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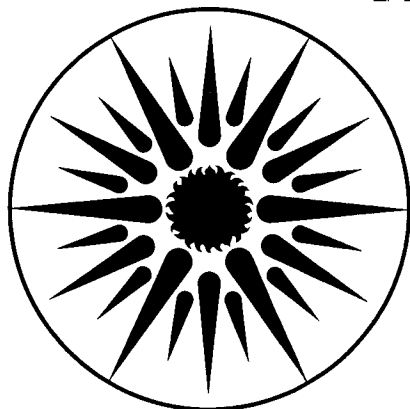
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EFFICIENCY STANDARDS

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and H. Ruderman

July 1984

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**ANALYSIS OF FEDERAL APPLIANCE ENERGY EFFICIENCY STANDARDS\***

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**July 1984**

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## ABSTRACT

This paper treats the major issues involved in the assessment of the economic impacts of appliance efficiency standards on consumers. The discussion summarizes the method used in analyzing standards, many of the key issues raised by the standards, the most important findings and results of the analysis, and some comments on selected issues.

The basic conclusion of the paper is that the analysis to date supports a finding that the net results of energy efficiency standards on residential appliances and space conditioning equipment are favorable from the perspective of energy and economic savings to consumers and to the nation as a whole. Although recognizing key sources of uncertainty, the authors note that a range of analyses performed by the study team using different assumptions have shown beneficial impacts of standards.

In spite of the fact that the U.S. Department of Energy (DOE) has issued a final rulemaking that requires no standards on residential appliances, the policy issues are still alive. A court case is pending against DOE on this rulemaking, and it is not known how the case will be resolved. Further, the legislation on which the rulemaking is based requires a reanalysis that could lead to standards within five years. Thus, the issues raised by this paper need to be carefully considered over the next several years as the reanalysis proceeds.

## ANALYSIS OF FEDERAL APPLIANCE ENERGY EFFICIENCY STANDARDS

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### INTRODUCTION

In 1978, Congress required the U.S. Department of Energy to develop and promulgate minimum energy efficiency standards for all major residential appliances and space conditioning equipment. During the Carter Administration, the Department of Energy (DOE) issued a notice of proposed rulemaking that gave notice of its intent to promulgate standards. After the Reagan Administration came into office, a new notice of proposed rulemaking was issued in which no standards were proposed. In August, 1983, the DOE made final its decision to issue no standards in a notice of final rulemaking for eight products.

While this may be thought to be the end of a major policy initiative to reduce energy use in residential equipment (which, taken together, use 16 quadrillion Btu per year or about 23 percent of total U.S. energy consumption), the policy is not yet dead for at least two reasons. First, a court suit filed by the Natural Resources Defense Council and other parties is contesting the DOE decision. Several state governments have entered the court proceedings, out of concern that the DOE ruling may invalidate their efforts to mandate minimum efficiency standards because of the language of the legislation, which provides for federal preemption of state standards. Second, the legislation required a reanalysis of the standards with the view of updating them within five years. Thus, under existing legislation, the federal government may decide within five years to promulgate standards.

This paper presents the results of the economic study of impacts of appliance energy efficiency standards, with particular emphasis on the effects on consumers. The significance of this paper--from the standpoint of possible policy action by the federal government--is that the results being presented have been obtained by the research team that has been supporting the DOE analysis continuously since 1979 and which is now responsible for leading the reanalysis effort.

## METHOD OF APPROACH

The basic approach to evaluating impacts of appliance standards is to estimate the differences in impacts between a base-case forecast (i.e., the expected energy efficiency and other parameters when no federal standards are promulgated) and a standards case forecast, in which the energy efficiency and related variables are determined or influenced by the federal policy. If the efficiency of new appliances, appliance usage, first costs, and operating costs were precisely known over the time horizon of the study (as they cannot be) for both the base case and the standards case, then the direct economic impact of the standards on appliance purchasers would also be exactly known. The impacts would be the difference between the two cases.

Figure 1 presents an overview of the research methodology. The general categories of data required are shown at the left: socioeconomic data for energy forecasting (e.g., projections of housing start); economic data (demand elasticities); economic forecasts (energy prices); and the economics of appliance efficiency improvements. The model used to project the base and standards cases is a version of the Oak Ridge Residential Energy Demand Forecasting Model.<sup>1</sup> Over the past several years, this model has been substantially improved at LBL for the purpose of analyzing standards.<sup>2</sup>

The results of the analysis, shown at the right in Figure 1, provide direct measures of the impact of standards on appliance purchasers and the nation: change in energy use as a function of time, change in the life-cycle cost of the appliance over time, net present benefit or cost of the standards to the consumer, and changes in shipments of products resulting from the standards. Impacts on manufacturers and on different classes of consumers cannot be evaluated directly from the models and data. However, estimates of these impacts have been obtained from the changes in life-cycle costs of the appliances and from additional data and models pertaining to the economics of the manufacturers and of different classes of consumers. Additional information on these two topics is presented in the DOE Economic Analysis Document.<sup>3</sup>

The analysis requires a great deal of data disaggregated by appliance. Only from such disaggregations can we estimate the retirement rates of individual appliances, the direct- and cross-price elasticities for energy by end use, and the cost of efficiency improvements for each appliance.

## KEY ISSUES

Some of the most important issues in the analysis of appliance efficiency standards involve the following questions:

- To what extent will market forces result in significant improvements in the energy efficiency of residential appliances without federal policies such as mandatory energy efficiency standards?
- What are the likely impacts of standards on consumers, manufacturers, other interest groups, and the national economy?
- How will the impacts on appliance purchasers vary among different income groups and among different regions of the country?
- How do the estimated impacts vary with different products and why? Are there different rationales for a government policy to be made for different appliances? If so, on what basis?
- What are the most important sources of uncertainty in estimates of the impacts of standards? How can such uncertainty be dealt with to improve the quality of public policy analyses?
- If standards are promulgated, might their effects be reduced or even eliminated by increased usage of more efficient products? What is the implication of such a "usage elasticity" on the analysis of policy?
- How does the interaction among end uses affect estimates of energy savings and economic impacts of appliance standards?
- How accurate are the underlying data on the cost of efficiency improvements for appliances? How can one account for technology improvements that will take place in the future?



## RESULTS

The analysis projected that the standards considered by DOE could result in reductions in residential energy use ranging between 11 quads and 19 quads over a 20-year time horizon. The most likely reduction in energy use was estimated to be 13 to 15 quads over the 20-year period. While this amounts to only 4.6 percent of aggregate residential energy demand over the 20 year time frame, the impact on demand *growth* is dramatic. Figure 2 shows projected energy demand with and without standards.

If the standards originally contemplated by DOE (designed to avoid requiring new, unproven technology and to be below the life-cycle cost minimums at current fuel prices) were introduced in 1986, overall residential energy demand growth would be reduced to zero for a decade. If the 1986 standards were combined with periodic updates as provided for in the legislation, the process could lead to level residential energy demand for two decades or longer.

The total economic impact on consumers is significant and positive. Even without periodic updates to and tightening of the minimum efficiency standards, energy demand is reduced by almost 0.5 quads per year within six or seven years of implementation. Assuming a cost to the consumer of \$6 per million Btu, this is a reduction in fuel costs of \$3 billion per year. The estimated net present benefit of minimum efficiency standards (fuel cost savings discounted at ten percent real minus increased first cost of more efficient appliances) is \$12 billion dollars, with a range between \$10 billion and \$16 billion.

Figure 3 shows the estimated energy savings and net economic benefits of the standards for the six products that consume the largest amount of energy. Water heaters and refrigerators yield the greatest potential energy savings. The net benefits are also greatest for these two products. Thus, the analysis to date suggests that, if standards are appropriate, the two products for which standards are most effective are water heaters and refrigerators. Room air conditioners and freezers also yield high net benefits per unit of energy saved.

We estimate standards have relatively little impact on furnaces. The major reason is that DOE originally proposed relatively low standards that would give little improvement in energy efficiency over that expected without standards. Since then, condensing furnaces with efficiencies substantially higher than these levels have been introduced and are selling well. Thus, a tighter minimum standard for furnaces could show substantial energy savings.

Central air conditioners show significant energy savings; however, the net benefits are not nearly so great per dollar invested or unit energy savings as for other products. This is because we assumed that measures to reduce energy use are added incrementally to existing central air conditioner models, making efficiency improvements relatively expensive. If a full redesign of central air conditioners and other products were evaluated, the cost of efficiency improvements could conceivably be different from and presumably lower than costs associated with adding efficiency measures to existing designs.

Figure 4 shows the projected annual energy savings for several of the most important variables for which sensitivity analyses were performed. The reference or base case assumes a real price escalation of approximately 4.4 percent per year for natural gas and 1.0 percent per year for electricity. The low energy price forecast assumes real energy price increases of 1.6 percent per year for natural gas and no increase and electricity. The high energy price forecast is for annual real price increases of 6.1 percent and 2.0 percent. The forecast labeled "historic efficiency" does not consider energy prices explicitly; rather, it assumes that the efficiency improvements for each appliance of the past decade continue into the future. The the high and low market share elasticity cases make different assumptions about market response to higher energy prices in terms of the energy efficiency of new product purchases. The results of research conducted to date<sup>4</sup> suggest that the reference case with a constant discount rate may best approximate reality.

#### COMMENTS ON OTHER KEY ISSUES

In the foregoing discussion, we have summarized some of the most important quantitative findings of our research on appliance efficiency standards to date. It is also useful to make note of some of the issues raised earlier in this paper. (For a much more extended discussion of these issues, the reader is referred to a paper in preparation by Levine, *et. al.*<sup>5</sup>)

##### *Will the market if left alone achieve substantially higher energy efficiencies?*

The research on this question is summarized in reference 4. The results of this analysis indicate that the market does bring about more efficient appliances largely in response to higher energy prices and advancing technology, but that these efficiencies appear to lag significantly behind the life-cycle cost minimum. Quantitatively, this lag is sufficiently great that substantial energy and economic savings to the consumer and to the nation are lost if only market forces are relied upon. In short, the market for energy efficiency in residential equipment appears to be operating poorly, for a number of reasons. (Many of these reasons are discussed in a forthcoming paper by Ruderman, *et. al.*<sup>6</sup>)

*How does the impact of the standards vary with different groups of consumers and among different regions of the nation?*

Two different groups have studied the effects of appliance standards on low income groups. Berkovec, *et. al.* have concluded that the low income groups will benefit from the standards, primarily because the purchase of more efficient equipment will result in significant net savings to all groups.<sup>7</sup> The DOE Economic Analysis Document presents an analysis, based on an estimate of the Gini coefficient, that the standards have a progressive effect on income distribution.<sup>3</sup>

Neither of these analyses is, in our judgment, complete. The effects of higher first costs of more efficient equipment on purchases of appliances by families of low income is unknown. Also, the effect of standards on the market for used residential appliances—a market widely used by low income groups—is not known. Thus, the overall effects of standards on the lower income groups is not well characterized.

The effects of the standards on the higher income groups can be inferred to be favorable from the overall analysis of consumer impacts presented in this paper.

The regional impacts of standards has been studied. This is primarily an issue for weather sensitive products such as heating and cooling equipment. It is also important in regions in which energy prices are significantly different from the national average. The analysis has shown that there are regions which would not benefit as much as the average or would suffer some net economic losses as a result of the standards for some products.<sup>8</sup> There are, in our judgment, at least two different responses to this problem. One may argue that a relatively small percentage of consumers ought to bear small losses for the benefit of the majority of consumers. Alternatively, one might suggest that regional standards be implemented, where the number of regions is sufficiently small that standards can be implemented without causing large administrative complexity or interfering with manufacturers' distribution chains. We do not, at this point, take a position on either of these alternative views, as we believe that further analysis can better define the implications of the views.

*What are the largest sources of uncertainty in the analysis?*

We have performed a large number of sensitivity analyses on the impacts of standards. Virtually all of the sensitivity studies show a net positive effect of the original DOE standards on consumers. Most of the sensitivity analyses also revealed that many of DOE's assumptions in the standards analysis were conservative (i.e., tended to underestimate potential benefits of the standards).

In spite of the results of the sensitivity analyses, there remains at least one area of considerable uncertainty that can have large effects on the results of the analysis. The cost versus efficiency curves (i.e., cost of making improvements in energy efficiency of individual products) is a major driving factor in the overall analysis. If these costs are overestimated, then the analysis overpredicts the magnitude of the energy savings as well as the cost of achieving the standards. If these costs are underestimated, then the energy savings resulting from the standards is likely to be higher than estimated, but the cost of achieving the standard levels will also be higher. Many of the changes in our estimates of impacts of standards over the last several years can be traced to changes in the cost versus efficiency relationships for several products.

An important refinement needed for future analysis is to examine the costs and benefits of standards for each class of a given product (e.g., top mount automatic defrost refrigerator) rather than for the product as a whole. This approach will reduce some of the uncertainty in the aggregation used to establish cost versus efficiency curves for products rather than for product classes, where the data are better known.

There are other important sources of uncertainty as well: the forecast of efficiency choice in the market in the absence of standards is necessarily fraught with uncertainty. Various sources of aggregation bias appear in different parts of the analysis.

There is clearly an important need for a better and more complete characterization of sources, magnitudes, and impacts of different types of uncertainty on the analysis results. Notwithstanding the uncertainties, it is nonetheless important to recognize that the results of a large number of analyses using a wide range of assumptions have given strong support for the findings that appliance energy efficiency standards yield substantial economic benefit to purchasers and users of residential appliances and space conditioning equipment.

*Will the purchase of more efficient equipment cause people to use the equipment more? Could this result in more rather than less energy being used?*

This issue has been raised by several authors. Two of the notable parties are the Regulatory Analysis Review Group of the then Cost of Living Council and Daniel Khazzoom in an article in *The Energy Journal*.<sup>9,10</sup> The basic argument is that consumers who purchase more efficient equipment will observe a reduction in fuel or electricity costs. The consumer will respond to this reduced fuel cost by using the product more in much the same way as a consumer would purchase more of any product (in this case fuel) as the price of the product declines.

The argument is correct in principle. In fact, this phenomenon is accounted for in the forecasting approach used in our analysis. However, it is not reasonable to believe that the increase in energy use would be greater than the savings resulting from the higher energy efficiency as both RARG and Khazzoom maintain. Furthermore, data on short term price elasticities do not support the idea that standards would cause an increase in energy use. (The data are compiled in an LBL internal document available from the author.) A reasonable estimate for those products whose usage varies significantly with the price of energy is that about 30 percent of the potential savings might go to higher usage and the remaining 70 percent actually achieved. This is roughly the fraction of actual savings realized in the analysis results presented in this paper. Furthermore, the 30 percent "lost" savings are presumably the choice of the consumer to enjoy greater amenity than was obtained in the absence of the standards. In this sense, the increased usage might be considered a benefit of standards. This could be a benefit in a time of shortage, as the consumer can give up this extra amenity at relatively low cost.

These comments only touch the surface of this issue. Our main interest in bring up the issue is that we believe it has been treated in a rather misleading manner in the published literature to date. We hope that our comments will in some measure redress this imbalance.

## CONCLUSIONS

Our basic conclusion is that appliance energy-efficiency standards would provide substantial economic and energy savings to both the nation and to the purchasers and users of residential equipment. While we recognize sources of uncertainty in the analysis, we believe that a strong case is made that (1) the market by itself will not achieve cost-effective levels of energy efficiency in residential equipment and (2) standards can achieve this end.

We do not necessarily conclude that standards are the *best* policy to achieve cost-effective efficiencies in residential appliances and space conditioning equipment. However, we do believe that it is a policy which, if implemented, has the greatest likelihood of achieving these goals.

As a result of our work to date and the fact that residential equipment is a very large consumer of energy (more than 20 percent of the national consumption), we believe that the reanalysis of the standards is very important and should be taken seriously in assessing policies to promote the efficient use of energy. We believe that the inability of the residential market to advance very quickly in its investments in energy-efficient products provides a basis for serious consideration of policies to facilitate these needed investments. Appliance efficiency standards represent one viable approach to this goal.

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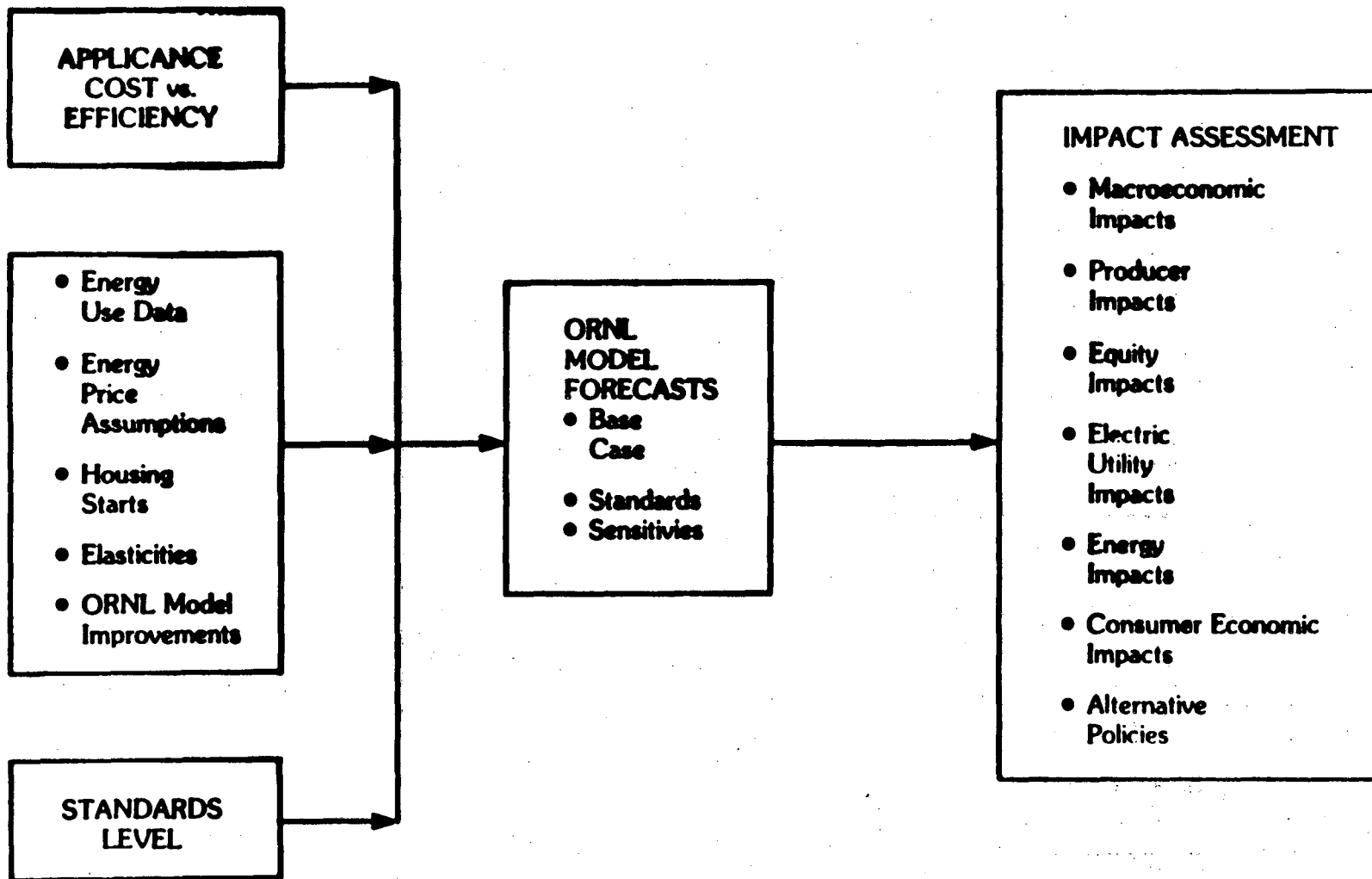


Figure 1. - Research Methodology

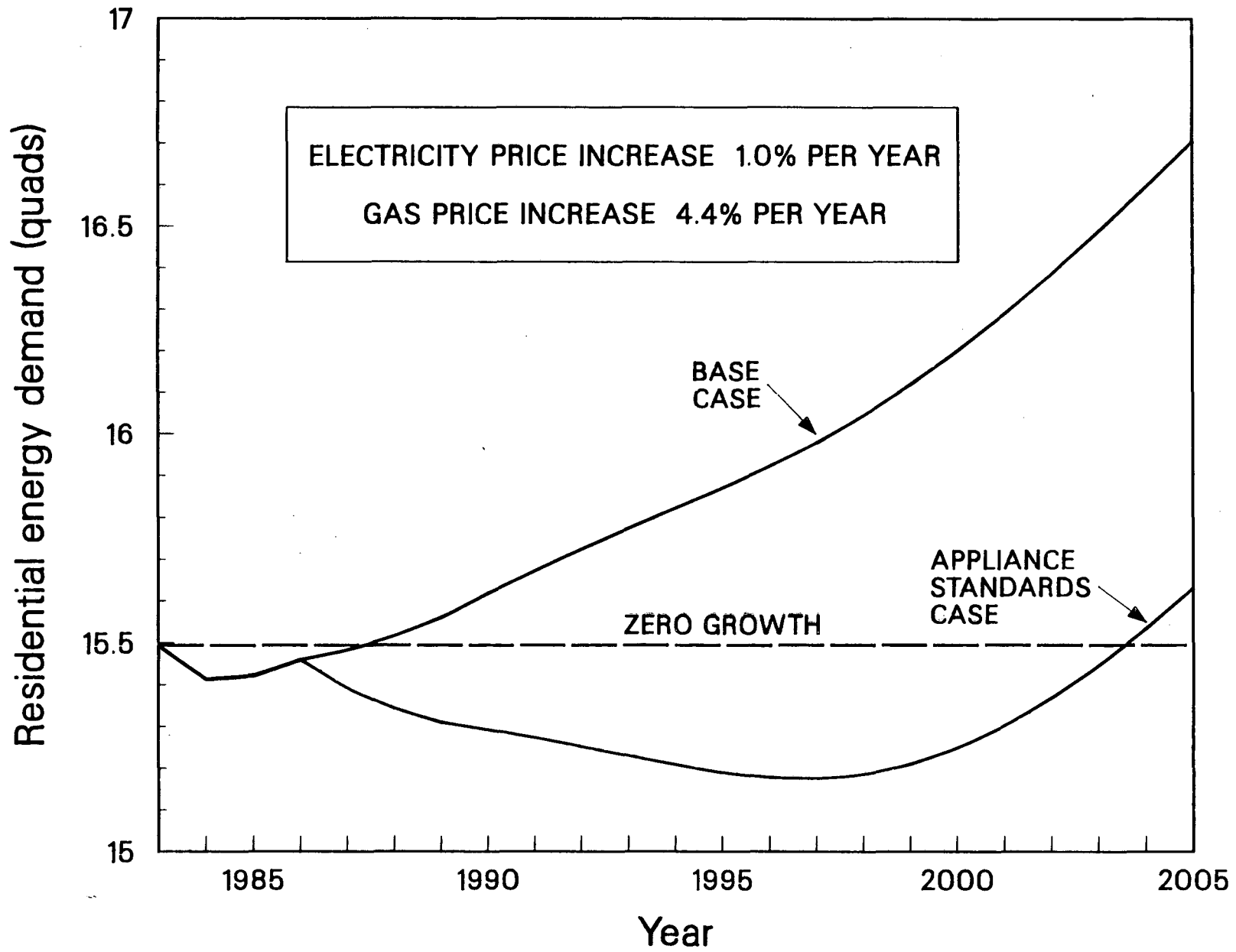
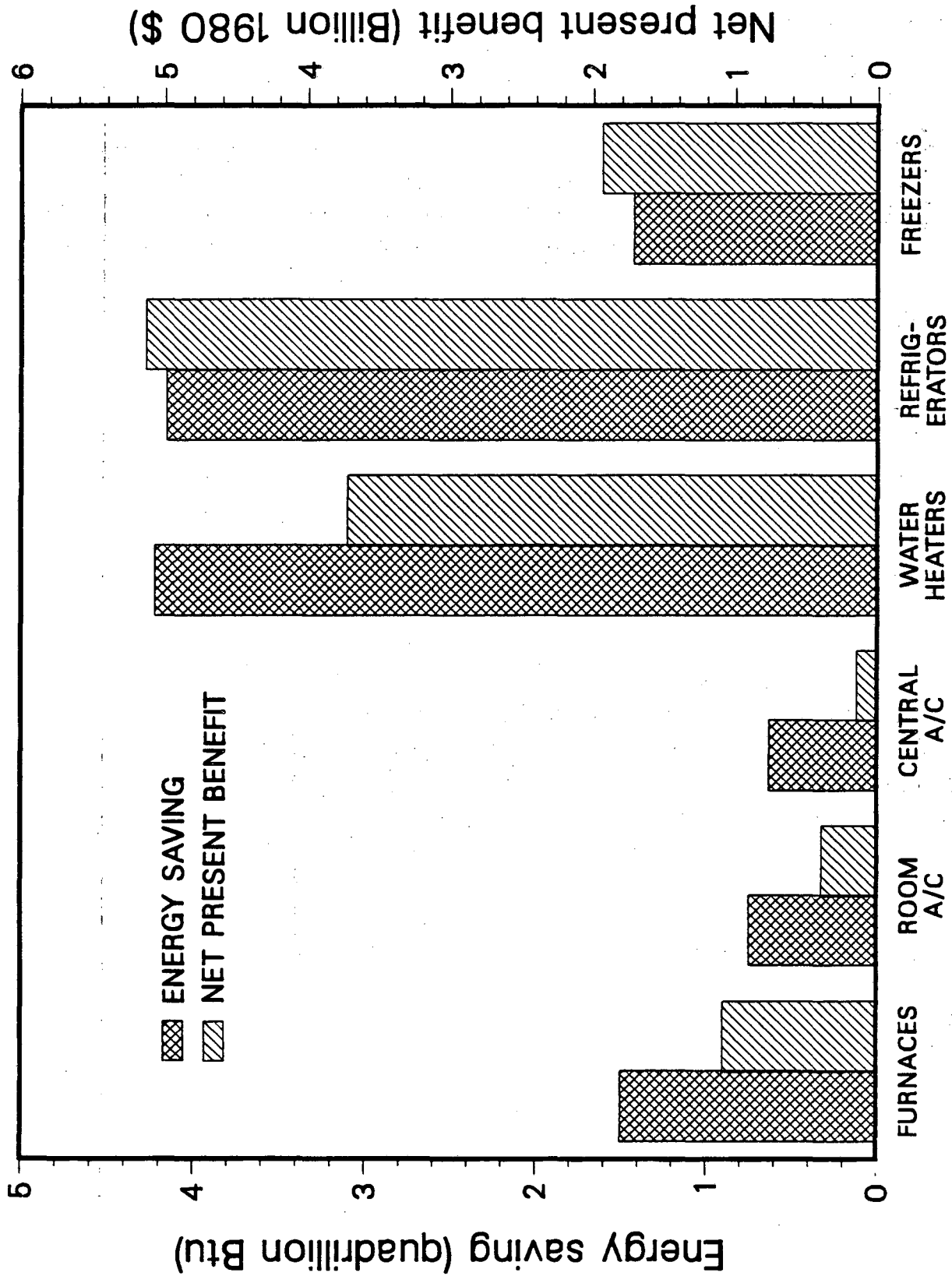


Figure 2. - Residential Energy Demand Forecasts

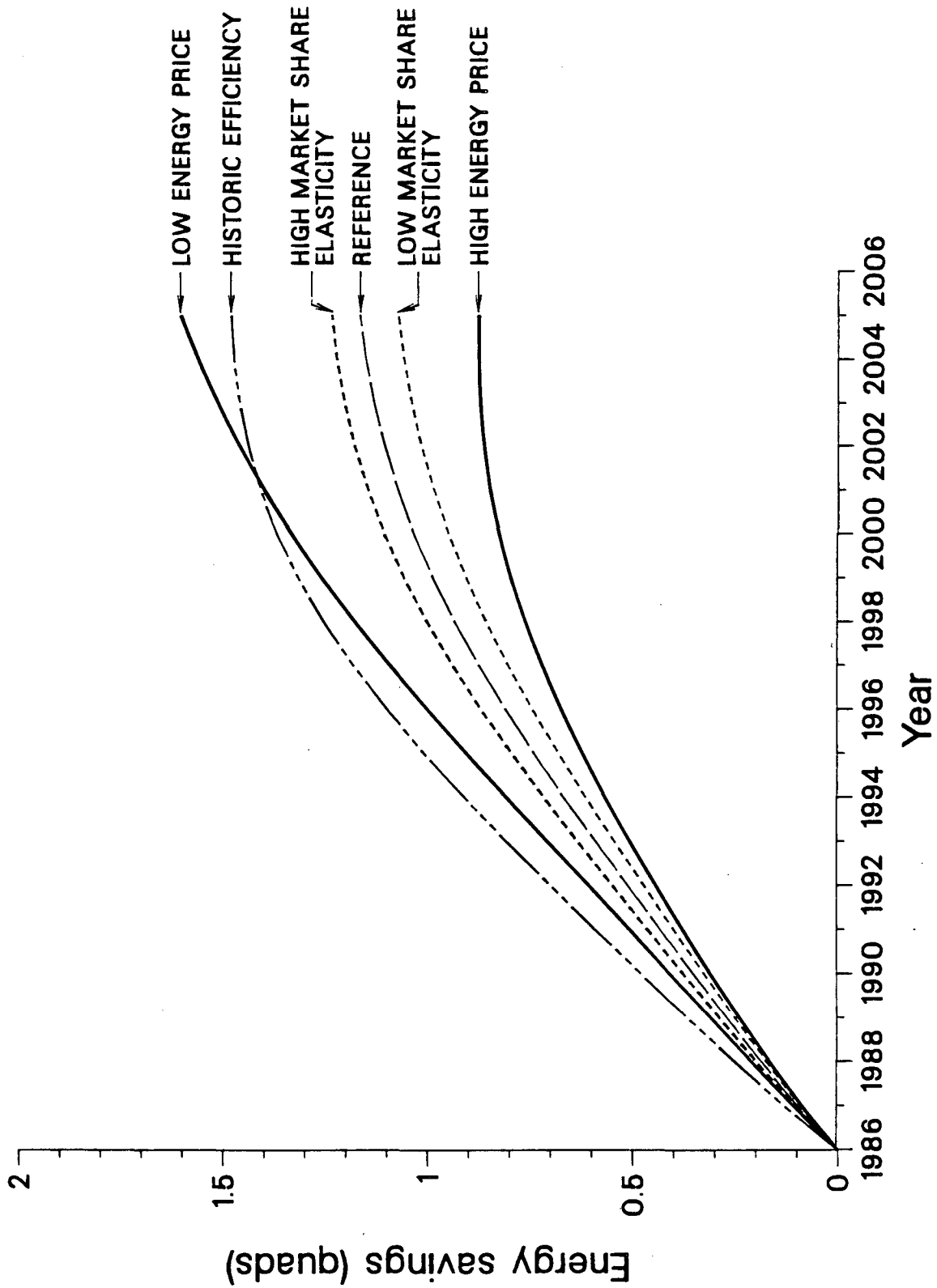


Figure 3. -- Energy Savings and Net Present Benefit of Standards



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Figure 4. - Sensitivity of Energy Savings to Base Case Assumptions



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