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The Regional Energy and Economic Impacts of The National Appliance Energy Conservation Act of 1987

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June 1988

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ABSTRACT

We use the LBL Residential Energy Model to forecast the energy and economic impacts of the National Appliance Energy Conservation Act of 1987 (NAECA) for each of ten regions of the United States. The act sets minimum standards for residential appliance efficiencies. We find that NAECA will save the nation nearly $25 billion (1987 dollars) in cumulative, net present benefits by 2015. The savings of nearly 5 Quads (1 Q = 1E15 Btus) consist of reductions in electricity generation of 800 TWh (1 TWh = 1E9 kWh) or 3 Quads and in direct fuel use of almost 2 Quads. Appliance shipments will be largely unaffected by the standards. We also discuss some implications of our analysis for utilities regarding future air conditioner/heat pump shipments, future water heater fuel choice, and minimum rebates required to stimulate purchase of efficient central air conditioners and refrigerators.

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INTRODUCTION

In March 1987, President Reagan signed the National Appliance Energy Conservation Act of 1987 (NAECA) into law. The act mandates minimum levels of energy efficiency for selected new residential appliances. The schedules for implementation and levels of efficiency vary by appliance, and the act provides for periodic reviews to ensure that the standards do not become obsolete.

The passage of the law represents the efforts of a unique coalition of environmentalists, appliance manufacturers, and utilities. Energy conservation standards for appliances were originally mandated by Congress in 1978 as part of the National Energy Conservation Policy Act (NECPA), but their development was halted in the early years of the Reagan Administration. At the same time, manufacturers were becaming uneasy with the patchwork of inconsistent standards passed by individual states (notably California). Environmental groups successfully sued the Department of Energy to promulgate the standards as originally called for in NECPA.

The Department of Energy was directed to evaluate the cost effectiveness of these standards from a variety of perspectives, including their impacts on consumers, manufacturers, utilities, the environment, and society in general. DOE's findings overwhelmingly indicate the positive benefits of the proposed appliance standards [LBL 1988]. These analyses were, however, performed at a high level of aggregation, with a nationwide perspective and little or no attention to regional variations.

In the present work, we focus explicitly on these variations with a region-by-region analysis of the NAECA standards. Our findings for individual regions may differ markedly from those of a nationwide analysis because of regional variations in appliance saturations, energy use, and, especially, the cost of electricity generation.

We estimate the social costs and benefits of NAECA for each of the 10 DOE planning regions. The costs are the incremental additional costs of more efficient appliances. The benefits are, primarily, the value of electricity avoided by more efficient appliances, in the form of reduced fuel inputs for existing generation, increased system reliability, or the deferral of future generating units. The detail inherent in our regional disaggregation allows us to comment on the opportunities for rebate programs that offer incentives for efficiency levels in excess of those called for by the standards.

THE NATIONAL APPLIANCE ENERGY CONSERVATION ACT OF 1987

Table 1 compares stock average and new appliance efficiencies, by end use, to those called for in NAECA. The "stock average" is the estimated average efficiency. New appliance efficiencies refer to the average efficiencies of appliances purchased in 1986. Under NAECA, new appliances must meet or exceed the efficiency levels in this table, starting in the years indicated.

The minimum efficiencies called for by NAECA are fairly stringent as can be observed in data from industry trade organizations. Table 1 also summarizes the fractions of 1986 shipments or models that would not meet the standard levels.

The data in Table 1 can be misleading, however, because they do not indicate difficulty of compliance. For example, adding 0.25 inches of insulation to an existing air space in water heaters for compliance is far less complicated than complete redesign of an appliance. In many cases, simple fixes or replacements of components are all that is required for compliance. For other appliances, notably air conditioners, expensive modifications are required.

The law provides for revisions to the standards. We will evaluate only those efficiency levels explicitly mandated by the current law. If one assumes that future revisions will go beyond current levels, our analysis is conservative.

Table 1. Existing Equipment Efficiencies vs. NAECA

Equipment Type	1986 Stock	1986 New	NAECA Standard	NAECA Year	Fraction of Current Shipments or Models Not in Compliance
Air Conditioning					
Room (EER)	6.5	7.7	8.6	1990	0.65[2]
Central (SEER)	7.4	8.8	10.0	1992	0.90[1]
Heat Pump (SEER)	7.8	8.6	10.0	1992	0.90[1]
Furnaces					
Natural Gas (AFUE)	65	74	78	1990	0.67[1]
Oil (AFUE)	75	80	78	1990	0.31[1]
Water Heating					
Electric (%)	81	83	88	1990	0.67[2]
Natural Gas (%)	48	49	54	1990	0.37[2]
Refrigerator/Freezer (EF)	5.9	7.1	7.5	1990	0.75[1]
Freezers (EF)	8.4	12.6	13.8	1990	0.67[1]

1. based on 1986 shipments
2. based on 1986 models

EER - Energy Efficiency Ratio
SEER - Seasonal Energy Efficiency Ratio
AFUE - Annual Fuel Use Efficiency
EF - Energy Factor

Sources: ARI, 1986; AHAM, 1987; Appliance Magazine, 1988; Norton, 1988

METHOD OF ANALYSIS

In this section, we describe the methods used to evaluate the impacts of NAECA. We begin with an overview of the method and conclude with detailed discussions of the end-use forecasting model, the economic valuation methods, and the definition of costs and benefits for the societal impact calculation.

We use a sophisticated end-use energy forecasting model, the LBL Residential Energy Model (REM), to estimate annual energy use for both a policy and a base case. The policy case incorporates NAECA, and the base case does not; all other conditions are held fixed between the two cases. Accordingly, differences in energy use between the two cases represent the energy impact of NAECA. The model also calculates the costs of more efficient appliances.

The largest impact of NAECA is reduced electricity consumption. We value this change at the point of generation using marginal electricity costs for energy and capacity. In order to estimate the capacity value of the electrical load shape changes resulting from NAECA, we use a second model, the LBL Residential Hourly and Peak Demand Model (RHPDM). This model uses historical end-use load and weather data to forecast the hourly electrical load impacts of the policy and base case energy forecasts.

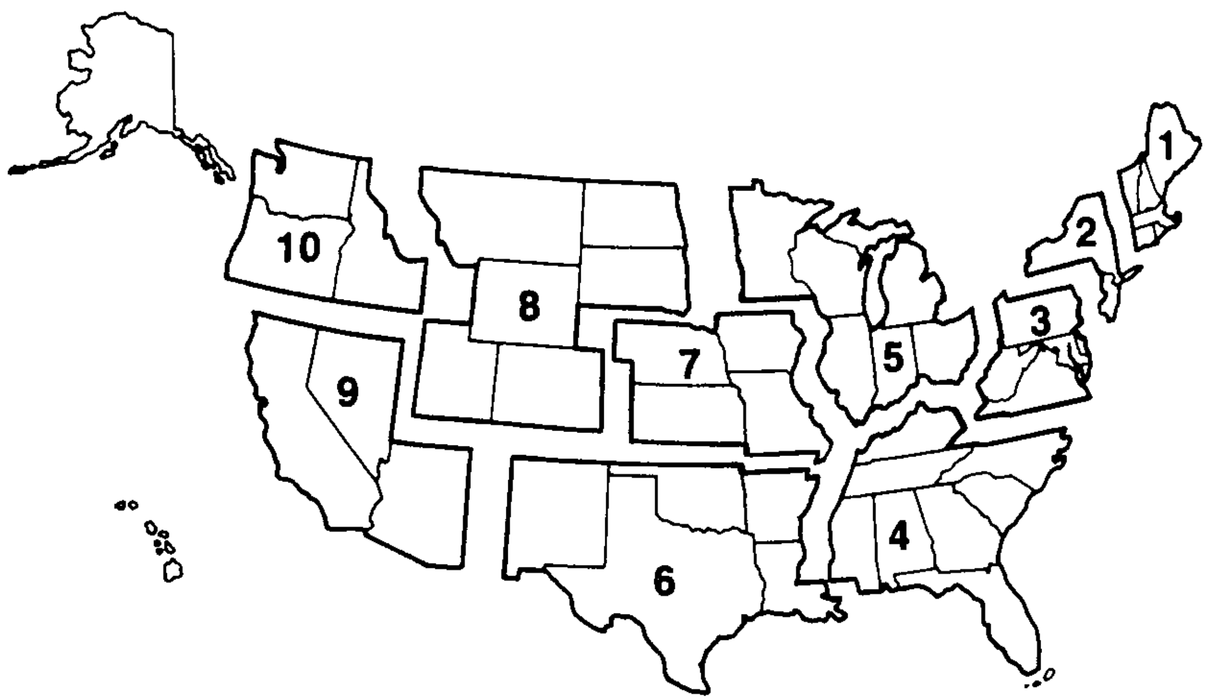
The cost-benefit analysis compares the value of decreases in electricity and other fuels with the increases in equipment costs, normalized for appliance shipments in the base case. The difference is the net social benefit (or cost) of NAECA. We perform this analysis separately for each of the 10 DOE regions. Figure 1 illustrates these regions.

End-year effects are difficult to characterize precisely in analyses of this type. For the purposes of the present work, we only forecast policy and base case energy use up to 2015. The net social benefit calculation, however, assumes that an appliance sold in 2015 will continue to produce savings for its mean lifetime. Mean lifetimes range from 13 years for water heaters to 23 years for furnaces.

The LBL Residential Energy Model

The analysis of NAECA rests ultimately on the use of a sophisticated end-use forecasting model, the LBL Residential Energy Model. The LBL Residential Energy Model (REM) is an engineering/economic model that produces a 35-year forecast of annual energy use for nine end uses (space heating, air conditioning, water heating, refrigerators, freezers, cooking, clothes dryers, lighting, and miscellaneous) [McMahon 1987]. It forecasts energy consumption for all domestic fuels, except wood, and explicitly accounts for interfuel substitution.

Figure 1. Federal Regions



Region 1
New England

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Region 2
New York/
New Jersey

New Jersey
New York

Region 3
Mid Atlantic

Delaware
District of Columbia
Maryland
Pennsylvania
Virginia
West Virginia

Region 4
South Atlantic

Alabama
Florida
Georgia
Kentucky
Mississippi
North Carolina
South Carolina
Tennessee

Region 5
Midwest

Illinois
Indiana
Michigan
Minnesota
Ohio
Wisconsin

Region 6
Southwest

Arkansas
Louisiana
New Mexico
Oklahoma
Texas

Region 7
Central

Iowa
Kansas
Missouri
Nebraska

Region 8
North Central

Colorado
Montana
North Dakota
South Dakota
Utah
Wyoming

Region 9
West

Arizona
California
Hawaii
Nevada

Region 10
Northwest

Alaska
Idaho
Oregon
Washington

The driving forces for REM forecasts are projections of future energy prices, numbers of households, personal income, and housing thermal integrity. Given these data, REM performs five major calculations (see Figure 2): future appliance efficiency choices, investments in thermal integrity improvements for buildings, turnover of housing units and appliances, changes in the market share for each technology and fuel (such as numbers of gas vs. electric water heaters), and changes in usage behavior (such as hours of air conditioner usage). These calculations rely on engineering and cost estimates for the range of available appliance designs (or thermal integrity improvements) and on relationships describing the influence of energy prices, equipment costs, income, and other factors on purchase and usage decisions.

Purchase decisions and fuel choices for appliances depend on economic criteria including equipment cost and operating expense. Operation of the appliance stock is simulated according to engineering and economic criteria and average weather conditions in each region. Empirical parameters representing market behavior are embedded in the appliance purchase algorithm. For all calculations, three housing types are represented, single family, multifamily, and mobile homes.

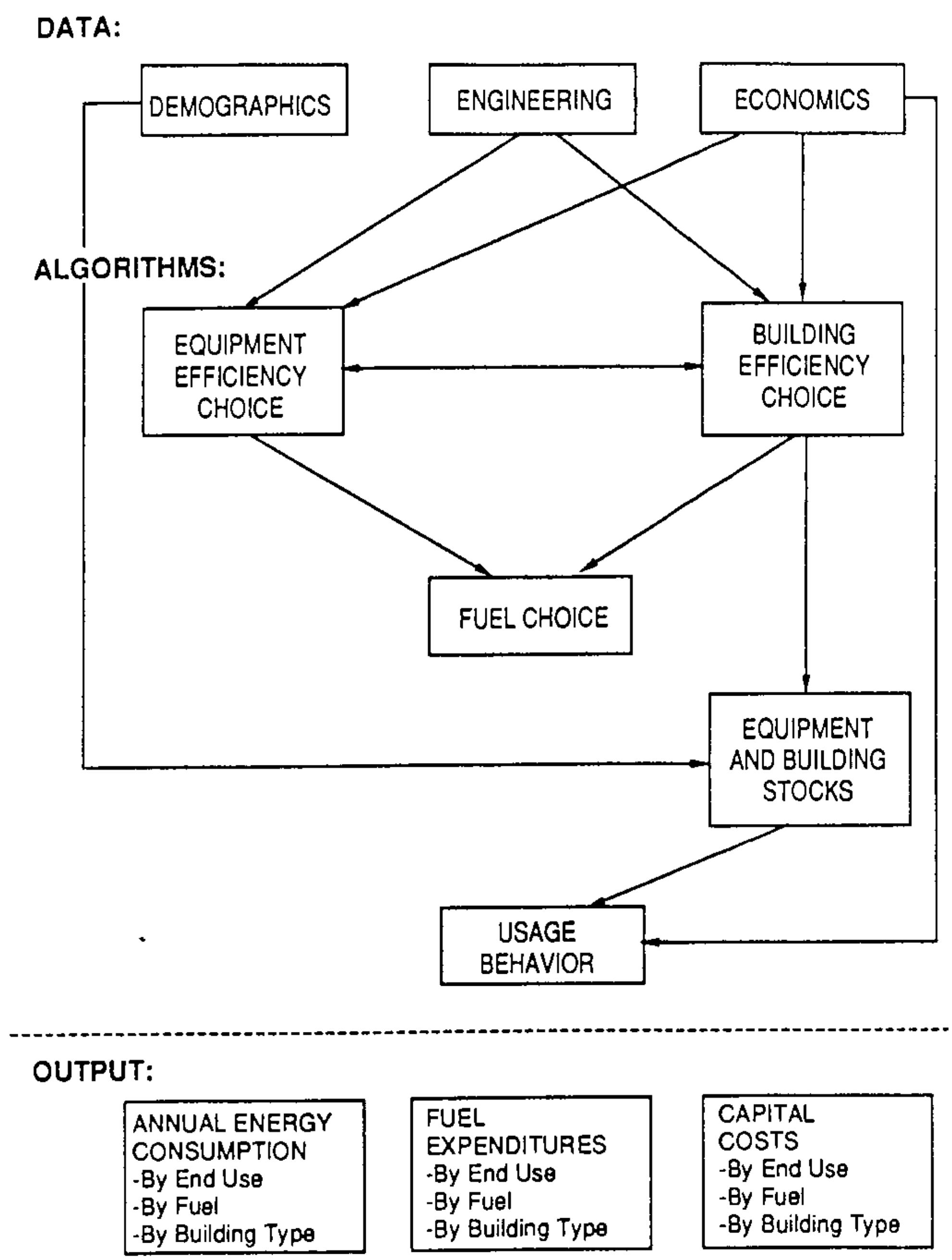
The model is the result of a long development effort that began at Oak Ridge National Laboratory in the mid-1970's [Hirst and Carney 1978]. Since that time, the model has undergone dramatic revisions. For example, the revised model now maintains a full distribution of appliance ages, and retires appliances in existing homes according to a probabilistic service lifetime. Therefore, the model has available a more complete description of the stock at any time, including a distribution of efficiencies. We have also created a separate appliance category for heat pumps; originally, they were included with central air conditioning.

More recently, we have incorporated a national data base of 1,300 households to estimate market share elasticities. This data base was used in the Electric Power Research Institute's REEPS model [EPRI 1984]. Because of the possibility of significant aggregation bias when using an analytical formulation (such as the nested logit approach) to represent the data, we rely on direct estimation from the data base. We believe this direct approach better captures the joint nature of the heating/cooling system decision in the presence of known interactions between different fuel and equipment price effects [Wood et al. 1987a; Wood et al. 1987b].

For the present analysis, the model has been modified to account explicitly for the interaction between internal gains and space conditioning loads. For example, the efficient refrigerators mandated by NAECA use less electricity and will contribute less energy, in the form of "free heat," to the internal gains of a residence. Reduced free heat will increase heating loads in winter and reduce cooling loads in summer. Accordingly, efficient air conditioning equipment, such as that called for by NAECA, will save less energy, because the loads placed on air conditioners have been lowered by making other appliances more efficient.

In its original form, REM was (and continues to be) used for DOE-sponsored national analyses of NAECA. For this project, we have adapted the model to forecast the impacts of NAECA for 10 DOE regions. The principal task in using the model at this level of detail is respecification of the input data based on local conditions.

FIGURE 2. LBL RESIDENTIAL ENERGY MODEL



Valuation of Electricity Savings

Reductions in electricity use are the primary benefit of NAECA. We evaluate these benefits at the point of generation using marginal energy and capacity costs. Marginal, as opposed to average, electricity costs reflect the incremental costs that are avoided by utilities as a result of reductions in electricity use. These costs exhibit substantial geographic variation in the US, depending on regional supply/demand conditions and fuel mixes of generating sources. Accordingly, we develop these costs separately for each of the ten DOE regions. The methods rely on techniques used to develop avoided cost offers for the purchase of power from cogenerators and small power producers pursuant to the Public Utilities Regulatory Policies Act of 1978. The technical support document developed by LBL [1988] for DOE contains a complete description of the valuation procedures.

Marginal capacity costs represent the capital component of electricity generating costs avoided by changes in loads. We use a more conventional, restricted definition in which they are taken to represent the marginal capital investment required to meet loads in excess of existing generating capacity [NERA 1977]. Since electricity can only be stored with great difficulty, marginal capacity, in this context, is best thought of as the marginal cost of maintaining a reliable supply of electricity. The capital cost of a combustion turbine, which is low compared with other supply investments such as a coal-fired power plant, represents the marginal investment needed for reliability.

Additional generating capacity only enhances reliability when existing generating capacity is deficient. For many DOE regions, substantial overcapacity means that the load impacts of NAECA will not contribute to system reliability until some time in the future. We use the DOE's Office of Energy Emergency Operations' analysis of reliability for the National Electric Reliability Council (NERC) regions to determine the first year when the load impacts of NAECA have reliability value. This definition considers future load growth and compares that to the availability of installed generating units and purchases [DOE 1988]. Table 2 summarizes by DOE region the future year in which NAECA first contributes to system reliability.

We calculate in four steps the load impacts of NAECA that contribute to reliability. First, another LBL model, the Residential Hourly and Peak Demand Model (RHPDM), is used to convert the annual forecasts of electricity consumption from REM into hourly loads. This model is an engineering model that relies on historical end-use load and weather data to allocate electricity use to each hour of the year. [Verzhbinsky 1984]. Second, an averaging procedure is used to account for non-coincidence between residential class loads and system loads. The averaging procedure defines the system load shape impact to be the averaged load impact of the highest 250 summer hourly residential class loads.

Table 2. First Year of Capacity Value for NAECA

NERC Region	Year
ECAR	1995
ERCOT	1997
MAAC	1990
MAIN	1994
MAPP	1997
NPCC	1993
SERC	1990
SPP	1997
WSCC	1997

Source: US DOE, 1988

This procedure usually reduces the capacity savings relative to the peak hour savings because of the non-coincidence of individual end-use peak demand savings with those of the residential class *. Third, transmission/distribution loss and reserve margin factors of 6% and 20%, respectively, are added. Fourth, if adjusted reserve margins are high, as in the Southwest, West, and Northwest (see table 2), adjusted savings produce no capacity value. Table 3 illustrates the significance of these adjustments for one sample year in the forecast.

Marginal energy cost savings represent the variable electricity generating cost savings resulting from NAECA. We developed these costs regionally by considering projected fuel mixes for electricity generation for future years (see LBL [1988] for additional details of the estimation process). Table 3 summarizes our regional estimates for marginal electric energy costs.

* It can also increase them; for example, in New England, peak hour savings are smaller than adjusted savings. This result occurs because the forecasted summer peak hour residential load in New England occurs at the beginning of the summer period, and consists primarily of heating and other non-cooling energy consumption. Most of the 250 highest summer loads, on the other hand, occur at the height of summer and contain substantial amounts of cooling energy. Since the standards save relatively more energy from cooling than heating appliances, the adjusted savings are higher than the peak hour savings in this case.

Table 3. Marginal Cost Calculation Inputs

DOE Region	1995 Capacity Value Peak Hour Savings (MW)	1995 Capacity Value Adjusted Savings (MW)	Marginal Energy Value 1995 (1987$/kWh)	Marginal Energy Value 2000 (1987$/kWh)
New England	27	68	0.046	0.058
New York/New Jersey	356	353	0.044	0.055
Mid Atlantic	723	598	0.038	0.045
South Atlantic	2242	2053	0.034	0.039
Midwest	1077	330	0.029	0.032
Southwest	1397	0	0.049	0.063
Central	386	169	0.035	0.042
North Central	39	0	0.029	0.034
West	1309	0	0.042	0.052
Northwest	81	0	0.042	0.052

Cost-Benefit Analysis

Our cost-benefit calculation attempts to distinguish between the impacts of NAECA on consumer amenity and the impacts on society's resources. We measure the former by considering the effects of standards on aggregate appliance shipments. We measure the latter by normalizing our costs and benefits to the number of base case shipments.

In theory, standards can have two opposite effects on consumers. If they raise the cost of the appliance beyond a certain point, sales will decrease. This decrease in sales will save energy, but it will have done so at the expense of the amenity the appliance would have provided the consumer. If, on the other hand, the increase in first cost is substantially offset by the decrease in life-cycle energy costs, sales may increase. In this case, energy use will also increase, but, now, the increase is a result of more consumers enjoying the amenities that the appliance provides.

We believe a meaningful cost-benefit calculation should account separately for the effects of standards on consumer amenities. Accordingly, we normalize our results to basecase equipment sales and hours of usage for the purposes of cost-benefit evaluation. The effect of this normalization is to hold amenity levels fixed between our base and policy cases. We report separately the impacts of NAECA on appliance shipments in order to capture one component of the amenity impacts of standards.

ENERGY AND ECONOMIC IMPACTS

We describe the energy and economic impacts of NAECA in two parts. First, we report NAECA's impact on cumulative energy use. Second, we report the normalized net present value of the standards. The normalization holds fixed the number of appliances sold so as to exclude changes in the level of energy services. As part of our discussion of the net present value of NAECA, we review changes in appliance shipments so we can comment on the ways NAECA affects consumer amenities.

Energy Impacts

Table 4 lists by region the cumulative energy impacts of NAECA by the year 2015. These cumulative savings include energy saved from the first year of the standards to 2015, as well as energy saved beyond 2015 from appliances still functioning after that year. For appliances purchased in 2010 and having a 15-year lifetime, for example, this convention will include energy saved by these appliances from 2010 to 2025. The figures reported in Table 4 include the effects of both more efficient appliances and changes in appliance shipments on energy use.

Table 4. Cumulative Energy Impacts of NAECA 1990 to 2015

	Base Case		Savings		Percentage Savings	
DOE Region	Electricity (TWh)	All Fuels (Quads)	Electricity (TWh)	All Fuels (Quads)	Electricity (%)	All Fuels (%)
New England	1261	18.1	13	0.1	1.0	0.7
New York/New Jersey	1833	28.6	27	0.3	1.5	1.0
Mid Atlantic	3464	30.9	69	0.2	2.0	0.8
South Atlantic	9112	21.8	320	0.1	3.5	0.4
Midwest	5234	63.1	110	0.5	2.1	0.8
Southwest	4022	23.1	135	0.2	3.4	0.8
Central	1584	14.3	38	0.1	2.4	0.7
North Central	1312	13.3	20	0.1	1.5	0.7
West	3423	26.9	61	0.3	1.8	1.1
Northwest	2087	5.8	29	(0.0)	1.4	(0.3)
Total	33332	245.8	822	1.9	2.5	0.8

We find that, as expected, NAECA will save primarily electricity (822 TWh = 2.8 Q). Using a source energy conversion factor of 11,500 Btu per kWh to express the electricity savings in units of primary energy use results in savings of nearly 10 Q.

The regional level of detail in our forecast allows us to examine the impacts of NAECA at a fine level of disaggregation. We find that the largest absolute and percentage electricity savings will occur in the South Atlantic and Southwest DOE regions (4 and 6). The large savings in these areas are due to both the high saturation of air conditioning and the relatively greater cooling loads found in these climates. Table 5 documents the large fraction of total electricity consumed for cooling in these regions.

We observe the lowest percentage electricity savings in New England, also a result of climate. Air conditioning saturations are lower and the amount of cooling required is smaller in this region, so savings are lower. Table 5 also suggests that relatively low percentage electricity savings in the New York/New Jersey, North Central, and Northwest regions are also explained by low cooling energy requirements.

Table 5. 1995 Residential Electricity Consumption by End Use

DOE Region	Heating (%)	Cooling (%)	Refrigeration (%)	Water Heating (%)	Other (%)
New England	16	2	23	16	42
New York/New Jersey	13	6	26	11	45
Mid Atlantic	25	7	17	20	31
South Atlantic	20	20	14	21	25
Midwest	17	6	24	17	35
Southwest	9	31	19	11	30
Central	16	15	22	13	34
North Central	26	1	21	15	36
West	9	12	26	11	42
Northwest	41	0	12	25	22
Total	18	13	19	17	32

Percentage savings for all other fuels are relatively modest and uniform, in comparison to those for electricity. Energy use by all other fuels, however, is actually expected to increase in the Northwest region. We speculate that this is a spill-over effect from the large amounts of electricity used for heating in this region. In the Northwest, NAECA reduces the attractiveness of electricity as a heating fuel because heat pumps (25% of electric heating appliances) become too expensive. (We document the effects of NAECA on regional air conditioner/heat pump shipments in a following section on implications for utilities.) In this situation, fossil fuel furnace sales increase, leading to increasing consumption of other fuels.

Economic Impacts

Table 6 reports the results of our cost-benefit analysis of NAECA. Both our costs and benefits have been normalized to the number of appliance shipments in the base case. The costs to society are the incremental expense of purchasing more efficient appliances. The benefits to society are primarily the value of avoided electricity generation. Our results (as in Table 4) reflect only the cumulative value of NAECA to the end of the lives of appliances operating in 2015.

Table 6. Net Present Value of NAECA 1990-2015
In Billions of 1987$, Discounted at 5% Real

DOE Region	Electricity Savings	Fuel Savings	Incremental Appliance Costs	Net Present Benefit
New England	0.7	0.6	-0.3	0.9
New York/New Jersey	1.4	1.4	-0.9	2.0
Mid Atlantic	2.8	1.1	-1.4	2.5
South Atlantic	9.9	0.4	-3.8	6.5
Midwest	2.9	2.1	-2.3	2.7
Southwest	7.0	0.7	-2.3	5.4
Central	1.4	0.3	-0.8	0.9
North Central	0.5	0.4	-0.5	0.4
West	3.0	1.1	-1.9	2.2
Northwest	1.1	0.1	-0.3	1.0
Total	30.7	8.2	-14.5	24.5

The results of our cost-benefit analysis indicate that the net present value of NAECA will be positive for every federal region. Overall, we estimate a net present benefit of $24 billion in 1987, valued at a 5% real discount rate. The value of avoided electricity relative to fuel is roughly in line with the source energy savings presented in Table 4, about 4 to 1.

The largest net present benefits are in the regions with the greatest electricity savings, the South Atlantic and the Southwest. The large amounts of cooling in these regions are the reason for this result. Since cooling loads tend to be coincident with electric system peak loads, cooling energy savings tend also to save electric capacity, which further increases the value of saved electricity in these regions.

Our cost-benefit analysis excludes the effects of standards on consumer amenity levels, as measured by changes in appliance sales. On this issue, we find that the higher price of more efficient appliances, offset by lower operating expenses, does little to affect national appliance sales. Table 7 summarizes the impacts of NAECA on appliance shipments. For most appliances, the effects are less than 1 percent of total shipments. For water heaters, refrigerators, and freezers, the effect of standards is to increase sales. In the case of freezers, standards increase sales notably. These phenomena result from the increased attractiveness of owning an appliance because of its low total life-cycle cost.

Table 7. Shipments of New Appliances 1990-2015

End Use	Base Case Shipments (millions)	Change in Shipments (millions)	Change in Shipments as a % of Base Case (%)
Heating	122	-0.2	-0.2
Cooling	141	-0.4	-0.3
Water Heat	196	1.5	0.2
Refrigerator	164	0.3	0.2
Freezer	51	1.1	2.2

IMPLICATIONS FOR UTILITIES

In the previous section, we documented the "bottom-line" regional energy and economic impacts of NAECA. In this section, we look in some detail at intermediate outputs of the REM forecasts so we can comment on three issues of relevance for utilities: changes in shipments of air conditioning equipment, changes in fuel choice for water heating, and rebate opportunities for efficiencies beyond those called for by the standards.

Air Conditioner Shipments

The NAECA standards will affect future sales of room air conditioners, central air conditioners, and heat pumps. The precise effects result from a complex interaction of equipment price, consumer preferences, and climatic conditions. The outcome of these changes will have important consequences for electric utilities with summer peaks. In addition, since electric heating is often an important opportunity for load growth, heat pump shipments are reported separately.

Table 8 summarizes changes in air conditioning appliance shipments by federal region. The table presents total shipments in the base case from 1990 to 2015 as a basis for evaluating the percentage changes in these shipments resulting from NAECA.

The most dramatic changes, on a percentage basis, occur in the Northwest. The relatively low cooling loads and energy prices of the Northwest mean that fewer consumers will be able to justify the higher purchase price of air conditioning equipment. Percentages can be misleading, however, because base case shipments to this region are already among the lowest in the country (for the same reasons).

Heat pump shipments are lower under NAECA for most regions of the country. In general, changes in heat pump shipments tend to follow those of central air conditioners. The effects, on a percentage basis, are typically smaller than those for central air conditioners because the use of heat pumps in the heating season tends to mitigate the higher first cost of cooling equipment. Reduced central air conditioner and heat pump sales tend to be offset by increases in room air conditioner sales. The net effect appears to be a slight reduction (0.2%) in air conditioning equipment sales (see Table 8 in the previous section).

Table 8. Changes in Air Conditioner Shipments 1990 to 2015

Federal Region	Room Air Base Case (millions)	Room Air Percent Change (%)	Central Air Base Case (millions)	Central Air Percent Change (%)	Heat Pumps Base Case (millions)	Heat Pumps Percent Change (%)
New England	3.96	0.2	0.30	-13.2	0.34	-5.9
New York/New Jersey	7.48	2.0	2.46	-3.0	0.47	0.0
Mid Atlantic	6.68	2.8	4.51	-2.2	2.08	1.5
South Atlantic	14.13	1.4	15.42	0.1	6.00	-2.3
Midwest	11.42	3.1	8.52	-4.5	1.77	-2.8
Southwest	8.46	1.1	14.35	0.0	1.03	-0.8
Central	3.23	2.0	4.33	-1.0	0.35	0.3
North Central	2.08	3.7	1.9	-14.9	0.42	-9.8
West	5.67	3.1	10.44	-0.3	1.68	-4.2
Northwest	1.10	-20.4	0.33	-30.8	0.38	-33.9
Total	64.20	1.7	62.54	-1.6	14.06	-2.7

Water Heating Fuel Choice

Table 9 reports on changes in water heating fuel choice resulting from the standards. We find that NAECA will tend to increase shipments of electric water heating equipment, at the expense of other types. The effect is small, increasing total electric water heating equipment sales by 1.5%. Since electricity tends to be more expensive than other fuels for water heating, these increases appear to result from the higher cost of efficient non-electric water heating equipment relative to efficient electric water heating equipment. The result is particularly striking when one considers that more electric water heaters shipped in 1986 would fail to meet the NAECA standard than would water heaters using other fuels (see Table 1). The greater reduction in the life-cycle cost of electric water heaters (despite their higher first cost) makes them more competitive with gas.

Table 9. Changes in Water Heater Fuel Choice 1990-2015

Federal Region	Electric		Natural Gas		Oil		Other	
	Base Case (millions)	Percent Change (%)	Base Case (millions)	Percent Change (%)	Base Case (millions)	Percent Change (%)	Base Case (millions)	Percent Change (%)
New England	3.04	3.3	3.12	-0.0	4.03	-2.4	0.32	-1.3
New York/New Jersey	2.98	3.2	5.85	1.0	6.38	-2.4	-0.48	-1.0
Mid Atlantic	9.51	1.4	6.08	-0.5	2.63	-3.4	0.63	-2.1
South Atlantic	30.70	0.4	6.11	-1.3	0.19	-3.6	1.63	-2.3
Midwest	13.45	1.6	18.07	-0.9	0.46	-3.5	1.44	-2.2
Southwest	8.62	2.4	13.93	-1.2	0.03	-3.4	2.25	-1.9
Central	3.32	1.7	4.61	-0.8	0.03	-3.6	1.11	-1.7
North Central	2.98	1.9	4.58	-1.0	0.04	-2.7	0.37	-2.4
West	7.99	3.5	19.72	-1.3	0.05	-3.8	1.65	-1.5
Northwest	7.20	0.3	0.87	-0.7	0.22	-5.0	0.15	-3.3
Total	89.78	1.5	81.92	-0.9	14.06	-2.7	10.02	-1.9

Rebate Opportunities

The engineering-economic appliance and fuel choice data base and model structure in REM can also help utilities and state agencies considering programs that offer rebates for even more efficient appliances. We discuss the prospects for rebates only for refrigerators and central air conditioners because they define extremes in the range of load shape impacts available from more efficient appliances. Efficient refrigerators reduce loads in all hours; efficient central air conditioners tend to reduce loads only during utility peak hours.

As described earlier, REM bases its forecasts of future appliance and fuel choices on the notion of a market discount rate. Market discount rates are calculated by evaluating historic appliance purchase decisions in conjunction with historic energy prices. The market discount rate is then used to project the purchaser's future appliance efficiency decisions.

For central air conditioners, we find that historic purchasing decisions imply a relatively low discount rate (15-20%). In other words, features that save energy are valued highly relative to increases in first cost of such appliances. This result together with the engineering relationship between increases in first cost and energy use for central air conditioners suggests that rebates of about 50-100 $/unit will be sufficient to induce high participation rates.

The caveat for central air conditioner rebates is that, at the upper end of the spectrum of efficiency, the technologies available for efficiency improvement have very different peak demand impacts. On the one hand, variable speed drives save energy, but little peak demand. On the other hand, high- efficiency, single-speed compressors save both energy and peak demand. Consequently, rebates designed to capture the substantial peak demand benefits available from highly efficient central air conditioners should distinguish between the means by which the efficiency gain is accomplished.

For refrigerators, we find that market discount rates are high (80-100%). Future energy savings play only a very small role in the purchaser's mind. For utilities to obtain the base-load energy savings available from rebates for refrigerators, the rebate must essentially offset the entire increase in first cost of each successive level of efficiency.

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