	1.02	95.26	1551
87	EMNGR01	Improve RAC in EMH non-elec homes, Nth	10	17	7.1	0.00	95.26	256
88	ESNER03	R-30 floor in ESF ER/RAC homes, North	1297	1482	7.1	0.33	95.59	224
89	NASGC01	Improve CAC to 1992 std in NMF non-elec homes, Sth	28	49	7.1	0.05	95.64	1023
90	NASEC01	Improve CAC to 1992 std in NMF elec htd homes, Sth	28	49	7.1	0.07	95.71	1405

Year 2010 MTP for Space Conditioning

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock *10^3*
91	ESNE03	R-30 floor in ESF ER/- homes, North	1297	1471	7.1	0.91	96.62	619
92	NSSEC03	Wall to R-19 in new SF homes, South	379	429	7.2	0.64	97.26	1484
93	NMSGC02	Improve CAC beyond 1992 std in NMH non-elec homes,	309	537	7.3	0.28	97.55	529
94	NMSEC02	Improve CAC beyond 1992 std in NMH elec htd homes,	309	537	7.3	0.45	98.00	846
95	NSSE03	Superwindows in NSF homes w/ ER/-, South(post-'95)	473	521	7.4	0.24	98.24	452
96	EASER01	Improve RAC in EMF elec htd homes, Sth	10	16	7.4	0.01	98.25	629
97	EASGR01	Improve RAC in EMF non-elec homes, Sth	10	16	7.4	0.02	98.26	1103
98	EMSEC02	Improve CAC beyond 1992 std in EMH elec htd homes,	309	525	7.4	0.05	98.32	101
99	ESSER03	Improve ceiling in ESF ER/RAC homes, South	410	443	7.5	0.36	98.67	809
100	EASGC03	Variable speed CAC compressor, EMF g/o homes, Sth	105	176	7.5	0.02	98.70	135
101	EASEC03	Variable speed CAC compressor, EMF elec homes, Sth	105	176	7.5	0.03	98.73	155
102	ESNE04	Improve ceiling in ESF homes, North	14	15	7.6	0.01	98.74	619
103	ESSEC03	Switch to improved HP in South ESF homes	109	162	7.7	0.24	98.98	1496
104	EMSGC02	Improve CAC beyond 1992 std in EMH non-elec homes,	309	501	7.8	0.06	99.04	126
105	EMNEC01	Improve CAC to 1992 std in EMH elec htd homes, Nth	43	69	7.9	0.00	99.04	27
106	NASHP01	Improve HP to 92 std in NMF HP homes, South	49	70	8.0	0.04	99.08	564
107	ESSE02	Improve ceiling in ESF ER/- homes, South	403	409	8.0	0.26	99.35	642
108	NMNEC01	Improve CAC to 1992 std in new elec htd MH, North	43	67	8.1	0.00	99.35	38
109	NMNGC01	Improve CAC to 1992 std in new non-elec MH, North	43	67	8.1	0.01	99.36	183
110	EMNGC01	Improve CAC to 1992 std in EMH non-elec homes, Nth	43	64	8.5	0.01	99.37	192
111	NSNER04	Ceiling to R-60 in new SF homes w/ ER/RAC, North	148	139	8.6	0.04	99.41	281
112	NSNE04	Ceiling to R-60 in new SF homes w/ ER/-, North	148	138	8.7	0.12	99.53	864
113	EASGC02	Improve CAC beyond 1992 std in EMF non-elec homes,	169	234	9.1	0.30	99.83	1287
114	EASEC02	Improve CAC beyond 1992 std in EMF elec htd homes,	169	234	9.1	0.35	100.18	1479
115	NASGR01	Improve RAC in NMF non-elec homes, Sth	10	13	9.2	0.00	100.18	99
116	NASER01	Improve RAC in NMF elec htd homes, Sth	10	13	9.2	0.00	100.18	318
117	NASGC03	Variable speed CAC compressor, NMF g/o homes, Sth	105	141	9.4	0.07	100.25	485
118	NASEC03	Variable speed CAC compressor, NMF elec homes, Sth	105	141	9.4	0.09	100.34	666
119	NSNEC06	Floor to R-30 in new SF homes, North	223	192	9.4	0.15	100.49	784
120	ESSEC04	Switch to improved HP in South ESF homes	330	399	9.4	0.60	101.09	1496

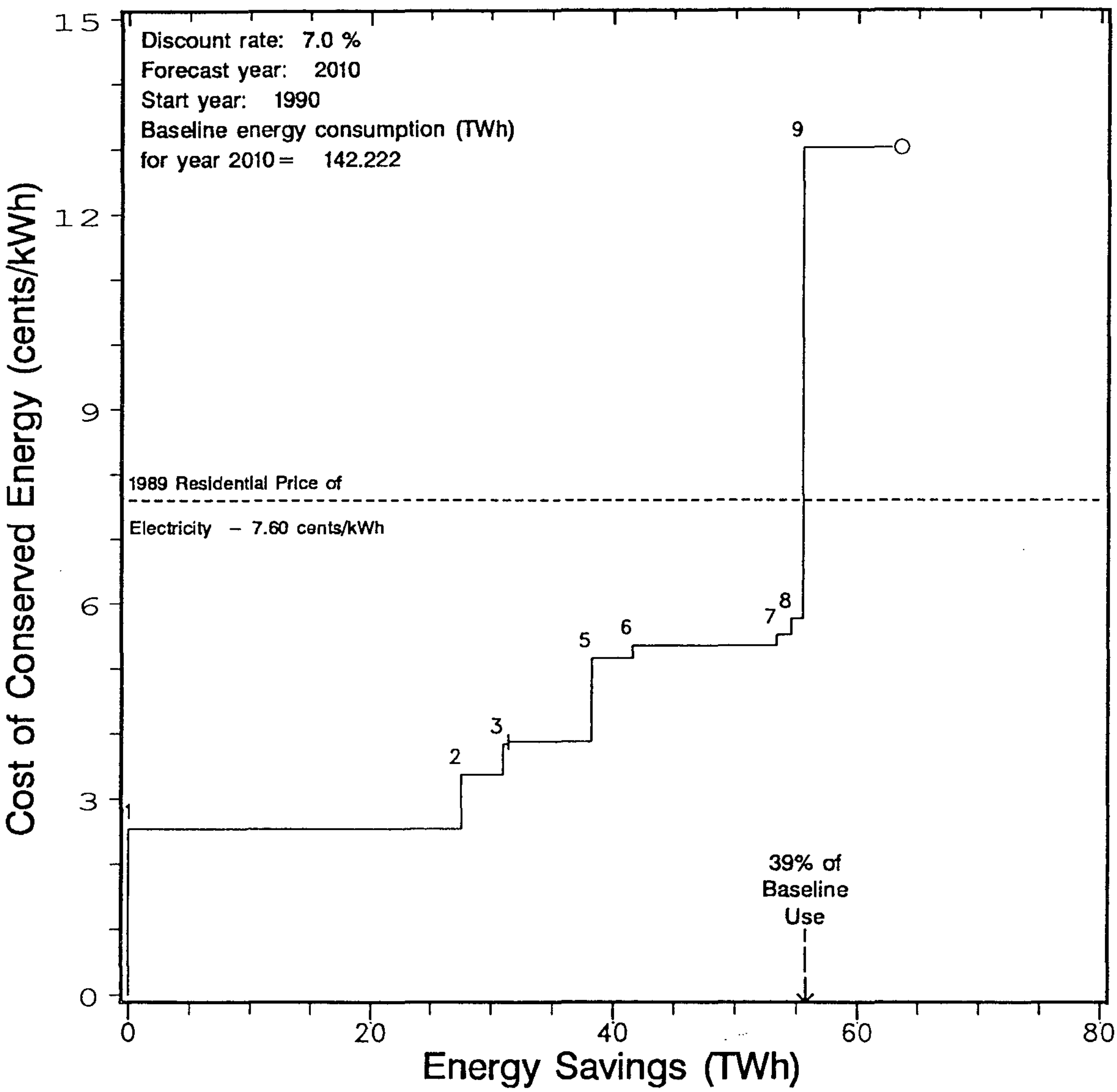
Year 2010 MTP for Space Conditioning

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
121	NSSEC04	Improve HP in South new SF ER/CAC homes	90	108	9.5	0.16	101.25	1484
122	ESSHP05	Improve ceiling in ESF HP homes, South	2	2	9.5	0.00	101.26	1865
123	NSNHP05	R-30 floor in new SF homes w/ HP, N (<'95)	311	261	9.7	0.16	101.41	596
124	ESNEC04	Improve ceiling insulation in ESF homes, North	480	393	9.9	0.26	101.67	661
125	NSNGC01	Improve CAC to 1992 std in NSF non-elec homes, Nth	43	54	10.0	0.22	101.89	3982
126	EANHP04	Improve HP(3) in EMF HP homes, North	228	254	10.2	0.30	102.18	1162
127	EMSHP03	Improve HP(2) in South EMH	114	127	10.3	0.00	102.18	13
128	ESNGC01	Improve CAC to 1992 std in ESF non-elec homes, Nth	43	52	10.4	0.36	102.54	6925
129	ESNHP07	Improve ceiling in ESF HP homes, North	555	425	10.6	0.36	102.90	838
130	NSNHP08	R-30 floor in new SF homes w/ HP, N (>'95)	311	226	11.2	0.48	103.38	2147
131	NMSHP03	Improve HP(2) in South NMH	114	115	11.3	0.01	103.39	71
132	NASGC02	Improve CAC beyond 1992 std in NMF non-elec homes,	169	187	11.4	0.10	103.49	538
133	NASEC02	Improve CAC beyond 1992 std in NMF elec htd homes,	169	187	11.4	0.14	103.63	738
134	EASHP03	Improve HP(2) in EMF HP homes, South	62	62	11.4	0.03	103.66	548
135	NSSGC03	Improve CAC in South new SF non-elec homes w/ CAC	309	336	11.6	0.85	104.51	2519
136	EMNER02	Improve RAC(2) in EMH elec htd homes, Nth(post2000	56	59	11.8	0.00	104.51	14
137	NSSER05	Ceiling to R-38 in new SF homes w/ ER/RAC, South	322	219	11.9	0.07	104.58	318
138	NSSHP04	Improve HP in South new SF HP homes	109	104	11.9	0.34	104.92	3230
139	EMNHP04	Improve HP(3) in North EMH	347	327	12.1	0.00	104.92	9
140	ESNER04	Improve windows in ESF homes, North	316	210	12.2	0.13	105.05	605
141	ESNE05	Improve windows in ESF homes, North	316	209	12.2	0.13	105.18	619
142	NSSER06	Variable speed RAC in south NSF homes (post-2000)	67	59	12.4	0.01	105.18	149
143	NSNEC07	Ceiling to R-30 in new SF homes, North	19	12	12.5	0.01	105.19	784
144	NSNHP06	R-30 ceiling in new SF homes w/ HP, N(<'95)	44	29	12.6	0.02	105.21	596
145	NSSHP05	Wall to R-19 in new SF homes w/ HP, South	328	210	12.6	0.68	105.89	3230
146	NSSE04	Ceiling to R-38 in new SF homes w/ ER/-, South	322	205	12.7	0.13	106.02	616
147	ESSER04	Improve windows in ESF ER/RAC homes, South	425	269	12.8	0.22	106.23	809
148	EMSHP04	Improve HP(3) in South EMH	419	360	13.3	0.00	106.24	13
149	ESSE03	Improve windows in ESF ER/- homes, South	425	259	13.3	0.17	106.41	642
150	EASER02	Improve RAC(2) in EMF elec htd homes, Sth(post2000	56	53	13.3	0.00	106.41	74

Year 2010 MTP for Space Conditioning

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
151	EASGR02	Improve RAC(2) in EMF non-elec homes, Sth(post2000	56	53	13.3	0.01	106.42	129
152	ESSER05	Improve wall in ESF ER/RAC homes, South	325	197	13.4	0.16	106.57	809
153	NSNGR01	Increase condenser rows in RAC in NSF non-elec, N	15	14	13.5	0.02	106.59	1202
154	ESSE04	Improve wall in ESF ER/- homes, South	325	191	13.8	0.12	106.71	642
155	NMSHP04	Improve HP(3) in South NMH	419	344	13.9	0.02	106.74	71
156	ESSGC03	Improve CAC(2) in ESF non-elec homes w/ CAC, South	293	263	14.0	1.46	108.20	5562
157	EANEC01	Improve CAC to 1992 std in EMF elec htd homes, Nth	27	23	14.6	0.02	108.22	765
158	EANGC01	Improve CAC to 1992 std in EMF elec htd homes, Nth	27	23	14.6	0.03	108.25	1421
159	ESNHP08	Improve windows in ESF HP homes, North	298	165	14.6	0.14	108.39	838
160	NSNHP09	R-30 ceiling in new SF homes w/ HP, N(>'95)	44	25	14.6	0.05	108.44	2147
161	ESNEC05	Improve window & wall in ESF homes, North	646	355	14.8	0.23	108.68	661
162	EASHP04	Improve HP(3) in EMF HP homes, South	228	164	15.8	0.09	108.77	548
163	NANGC01	Improve CAC to 1992 std in NMF elec htd homes, Nth	27	21	16.0	0.02	108.79	919
164	NANEC01	Improve CAC to 1992 std in NMF elec htd homes, Nth	27	21	16.0	0.03	108.81	1239
165	NSNGC02	Improve CAC in North NSF non-elec homes w/ CAC	264	208	16.0	0.83	109.64	3982
166	NANHP04	Improve HP(3) in NMF HP homes, North	228	161	16.1	0.03	109.67	171
167	ESNGC02	Improve CAC in North ESF non-elec homes w/ CAC	264	201	16.5	1.39	111.06	6925
168	NASGR02	Improve RAC(2) in NMF non-elec homes, Sth(post2000	56	42	16.6	0.00	111.06	47
169	NASER02	Improve RAC(2) in NMF elec htd homes, Sth(post2000	56	42	16.6	0.01	111.07	151
170	ESSEC05	Improve ceiling insulation in ESF homes, South	403	187	17.5	0.28	111.35	1496
171	NSSGR02	Increase condenser area of RAC, NSF non-elec, Sth	87	54	17.7	0.02	111.37	435
172	NSNGR02	Variable speed RAC, NSF non-elec, North (>2000)	83	46	19.8	0.02	111.40	539
173	ESSHP06	Improve windows in ESF HP homes, South	360	135	21.6	0.25	111.65	1865
174	NSNGR03	Increase condenser area of RAC, NSF non-elec, Nth	26	12	23.8	0.01	111.65	539
175	NASHP03	Improve HP(2) in NMF HP homes, South	62	26	26.9	0.01	111.67	564
176	NSSGC04	Improve CAC(2) in NSF non-elec homes w/ CAC, South	293	133	27.8	0.34	112.00	2519
177	NSNGC03	Improve CAC(2) in North NSF non-elec homes w/ CAC	250	82	38.4	0.33	112.33	3982

Year 2010 MTP for Refrigeration

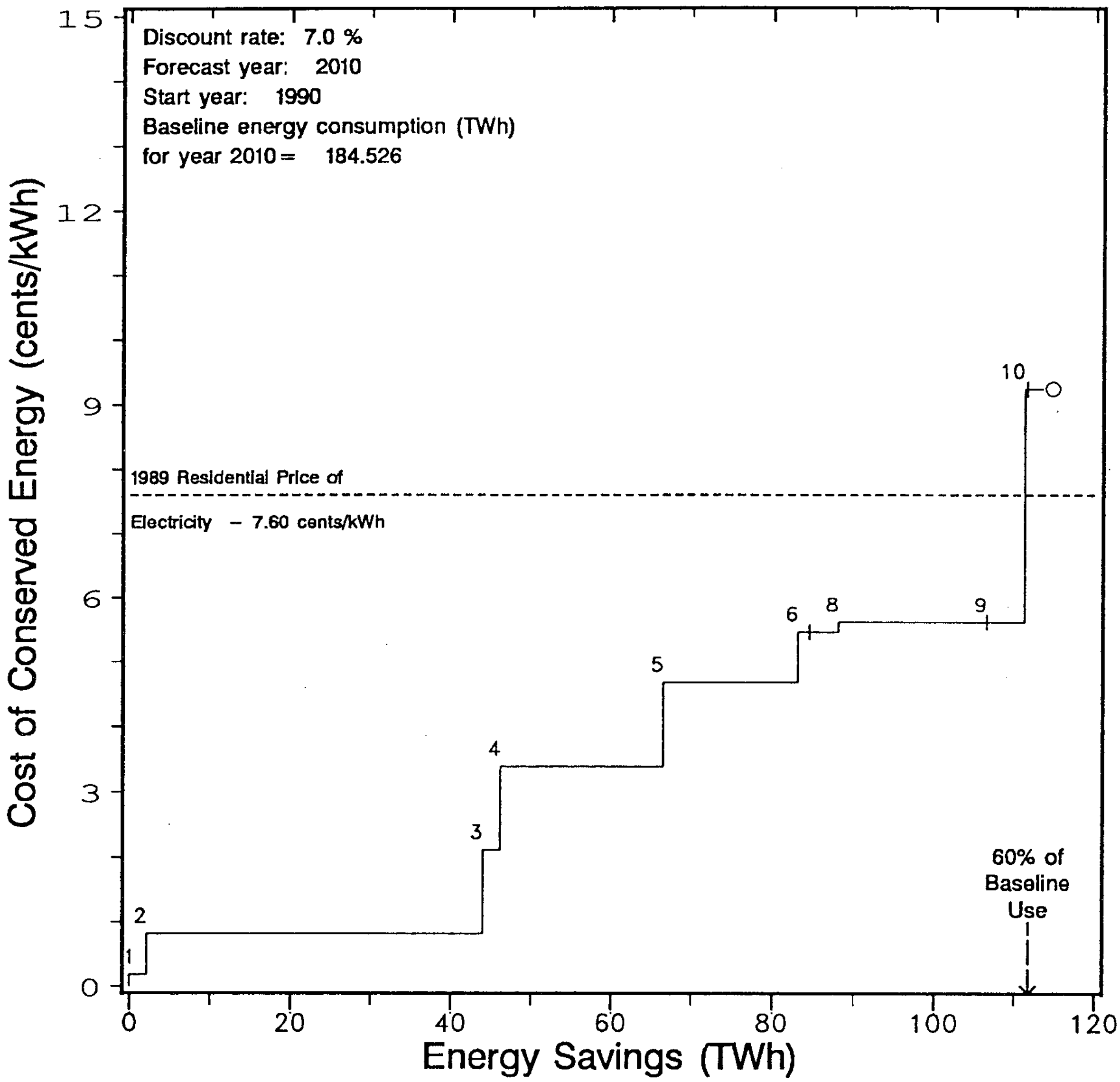


A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measur es). The width of the step indicates the nationwide electricity savings fro m the measure and the height of the measure indicates the cost of conserve d electricity.

Year 2010 MTP for Refrigeration

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	REF01	Improve refrigerator to 1993 standard	53	203	2.5	27.52	27.52	135449
2	FRZR01	Improve freezer to 1993 DOE standard	37	100	3.4	3.42	30.94	34248
3	FRZR03	5.3 EER compressor for freezer (post-2000)	10	25	3.8	0.47	31.41	18705
4	REF12	Recycle refrigerator condenser heat (post-2000)	40	100	3.9	6.81	38.22	68137
5	FRZR02	Evacuated panels for freezer (post 1995)	74	132	5.2	3.35	41.58	25402
6	REF02	Evacuated Panels for refrigerator (post 1995)	62	113	5.4	11.80	53.37	104387
7	REF13	Raise refrig compressor EER to 5.3 (post 2000)	10	18	5.5	1.23	54.60	68137
8	FRZR04	Freezer condenser gas heat	31	50	5.8	0.94	55.53	18705
9	REF03	Two-Compressor System for refrigerator (post 1995)	93	69	13.0	7.20	62.74	104387

Year 2010 MTP for Water Heating

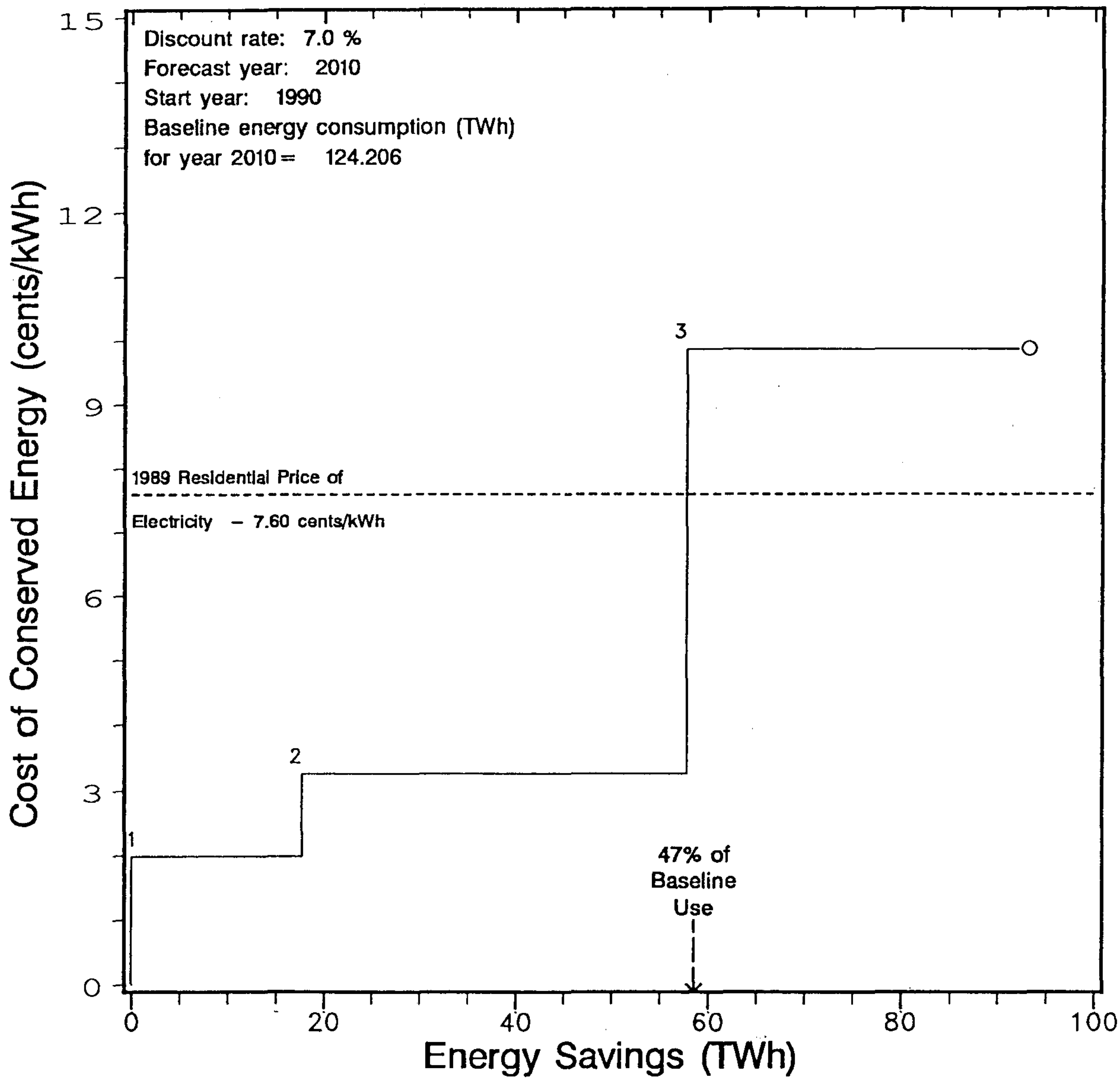


A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measures). The width of the step indicates the nationwide electricity savings from the measure and the height of the measure indicates the cost of conserved electricity.

Year 2010 MTP for Water Heating

Label	Measure Code	Measure Name	Incr. Cost 1989$/unit	Energy Savings kWh/unit	CCE cents/kWh	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	EWH01	Improve clotheswasher to 1994 standard	1	45	0.2	2.14	2.14	47969
2	EWH02	Reduce hot water consumption	50	873	0.8	41.88	44.02	47969
3	EWH03	Improve dishwasher to 1994 standard	8	45	2.1	2.16	46.18	47969
4	EWH04	Reduce standby losses	120	425	3.4	20.39	66.56	47969
5	EWH08	Replace electric water heater with gas	1380	3539	4.7	16.61	83.17	4693
6	EWH07	Horizontal axis clotheswasher w/ EWH (1995-2000)	137	285	5.5	1.38	84.55	4855
7	EWH10	Horizontal axis clotheswasher w/ EWH(post-2000)	137	285	5.5	3.55	88.11	12473
8	EWH08	Heat pump water heater (post-2000)	504	1076	5.6	18.41	106.51	17106
9	EWH05	Heat pump water heater (1995-2000)	504	1076	5.6	4.64	111.16	4315
10	EWH06	Horizontal axis clotheswasher w/ HPWH (1995-2000)	116	143	9.2	0.26	111.41	1798
11	EWH09	Horizontal axis clotheswasher w/HPWH(post-2000)	116	143	9.2	1.98	113.39	13898

Year 2010 MTP for Lighting

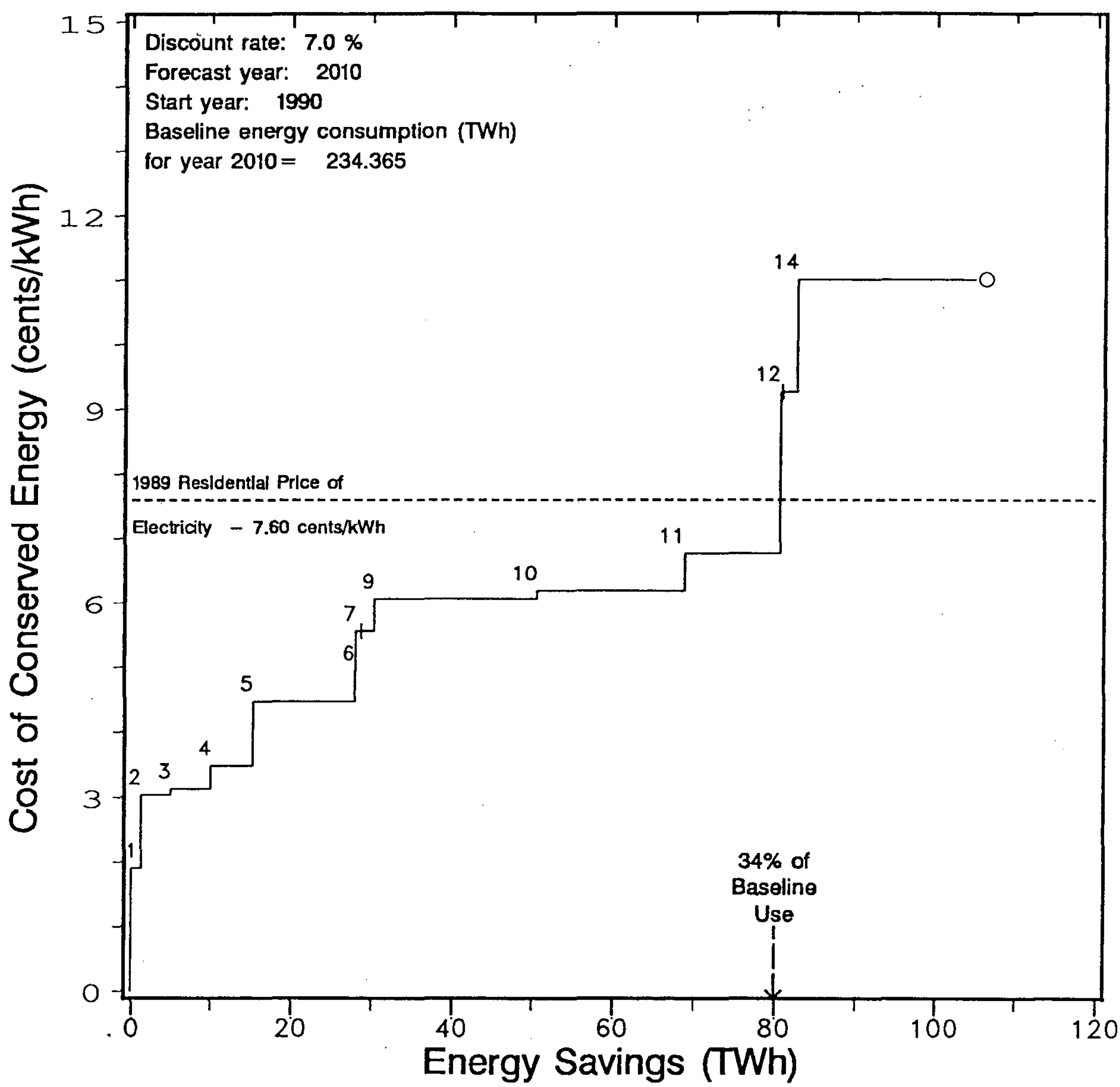


A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measur es). The width of the step indicates the nationwide electricity savings fro m the measure and the height of the measure indicates the cost of conserve d electricity.

Year 2010 MTP for Lighting

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	LTG01	Timer & Photocell (outdoor)	27	151	2.0	17.69	17.69	117175
2	LTG02	Compact Fluorescent Lamps	102	342	3.3	40.07	57.77	117175
3	LTG03	Compact Fluorescent Fixtures	263	293	9.9	34.33	92.10	117175

Year 2010 MTP for Other



A supply curve of conserved electricity for the United States residential sector. Each step represents a conservation measure (or a package of measur es). The width of the step indicates the nationwide electricity savings fro m the measure and the height of the measure indicates the cost of conserve d electricity.

Year 2010 MTP for Other

Label	Measure Code	Measure Name	Incr. Cost *1989$/unit*	Energy Savings *kWh/unit*	CCE *cents/kWh*	Energy Savings Measure TWh	Energy Savings Cumulative TWh	Applicable Stock 10^3
1	MISE03	Improve dishwasher motor to 1994 standard	4	23	1.9	1.23	1.23	52729
2	CTV01	Efficient color TV set	8	34	3.0	3.71	4.94	108973
3	CD-E01	Improve clothes dryer to 1994 NAECA standard	22	73	3.1	5.08	10.02	69599
4	MISE02	Upgrade furnace fan efficiency	48	150	3.5	5.27	15.29	35153
5	CD-E02	Heat pump dryer	230	525	4.5	12.63	27.93	24068
6	BWTV01	Efficient black and white TV set	1	3	4.9	0.11	28.03	43355
7	MISE07	Horiz axis clthswshr w/EWH (motor svgs) 1995-2000	32	65	5.6	0.66	28.70	10263
8	MISE05	Horiz axis clthswshr w/EWH (motor svgs) post-2000	32	65	5.6	1.64	30.33	25315
9	CD-E03	Switch electric clothesdryer to gas	480	807	6.1	20.22	50.55	25056
10	ERNG02	Switch from electric to gas range	590	944	6.2	18.29	68.84	19384
11	ERNG01	Induction cooktop and improved oven (post-1995)	171	250	6.8	11.78	80.62	47110
12	MISE04	Horiz axis clthswshr w/HPWH (motor svgs) 1995-2000	53	65	9.3	0.25	80.86	3801
13	MISE06	Horiz axis clthswshr w/HPWH (motor svgs) post-2000	53	65	9.3	1.82	82.69	28209
14	MISE01	Improve miscellaneous appliance motor efficiency	190	190	11.0	22.26	104.95	117175

APPENDIX 6: DETAILED DESCRIPTION OF LIGHTING ANALYSIS

This appendix contains documented spreadsheets used to create the lighting baseline and the lighting efficiency measures. Indoor lights are assumed on from 3-5 hours per day, and outdoor lights from 6-12 hours/day. Measures considered are: 1) Timer and Photocell to control outdoor lights; 2) Compact Fluorescent screw-in lamps where applicable without fixture change. Where CFLs do not fit, energy-efficient incandescents (indoors) and halogen reflector lamps (outdoors) are installed; 3) Compact Fluorescent Fixture replacement for the remaining incandescents, indoors and outdoors.

LIGHTING BASE CASE ASSUMPTIONS

BASE CASE - Large SF (>2400 sq ft) 14.4 % of total

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Cost (1990$)	Relamp Life (yrs)
Interior							
3	Inc	100	5	0.85	465	$2.25	0.55
5	Inc	75	5	0.85	582	$3.75	0.55
4	Inc	60	3	0.9	237	$3.00	0.91
Exterior							
1	Inc	60	6	1	131	$0.75	0.46
1	Inc	75	6	1	164	$7.99	0.46
1	Inc	150	6	1	329	$7.99	0.46
Total	15				1908	$25.73	0.63

Base Case - Medium SF (incl. duplex) 38.8% of total

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Cost (1990$)	Relamp Life (yrs)
Interior							
2	Inc	100	5	0.85	310	$1.50	0.55
3	Inc	75	5	0.85	349	$2.25	0.55
2	Inc	60	4	0.95	166	$1.50	0.68
Exterior							
1	Inc	60	6	1	131	$0.75	0.46
1	Inc	75	6	1	164	$7.99	0.46
Total	9				1121	$13.99	0.56

Base Case - Small SF, Mobile Home 19.2 % of total

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Cost (1990$)	Relamp Life (yrs)
Interior							
1	Inc	100	5	0.85	155	$0.75	0.55
2	Inc	75	5	0.85	233	$1.50	0.55
2	Inc	60	4	0.95	166	$1.50	0.68
Exterior							
1	Inc	60	6	1	131	$0.75	0.46
Total	6				686	$4.50	0.58

Base Case - Apt (2 or more units, no duplexes) 27.6 % of total

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Cost (1990$)	Relamp Life (yrs)
Interior							
3	Inc	75	4	0.85	279	$2.25	0.68
3	Inc	60	4	0.9	237	$2.25	0.68
Exterior							
1	Inc	60	12	1	263	$0.75	0.23
Total	7				779	$5.25	0.62
BASE CASE WEIGHTED AVERAGE					1056	$11.45	0.59

DEFINITION OF TERMS AND ASSUMPTIONS

1. % of total (population) values are from RECS1987 and are used to determine the weighted average cost, UEC and relamp life.
2. Cost assumes $0.75 per incandescent lamp. In the base case, all lamps are assumed to be incandescent ('Inc').
3. Relamp life is equal to the rated lamp life (1000 hrs for incandescents) divided by the number of hours of use per year.
4. Fraction/yr indicates the fraction of the year that the lamp is used. Vacation periods lower the fraction for interior lights, but we assume that exterior lights will be used even during vacation periods.
5. Saturations and hours of use are from the following utilities' residential appliance saturation surveys: Philadelphia Electric, Utah Power, Detroit Edison, Public Service Co. of Colorado, Cincinnati Gas and Electric, West Penn Power, Public Service Indiana, and Iowa-Ilinois Gas and Electric.
6. Lifetimes and wattages are from various manufacturers' catalogs.

ASSUMPTIONS FOR FIRST LIGHTING CONSERVATION MEASURE (LTG01)
Timer and Photocell for Exterior Lights

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Cost (1990$)	Relamp Life (yrs)
LTG01 - Large Single Family							
Interior							
3	Inc	100	5	0.85	465		0.55
5	Inc	75	5	0.85	582		0.55
4	Inc	60	3	0.9	237		0.91
Exterior							
1	Inc	60	3	1	66		0.91
1	Inc	75	3	1	82		1.83
1	Inc	150	3	1	164		1.83
		Timer & Pcell $100 x 0.35 sat				$35.00	
Total	15				1596	$35.00	0.84
LTG01 - Medium Single Family							
Interior							
2	Inc	100	5	0.85	310		0.55
3	Inc	75	5	0.85	349		0.55
2	Inc	60	4	0.95	166		0.68
Exterior							
1	Inc	60	3	1	66		0.91
1	Inc	75	3	1	82		1.83
		Timer & Pcell $100 x 0.35 sat				$35.00	
Total	9				974	$35.00	0.76
LTG01 - Small SF, Mobile Home							
Interior							
1	Inc	100	5	0.85	155		0.55
2	Inc	75	5	0.85	233		0.55
2	Inc	60	4	0.95	166		0.68
Exterior							
1	Inc	60	3	1	66		0.91
		Timer & Pcell $100 x 0.35 sat				$35.00	
Total	6				620	$35.00	0.65
LTG01 - Apartment							
Interior							
0	Inc	100	4	0.85	0		0.68
3	Inc	75	4	0.85	279		0.68
3	Inc	60	4	0.9	237		0.68
Exterior							
1	Inc	60	6	1	131		0.46
Timer & Pcell $100 x 0.5 sat x 0.25 shared						$12.50	
Total	7				647	$12.50	0.65
LTG01 WEIGHTED AVERAGE					905	$28.79	0.72
UNIT ENERGY SAVINGS (kWh)					151		
ENERGY SAVINGS ($)						$13.14	
UNIT ADDED COST						$28.79	

NOTES:
1. This measure decreases the average hours outdoor lights are on in single family & mobile homes from 6 hours (basecase) to 3 hours. We assume 35% leave the lights on more than 3 hours/day and do not already have a timer.
2. In the apartment building basecase, we assume that 50% of all units leave exterior lights on more than 6 hours/day. In this measure, we reduce the hours of operation of those lamps from 12 to 6 hours/day. Each timer and photocell is assumed to be shared by an average of four apartment units.
3. Saturations are from utility residential appliance saturation surveys (see basecase).
4. Cost data are from Grainger's General Catalog, No.377, 1990.

ASSUMPTIONS FOR SECOND LIGHTING CONSERVATION MEASURE (LTG02)

*Compact Fluorescents (CF) where possible without fixture change; energy saving incandescents elsewhere. These include krypton lamps indoors (IncES) and halogen lamps outdoors (Hal).

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Cost (1990$)	Relamp Life (yrs)
LTG02 - Large Single Family							
Interior							
2.1	IncES	95	5	0.85	309	$1.73	0.55
2.5	IncES	70	5	0.85	271	$2.06	0.55
1.6	IncES	55	3	0.9	87	$1.32	0.91
0.9	CF	29	5	0.85	40	$27.09	5.48
2.5	CF	22	5	0.85	85	$68.85	4.93
2.4	CF	17	3	0.9	40	$33.60	9.13
				834			
Exterior							
0.5	IncES	55	3	1	30	$0.41	0.91
0.5	CF	17	3	1	9	$7.00	9.13
0.5	CF	22	3	1	12	$13.77	9.13
0.5	Hal	45	3	1	25	$5.63	1.83
1	Hal	65	3	1	71	$11.26	1.83
Total	15				981	$172.73	3.70
LTG02 - Medium Single Family							
Interior							
1.4	IncES	95	5	0.85	206	$1.16	0.55
1.5	IncES	70	5	0.85	163	$1.24	0.55
0.8	IncES	55	4	0.9	58	$0.66	0.68
0.6	CF	29	5	0.85	27	$18.06	5.48
1.5	CF	22	5	0.85	51	$41.31	4.93
1.2	CF	17	4	0.95	28	$16.80	6.84
				106			
Exterior							
0.5	IncES	55	3	1	30	$0.41	0.91
0.5	CF	17	3	1	9	$7.00	9.13
0.5	CF	22	3	1	12	$13.77	9.13
0.5	Hal	45	3	1	25	$5.63	1.83
Total	9				610	$102.98	3.50
LTG02 - Small SF, Mobile Home							
Interior							
0.7	IncES	95	5	0.85	103	$0.58	0.55
1	IncES	70	5	0.85	109	$0.83	0.55
0.8	IncES	55	4	0.9	58	$0.66	0.68
0.3	CF	29	5	0.85	13	$9.03	5.48
1	CF	22	5	0.85	34	$27.54	4.93
1.2	CF	17	4	0.95	28	$16.80	6.84
				76			
Exterior							
0.75	IncES	55	3	1	45	$0.62	0.91
0.25	CF	17	3	1	5	$3.50	9.13
Total	6				395	$57.49	3.20
LTG02 - Apartment							
Interior							
1.5	IncES	70	4	0.85	130	$1.24	0.68
1.2	IncES	55	4	0.9	87	$0.99	0.68
1.5	CF	22	4	0.85	41	$41.31	6.84
1.8	CF	17	4	0.9	40	$25.20	6.84
Exterior							
0.75	IncES	55	6	1	90	$0.62	0.46
0.25	CF	17	6	1	9	$3.50	4.56
Total	7				398	$70.63	3.70

LTG02 WEIGHTED AVERAGE	563	$95.36	3.53
UNIT ENERGY SAVINGS (kWh)	342		
ENERGY SAVINGS ($)		$29.73	
UNIT ADDED COST		$83.92	

Annualized unit added cost = $83.92 * CRF = $83.92 * 0.329 = $27.61
Net present value (incremental) = ($27.61 - $20.48) * 15 = $107

NOTES:
1. Because existing lamps can be retrofit by one of two lamp types, "number of lamps" may not be an integer.
2. Of interior lights, 30% of 100W fixtures, 50% of 75 W and 60% of 60W are retrofit. Of exterior lights, 50% of large and medium single family and 25% of small SF/mobile homes and apartments are retrofit.
3. The "unit added cost" is equal to the weighted average cost minus the basecase weighted average cost.
4. The annualized unit cost of the measure is equal to the unit added cost times the capital recovery factor (D.R. = 7% and lifetime = 3.53 years).
5. The cost of the measure relative to the basecase (net present value) is equal to the difference between the annualized unit added costs of this measure and the basecase, times the lifetime of the lighting enduse (15 years).
6. Cost data are from Energy Federation Inc catalog, Massachusetts, March 1990.
7. Lifetimes and wattages are from various manufacturers' catalogs.
8. Saturations were estimated by LBL Principal Research Associate Barbara Atkinson.
9. Unit energy savings assumes that LTG01 precedes this measure.

ASSUMPTIONS FOR THIRD LIGHTING CONSERVATION MEASURE (LTG03)
*Compact Fluorescent Fixtures (CF fix) retrofit for remaining incandescents that could not accept screw-in fluorescents.

Number of Lamps	Type	Watt/ Lamp	Hrs/ Day	Fraction/ Year	UEC kWh	Fixture Cost (1990$)	Lamp Cost (1990$)	Relamp Life (yrs)
LTG03 - Large Single Family								
Interior								
2.1	Cf fix	29	5	0.85	94	$174.76	$63.21	5.48
2.5	CF fix	22	5	0.85	85	$208.05	$68.85	5.48
1.6	CF fix	17	3	0.9	27	$133.15	$22.40	9.13
0.9	CF	29	5	0.85	40		$27.09	5.48
2.5	CF	22	5	0.85	85		$68.85	4.93
2.4	CF	17	3	0.9	40		$33.60	9.13
Exterior								
0.5	CF fix	17	3	1	9	$41.61	$7.00	9.13
0.5	CF	17	3	1	9		$7.00	9.13
0.5	CF	22	3	1	12		$13.77	9.13
0.5	CF fix	22	3	1	12	$41.61	$13.77	9.13
1	Hal	65	3	1	71		$1.83	1.83
Total	15				486	$599.18	$327.37	6.60
LTG03 - Medium Single Family								
Interior								
1.4	CF fix	29	5	0.85	63	$116.51	$42.14	5.48
1.5	CF fix	22	5	0.85	51	$124.83	$41.31	5.48
0.8	CF fix	17	4	0.9	18	$66.58	$11.20	6.84
0.6	CF	29	5	0.85	27		$18.06	5.48
1.5	CF	22	5	0.85	51		$41.31	4.93
1.2	CF	17	4	0.95	28		$16.80	6.84
Exterior								
0.5	CF fix	17	3	1	9	$41.61	$7.00	9.13
0.5	CF	17	3	1	9		$7.00	9.13
0.5	CF	22	3	1	12		$13.77	9.13
0.5	CF fix	22	3	1	12	$41.61	$13.77	9.13
Total	9				281	$391.13	$212.36	6.50
LTG03 - Small SF, Mobile Home								
Interior								
0.7	CF fix	29	5	0.85	31	$58.25	$21.07	5.48
1	CF fix	22	5	0.85	34	$83.22	$27.54	5.48
0.8	CF fix	17	4	0.95	19	$66.58	$11.20	6.84
0.3	CF	29	5	0.85	13		$9.03	5.48
1	CF	22	5	0.85	34		$27.54	4.93
1.2	CF	17	4	0.95	28		$16.80	6.84
Exterior								
0.75	CF fix	17	3	1	14	$62.42	$10.50	9.13
0.25	CF	17	3	1	5		$3.50	9.13
Total	6				179	$270.47	$127.18	6.45
LTG03 - Apartment								
Interior								
0	CF fix	29	5	0.85	0	$0.00	$0.00	5.48
1.5	CF fix	22	5	0.85	51	$124.83	$41.31	5.48
1.2	CF fix	17	4	0.95	28	$99.86	$16.80	6.84
0	CF	29	5	0.85	0		$0.00	0.00
1.5	CF	22	5	0.85	51		$41.31	6.84
1.8	CF	17	4	0.9	40		$25.20	6.84

Exterior							
0.75 CF fix	17	6	1	28	$62.42	$10.50	4.56
0.25 CF	17	6	1	9		$3.50	4.56
Total 7				208	$287.11	$138.62	6.23
LTG03 WEIGHTED AVERAGE				271	$369.21	$192.21	6.43
UNIT ENERGY SAVINGS				293			
ENERGY SAVINGS ($)					$25.45		
UNIT ADDED COST					$369.21	$108.30	

Annualized unit added cost = $108.30 * CRF = $108.30 * 0.198 = $21.44
Net present value (incremental) = ($21.44 - $27.61) * 15 = -$92.55 + $369.21 = $276.66

NOTES:
1. The "unit added cost" of the lamps ($108.30) is equal to the weighted average cost minus the unit added cost of the preceeding measure, LTG02.
2. The annualized unit cost of the lamps is equal to the unit added cost times the capital recovery factor (D.R. = 7% and lifetime = 6.43 years). The fixture cost is a one-time cost of $369.21.
3. The net cost of this measure over LTG02 (net present value) is equal to the difference between the annualized unit added lamp costs of the two measures times the lifetime of the lighting enduse (15 years), plus the cost of the fixtures.
4. Cost data are from Energy Federation Inc catalog, Massuachusetts, March 1990 and Real Goods' Alternative Energy Sourcebook catalog, CA, 1990.

APPENDIX 7: PEAR BATCH INPUT FILES

This appendix shows the space conditioning prototype input assumptions as they appear in the input files to the batch version of PEAR (EAP 1987).

PEAR BATCH FILES FOR NEW SINGLE FAMILY HOMES

A. NORTH ELECTRIC FURNACE

```
> RUN = USN-ER  CITY = CHICAGO , FOUND-TYP = BASMNT,
N-WINDOW =46.4, S-WINDOW =46.4,
W-WINDOW = 46.4, E-WINDOW = 46.4,
CEIL-R = 29, WALL-R = 15, INFILT= 0.4,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 15, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96, WIND-LAYS = 2
PROTO= 2S, AREA=1856, FOUND-R = NONE
PERIM = 128.7, WALLAREA = 1930.7
```

B. NORTH GAS/OTHER HEATED

```
> RUN = USN-GAS  CITY = CHICAGO  FOUND-TYP = BASMT,
N-WINDOW =54.425, S-WINDOW =54.425,
W-WINDOW = 54.425, E-WINDOW = 54.425,
CEIL-R = 28, WALL-R = 14, INFILT= 0.56,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 12, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = GFUR, HTG-EFF = 80, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 2S, AREA=2177, FOUND-R=NONE
PERIM = 132, WALLAREA = 1979.5
$
?          WIND-LAYS
% SETBASE
* 0.26       1
* 0.74       2
```

C. NORTH HEAT PUMP

```
> RUN = USN-HP  CITY = CHICAGO , FOUND-TYP = BASMNT,
N-WINDOW =55.55, S-WINDOW =55.55,
W-WINDOW = 55.55, E-WINDOW = 55.55,
CEIL-R = 28, WALL-R = 14, INFILT= 0.4,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 13, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = HP, CLG-EFF = 9.86
PROTO= 2S, AREA=2222, FOUND-R = NONE
PERIM = 133.4, WALLAREA = 1999.9
$
?   WIND-LAYS
% setbase
* 0.87   2
* 0.13   1
```

E. SOUTH HEAT PUMP

```
> RUN = USS-HP  CITY = CHARLESTO  FOUND-TYP = SLAB,
N-WINDOW =45.575, S-WINDOW =45.575,
W-WINDOW = 45.575, E-WINDOW = 45.575,
CEIL-R = 25, WALL-R = 11, INFILT= 0.63,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 0, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = HP, CLG-EFF = 9.86,
```

```
PROTO= 1S, AREA=1823
PERIM = 186.6, WALLAREA = 1280.9

?           WIND-LAYS   FOUND-R
% SETBASE
* 0.198       1            NONE
* 0.112       1            R5-2
* 0.442       2            NONE
* 0.248       2            R5-2
```

F. SOUTH ELECTRIC FURNACE

```
> RUN = USS-ER  CITY = CHARLESTO  FOUND-TYP = SLAB,
N-WINDOW =47.35, S-WINDOW =47.35,
W-WINDOW = 47.35, E-WINDOW = 47.35,
CEIL-R = 28, WALL-R = 10, INFILT= 0.62,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 0, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1894
PERIM = 186.6, WALLAREA = 1999.9
$
?           WIND-LAYS   FOUND-R
% SETBASE
* 0.12        1            NONE
* 0.37        1            R5-2
* 0.12        2            NONE
* 0.39        2            R5-2
```

G. SOUTH GAS/OTHER HEATED

```
> RUN = USS-GAS  CITY = CHARLESTO  FOUND-TYP = SLAB,
N-WINDOW =51.775, S-WINDOW =51.775,
W-WINDOW = 51.775, E-WINDOW = 51.775,
CEIL-R = 25, WALL-R = 14, INFILT= 0.56,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 0, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = GFUR, HTG-EFF = 80, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=2071
PERIM = 186.6, WALLAREA = 1365.2
$
?           WIND-LAYS   FOUND-R
% SETBASE
* 0.198       1            NONE
* 0.122       1            R5-2
* 0.422       2            NONE
* 0.258       2            R5-2
```

PEAR BATCH FILES FOR EXISTING SINGLE FAMILY HOMES

A. NORTH ELECTRIC FURNACE

```
> RUN = NRTH-E  CITY = CHICAGO , FOUND-TYP = BASMNT,
N-WINDOW =39.55, S-WINDOW =39.55,
W-WINDOW = 39.55, E-WINDOW = 39.55,
CEIL-R =20.84 , WALL-R = 4.68, INFILT= 0.54,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 11, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1582, FOUND-R=NONE
PERIM = 168, WALLAREA = 1344
$
?       WIND-LAYS
% baseline
* .241    1
* .759    2
```

B. SOUTH ELECTRIC FURNACE

```
> RUN = STH-E  CITY = CHARLESTO , FOUND-TYP = SLAB,
N-WINDOW =36.75, S-WINDOW =36.75,
W-WINDOW = 36.75, E-WINDOW = 36.75,
CEIL-R = 18, WALL-R = 3.94, INFILT= 0.71,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 0, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1470
PERIM = 162, WALLAREA = 1296
$
?       FOUND-R  WIND-LAYS
% baseline
* .3337  NONE      1
* .3703  NONE      2
* .1403  R5-2      1
* .1557  R5-2      2
```

C. NORTH HEAT PUMP

```
> RUN = NTH-HP  CITY = CHICAGO , FOUND-TYP = BASMNT,
N-WINDOW =46.325, S-WINDOW =46.325,
W-WINDOW = 46.325, E-WINDOW = 46.325,
CEIL-R = 23.98, WALL-R = 6.83, INFILT= 0.45,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 11, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = HP, CLG-EFF = 9.86,
PROTO= 1S, AREA=1853
PERIM = 182, WALLAREA = 1456
FOUND-R=NONE
$
?         WIND-LAYS
% baseline
* .281        1
* .719        2
```

D. SOUTH HEAT PUMP

```
> RUN = STH-HP  CITY = CHARLESTO , FOUND-TYP = SLAB,
```

```
N-WINDOW =44.6, S-WINDOW =44.6,
W-WINDOW = 44.6, E-WINDOW = 44.6,
CEIL-R = 21.53, WALL-R = 6.22, INFILT= 0.7,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 0, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = AC, CLG-EFF = 9.86,
PROTO= 1S, AREA=1784
PERIM = 179, WALLAREA = 1432

?      FOUND-R  WIND-LAYS
% baseline
* .2928  NONE      1
* .3712  NONE      2
* .1482  R5-2      1
* .1878  R5-2      2
```

```
E.   NORTH GAS/OTHER HEATED
>  RUN = NTH-G  CITY = CHICAGO , FOUND-TYP = BASMNT,
N-WINDOW =38.75, S-WINDOW =38.75,
W-WINDOW = 38.75, E-WINDOW = 38.75,
CEIL-R = 21.13, WALL-R = 2.06, INFILT= 0.62,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 11, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = GFUR, HTG-EFF = 82, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1550
PERIM = 166, WALLAREA = 1328
FOUND-R = NONE
$
?    WIND-LAYS
% baseline
* .21  1
* .79  2
```

```
F.   SOUTH GAS/OTHER HEATED
>  RUN = STH-G  CITY = CHARLESTO , FOUND-TYP = SLAB,
N-WINDOW =36.675, S-WINDOW =36.675,
W-WINDOW = 36.675, E-WINDOW = 36.675,
CEIL-R = 17.39, WALL-R = 2.12, INFILT= 0.72,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 0, WIND-SASH = WOOD, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1467
PERIM = 162, WALLAREA = 1296
$
?      FOUND-R  WIND-LAYS
% baseline
* .4712  NONE      1
* .3718  NONE      2
* .0878  R5-2      1
* .0692  R5-2      2
```

PEAR BATCH FILES FOR NEW MOBILE HOMES

A. NORTH ELECTRIC FURNACE AND HEAT PUMP

```
> RUN = NMH-NG  CITY = CINCINNAT  FOUND-TYP = CRAWL,
N-WINDOW =29.88, S-WINDOW =29.88,
W-WINDOW = 29.88, E-WINDOW = 29.88,
CEIL-R = 26, WALL-R = 18, INFILT= 0.36,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 14, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1195
PERIM = 147.6, WALLAREA = 1180.7, WIND-LAYS=2

?    HTG-EQP     HTG-EFF    CLG-EQP    CLG-EFF
# HP   HP          7.24        HP          9.86
```

B. SOUTH ELECTRIC FURNACE

```
> RUN = NMH-S  CITY = CHARLESTO  FOUND-TYP = CRAWL,
N-WINDOW =29.88, S-WINDOW =29.88,
W-WINDOW = 29.88, E-WINDOW = 29.88,
CEIL-R = 20, WALL-R = 12, INFILT= 0.45,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 10, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1195
PERIM = 147.6, WALLAREA = 1180.7
$
?          WIND-LAYS
% SETBASE
* 0.26       2
* 0.74       1
```

C. SOUTH HEAT PUMP

```
> RUN = NMH-SHP  CITY = CHARLESTO  FOUND-TYP = CRAWL,
N-WINDOW =29.88, S-WINDOW =29.88,
W-WINDOW = 29.88, E-WINDOW = 29.88,
CEIL-R = 20, WALL-R = 12, INFILT= 0.45,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 10, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = HP, CLG-EFF = 9.86,
PROTO= 1S, AREA=1195
PERIM = 147.6, WALLAREA = 1180.7
$
?          WIND-LAYS
% SETBASE
* 0.26       2
* 0.74       1
```

PEAR BATCH FILES FOR EXISTING MOBILE HOMES

A. NORTH ELECTRIC FURNACE

```
> RUN = EMH-NG  CITY = CINCINNAT  FOUND-TYP = CRAWL,
N-WINDOW =25.62, S-WINDOW =25.62,
W-WINDOW = 25.62, E-WINDOW = 25.62,
CEIL-R = 14.2, WALL-R = 10.8, INFILT= 0.45,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 10.8, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=1025
PERIM = 133.4, WALLAREA = 1067.3, WIND-LAYS=2
```

B. NORTH HEAT PUMP

```
> RUN = EMH-NHP  CITY = CINCINNAT  FOUND-TYP = CRAWL,
N-WINDOW =20, S-WINDOW =20,
W-WINDOW = 20, E-WINDOW = 20,
CEIL-R = 14.2, WALL-R = 10.8, INFILT= 0.45,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 10.8, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = HP, CLG-EFF = 9.86,
PROTO= 1S, AREA=800
PERIM = 157.3, WALLAREA = 1258.7, WIND-LAYS=2
```

C. NORTH GAS/OTHER HEATED

```
> RUN = EMH-NO  CITY = CINCINNAT  FOUND-TYP = CRAWL,
N-WINDOW =20.1, S-WINDOW =20.1,
W-WINDOW = 20.1, E-WINDOW = 20.1,
CEIL-R = 14.2, WALL-R = 10.8, INFILT= 0.45,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 10.8, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = GFUR, HTG-EFF = 80, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=804
PERIM = 158, WALLAREA = 1264, WIND-LAYS=2
```

D. SOUTH ELECTRIC FURNACE

```
> RUN = EMH-S  CITY = CHARLESTO  FOUND-TYP = CRAWL,
N-WINDOW =23.5, S-WINDOW =23.5,
W-WINDOW = 23.5, E-WINDOW = 23.5,
CEIL-R = 10.8, WALL-R = 10.8, INFILT= 0.56,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 6.8, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=940
PERIM = 170.6, WALLAREA = 1364.8, WIND-LAYS= 1
```

E. SOUTH HEAT PUMP

```
> RUN = NMH-SHP  CITY = CHARLESTO  FOUND-TYP = CRAWL,
N-WINDOW =26.0, S-WINDOW =26.0,
W-WINDOW = 26.0, E-WINDOW = 26.0,
CEIL-R = 10.8, WALL-R = 10.8, INFILT= 0.56,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
```

FLOOR-R = 6.8, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = HP, HTG-EFF = 7.24
CLG-EQP = HP, CLG-EFF = 9.86,
PROTO= 1S, AREA=1040
PERIM = 134., WALLAREA = 1072., WIND-LAYS= 1

F. SOUTH GAS/OTHER HEATED
> RUN = NMH-SO CITY = CHARLESTO FOUND-TYP = CRAWL,
N-WINDOW =21.18, S-WINDOW =21.18,
W-WINDOW = 21.18, E-WINDOW = 21.18,
CEIL-R = 10.8, WALL-R = 10.8, INFILT= 0.56,
ROOF-COLOR = DARK, WALL-COLOR = DARK, WALL-MASS = NONE,
FLOOR-R = 6.8, WIND-SASH = ALUM, GLASS-TYP = REG,
MOV-INS = NONE, HTG-EQP = ER, HTG-EFF = 100, SETBACK = YES,
CLG-EQP = AC, CLG-EFF = 9.96,
PROTO= 1S, AREA=847
PERIM = 156, WALLAREA = 1248, WIND-LAYS= 1

APPENDIX 8: CCE PATHS FOR SPACE CONDITIONING

This appendix shows detail on calculating the cost of conserved energy and energy savings for space conditioning measures. The last page of this appendix contains the detailed description of the ceiling and window options for existing buildings.

CCE PATH for
NEW SINGLE FAMILY -- ELECTRIC FURNACES

A. NORTH (Chicago, IL)

	HTG kWh	CLG kWh	UES kWh	Delta $	CCE c/kWh
CASE1: ER with CAC					
baseline	11809.4	963.9			
switch to HP#2: 8.83 HSPF, 10.96 SEER	4566.50	909.21	7297.6	222.00	0.3
triple glazing	3880.03	888.65	707.0	222.72	2.5
switch to HP#4: 9.5 HSPF, 13.3 SEER	3606.39	732.30	430.0	190.00	5.1
wall to R-19	3360.62	721.34	256.7	185.60	5.8
-----branch (pre-95)					
floor to R-30	3179.96	710.11	191.9	222.72	9.4
ceiling to R-30	3168.85	709.25	12.0	18.56	12.5
-----branch (post-95)					
superwindows	2901.02	637.89	543.1	464.0	6.9
floor to R-30	2745.06	627.97	165.9	222.72	10.8
ceiling to R-30	2735.47	627.21	10.4	18.56	14.4
CASE2: ER, no clg					
baseline	11809.37				
----branch (pre-95)					
triple glazing + wall to R-19 + floor to R-30 (<95)	8594.47		3214.90	631.04	1.6
----branch (post-95)					
superwindows + wall to R-19 + floor to R-30 (>95)	7222.19		4587.18	1095.04	1.9
ceiling to R-49 + wall to R-27	4702.01		2520.18	1540.48	4.9
ceiling to R-60	4564.50		137.51	148.48	8.7
CASE3: ER w/ RAC					
baseline	11809.4	298.81			
triple glazing + wall to R-19 + floor to R-30 (<95)	8594.47	282.32	3231.4	631.04	1.6
superwindows + wall R-19 + floor R-30 (>95)	7222.19	247.24	4638.7	1095.04	1.9
ceiling R-49 + wall R-27	5506.78	237.67	1725.0	1354.88	6.3
ceiling to R-60	5369.27	236.01	139.2	148.48	8.6

(no RAC efficiency improvement measures are cost-effective in the north).

B. SOUTH (Charleston, SC)

	HTG kWh	CLG kWh	UES kWh	Delta $	CCE c/kWh
CASE1: ER with CAC					
baseline	9114.35	3582.97			
switch to HP#3: 9.06 HSPF, 13.03 SEER	3434.91	2806.28	6456.1	322.00	0.6
0.4 ACH, spec.sel.windows + R-5,2ft fndn	2257.69	1073.62	2909.88	681.84	1.9
wall to R-19	1889.92	1012.46	428.9	378.80	7.1
switch to HP#4: 9.5 HSPF, 13.3 SEER	1802.38	991.91	108.1	90.00	9.5
switch to HP#5: 9.93 HSPF, 15.14 SEER	1724.33	948.95	121.0	330.00	31.2
CASE2:ER with RAC					
baseline	9114.4	1218.2			
R5-2ft fndn + triple glazing + 0.4 ACH + wall R-19	3690.3	1018.3	5623.9	1061	1.5
RAC#1: Increase condenser rows (9.42 EER)	3690.3	973	45.4	12	2.9
__branch: ceiling to R-30 (pre-95)	3620.5	969.8	72.9	57	6.3
ceiling to R-30 + superwindows (post-1995)	3099.1	412.6	1151.6	530	3.7
ceiling to R-38 (post-1995)	2893.9	398.3	219.4	322	11.8
var speed RAC (post-2000)	2893.9	339	59.4	67	12.3
Incr. condenser area (post-2000)	2893.9	323	15.8	20	14.2
CASE 3: ER with no cooling					
baseline	9114.4				
0.4 ACH, 3 glazing, R-19 wall, R-5,2ft foundation	3690.3		5424	1061	1.6
ceiling to R-30	3620.5		70	57	6.6
superwindows (post-1995)	3099.1		521	473	7.3
ceiling to R-38	2893.9		205	322	12.6

CCE PATH for
NEW SINGLE FAMILY -- GAS FURNACES AND HEAT PUMPS

	HTG kWh	CLG kWh	UES kWh	Delta $	CCE c/kWh
A. NORTH HEAT PUMP (Chicago, IL)					
baseline	6825.15	1047.46			
improve to 1992 std: 7.46 HSPF, 10.5	6623.87	1005.83	242.9	71	3.3
triple glazing	5474.41	966.94	1188.4	311	2.1
improve HP #3: 9.5 HSPF, 13.3 SEER	4298.85	763.37	1379.1	241.00	2.0
R-19 wall	3978.94	748.44	334.8	266.64	6.4
---branch (pre-95)					
floor to R-30 (pre-95)	3732.93	733.37	261.1	311.08	9.6
ceiling to R-30 (pre-95)	3706.55	731.21	28.5	44.44	12.5
---branch (post-95)					
superwindows	3442.34	630.45	654.6	555.50	6.8
floor to R-30	3229.50	617.75	225.5	311.08	11.1
ceiling to R-30	3206.68	615.94	24.6	44.44	14.5
ceiling to R-38	3138.75	610.75	73.1	155.54	17.1
B. SOUTH HEAT PUMP (Charleston, SC)					
baseline	3225.4	3408.4			
improve to 1992 std: 7.46 HSPF, 10.5	3130.3	3218.2	285.4	85.91	3.4
improve HP #2: 9.06 HSPF, 13.03 SEER	2577.5	2648.9	1122.1	182.71	1.9
0.4 ACH + spec.sel.windows + R5-2ft fndn	1795.4	1033.2	2397.8	710.97	2.4
improve HP #3: 9.5 HSPF, 13.3 SEER	1712.2	1012	104.1	108.90	12.0
wall to R-19	1532.9	981.1	210.4	328.14	17.8
D. NORTH GAS FURNACE (Chicago, IL)					
CASE1: with CAC					
baseline		1042			
AC to 1992 std: 10.5 SEER		988	54	43	10.1
AC #2: 13.3 SEER		780	208	264	10.2
AC #3: 14.87 SEER		698	82	250	38.2
CASE2: with RAC					
baseline		323			
RAC#1: Incr condenser rows (9.42 EER)		309	14	15	11.4
RAC#2: Increase condenser area (9.88 EER)		294	14	109	83.1
______________________ post 2000:					
RAC#3: (from RAC#1) variable speed(>2000)		262	46	83	19.7
RAC#4: Increase condenser area (9.88 EER)		250	12	26	22.9
C. SOUTH GAS FURNACE (Charleston, SC)					
CASE1: with CAC					
baseline		3576			
AC to 1992 std: 10.5 SEER		3407	169	50	3.7
spectrally selective windows		1594	1813	311	1.4
AC #2: 13.3 SEER		1258	336	309	11.6
AC #3: 14.87 SEER		1125	133	293	27.7
AC #4: 15.23 SEER		1099	27	82	38.8
CASE2: with RAC					
baseline		1216			
RAC#1: Incr condenser rows (9.42 EER)		1162	54	12	2.4
RAC#2: Increase condenser area (9.88 EER)		1108	54	87	17.7
______________________ post 2000:					
RAC#3: (from RAC#1) variable speed(>2000)		989	173	67	4.2
RAC#4: Increase condenser area (9.88 EER)		942	46	20	4.9

CCE PATH for
EXISTING SINGLE FAMILY -- ELECTRIC FURNACES

	HTG kWh	CLG kWh	UES kWh	Delta $	CCE c/kWh
A. NORTH (Chicago, IL)					
Case 1: with central air conditioning					
baseline	18310.5	985.0			
switch to HP#3: 9.06 HSPF, 13.03 SEER	6639.1	803.7	11852.7	822.00	0.8
ACH to 0.41 + R-6.15 walls, ceil options1&2,5&6	5811.1	789.4	842.2	273.52	2.6
switch to HP#4: 9.5 HSPF, 13.3 SEER	5542.0	773.4	285.2	90.00	3.6
ceiling options 5&6	5174.4	748.2	392.8	480.27	9.9
R-8.43 wall + window op.1	4836.6	731.6	354.5	645.91	14.7
ceiling option 7	4754.7	726.1	87.3	213.45	19.7
Case 2: with room air conditioning					
baseline	18310.5	305.3			
ACH to 0.41 + R-6.15 wall + ceiling options 1&2	15942.2	299.9	2374	274	0.9
R-8.43 wall + ceil options 3,5,6&7 + wind op.1	13243.0	280.9	2718.2	1354.0	4.0
R-30 floor	11772.4	269.2	1482.2	1297.2	7.1
window options 2&3			210.2	315.5	12.1
Case 3: no cooling					
baseline	18310.5				
ACH to 0.41 + R-6.15 wall + ceil options 1,2,5&6			3583	754	1.7
R-8.43 wall + ceil option 7 + window option 1			1469	859	4.7
R-30 floor			1471	1297	7.1
ceiling option 3			15	14	7.6
window options 2&3			209	315	12.2
B. SOUTH (Charleston, SC)					
Case 1: with central air conditioning					
baseline	8200.8	3235.5			
switch to HP#3: 9.06 HSPF, 13.03 SEER	3090.6	2540.7	5805	822.00	1.6
ACH to 0.46 + walls to R-6.45 + ceil to R-21.81	2445.5	2409.6	776.2	444.39	4.6
switch to HP#4: 9.5 HSPF, 13.3 SEER	2332.3	2360.7	162.2	90.00	6.3
switch to HP#5: 9.93 HSPF, 15.14 SEER	2231.3	2073.8	387.9	330.00	9.7
ceiling to R-31.2	2090.7	2027.5	186.8	402.60	17.4
window option 1	2001.7	2007.6	108.9	425.29	31.5
Case 2: with room air conditioning					
baseline	8200.8	1100.1			
ACH to 0.46 + wall to R-6.45 + ceil to R-21.52	6500.4	1043.9	1756.6	444.39	2.0
RAC#1: Increase condenser rows (9.42 EER)	6500.4	997.4	46.5	15.00	3.5
ceil to R-21.81 + ceil to R-31.2 (branches)	6080.3	974.6	442.9	409.65	7.45
window option 1	5821.4	965.0	268.5	425.29	12.77
wall to R-8.29	5630.4	959.5	196.5	325.00	13.33
ceil to R-36.9 (branch)	5548.1	952.3	89.5	178.94	16.12
Case 3: no cooling					
baseline	8201				
ACH to 0.46 + wall to R-6.45 + ceil to R-21.81	6489		1711.7	451	2.1
ceil to R-31.2 (branch)	6080		408.8	403	7.9
window option 1	5821		258.9	425	13.2
wall to R-8.29	5630		191.0	325	13.7
ceil to R-36.9 (branch)	5548		82.3	179	17.5

CCE PATH for
EXISTING SINGLE FAMILY -- HEAT PUMPS

	HTG kWh	CLG kWh	UES kWh	Delta $	CCE c/kWh
A. NORTH (Chicago, IL)					
baseline	8721.7	1024.8			
switch to '92std: 7.46 HSPF, 10.5 SEER	8081.9	945.3	719.3	71	1.1
ceiling option 1	8014.1	941.4	71.6	7	0.8
switch to HP#2: 9.06 HSPF, 13.03 SEER	6598.8	758.6	1598.1	151	1.1
ACH to 0.42 + walls to R-8.49	6253.4	751.0	353.0	121	2.8
switch to HP#3: 9.5 HSPF, 13.3 SEER	5963.8	735.7	304.9	90	3.4
ceiling option 2	5959.2	735.5	4.8	3	5.2
ceiling options 6&7	5558.0	711.6	425.1	555	10.5
window option 1	5399.9	704.3	165.4	298	14.5
B. SOUTH (Charleston, SC)					
baseline	4121	3552			
switch to '92std: 7.46 HSPF, 10.5 SEER	3999	3352	320.5	86	3.1
ceilings option 1	3975	3346	30.8	5	1.8
switch to HP#3: 9.5 HSPF, 13.3 SEER	2986	2641	1693.2	292	2.0
ACH to 0.48 + walls to R-7.95	2493	2542	593.0	304	4.1
ceilings to R-22.54	2492	2541	1.7	2	10.5
window option1	2383	2515	135.1	360	21.5

DESCRIPTION OF CEILING AND WINDOW OPTIONS FOR EXISTING SINGLE FAMILY HOMES

1. CEILING OPTIONS

1. Add R-19 to all non-insulated ceilings, including existing partially insulated ceilings. Raises average ceiling R-value to R-20.6.
2. Add R-30 to all non-insulated ceilings, including existing partially insulated ceilings. Raises average ceiling R-value to R-32.1.
3. Add R-49 to all non-insulated ceilings, including existing partially insulated ceilings. Raises average ceiling R-value to R-51.4.
4. Add R-60 to all non-insulated ceilings, including existing partially insulated ceilings. Raises average ceiling R-value to R-62.4.
5. Add R-11 to all insulated ceilings, not including partially insulated ceilings. Raises average ceiling R-value to R-14.4.
6. Add R-19 to all insulated ceilings, not including partially insulated ceilings. Raises average ceiling R-value to R-20.6.
7. Add R-30 to all insulated ceilings, not including partially insulated ceilings. Raises average ceiling R-value to R-32.1.
8. Add R-49 to all insulated ceilings, not including partially insulated ceilings. Raises average ceiling R-value to R-51.4.

2. WINDOW OPTIONS

1. Add single-glazed storm windows (external or internal) to single-glazed windows on all homes. Includes homes with a mixture of window types.
2. Replace all single-glazed windows with double-glazed, low-e units. Includes the replacement of single-glazed windows in homes with a mixture of window types.
3. Replace all single-glazed windows with double-glazed, low-e, argon-filled units. Includes the replacement of single-glazed windows in homes with a mixture of window types.

---existing double-glazed window branch:

4. Replace all double-glazed windows with double-glazed, low-e units. Includes the replacement of double-glazed windows in homes with a mixture of window types.
5. Replace all double-glazed windows with double-glazed, low-e, argon-filled units. Includes the replacement of double-glazed windows in homes with a mixture of window types.

APPENDIX 9: UTILITY RASSs USED IN FUEL SWITCHING ANALYSIS

This appendix shows which utility residential appliance saturation surveys (RASSs) were used to estimate the fuel switching potential summarized in Table 14. We calculated residential-customer-weighted saturations from the utility RASSs. Many of the RASSs are confidential, so we do not include saturations for individual utilities here.

UTILITY RASSes USED FOR ESTIMATES OF FUEL SWITCHING POTENTIAL

Note: X indicates utility data was included for the particular enduse.

Utility	Customer Pop'n	Water Heater	Range	Dryer
Alabama Power	956146	X	X	X
Arizona Public Service Co	473121	X	X	X
Baltimore Gas & Electric	895881	X	X	X
Bonneville Power Administration	2960000	X	X	X
Central Hudson G&E	263500	X	X	X
Central Maine	426049	X	X	X
Cincinnati G&E	553307	X	X	X
Detroit Edison	1700732	X	X	X
Florida Power & Light (Miami)	2419770	X	X	X
Florida Power Corp. (Petersburg)	946389	X	X	X
Georgia Power	1251473	X	X	X
Houston Power	1192386	X	X	X
Illinois Power	535721	X	X	
Iowa-Illinois G&E	244146	X	X	X
Long Island Lighting Co.	2820012	X	X	X
New England Power Service (MA)	1067567	X	X	X
New York State E&G	621500	X	X	X
Niagara Mohawk	1690000	X	X	X
Northeast Utilities (CT)	902000	X	X	X
Northeast Utilities (MA)	173000	X	X	X
Northern States (Minn)	1069079	X	X	X
Oklahoma G&E	548003	X	X	X
Orange & Rockland Utilities (NY)	208266	X	X	X
Pacific G&E	3800000	X	X	X
Pacific Power/ Utah Power (CA)	26805	X	X	X
Pacific Power/ Utah Power (ID)	7108	X	X	X
Pacific Power/ Utah Power (MT)	23583	X	X	X
Pacific Power/ Utah Power (OR)	343001	X	X	X
Pacific Power/ Utah Power (WA)	85284	X	X	X
Pacific Power/ Utah Power (WY)	81146	X	X	X
Pennsylvania Power & Light	889873	X	X	X
Philadelphia Electric	1297080	X	X	X
Portland General Electric (OR)	484293	X	X	X
Public Serv. E&G (NJ) Elec cust	213100	X	X	X
Public Serv. E&G (NJ) Gas cust	186200	X	X	X
Public Service Co. Colorado	944673	X	X	X
Public Service E&G (NJ), Comb.E&G	1434400	X	X	X
Public Service Indiana	499432	X	X	X
Puget Power	618000		X	X
Rochester Gas & Electric	289188	X	X	X
Sacramento Municipal Utility	328534	X	X	X
Salt River Project (AZ)	473776	X	X	X
San Diego G&E	919000	X	X	X
Seattle City Light	278724	X	X	X
Sierra Pacific Power Co.	185947	X	X	X
So. California Edison	3200000	X	X	X
Tampa Electric	398817	X	X	X
Tennessee Valley Authority	2800000	X	X	
Texas Utilities	1342907	X	X	X
Union Electric (MO)	951154	X	X	
Utah Power	465344	X	X	X
Virginia Power	1566400	X	X	X
West Penn Power (PA)	536700	X	X	X
Wisconsin Electric Power Co	766387	X	X	

TOTAL POP'N
49,354,904

APPENDIX 10: ACCESS LOGIC

This appendix summarizes the logic the supply curve program uses to calculate the frozen efficiency baseline and the energy savings in the technical potential case.

ACCESS Program: Description of Logic

1. Introduction

The ACCESS supply curve program runs on a Sun-4 mainframe computer and uses the Informix relational database management system to store, analyze and process data. UNIX batch files run a series of Informix programs which create data files for the SAS-operated graphics programs. The graphics programs create supply curves of conserved energy. The user of ACCESS may create new data files, alter existing files, specify the parameters of the supply curve forecast (e.g., the forecast time period, the fuel price forecast, the type of fuel analyzed, etc.).

The logical framework behind the supply curve program is described below.

2. Definition of Terminology

In order to analyze energy savings potential in the residential sector, the sector's net energy use must be disaggregated into appliance types and/or services provided. For this purpose, we define various *enduses*. An enduse can be either an appliance which provides a service (such as a refrigerator, freezer, clothes dryer, etc.), or it can be the service itself (e.g., space conditioning). One space conditioning enduse might be modeled as a single-family home in the North with electric resistance heating and no cooling. Another enduse might represent all homes built after 1990 in the South with heat pumps. The strategy of employing many enduses to model a complex energy use such as space conditioning allows us to choose the most appropriate conservation measures for each situation.

Once we have divided energy consumption into enduses, we can apply energy saving devices, or *measures* to them. A measure is a device that can be applied to a certain fraction of the total enduse stock at a certain cost and resulting in a certain amount of energy savings. We call this fraction of the enduse stock the *eligible fraction*. A measure might be as simple as wrapping a blanket around a water heater, or as complex as a multi-component improvement in the building envelope plus improvements to the efficiency of the heating and cooling equipment.

The measures are ranked in order of their cost-effectiveness using the cost of conserved energy (CCE). The calculation of CCE is described in the main text. Once we have determined the most cost-effective sequence of measures, we can calculate the cost and energy savings of each measure relative to its preceding measure. These *incremental* costs and savings are used to calculate the CCE for the supply curve plot.

In order to calculate the energy savings that result from implementation of a measure, we need to specify a *baseline* consumption level. The baseline must also be a forecast, since efficiency measures take time to implement. In our study, we assume that we begin to implement measures in 1990 and seek to find the potential savings that could be achieved by the year 2010. Our baseline forecast is a *frozen efficiency* forecast. The frozen efficiency forecast assumes that all appliances existing today remain at the 1990 stock-weighted average efficiency until replaced. Appliances are replaced by the average unit bought in 1990 whose efficiency is from LBL's Residential Energy Model (LBL-REM). All units that are added after 1990 and are not replacements of retired units are called *additional units* and have the same efficiency as a 1990 new unit. We assume a constant rate of replacement, or *retirement*, that is based on the *lifetime* of the equipment. The lifetime is the average mechanical lifetime that can be expected for a particular appliance.[1] Each year, the same number of units, namely N/L, retires, where N is the number of units in 1990 and L is

[1] We use the best estimates of product lifetime available, although the study from which the estimates come is now ten years old: "Energy Capital in the U.S. Economy", Brookhaven National Laboratory & the U.S. Department of Energy, November 1980.

the mechanical lifetime of the equipment.

For the space conditioning enduse, which we have modeled as various prototype homes due to the interdependent nature of house location, envelope type, and heating and cooling requirements, we have assumed that all *existing* homes (homes built prior to 1990) can be retrofit by 2010. *New* homes (those homes built between 1990 and 2010) receive space conditioning improvements (over the way they would otherwise have been built) at the time of construction.

In order to find the aggregate energy savings or use for the residential sector, we need to know the number of units within each enduse in any year. This number is called the *stock*. The efficiency of the stock, as well as the number of units, changes over time, due to old units retiring as they reach the end of their lifetime, and to units being added (e.g., a second refrigerator in an existing home, or a refrigerator required for a new home). The stock forecast is from LBL-REM.

The analysis of energy conservation potential is based on a *technical potential/best available technology scenario*. This scenario estimates the maximum possible savings that could be achieved if the most efficient conservation technologies were deployed in all eligible households. The level of service provided remains constant or is improved.

A summary of definitions of terms used in this section follows.

- *Enduse* An appliance providing a service (such as a refrigerator) or the service itself (for example, space conditioning).
- *Measure* An energy saving device which is applied to an enduse.
- *Baseline UEC* Energy consumption if no efficiency measures are employed.
- *Frozen efficiency baseline* A forecast that assumes all appliances (or enduses) existing in 1990 remain at the 1990 stock-weighted average efficiency until they retire and are replaced with new units having the average efficiency of new units bought in 1990. All units added after 1990 also have the efficiency of 1990 new units.
- *Existing home* A home that exists in 1990 (i.e., that was built prior to 1990).
- *New home* A home that was built between 1990 and 2010.
- *Stock* The number of units that comprise an enduse in any given year.
- *Additional units* The number of units in each year that exceeds the number of units in 1990, that is, the number of units added to the 1990 stock. Examples of additional units are: a second refrigerator in an existing home, a refrigerator required for a new home, etc. Note that additional units do *not* include replacements of existing 1990 units.
- *Technical potential scenario* This scenario estimates the maximum possible savings that could be achieved if the most efficient conservation technologies were deployed in all eligible households. The level of service provided remains constant or is improved.

3. The Supply Curve Methodology

3.1. Energy Savings in the Forecast Year (2010)

The first step in determining the energy savings resulting from a conservation measure is to assess the number of units (N) that are eligible for that measure. We assume that measures will be implemented only at the time at which the 1990 existing units would naturally retire. We use a constant absolute rate of retirement that depends on the lifetime of the appliance: each year the total number of 1990 stock that retires is simply (1/lifetime) times the number of 1990 units. Conservation measures are applied to additional units (units that are in addition to replacements of 1990 units) at the time they are added.

For space conditioning retrofits, we assume that all physically eligible homes will be retrofit by the year 2010 in the Technical Potential scenario.

We have created three types of enduses to account for the different energy uses in homes: new home space conditioning, existing home space conditioning, and appliances in existing and new homes. Appliances in new homes and in existing homes are treated identically.

3.1.1. Number of units eligible for a measure

Two types of constraints affect the number of units in an enduse that are eligible for a measure: physical and chronological. Physical constraints reflect the physical barriers to implementing a particular measure, such as whether some fraction of the stock has already implemented the measure, or whether there is gas service in the home (for fuel-switching measures), etc. The physical constraint for each measure is input by the user. Chronological constraints shorten the amount of the total forecast time period in which the measure may be applied. Such constraints depend upon two factors: (1) the lifetime of the enduse and (2) the year in which the measure becomes commercially available.

The formulae used by ACCESS to calculate the number of units (N) eligible for a measure follows. There are three enduse types: new home space conditioning, existing home space conditioning, and appliances. Within each enduse type, we must evaluate different cases, such as whether the measure is commercially available in the beginning year of the forecast or whether it becomes available in a subsequent year; and we must compare the enduse lifetime to the number of years in which the measure could possibly be applied to stock units. Only chronological constraints will be evaluated in this section; the physical constraints will be addressed subsequently.

3.1.1.1. New Home Space Conditioning

(1) *Measure is available in 1990*

If the measure is aleady available in 1990, then all homes built between 1990 and 2010 will be eligible to receive the measure.

$$N_{new1} = stock_{2010}$$

(2) *Measure is available sometime after 1990*

If the measure becomes commercially available sometime after 1990 (in year y), then only the homes built between year y and year 2010 will be eligible for the measure (since we assume that new home measures can be implemented only at the time of construction).

$$N_{new2} = stock_{2010} - stock_y$$

3.1.1.2. Space Conditioning in 1990 Existing Homes Still Existing in 2010

For existing homes, we have only considered measures that are commercially available in 1990, therefore

$$N_{existing} = stock_{2010}$$

Note: The stock of "existing" homes (i.e., those homes that existed in 1990) decreases over time due to retirement. The homes that replace them are included in the new home space conditioning stock.

3.1.1.3. Appliances

We assume a constant absolute retirement rate of ((1/L) times the number of 1990 units per year), where L is the lifetime of the appliance. We apply conservation measures to units existing in 1990 only at the time at which they are retired and a new replacement is bought. There is no "early retirement". We apply conservation measures to additional units (the number of units in each year that exceeds the number of units in 1990) as they are introduced into the stock. The forecast of additions is from LBL-REM. The time period, T, of the analysis is 20 years in this particular case (i.e., 1990 to 2010). The calculation of the number of units, N, to which a measure is applied, follows.

(1) *Measure is commercially available in 1990*

If the measure is commercially available in 1990, there are two possible situations that can occur by the year 2010. If the lifetime is less than the forecast period, then all 1990 existing units will have retired by 2010. If the lifetime is longer than the forecast period, then only a fraction of the 1990 stock will have been replaced, as described below.

(1a) *Lifetime <= forecast time period (L <= T)*

If the lifetime of the enduse is less than or equal to the time period of the forecast, all 1990 units will have retired. Therefore, all units existing in 2010 are eligible for this measure.

$$N_{appl1} = stock_{2010}$$

(1b) *Lifetime > forecast time period (L > T)*

If the lifetime of the enduse is greater than the time period of the forecast, only a fraction of the 1990 units will have retired. However, all units that have been added to the stock since 1990 (additions) are eligible. Thus, the number of units eligible for the measure is equal to the number of units that have retired plus the number of additions.

$$N_{appl2} = (stock_{2010} - stock_{1990}) + stock_{1990} * \frac{T}{L}$$

(2) *Measure is commercially available after 1990*

If the measure is only available after 1990 (in year y), we must make some modifications to the above equations in order to account for the shortened period of possible implementation.

(2a) *Lifetime > (2010 - y)*

If the lifetime of the enduse is greater than the time period between the year the measure becomes commercially available (year y) and 2010, then only a fraction of the units existing in year y will have retired. The number of units eligible for this measure is thus the number of units that have retired, plus the number of units that have been added between the years y and 2010.

$$N_{appl3} = (stock_{2010} - stock_y) + stock_y * \frac{(2010-y)}{L}$$

(2b) *Lifetime <= (2010 - y)*

If the lifetime of the enduse is less than or equal to the time period between the year the measure becomes commercially available (year y) and 2010, then all of the units existing in year y will have retired. Therefore the number of units eligible for this measure is the total number of units in 2010.

$$N_{appl4} = stock_{2010}$$

3.1.2. Calculation of the Frozen Efficiency Baseline

The frozen efficiency forecast of energy consumption in 2010 is the total residential energy consumption predicted if no efficiency measures are taken. The forecast assumes that all appliances existing in 1990 will remain at the 1990 stock-weighted average efficiency until they retire and are replaced with units having the average efficiency of 1990 new units. We assume a constant rate of replacement that is dependent upon the lifetime of the appliance. All units added after 1990 also have the average efficiency of 1990 new units.

For space conditioning enduses, the energy consumption of existing homes is the product of the number of 1990 stock homes still existing (a program input from LBL-REM) and the baseline UEC. The energy use of homes built after 1990 is simply the product of the number of new homes and the new home baseline UEC.

The energy use of each enduse is made up of three parts: (1) energy use of units added since 1990, (2) energy use of the fraction of 1990 stock that has not been replaced by 2010, and (3) energy use of the fraction of 1990 stock that has been replaced. The lifetime of the enduse determines how many units have been replaced, and so we look at two cases:

(1) Lifetime <= 20

All 1990 stock units have been replaced, thus

$$Energy\ (E) = stock_{2010} * uec\_new$$

(2) Lifetime > 20

Only a portion of the 1990 stock will have been replaced.

$$Energy(E) = E_1 + E_2 + E_3$$

where E(1) = consumption of units added since 1990, or

$$E_1 = (stock_{2010} - stock_{1990}) * uec\_new ,$$

and E(2) = consumption of 1990 stock that has not been replaced

$$E_2 = stock_{1990} * \frac{(L-20)}{L} * uec\_ex ,$$

and E(3) = consumption of 1990 stock that has been replaced

$$E_3 = stock_{1990} * \frac{20}{L} * uec\_new$$

where

L = lifetime of the enduse

uec_ex = unit energy consumption of existing 1990 units

uec_new = unit energy consumption of a new unit in 1990.

3.1.3. Calculation of Energy Savings

The energy savings for each measure is calculated independently of the frozen efficiency baseline, then summed over all the measures and subtracted from the baseline. The energy savings for each measure is equal to the number of units (N) that are candidates for a measure when time constraints are taken into consideration (as determined in the previous section) times the user-input physical constraint on the number of units that are eligible for the measure (aplbl_stock), times the amount of energy the measure saves over the preceding measure. The latter is called the unit energy savings (UES). Thus, the energy savings is calculated with the following equation:

$$Savings = N * aplbl\_stock * UES$$

The physical constraint (aplbl_stock) is a required input for each measure. The physical constraints apply to existing homes in 1990. New homes are likely to present different physical constraints to appliances that are placed in them than existing homes would, but we have not accounted for the possible difference (apart from in the space conditioning enduses, where new homes and existing homes are separate enduses, and thus have inherently different characteristics).

For appliance and existing home space conditioning enduses, the baseline level of unit energy consumption (UEC) is the average UEC of units bought in 1990. Unit energy savings (UES) for the first measure of each enduse is calculated from this new unit baseline UEC. Savings that would occur naturally due to turnover are accounted for in the frozen efficiency baseline. We therefore avoid double-counting the naturally-occurring savings due to turnover.