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The Impact of Energy Pricing and Discount Rate Policies on Energy Conservation in Federal Buildings

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, ***Secretary***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

ABSTRACT

The study investigates how energy conservation projects for federal buildings would be affected by a change in pricing and discount rate policies. It focuses on a move from average market prices of energy to marginal-cost prices and on a change from a 7 percent discount rate to a 10 percent discount rate. Graphical and numerical comparisons of hypothetical cases in selected geographical areas illustrate the expected impact on selection, design and sizing, and priority of energy-saving projects.

ACKNOWLEDGMENTS

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SI CONVERSION

In view of the currently accepted practice of the building industry in the United States, some common U. S. units of measurement have been used in this report. In recognition of the position of the United States as a signatory to the General Conference of Weights and Measures, which gave official status to the metric SI system of units in 1960, appropriate conversion factors have been provided in the table below. The reader interested in making further use of the coherent system of SI units is referred to:

> U. S. Department of Commerce, National Bureau of Standards, The International System of Units (SI), NBS Special Publication 330, 1977 Edition. (Washington, D. C.: U. S. Government Printing Office, 1977.)

Metric Conversion Factors

Length:	1 inch (in) = 25.4 millimeters (mm)
Energy:	1 British thermal unit (Btu) = 1.05506 kilojoules (kj)

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EXECUTIVE SUMMARY

The National Energy Conservation Act of 1978 required the Department of Energy to incorporate marginal energy prices in its methodology and procedures for life-cycle cost analyses of energy systems for federal buildings. In addition, the Energy Security Act of 1980 legislated a change in the discount rate from 10 percent to 7 percent for energy-related projects.

The purpose of this report is to assess the impact on the selection of federal energy conservation and renewable energy projects of 1) average prices versus marginal-cost prices, and 2) a 10 percent discount rate versus a 7 percent discount rate.

The report defines average prices, marginal prices, and discount rates and states briefly their economic meanings in the context of conservation and renewable energy projects. It discusses the economic efficiency arguments in support of marginal-cost pricing. Graphical and numerical comparisons show the differences between the average prices and the preliminary marginal-cost prices estimated by DoE. Unresolved issues regarding the choice between marginal-cost prices and average prices are touched upon.

Hypothetical case studies demonstrate the impact of alternative pricing and discount rate policies on the selection of projects. The evaluation measures are calculated according to the life-cycle methods and procedures prescribed by the Code of Federal Regulations under the

title "Federal Energy Management and Planning Programs". Average prices and preliminary marginal-cost prices of energy come from the 1984 30-year price forecasts of the U.S. Department of Energy. The sample projects are assumed to be located in three DoE energy price regions: the Midwest, the Northwest, and the average of all DoE price regions. The Midwest shows the smallest and the Northwest the greatest difference between average and marginal-cost prices of electricity. The average and marginal-cost prices of oil, natural gas, and coal were projected by DoE to be identical.

The case studies illustrate how energy conservation projects are affected by the pricing and discount rate policies. They compare the net savings of projects which save distillate with those which save electricity at average or marginal-cost prices and show how the design and size of projects change as prices and discount rates are changed. A comparison of savings-to-investment ratios shows how selection among projects changes as prices and discount rates are changed.

The results show that the decision to accept a given electricity project is strengthened by marginal-cost pricing, and the decision is unaffected for projects involving the other types of fuel. Marginal-cost pricing will tend to increase the size of electricity projects or favor more costly designs. Additionally, marginal-cost pricing will tend to increase the priority of electricity-saving projects relative to projects that conserve other types of energy. With a limited budget, marginal-cost pricing of electricity will tend to drive out distillate-saving projects. In regions where the average price of electricity is considerably higher than the average price of other fuels, a change to marginal-cost pricing will increase the existing tendency to favor electricity-saving projects over distillate-saving projects.

A change from the currently required 7 percent discount rate for evaluating federal energy conservation projects to the 10 percent rate governing most other federal projects would offset in part the impact of marginal-cost pricing. In reducing the present value of future energy savings, raising the discount rate tends to make the choice of energy pricing policies somewhat less important. Taken alone, an increase in the discount rate from 7 percent to 10 percent would make fewer energy projects cost effective. An increase in the rate would also mean that a less costly project design or size must be selected to maintain the same degree of cost effectiveness.

1.0 Introduction

1.1 Background

The National Energy Conservation Policy Act (NECPA) of 1978 directed the U.S. Department of Energy (DoE) to provide uniform methodology and procedures for life-cycle cost (LCC) analyses.[1] Federal agencies were directed to use LCC analyses in allocating budgets for conservation and renewable energy projects (henceforth referred to as energy conservation projects) in the more than 400,000 buildings owned and operated by the U.S. Government. The result of this legislation was Subpart A of Part 436 in Title 10 of the Code of Federal Regulations, "Federal Energy Management and Planning Programs; Methodology and Procedures for Life Cycle Cost Analyses" (1979).[2]

The act further directed DoE to develop, as soon as feasible, estimates of current and future marginal costs of the various types of energy and to use these as prices in carrying out economic evaluations. In the interim, average market prices were to be used. From 1979 until the present, DoE has provided average market prices, published annually as Appendices B and C of Subpart A of 10 CFR Part 436.[3] A set of preliminary marginal fuel costs were developed in 1984, but these were not incorporated into the methodology. There are unresolved issues regarding the use of marginal energy costs for making federal energy-related investments.

NECPA did not specify the discount rate to be used for evaluating federal energy conservation projects; therefore, the 10 percent real rate (i.e., not including inflation) required by the Office of Management and Budget (OMB), Circular A-94, automatically applied.(4) The Energy Security Act of 1980 subsequently specified that federal agencies use a 7 percent real rate in evaluating energy conservation and renewable energy projects.(5) This meant that non-energy related building projects were to be evaluated with a 10 percent rate and energy-related projects with a 7 percent rate. This practice also is to be examined.

1.2 Purpose

The purpose of this paper is to assess the impact of alternative pricing and discount rate policies on the selection of energy conservation and renewable energy projects undertaken by the U.S. Government. Specifically, the effect of two alternatives will be evaluated: (1) marginal-cost prices versus average market prices (comparing the 1984 projections of average market prices with the 1984 preliminary marginal-cost prices), and (2) a 10 percent discount rate versus a 7 percent discount rate.

1.3 Organization

The remainder of the paper is organized into four sections. Section 2 defines terms and gives perspective to the problem, explains the significance of alternative pricing policies, and touches on some of the issues related to the choice of pricing policies. It also gives an account of the differences between DoE-estimated marginal-cost prices and average market prices of energy for three selected geographical regions. Section 3 summarizes the basic concepts of discounting and describes the expected direction of impact of a 10 percent versus a 7 percent discount rate. Section 4 describes the data and assumptions, the calculation procedures, and the results of the selected case studies. Section 5 summarizes and concludes the paper.

2.0 Pricing Policy: Average Prices versus Marginal-cost Prices

2.1 Definitions and Perspective

As used here "energy price" refers to the value a federal agency is to assign to a unit of energy for the purpose of evaluating energy-related investment decisions. To be consistent with DoE nomenclature, "average price" is used to refer to the average of the market prices of a designated region, as estimated by DoE and published as part of the LCC methodology and procedures. "Marginal-cost price" refers to the DoE estimate of the average of marginal-cost-based prices. The term "average-cost prices" will refer to prices that are based on average costs to distinguish them from the DoE projected averages of market prices.

Average and marginal costs and prices are central concepts in economic theory. In the most general sense, "average cost" is the total cost of a good or service divided by the number of units produced. "Marginal cost" is the increase in total cost resulting from the production of a one-unit increment of output. Market prices may reflect average costs or marginal costs, or may be established by the supplier according to some other rule or procedure. If market prices of energy reflected the marginal cost of supply, DoE could meet the requirements of NECPA for marginal-cost pricing simply by providing estimates of average market prices, as they have been doing. But if suppliers do not price according to their marginal costs, DoE, in order to comply with NECPA, will have to estimate the marginal cost of supply by region and substitute those estimates for the "average prices" in appendices B & C of the Methodology for Life Cycle Cost Analysis.

2.2 The Significance of Energy Prices

Energy prices are important for federal investment decisions because they guide the amount of resources that federal agencies will allocate both to energy purchases and to efforts to conserve energy and replace nonrenewable energy with renewable sources. The higher the price of one energy source relative to another, the greater the effort to substitute the cheaper source for the more expensive source. The higher the price of energy, the greater will be the effort to conserve energy or replace it with renewable sources. A project to conserve higher-priced energy will receive greater priority than a project to conserve lower-priced energy, other things being the same. Thus, if market prices of energy differ from their marginal costs and if federal agencies are directed to use estimated marginal-cost prices of energy instead of market prices in designing, constructing, operating, and maintaining federal buildings, their decisions regarding the nature, size, and priority of projects will change.

2.3 Marginal-cost Pricing

The interest of Congress in marginal-cost pricing, as expressed in NECPA, stems from the widely accepted view in economic theory that marginal-cost pricing is necessary to elicit an output level that is socially efficient. Price-equal-to-marginal-cost correctly signals the cost to society of producing one unit more of a good or the savings to society of producing one unit less. If the price of a good or service is set greater than its marginal cost, too little of the good or service will be demanded. If the price is less than marginal cost, some people will consume goods and services which cost society more than they are worth to the consumer and too many scarce resources will be devoted to producing those items.

In the case of federal investment in energy conservation and renewable energy, the efficiency argument would hold that if the price of energy is less than its marginal cost, too much energy will be consumed and too little will be spent for conservation and renewable energy. By making its decisions about building design and operation on the basis of energy prices which are below their marginal cost of supply, the Federal Government would make socially inefficient investment decisions.

In the textbook case of a perfectly competitive market, the tendency is towards an equilibrium point at which marginal cost, average cost, and price are all equal: the profit-maximizing firm will expand its output up to the point where the cost of the last unit (the marginal unit) equals the per unit price obtainable for the product in the market, while competitive forces will result in minimum average supply costs. If a producer earns a return above what is required to stay in business, or above what the money invested could earn elsewhere at equal risk, other producers will be induced to enter the market until the price is driven down by competitive forces to where it equals the cost of a one-unit increase in production, including a return on the capital invested, i. e. marginal cost pricing will tend to result naturally.

In the real world, however, there are many forces which may cause a divergence between marginal cost and price. For example, industries that are characterized by high fixed costs may exhibit increasing returns to scale such that average costs decline as production is expanded. This means that marginal cost will be less than average cost. In this situation, a producer selling at a price equal to marginal cost will have unit revenue less than unit cost and total costs will not be covered. These conditions tend to lead naturally towards monopoly by driving weaker competitors out of business, and the remaining producers gain the market power to set prices higher than marginal cost. To protect the public interest in such cases, the government sometimes intervenes to regulate industries with strong natural monopolistic tendencies.

Traditionally, electric utilities have exhibited high fixed costs and increasing returns to scale and, therefore, have been subject to regulation to ensure that pricing policies are "in the public interest." Regulatory authorities attempt to set prices so that no monopoly profits accrue to the utility but that its returns are high enough to attract capital and to guarantee continued service. Regulated prices have usually been based on average cost rather than on marginal cost for the reasons outlined above.

Recent capital shortages, increasing costs of fuel and equipment, and declining load factors, however, have caused marginal costs to exceed average costs in electricity production. These driving forces have led utility companies, regulatory bodies, and policymakers to examine whether the pricing of electricity as traditionally practiced might contribute to an uneconomic growth in demand. They have looked to a pricing structure based on marginal rather than average cost as a means of helping to eliminate possible distortions.(6) The Public Utility Regulatory Policies Act of 1978 (PURPA) under Title I sets standards for the use of marginal-cost pricing "to encourage conservation of energy by electric utilities; the optimization of the efficiency of use of facilities and resources by electric utilities; and equitable rates to electricity consumers."(7) Utility companies are now in the process of developing alternative pricing policies to reflect their marginal costs of supplying electricity, but at this time marginal-cost pricing of electricity is not prevalent.

Prices not only have the purpose of raising money to pay for the cost of the system, they also serve as signals to consumers to adjust their demand. Electricity is demanded in a cycle of peak and off-peak quantities. Since it is to a large extent non-storable, it can be looked at as two separate products sold at essentially the same regulated price. The cost of expanding the system to meet peak demand (i.e., the marginal cost), however, is far greater than the price charged, whereas off-peak electricity is relatively less expensive to provide than is indicated by the price charged. When two products with different costs are priced the same, decisions are made on the basis of incorrect price signals. The average-cost price of peak-load electricity is lower than the production cost, so that consumption is increased beyond the point where the costs of resources and the value of additional consumption are in balance, and too much electricity is consumed. The average-cost price of off-peak electricity is too high, so that too little of it is consumed. Thus, prices based on marginal costs more accurately reflect the cost of resources and result in an economically efficient load and quantity demanded.[6]

In contrast to electricity where wide divergences are estimated between prices now charged and marginal costs of supply, other fuels may have little or no divergences between their market prices and marginal costs. For coal and oil, the Energy Information Adminstration (EIA) estimates identical marginal-cost prices and average market prices, consistent with the conclusion that no single coal or oil firm has a market share large enough to influence prices significantly. For natural gas, as well, marginal-cost prices and average market prices are predicted by EIA to converge since most of the price ceilings imposed by regulation (Natural Gas Policy Act, 1978) are scheduled to be lifted by 1987.[8]

A difference between marginal-cost prices and average prices of electricity--estimated marginal-cost prices being significantly higher than average prices--has implications for government energy conservation programs. Before assessing the impacts, let us review certain issues that have arisen regarding the selection of an energy pricing policy.

2.4 Issues regarding the Choice of Marginal-cost Prices versus Average Prices of Electricity

Since the marginal-cost price of electricity rather than the average price reflects the true cost of expanding electricity consumption, the use of marginal-cost prices rather than average prices for making decisions about federal energy conservation projects would, in theory, produce a socially more efficient use of resources. The conditions that make marginal-cost based prices the better choice are, however, imperfectly realized in practice. Before one can conclude that it is desirable to base federal energy conservation decisions on marginal-cost pricing of energy, certain issues need to be resolved.

One issue is that agencies would be faced with the dilemma of having to make decisions on the basis of prices which--even though they may be more appropriate from a social efficiency standpoint--are not those actually charged by utility companies. As a result, the net savings that are estimated to accrue in a social sense will not have much relevance for the agencies' budgetary calculations.

The estimation of marginal costs presents another difficulty. When one tries to calculate actual marginal costs, problems of interpretation arise as to what is the appropriate marginal cost involved: a) the cost of the short-term variation in production from hour to hour or season to season as demand goes up or down, or b) the long-run marginal cost which includes the cost of an increase in capacity as well as the cost of additional fuel needed to meet new demand. It is inconceivable that for long-run projections, prices can be set to follow the true variation in marginal costs from hour to hour or season to season: an average value must be adopted depending on how the incremental demand for electricity is added to the existing load requirements.

For calculating the preliminary marginal price projections, DoE assumes that demand is spread over the entire time spectrum so that the ratio of peak to average demand remains unchanged. This method of incrementing demand is consistent with the assumption that new demand will follow the same load pattern as existing demand, but it may result in an average marginal price inconsistent with what an individual electric utility company considers to be its marginal cost.

Another issue is the possible divergence between social and private marginal costs, such as will arise if the incremental cost to society of adding one more unit of output does not correspond to the incremental cost incurred by producers. Pollution costs, for instance, might cause a divergence if decisionmakers do not include in their marginal costs the cost of pollution to society.

Theoretically, the divergence between private and social marginal costs can be corrected by imposing taxes or controls or both. This "internalizes" the costs of pollution, which will then be taken into account when decisionmakers determine their level of output. To achieve an optimal output level, private marginal costs and social marginal costs must be equal. There are, however, a number of practical problems associated with determining the optimal levels of pollution and thus of taxation and control, and there is an ongoing discussion as to how external costs can properly be internalized.[1]

The question is whether the energy price estimation procedures should and can adequately take externalities into account. The DoE preliminary estimates of marginal-cost prices were the same as average prices for all energy sources other than electricity. Implicit in this is the assumption either that existing taxes adequately account for externalities or that externalities not accounted for by taxes are not to be included in the marginal-cost prices to be used in making federal energy-related investments.

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[1] See for example, "A Framework for Marginal Cost-based Time-differentiated Pricing in the United States", a report prepared by National Research Associates, Inc., New York, February 1977 (6), and "Equity, Efficiency, and Sulfur Emissions Reductions," by Carl Pechman in Public Utilities Fortnightly, Vol. 115, No. 10, May 1985 (9), for contrasting views about the internalization of pollution costs in the U.S.

DoE in the past has addressed the problem of externalities. The Notices of Proposed Rulemaking to amend Subpart A of Part 436, 10 CFR, on "Methodology and Procedures for Life-Cycle Cost Analyses" originally proposed to exclude "the effects of price controls, taxes and subsidies relating only to energy" from the working definition of marginal fuel costs. Similarly, DoE initially considered an oil import premium which was to internalize the external costs associated with the importation of an additional barrel of oil. On further evaluation, however, Doe implemented neither of these suggested changes.[10]

An additional issue arises from the expected consequence of replacing the DoE average price estimates with DoE estimates of marginal costs, namely the increased conservation of electricity. As will be shown in section 4, this effect will likely mean less conservation of oil and other energy types unless additional total federal funds for conservation are made available. This is an issue because the original focus of NECPA was on conserving oil.

2.5 Comparison of DoE's Projections of Average Energy Prices and Preliminary Marginal-cost Prices

The following comparisons express the differences between marginal-cost prices and average prices in percentages and in absolute values to show the magnitude of a change in pricing policy and to provide a basis for the case studies in section 4. Compared are the prices of commercial electricity and commercial distillate. Electricity is the only fuel type for which DoE projections show a marked difference between marginal-cost price and average price. Distillate is an example of a fuel type for which marginal-cost price and average price are projected to be the same. The reason for focusing on the distillate price is that, as a consequence of the 1973 oil shock, legislated energy conservation programs emphasize oil conservation. The prices of other fossil fuels (gas, coal) are expected to closely track the price of distillate and are not graphed separately. To make clear that the average and the marginal-cost price of distillate are identical, the price of distillate will be refered to as "average/marginal price" in the following comparisons and case studies.

2.5.1 Comparison of Average Prices and Marginal-cost Prices of Electricity

DoE's projected marginal-cost electricity prices for 1985-86 are on average across the nation about 30 percent higher than average electricity prices, and the difference increases about fourfold by early in the next century. This is evident from figure 1 which shows the percentage difference between marginal-cost prices and average prices of electricity in the industrial, commercial, and residential sectors, based on projections by DoE for the country as a whole.

Figure 2 shows the percentage difference between the projected marginal-cost price of electricity and the corresponding average price broken out for two regions: the Midwest and the Northwest. For

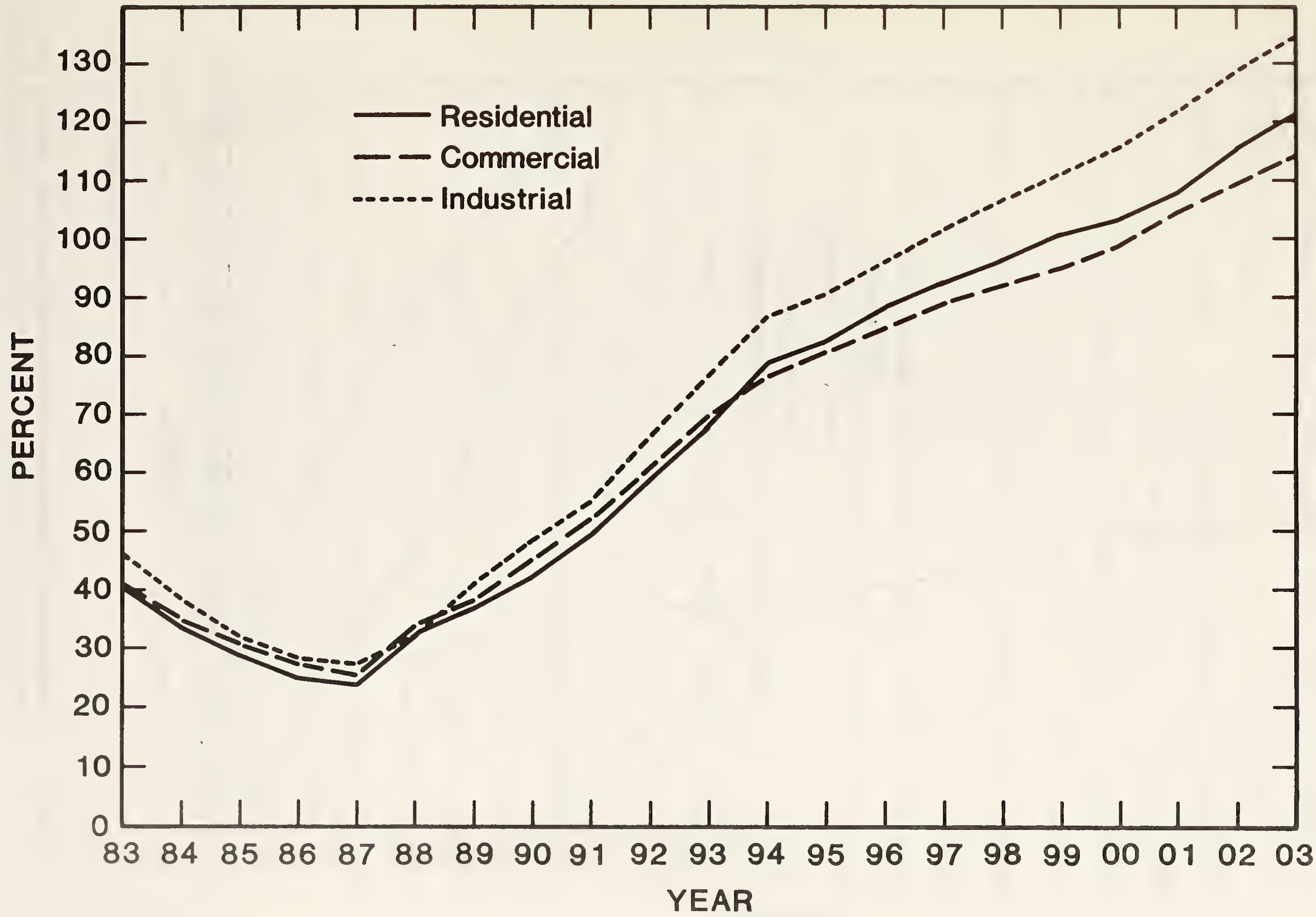


Figure 1. Percentage Differences between Marginal-cost Prices and Average Prices of Electricity - U. S. Average

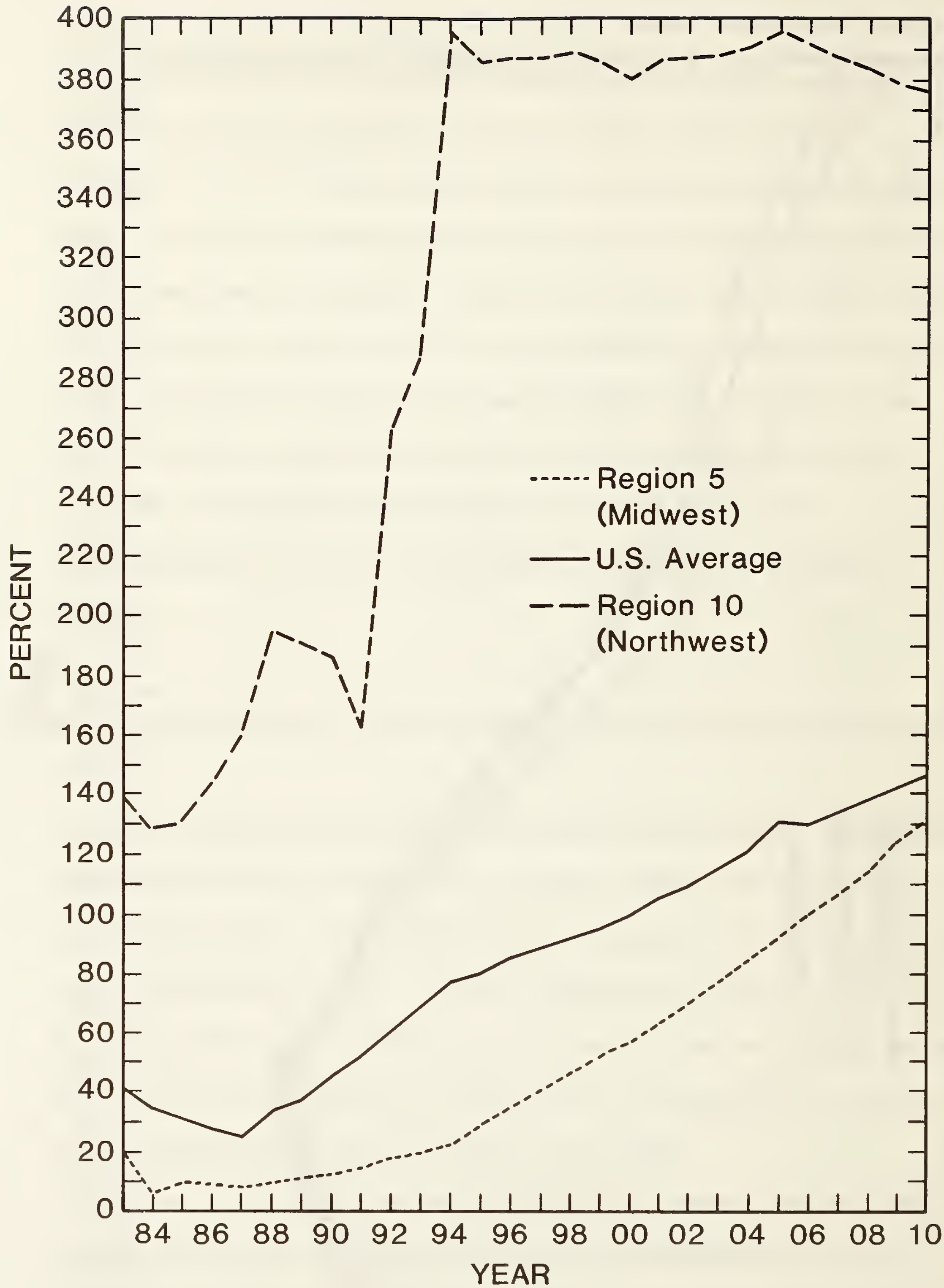
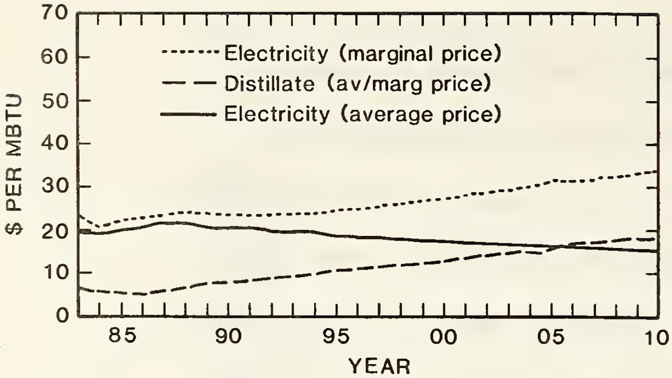


Figure 2. Percentage Differences between Marginal-cost Prices and Average Prices of Commercial Electricity - Selected Regions

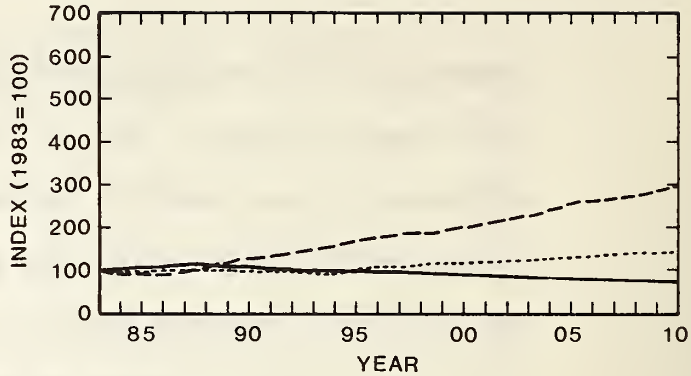
comparison, the percentage difference for the nation as a whole is also shown in figure 2. For the Midwest region, the percentage difference is less than for the country as a whole, but nevertheless is projected to be more than 100 percent by the turn of the century. The difference increases because, as figure 3a shows, in the Midwest region the projected average price of electricity (constant $) decreases from about $20 to $14 over the forecasting period, whereas the projected marginal-cost price increases from about $23 to about $33 (constant $). A similar relationship exists between projected U.S. marginal-cost prices and average prices of electricity, as can be seen from figure 3b.

For the Northwest region, the percentage difference is substantially greater than for the country as a whole. Figure 2 shows the projected marginal-cost price to be 130 to 140 percent greater than the average price in 1985-86, increasing to almost 400 percent greater by the mid-1990's, and maintaining this high percentage differential into the first decade of the next century. This large difference is explained by the fact that marginal costs are dominated by the high capital costs of that region's nuclear plants, which will determine marginal-costs in the late 1980's, while the average prices reflect the relatively inexpensive hydroelectric power. As figure 3c shows, the large gap between projected marginal-cost and average prices in the Northwest results from the large projected rise in the marginal-cost price rather than from any projected decrease in the average price.

Midwest

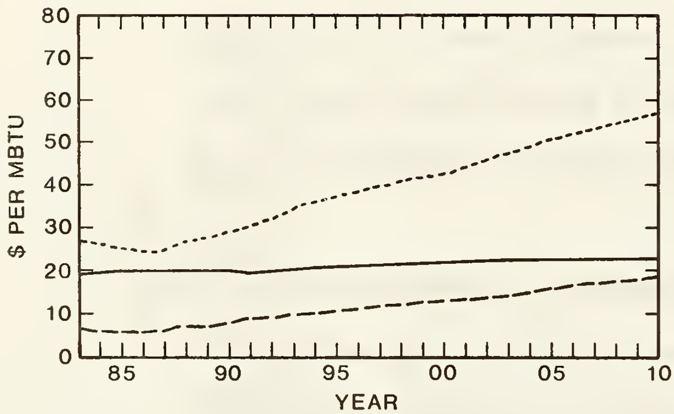


3a

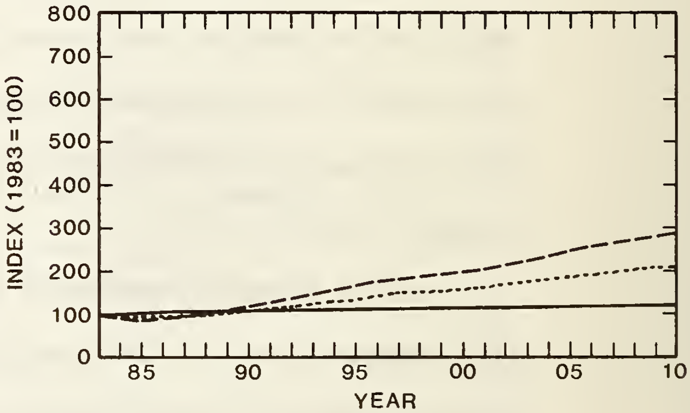


4a

U.S. Average

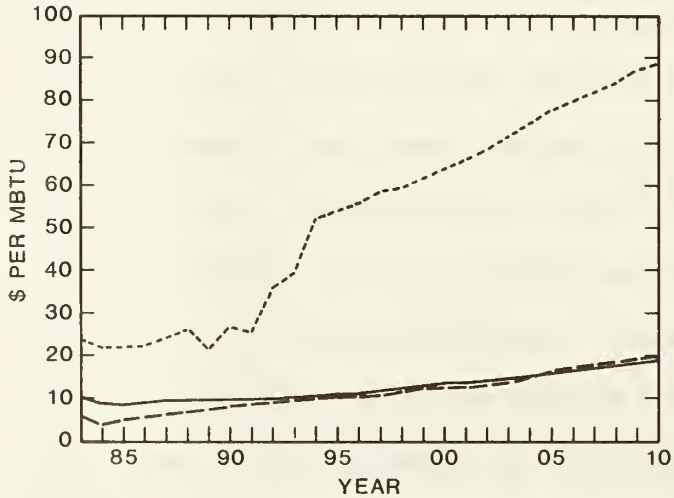


3b

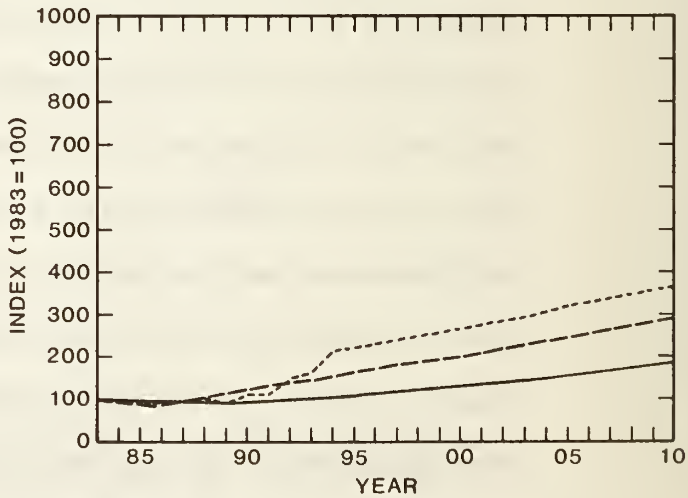


4b

Northwest



3c



4c

Figure 3. Average and Marginal-cost Prices in Constant $/MBtu Electricity and Distillate

Figure 4. Price Indices Electricity and Distillate

2.5.2 Comparison of Electricity Prices with Distillate Prices

Figures 3a to 3c show the average and marginal-cost prices for electricity and distillate in constant dollars per million Btu. Figures 4a to 4c show the same prices converted to indices to facilitate comparison of future trends. There are two curves for electricity prices but each figure has only one curve for distillate, since average and marginal-cost prices of distillate are projected to be the same.

For the Midwest, the average/marginal price of distillate is projected to triple by the end of the projection period, the average price of electricity to decline slightly, and the marginal-cost price of electricity to rise by about 50 percent. As figure 3a shows, the initial prices of electricity are higher than the initial price of distillate. DoE projects the price of distillate to increase from \$6.22 to \$18.22 over the 25-year period, the average price of electricity to decline from \$19.77 to \$14.43, and the marginal-cost price of electricity to increase from \$23.57 to \$33.23. The result is that by the year 2005 the average price of electricity in the Midwest is projected to be only slightly higher than that of distillate despite the rapid rise of distillate prices. In contrast, the marginal-cost price of electricity remains substantially above the price of distillate throughout the period, favoring electricity conservation projects over distillate projects.[1]

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[1]The price data are based on delivery at the periphery of the building and are not adjusted for differences in plant or equipment efficiencies which can offset the relative costs of energy consumed. Therefore, the price comparisons suggest tendencies for preference of one fuel type over another but do not indicate precisely which type is most economic for a given use.

Figures 3b and 4b allow a similar comparison for the U.S. as a whole. The main difference for the U.S., as compared with the Midwest, is that the average price of electricity is projected to increase slightly, rather than decline, while the marginal-cost price is projected to double. The result is that both average and marginal-cost prices of electricity remain above the distillate price throughout the projection period despite the more rapid rise in the distillate price; the gap widens between electricity and distillate's marginal-cost prices and narrows between their average prices.

For the Northwest, figure 4c shows about the same trend in the distillate price projection as for the Midwest and the U.S. as a whole, but both average and marginal-cost prices of electricity rise much more. Figure 3c shows, however, that the initial average electricity price in the Northwest is about half what it is in the Midwest and the U.S. as a whole. In the Northwest, the average electricity price tracks the average/marginal price of distillate very closely after about 1993. The initial marginal-cost price of electricity in the Northwest is nearly as high as for the nation as a whole and its projected rate of increase is even higher. As a result, the gaps between marginal-cost electricity price and distillate price, and between marginal-cost electricity price and average electricity price become greatest in this region.

Figure 5 depicts the difference between electricity prices and distillate prices for the two pricing policies. It shows the percentage difference between the average electricity price and the distillate price (solid lines), and the percentage difference between the marginal-cost electricity price and the distillate price (dashed lines). The difference

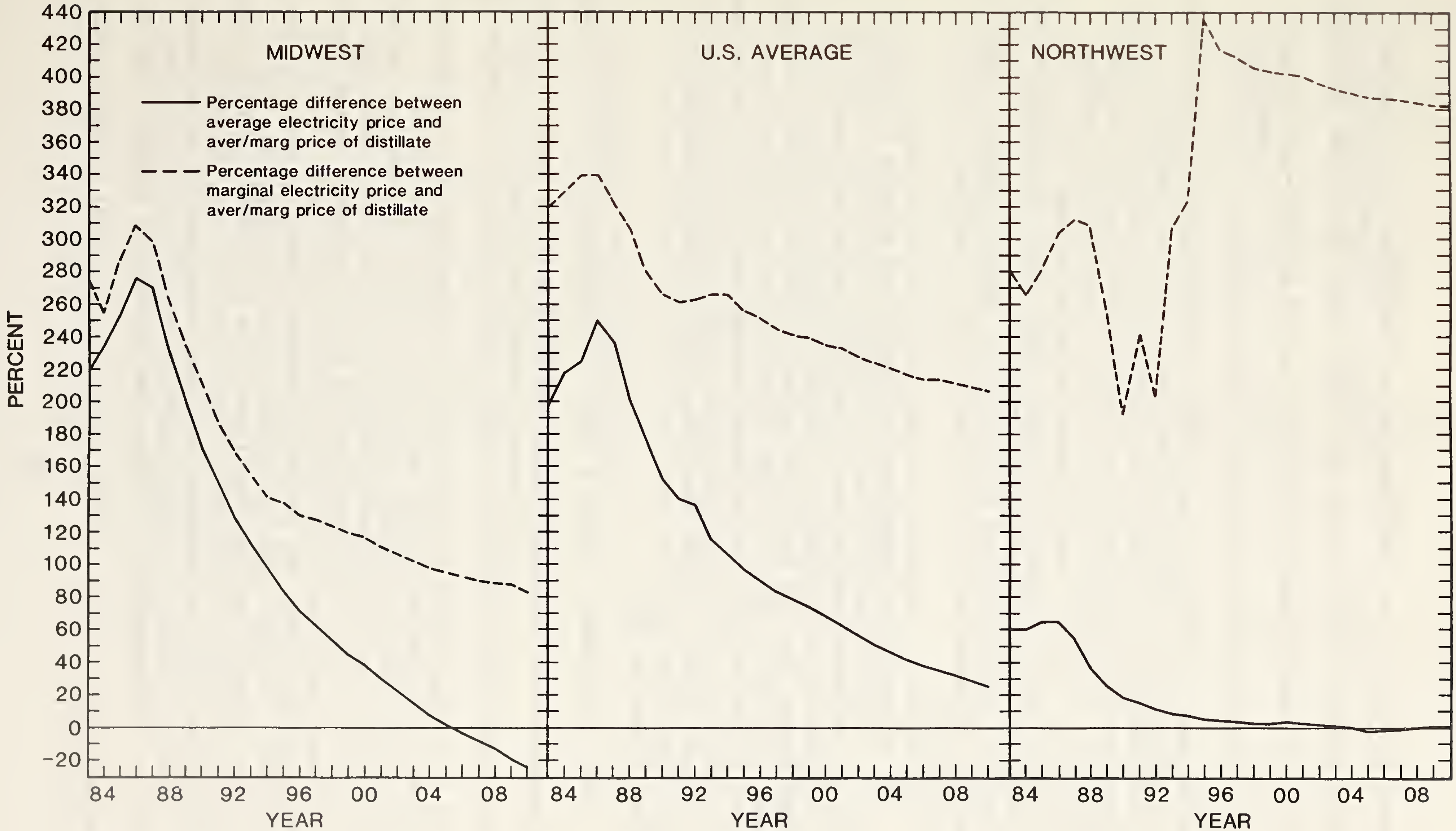

Figure 5. Percentage Differences between Electricity and Distillate Prices

between electricity and distillate prices diminishes for the Midwest region, as well as for the U.S. as a whole, over the 25-year projection period, but remains substantial in the case of marginal-cost prices of electricity versus distillate prices. For the Midwest, the projected marginal-cost electricity price is more than 300 percent greater than the price of distillate in 1985-86 and is projected to be about 80 percent higher than the distillate price by 2010. In contrast, the average electricity price is about 275 percent greater than the distillate price in 1985-86, and is projected to be about 25 percent below the distillate price by 2010.

The corresponding comparison for the U.S. as a whole in figure 5 shows the projected marginal-cost electricity price to be nearly 350 percent higher than the distillate price in 1985-86, and more than 200 percent higher by 2010. The projected average electricity price is about 250 percent higher than the distillate price in 1985-86 and about 25 percent higher by 2010.

For the Northwest, figure 5 shows the percentage difference between the marginal-cost electricity price and the distillate price to increase over the projection period, from about three times higher in 1985-86 to about four times higher by the middle of the next decade. The pattern of difference between the average electricity price and distillate price is similar to that for the Midwest and the U.S. as a whole, except that the differences are muted. The projected average electricity price is about 60 percent greater than the distillate price in 1985-86, falling to near zero by 1995. This is consistent with the convergence of prices shown in figure 3c. The comparison of differences in figure 5 suggests that the greatest impact of marginal-cost pricing would be felt in the Northwest.

3.0 Discount Rate Policy

3.1 Background

Valid economic evaluations and comparisons of investment projects require that cash flows over time be converted to a time-equivalent basis, e.g. present values or annual values. The time adjustment, usually called "discounting," is accomplished through the use of compound interest formulas, or factors computed from the formulas. The formulas and factors incorporate the investor's opportunity cost in terms of an interest rate, usually referred to as the "discount rate." It is the rate that makes the investor indifferent between paying or receiving a dollar now or at some future time. With future amounts expressed in constant dollars, that is, excluding purely inflationary or deflationary changes, the discount rate should be a real rate, that is, also excluding purely inflationary or deflationary changes.

3.2 Impact of Lower versus Higher Discount Rates

The discount rate is a critical factor for evaluating capital investment projects, such as energy conservation and renewable energy projects, which entail upfront expenditures and future benefits. The choice of a higher or lower discount rate may make the difference between acceptance or rejection of a project. A project yielding positive net benefits at a discount rate of 7 percent may show a loss when evaluated at 10 percent. The choice of discount rate can affect the proportion of the economy's resources that is used by the public sector by influencing the number of projects that is accepted or rejected. The discount rate can also affect the type of project undertaken. A high discount rate makes durable projects, whose benefits become available in the more distant future, appear less attractive, other things being equal.

For evaluating most investments of the federal government, OMB has specified that a real rate of 10 percent be used (OMB Circular A-94). The Energy Security Act of 1980 prescribed a different discount rate specifically for the Federal Energy Management Program: a real rate of 7 percent. The lower the discount rate, the higher the present value equivalent of future amounts. Other things equal, a change from a 10 percent discount rate to a 7 percent discount rate can be expected to increase the net savings and savings-to-investment ratios (and shorten the payback period) of energy conservation projects, which have their savings in the future, and, therefore, to encourage federal expenditures for conserving energy.

4.0 Impact Assessment -- Case Studies

Based on the relationships among investment decisions, energy prices, and discount rates, the question is what would be the expected impact on federal energy conservation of the specific changes in energy prices and the discount rate described in sections 2 and 3. Case studies serve to illustrate this impact. The approach applies the economic criteria set forth in 10 CFR sec. 436[2] under specified conditions to see how the decisions are affected by the use of marginal-cost versus average energy prices and a 10 percent versus a 7 percent discount rate. The case studies are based on the energy price data projected by EIA in 1984[3] and described in section 2. Although other conditions and other specific price projections would yield different numerical results, this approach indicates the general direction and magnitude of the impact.

4.1 Criteria

The federal LCC Rules specify the following criteria for (1) accepting a given project, (2) designing or sizing a project, and (3) assigning priority to a project:

(1) Accept a given project as cost effective,

   (a) if the building's life-cycle costs are lower with the project than without it, or

   (b) if the project yields positive net savings, or

(c) if the ratio of project savings to costs is greater than one.

(2) Choose the project design or size that

(a) minimizes life-cycle costs of the building, or

(b) maximizes net savings from the project.

(3) Assign priority by

ranking cost-effective projects in descending order of their SIR's until the budget is exhausted, such that total net savings are maximized.

These criteria are used in the following case studies to assess the impact of the alternative energy pricing policies and discount rates.

4.2 Data and Assumptions

The case studies are performed for the hypothetical set of data and assumptions summarized below:

Sample Project: (Hypothetical)	1" or 2" Insulation of bare hot water pipes in the unused basement of a laboratory complex of a Federal Science Agency
Locations:	DoE Regions Midwest, Northwest, and average of all U.S. DoE regions
DoE Pricing Policy:	Average prices and marginal-cost prices of fuel.

Investment Costs:[1]	for 1" insulation: $2500 for 2" insulation: $4550
Energy Savings:[2]	for 1" insulation: 245.8 x 10^6 Btu for 2" insulation: 260.0 x 10^6 Btu
Discount Rates:	7% and 10% real rates
Economic Life:	25 Years

4.3 Results

Table 1 summarizes the principal evaluation measures, calculated from the data and assumptions of section 4.2, which are needed to apply the decision criteria listed in section 4.1. Column (1) identifies the DoE price regions for the hypothetical projects; column (2) shows the types of energy; column (3) indicates the pricing policy alternatives; column (4) gives base year prices in 1984 dollars; columns (5), (6), (7), and (8) list the estimated total energy savings in present value dollars from using 1" or 2" insulation under the alternative pricing policies, with either a 7 percent or a 10 percent discount rate, over the 25 year period; columns (9), (10), (11), and (12) give the estimated present value savings net of investment costs under the same conditions; columns (13) and (14) list the savings-to-investment ratios for 1" insulation at a 7 percent and a 10 percent discount rate; columns (15) and (16)

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[1]The investment costs will be adjusted by a 10 percent investment cost factor as allowed by the current LCC Rule.(2)

[2]It is assumed that the basement temperature is constant among the locations, such that the quantity of savings is uniform.

Table 1. Net Savings and SIR's with Average and Marginal-cost Prices

Sample Project: 1" and 2" Insulation of Bare Hot Water Pipes in an Unused Basement of a Laboratory Complex of a Federal Science Agency

Location	Energy Type (Commercial)	DoE Pricing Policy	Base Year Price	Energy Savings in $				Net Savings in $				SIR		SIR	
				7%		10%		7%		10%		7%	10%	7%	10%
				1"	2"	1"	2"	1"	2"	1"	2"	1"		1" to 2"	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Midwest	Distillate	Av./Marg.Price	$ 6.11	28,145	29,771	20,515	21,700	25,895	25,676	18,265	17,605	12.51	9.12	.88	.64
	Electricity	Average Price	$20.59	56,531	59,797	44,790	47,378	54,281	55,702	42,540	43,283	25.12	19.90	1.77	1.40
	Electricity	Marginal Price	$21.77	64,320	68,036	49,177	52,018	62,070	63,941	46,927	47,923	28.59	21.86	2.01	1.54
Northwest	Distillate	Av./Marg.Price	$ 6.27	28,650	30,305	20,898	22,106	26,400	26,210	18,648	18,011	12.73	9.28	.90	.65
	Electricity	Average Price	$10.09	32,749	34,657	24,801	26,234	30,499	30,562	22,551	22,139	14.55	11.02	1.03	.77
	Electricity	Marginal Price	$22.97	110,831	117,234	79,101	83,670	108,581	113,139	76,851	79,575	49.26	35.16	3.47	2.48
U.S. Average	Distillate	Av./Marg.Price	$ 6.33	28,753	30,414	20,989	22,202	26,503	26,319	18,739	18,107	12.78	9.33	.90	.66
	Electricity	Average Price	$20.08	61,103	64,633	47,234	49,963	58,853	60,538	44,984	45,868	27.15	20.99	1.91	1.48
	Electricity	Marginal Price	$27.23	97,185	102,799	72,420	76,604	94,935	98,704	70,170	72,509	43.19	32.19	3.04	2.27

show the incremental savings-to-investment ratio for the difference in insulation between 1" and 2", under the 7 percent and 10 percent discount rate assumptions.

Sections 4.3.1 through 4.3.3 deal with the effects of the change in pricing policy, i.e., marginal-cost prices versus average prices. To illustrate the possible switch from one fuel type to another, the sample projects are assumed to save either electricity or distillate. Section 4.4 discusses the effect of alternative discount rates, i.e., 10 percent versus 7 percent. The combined effect is summarized in section 4.5.

4.3.1 Project Acceptance or Rejection

Following the decision criterion of accepting the project if it yields positive net savings, one can see from columns (9) to (12) of table 1 that this particular project would be deemed cost effective regardless of which energy pricing policy or discount rate was used. As one would expect, however, the cut-off points for investment costs, beyond which the project would not be cost effective, are affected by the pricing policy and discount rate and differ for the various cases depending on their location.

For the Midwest case, project costs for 2" insulation, for example, could be about <u>seven times greater</u> if, at the 7 percent discount rate, savings were in electricity at average prices instead of in distillate (($55,702-25,676) / 4,095 = 7.33). If the savings were in electricity at marginal prices instead of distillate, costs could be about <u>nine times</u>

greater ($63,941-25,676 / 4095 = 9.34) and still be acceptable.

In the Northwest, the same hypothetical example would allow project costs to be about the same, if savings were in electricity at average prices instead of in distillate, but twenty-one times greater if savings were electricity at marginal prices.

For the U.S. as a whole, if energy savings were based on average prices of electricity instead of distillate, the 2" insulation project would be acceptable even if, at a 7 percent discount rate, project costs were over eight times greater than those assumed. If the net savings based on marginal electricity prices were compared with those for distillate, the project cost could be almost eighteen times greater and still be acceptable.

Thus, the use of the projected marginal rather than average energy prices increases considerably the existing tendency of electricity-conserving projects to be more cost effective than projects to conserve other types of fuel.

The case studies show another effect of using marginal-cost prices: the gap between actual savings (based on the average of market prices) and theoretical savings (based on marginal-cost prices) can be quite large. For example, in the Northwest, in the case of 2" insulation, with a 7 percent discount rate, the estimated present value of energy savings is $34,657 based on projected average prices of electricity, but it is $117,234 based on projected marginal-cost prices. The difference of $82,577 is the present value of savings estimated to accrue to society in general from the investment—not to the agency which must make the project decision.

4.3.2 Project Design/Sizing

If one follows the decision criterion of choosing the design or size that maximizes net savings, a comparison of columns (9) and (10) and columns (11) and (12) shows that the sizing decision is not changed in the Midwest case examples by the use of marginal-cost rather than average prices. If distillate were the fuel, the decision would be to choose the smaller level of insulation. If electricity were the fuel, the decision would be to choose the larger level of insulation regardless of whether average or marginal-cost prices were used. In the Northwest case examples, the effect of pricing policy on the sizing decision is shown to be sensitive to the discount rate. If 10 percent discount rate were applied, the larger level of insulation would be chosen only if marginal electricity prices were used. But if a 7 percent rate were used, the larger level of insulation would be chosen regardless of whether average or marginal prices were used.

In general, the impact of using higher energy prices is to increase the cost-effective design or size of a project, that is, to increase the size of the expenditure for energy conservation. Raising prices for electricity relative to other fuel types would, therefore, tend to increase the expenditure for electricity-conserving projects relative to other projects. The specific impact, however, is dependent on the particular circumstances, as demonstrated above.

4.3.3 Project Priority and Allocation of Total Budget

The SIR's for a 1" insulation project, given in columns (13) and (14) of table 1 and graphed in figure 6, provide guidance on how to asssign project priority. The higher the SIR, the more likely a project is to be funded from limited resources, other things being the same. Hence, in the Midwest, the electricity project is clearly more likely to be funded than the distillate project regardless of whether marginal-cost or average pricing is used, but its priority relative to the distillate project is boosted if marginal-cost prices are used.

In the Northwest, there is only a small difference between the SIR for the project saving distillate and the SIR for the project saving electricity based on average prices (12.73 vs. 14.55 at a 7 percent discount rate). With average electricity prices, only slightly different assumptions about project costs and energy savings would make the distillate-saving project preferable to the electricity-saving project. In contrast, the SIR for the project saving electricity based on marginal-cost prices is almost four times as high as the SIR for the project saving distillate (49.26 vs. 12.73 at a 7 percent discount rate). Therefore, the use of marginal prices would strongly shift project priority towards the electricity-saving investment.

In the case examples for the U.S. as a whole, the use of marginal-cost rather than average prices also significantly raises the relative priority of electricity-saving projects over distillate-saving projects.

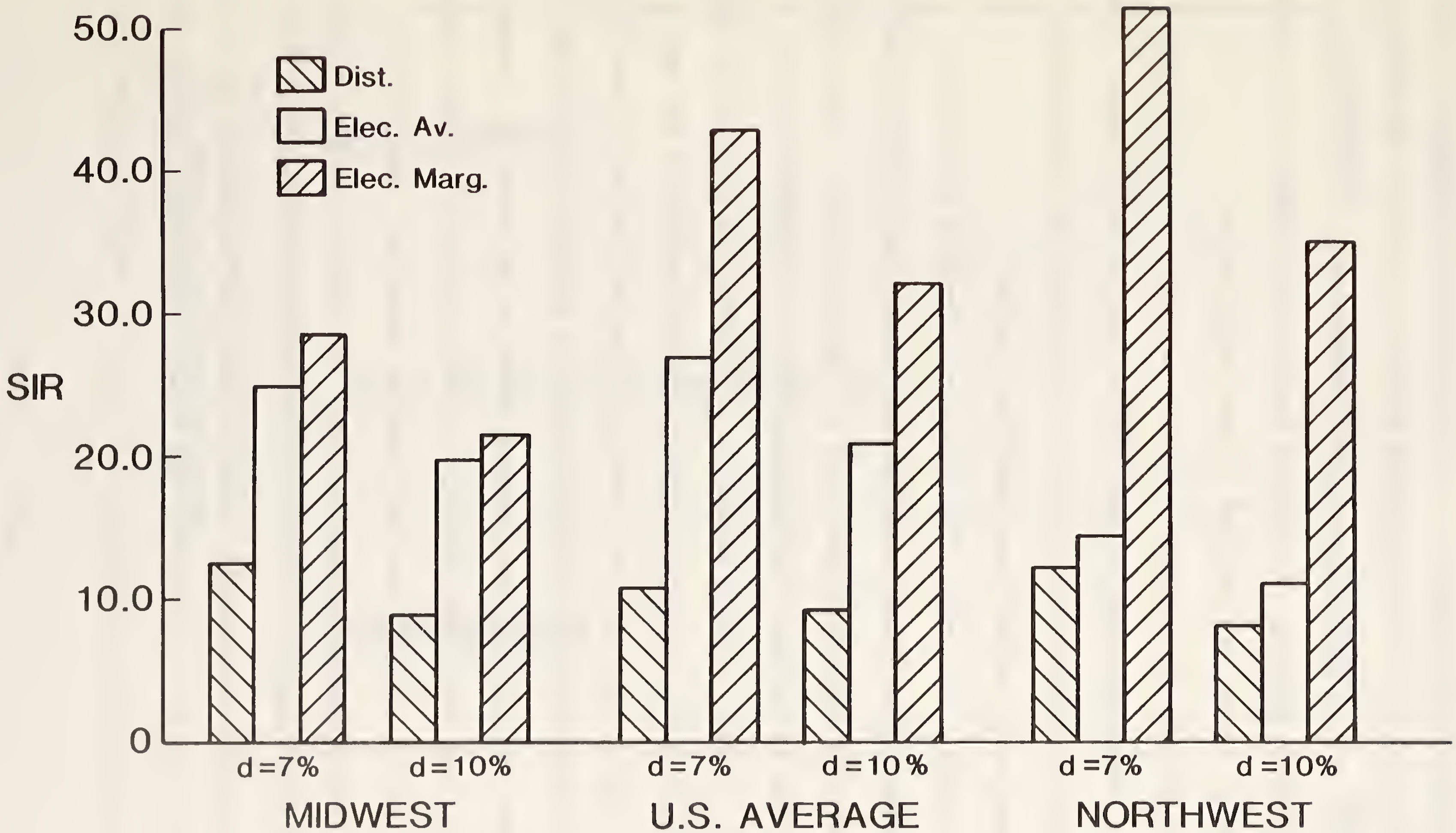

Figure 6. Savings-to-Investment Ratios of Hypothetical Projects

By raising the SIR's on electricity-saving projects by 50 percent, while leaving the SIR's of distillate-saving projects unchanged, the use of marginal-cost prices could cause electricity-saving projects to displace distillate-saving projects when agency conservation budgets are limited. This potential effect is discussed in more detail below.

If one follows the decision criterion to accept cost-effective projects in descending order of their SIR's, the following example shows how a change in pricing policy alters the allocation of limited funds between electricity projects and distillate projects.

To illustrate the impact, the following procedure was used to develop sample SIR's: First, a set of ten hypothetical distillate-saving projects was specified such that, with a 7 percent discount rate, the energy savings in dollars, when combined with an investment cost of $2,250, will result in SIR's from 10 to 1. Second, the quantity of energy saved in million Btu was derived from the dollar savings of the ten initial projects. SIR's for ten counterpart projects saving electricity at average prices and ten counterpart projects saving electricity at marginal-cost prices were then computed based on the quantity of energy saved by the ten distillate projects. In this way, study period, discount rate, and capital outlays were held constant among the total thirty projects. This procedure allows the effect of energy pricing on project priorities to be examined. Distillate- and electricity-saving projects were then arrayed in descending order of their SIR's. Figures 7a, 7b, and 7c depict the project rankings for the Midwest, Northwest, and the U.S. as a whole, respectively. Tables 2a, 2b, and 2c, which are paired with

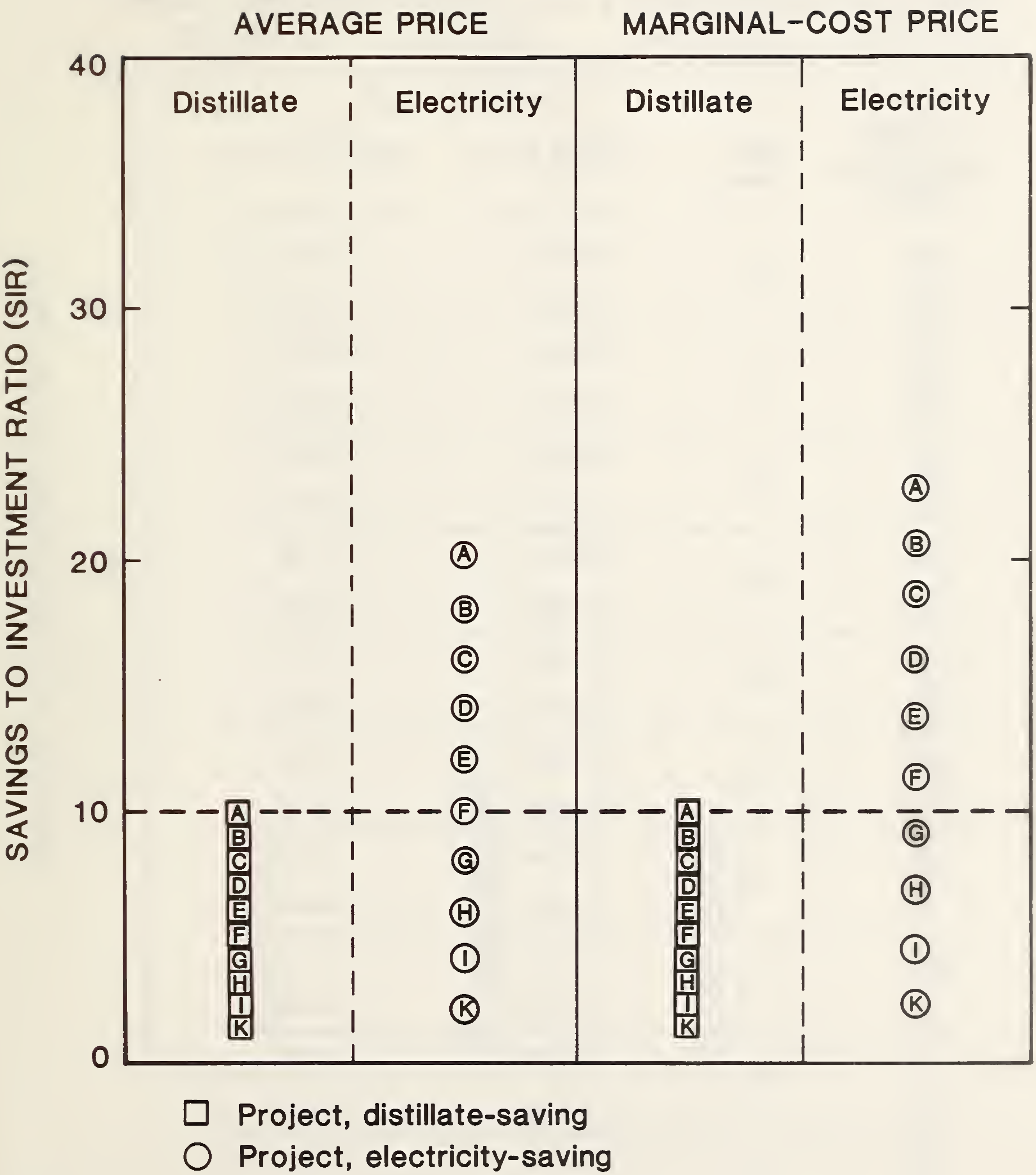

Figure 7a. Ranking by SIR's of a Set of Hypothetical Projects - MIDWEST

Table 2a. Energy Savings of a Set of Hypothetical Projects - MIDWEST

Project[a] (□ Distillate-saving, ○ Electricity-saving)	MBtu Saved	Energy Savings[b] Average Price $	Energy Savings[b] Marginal Price $
A (□)	196	22,500	22,500
A (○)		45,100	51,300
B (□)	177	20,250	20,250
B (○)		40,700	46,300
C (□)	157	18,000	18,000
C (○)		36,200	41,100
D (□)	137	15,750	15,750
D (○)		31,600	36,000
E (□)	118	13,500	13,500
E (○)		27,100	30,800
F (□)	98	11,250	11,250
F (○)		22,600	25,700
G (□)	79	9,000	9,000
G (○)		18,000	20,600
H (□)	59	6,750	6,750
H (○)		13,500	15,400
I (□)	39	4,500	4,500
I (○)		9,000	10,200
K (□)	20	2,250	2,250
K (○)		4,500	5,100

[a] The investment cost for each project is $2,250. (See text for construct of projects.)

[b] The energy savings are evaluated with a discount rate of 7 percent.

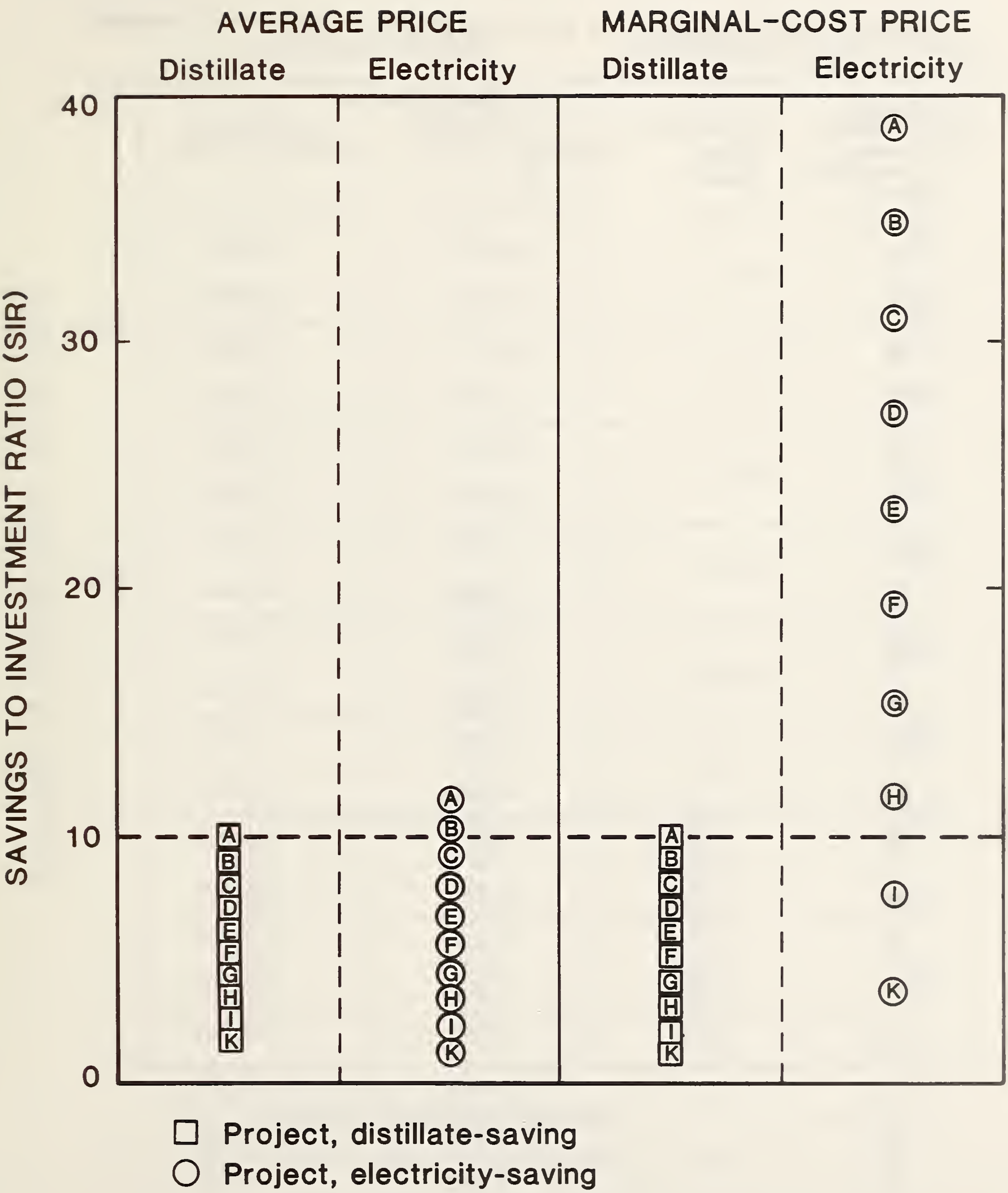

Figure 7b. Ranking by SIR's of a Set of Hypothetical Projects - NORTHWEST

Table 2b. Energy Savings of a Set of Hypothetical Projects - NORTHWEST

Project[a] ☐ Distillate-saving ◯ Electricity-saving	MBtu Saved	Energy Savings[b] Average Price $	Marginal Price $
☐A	193	22,500	22,500
◯A		25,900	87,000
☐B	174	20,250	20,250
◯B		23,300	78,300
☐C	154	18,000	18,000
◯C		20,800	69,600
☐D	135	15,750	15,750
◯D		18,200	60,900
☐E	116	13,500	13,500
◯E		15,600	52,200
☐F	97	11,250	11,250
◯F		13,000	43,500
☐G	77	9,000	9,000
◯G		10,400	34,800
☐H	58	6,750	6,750
◯H		7,800	26,100
☐I	39	4,500	4,500
◯I		5,200	17,400
☐K	19	2,250	2,250
◯K		2,600	8,700

[a] The investment cost for each project is $2,250. (See text for construct of projects.)

[b] The energy savings are evaluated with a discount rate of 7 percent.

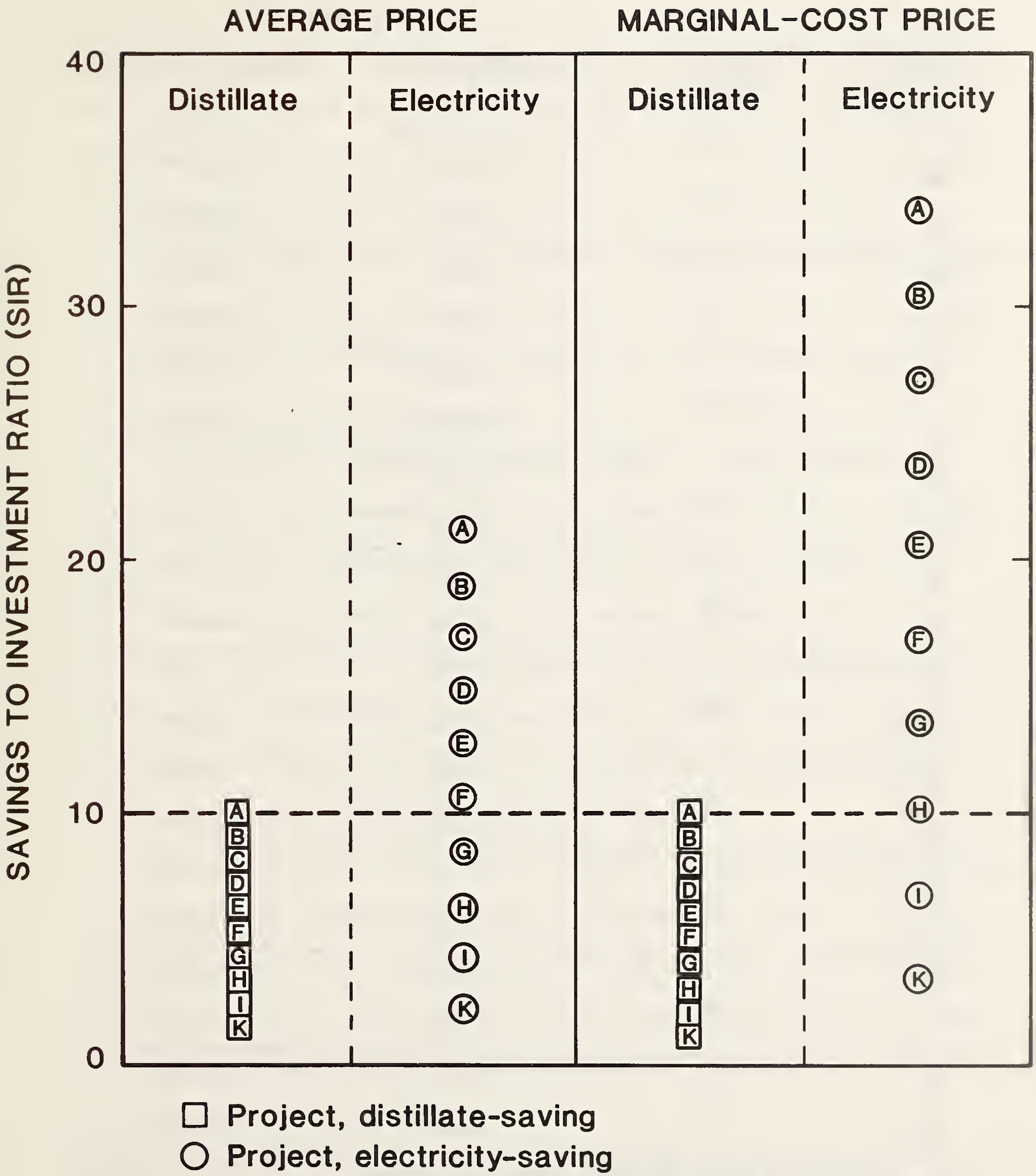

Figure 7c. Ranking by SIR's of a Set of Hypothetical Projects - U.S. AVERAGE

Table 2c. Energy Savings of a Set of Hypothetical Projects - U.S. AVERAGE

Project[a] □ Distillate-saving ○ Electricity-saving	MBtu Saved	Energy Savings[b] Average Price $	Marginal Price $
□ A	192	22,500	22,500
○ A		47,800	76,000
□ B	173	20,250	20,250
○ B		43,000	68,400
□ C	154	18,000	18,000
○ C		38,200	60,800
□ D	135	15,750	15,750
○ D		33,500	53,200
□ E	115	13,500	13,500
○ E		28,700	45,600
□ F	96	11,250	11,250
○ F		23,900	38,000
□ G	77	9,000	9,000
○ G		19,100	30,400
□ H	58	6,750	6,750
○ H		14,300	22,800
□ I	38	4,500	4,500
○ I		9,600	15,200
□ K	19	2,250	2,250
○ K		4,800	7,600

[a] The investment cost for each project is $2,250. (See text for construct of projects.)

[b] The energy savings are evaluated with a discount rate of 7 percent.

each of the figures, list the corresponding energy savings in million Btu and in dollar values for the distillate and electricity projects. The left-hand side of each figure depicts project rankings based on average prices; the right-hand side those based on marginal-cost prices.[1]

If it is assumed that the projects are independent and that there is a floating budget constraint such that only projects with, say, an SIR of 10 or above will be undertaken, a comparison of the SIR's, based on average versus marginal-cost prices, suggests the following results:

In the case of the Midwest region, figure 7a shows that the allocation of funds between electricity projects and distillate projects would be little affected by pricing policy. In either instance, six electricity projects and one distillate project appear feasible. If, instead, a cutoff SIR of 9.00 were selected, the use of marginal-cost prices would allow acceptance of one additional distillate project and one additional electricity project, while the use of average prices, would allow only one additional distillate project.

By contrast, for the Northwest, where the difference between average and marginal-cost electricity prices is much greater than in the Midwest, figure 7b shows a much greater impact of pricing policy on the selection of projects. With a cutoff SIR of 10, only three projects appear acceptable under average pricing: two electricity and one distillate.

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[1]Since all of the thirty projects have SIR's equal to or greater than one, they all are cost effective and would be justified on economic grounds if funding permitted.

But with marginal-cost pricing, eight electricity projects and one distillate project appear acceptable. Hence, it is likely that only electricity-conserving projects would be done.

For the U.S. as a whole, figure 7c shows that with an SIR cutoff of 10, average pricing results in the acceptance of one distillate project and six electricity projects. A switch to marginal-cost pricing adds two new electricity projects to the acceptable list, which may eliminate the distillate project, depending on total funding.

In summary, it is evident from figures 7a, 7b, and 7c, that if the budget is limited, such that not all cost-effective energy projects can be undertaken, the change in pricing policy from average prices to marginal-cost prices can drive out distillate-saving projects.

4.4 Impact of the Discount Rate

A comparison of net savings in column (9) versus (11) and column (10) versus (12) of table 1 shows the inverse relationship of net savings and the discount rate. A lower discount rate will result in more projects accepted and in up-sizing of projects. Other factors remaining the same, the projects appear more cost effective with a 7 percent discount rate than a 10 percent rate, and the larger size of the project is more likely to be cost effective with a 7 percent rate than a 10 percent rate.

Looking again at table 1 and comparing the difference in net savings between fuel types in the 7 percent discount column with the difference in net savings in the 10 percent discount column, one can see that the size of the gap is a function of the discount rate. The difference in net savings is greater, the lower the discount rate. For instance, in the Midwest, for 2" insulation, the difference in net savings between electricity at marginal prices and distillate at average/marginal prices is $38,265 (38,265=63,941-25,676) with a 7 percent discount rate and $30,318 (30,318=47,923-17,605) with a 10 percent discount rate (cols. 10 and 12). In the Northwest, the difference in net savings between electricity at marginal-cost prices and distillate at average/marginal prices is $86,929 (86,929=113,139-26,210) with a 7 percent discount rate and $61,564 (61,564=79,575-18,011) with a 10 percent discount rate.

4.5 Combined Effect of Pricing Policy and Discount Rate Changes

Figure 8 provides a graphic summary of the impact of alternative pricing policies and alternative discount rates on net savings of the hypothetical projects for each region examined. The graphs show the widened gap between net savings for a distillate-conserving project and an electricity-conserving project when marginal-cost pricing is used. The graphs also show that the higher the discount rate, the lower the net savings, and the lower the difference in net savings between the fuel types. Thus, the choice of fuel pricing policy has slightly less impact, the higher the discount rate.

Sample Project: 2" insulation of bare hot water pipes

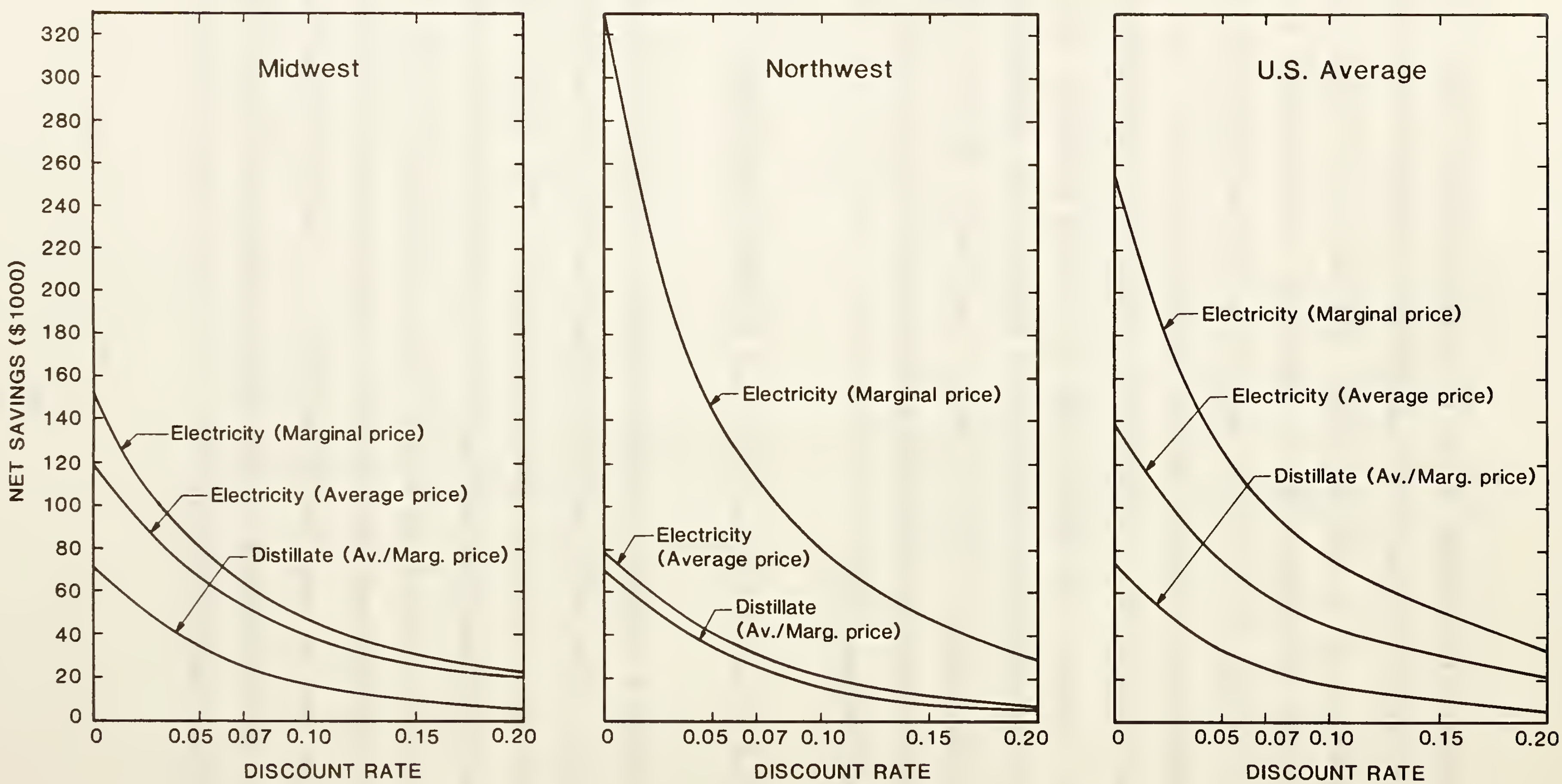

Figure 8. Comparison of Pricing Policies at Various Discount Rates

5.0 Summary and Conclusions

This study has investigated how the selection of energy conservation and renewable energy projects undertaken by the Federal Government will be affected if benefits and costs are calculated with marginal-cost prices rather than average prices. In addition, it has compared the impact on conservation decisions of two discount rates: 7 and 10 percent. It has also examined the interaction of the pricing and discounting policies.

Some general theoretical advantages of marginal-cost pricing were discussed. A numerical and graphical analysis of a set of hypothetical retrofit projects provided the basis for a quantitative illustration of the specific kinds of impacts of the alternative pricing and discounting policies. DoE 1984 projections of average and marginal-cost prices of distillate and electricity were used for the comparative analyses. The focus was on the DoE regions exhibiting the least and the greatest degree of impact: the Midwest and the Northwest, respectively, and the average of all DoE regions. All other data and assumptions were held constant in order to isolate the impact of price and discount rate changes.

The following inferences were drawn from the hypothetical case studies:

A change from average prices to marginal-cost prices can be expected to increase the estimated cost effectiveness of electricity-saving projects and, hence, their chance of being accepted. The use of marginal-cost prices will tend to increase the cost-effective design or size of electricity-saving projects relative to distillate-saving projects. Marginal-cost prices are likely to raise the relative priority of electricity-saving projects and, hence, more of them will tend to be funded out of a limited budget. Depending on the size of the budget, electricity-saving projects will tend to displace projects saving distillate.

A discount rate of 10 percent instead of 7 percent reduces slightly the effect of a change in pricing policies: the higher the discount rate, the smaller the effect of a higher energy price on net savings and thus the smaller the shift of priority from distillate-saving to electricity-saving projects.

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The study investigates how energy conservation projects for federal buildings would be affected by a change in energy pricing and discount rate policies. It focuses on the choice between marginal-cost prices versus average market prices and a 10 percent discount rate versus a 7 percent discount rate. Graphical and numerical comparisons of hypothetical cases in selected geographical areas illustrate the expected impact on selection, design and sizing, and priority of energy-saving projects.

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