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ENERGY DIVISION

JUSTIFICATION FOR ELECTRIC-UTILITY ENERGY-EFFICIENCY PROGRAMS

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SUMMARY

The electricity industry is in the midst of a major restructuring. No one yet knows what the final form and regulation of the industry will be. Historically, utilities ran demand-side management (DSM) programs as low-cost alternatives to power plants. Currently, utilities are increasingly using DSM to retain customers, to increase market share, and to improve customer service as ways to enhance profitability. In the future, regulated, local distribution companies are likely to continue to deliver energy-efficiency services to customers, as will a host of unregulated energy-service companies, equipment vendors, and power marketeters. These changes in DSM-program orientation and delivery suggest that DSM in the future will be very different from that of the past. What are the implications of these changes for the historic justifications used by regulators to encourage utilities to run such programs?

During the past several years, more and more electric utilities have been running DSM programs. These programs improve the efficiency with which customers use electricity and affect the timing of that use (e.g., to shift it away from high-cost times). Utilities run such programs for two primary reasons. One is to improve customer service. The second is to acquire resources that, just like power plants, can meet customer energy-service needs. DSM programs are often less expensive and environmentally cleaner than power plants. In 1994, utility DSM programs cut potential summer peak demand by 7% and annual electricity use by 2% nationwide.

Government officials, policy analysts, consumer groups, environmental organizations, and others offered many reasons in the late 1970s and early 1980s to justify requirements that electric utilities help their customers become more energy efficient:

- Defer construction of new, large, expensive, and polluting power plants.
- Reduce the adverse environmental effects of electricity production and transmission.
- Compensate for distortions in electricity prices. Retail prices, which were based on embedded costs, were typically below avoided supply costs. Thus, the price signal being sent to consumers told them to overconsume.
- Reduce dependence on foreign oil to generate electricity.
- Compensate for the absence of government programs and standards intended to improve the efficiency of electricity use.

- Overcome market barriers that prevent customers from adopting cost-effective energy-efficiency practices and measures.

- Recognize that electric utilities are in a unique position and have a least-cost-planning obligation to help their customers improve their efficiency of energy use.

Much has changed since then. These changes will affect the types of DSM programs that utilities will operate in the late 1990s and the amounts of energy and demand reductions that remain cost-effective. They will also affect decisions by regulatory commissions to rely on utilities to use ratepayer funds to operate these programs.

Today's avoided costs are much lower than those of 15 years ago because natural gas prices are low, many utilities have excess capacity, and wholesale power markets are becoming actively competitive. All else being equal, lower avoided costs reduce the amount of DSM that remains cost-effective. On the other hand, advances in energy-efficiency technologies and DSM-delivery methods suggest that, even with lower avoided costs, there remain significant opportunities to save electricity cost-effectively. Some utilities have successfully run low-cost DSM programs and they will, in principle, be able to continue to acquire cost-effective DSM resources in the future.

Several laws and regulations have reduced the environmental effects of electricity production. The environmental costs of electricity production and transmission that are not internalized remain a continuing source of concern and an important justification for programs to improve energy efficiency. Recent studies of the environmental damages associated with electricity production show lower values than those previously developed. Whether these estimates are more accurate than earlier ones or whether they merely reflect the substantial uncertainties associated with quantification and monetization of environmental damages is unclear. It is clear that new power plants are much cleaner than old ones and that growth in electricity use is offsetting these technological gains for some emissions. Moreover, governments may impose further restrictions on emissions of nitrogen oxides, small particulate matter, and air toxics. Nevertheless, emissions of carbon dioxide (a key contributor to global warming) are now not controlled at all; cutting carbon dioxide emissions is an important justification for energy-efficiency programs.

Other factors affecting the need for and benefits of DSM programs include the existence of other government and private-sector energy-efficiency efforts, changing perceptions of the importance of market failures and market barriers to customer adoption of energy-efficiency actions, and the role of utilities themselves. Although government appliance standards and building codes have had major effects on electricity use, utility DSM programs are often a key element in making government standards and codes work well. That is, there are important synergistic effects between utility and government efforts to improve energy efficiency.

Finally, debates about the appropriateness of government intervention in energy-service markets (either directly through codes and standards or indirectly through mandates to utilities) continue. While the scope of these debates has narrowed in recent years, they are still often dominated by fundamental value differences about the relative merits of competition and regulation in these markets. Clearly, neither markets nor regulators are perfect, and the appropriate balance cannot be established by fiat but rather must be based on detailed examination of the workings of particular markets, end uses, perceived market barriers, and participants in these markets.

In summary, the historic rationale for public policies to improve customer electricity use remains unchanged—improve economic efficiency and reduce the environmental effects of electricity production and transmission. At the same time, the role of utilities as instruments to achieve these public-policy goals is being challenged by the likely erosion of the retail-monopoly franchise. DSM programs, however, are in no danger of disappearing, as utilities begin to take advantage of the strategic importance of such programs for the survival of the firm in an increasingly competitive electricity market. However, the question is whether there is a need for additional public policies to ensure that market-based outcomes reflect societal interests. Future regulatory-commission decisions will help answer that question.

LIST OF ACRONYMS

CCE	Cost of conserved electricity (¢/kWh)
DOE	U.S. Department of Energy
DSM	Demand-side management
EIA	Energy Information Administration
EPAct	Energy Policy Act of 1992
ESCO	Energy-service company
GDP	Gross domestic product
IRP	Integrated resource planning
LBNL	Lawrence Berkeley National Laboratory
ORNL	Oak Ridge National Laboratory
PUC	Public utility commission
RCG	RCG/Hagler, Bailly, Inc.
T&D	Transmission and distribution

INTRODUCTION

This report examines the various reasons why electric utilities run programs to help customers cut their electric bills. These demand-side management (DSM) programs improve overall efficiency of electricity use and affect the timing of that use. Utilities seriously began to run DSM programs about 15 years ago, just after the second Arab oil embargo. Are the reasons that motivated the programs then still valid today? Are there other reasons why utilities should make such investments in the late 1990s?

THE BASELINE: HISTORIC IMPROVEMENTS IN EFFICIENCY

During the past two decades, the United States has made tremendous strides in improving electric-energy efficiency. Between 1960 and 1973, U.S. electricity use grew at an average rate of 7.3%/year, almost double the 4.0%/year growth in Gross Domestic Product (GDP) [Energy Information Administration (EIA) 1993b]. Between 1973 and 1993, however, electricity use grew at only 2.6%/year, roughly one-third its pre-1973 growth rate. And this growth in electricity use was only slightly above the GDP growth of 2.4%/year. Based on this very aggregate measure of electricity use per unit GDP, efficiency of electricity use roughly doubled after 1973.

Schipper, Howarth, and Geller (1990) examined the details of U.S. energy use between 1973 and 1987. They studied changes in aggregate activity levels in the transportation, manufacturing, commercial, and residential sectors; the composition of activities in each sector; and the changes in energy intensity for various end uses in each sector. Their results show substantial improvements in electric-energy efficiency. For example, the energy intensity of electric heating in commercial buildings (kWh/ft^2) dropped by 18% between 1973 and 1987. And the efficiency of new refrigerator/freezers nearly tripled between 1973 and 1993 (Geller and Nadel 1993). To some extent, improvements in electric-energy efficiency have been masked at the aggregate level by the substitution of electricity for direct use of fossil fuels and the proliferation of new electric end uses (e.g., personal computers).

These changes in energy efficiency were caused by a combination of factors, including structural changes in the U.S. economy (especially the shift from manufacturing to services), changes in electricity and fossil-fuel prices, development and commercialization of new energy-efficient products and services, government energy-efficiency programs, and electric-utility DSM programs.

In 1993, U.S. electric utilities spent $2.8 billion on DSM programs (Hadley and Hirst 1995). Utility spending on DSM programs increased dramatically between 1989 and 1993, growing from 0.5 to 1.5% of utility operating revenues. In return for these expenditures, utility DSM programs cut electricity use and peak demand in 1993 by 44,000 GWh and 40,000 MW, respectively. These reductions are equivalent to 1.6% of annual electricity sales and 6.8% of summer peak demand. The trends, as reported by utilities in early 1994, suggest continued growth in utility DSM-program effects and little change in annual expenditures (Fig. 1). Since preparing these estimates in early 1994, many utilities have reduced their planned DSM expenditures and, to a lesser extent, their planned energy and demand reductions (Schweitzer and Pye 1995).

These estimates do not include the indirect effects of utility DSM programs on equipment markets and on state and federal efficiency standards. Improvements in fluorescent-lamp ballasts illustrate the ability of utilities to help transform markets. Although they were not developed until the late 1970s, electronic ballasts have already captured a 25% market share. Other technologies with similar histories include compact fluorescent lamps and variable-speed drives. All three technologies can thank utility DSM programs for their widespread availability. Similarly, coordination of utility programs with federal appliance standards has yielded steady reductions in the electricity use of new residential refrigerators. This synergistic process helped smooth implementation of the 1990 and 1993 refrigerator and freezer standards.

U.S. electric-energy efficiency, with substantial assistance from utilities, has increased dramatically during the past two decades. Nevertheless, analyses conducted by the Electric Power Research Institute, Lawrence Berkeley National Laboratory (LBNL), and others show considerable potential to further improve efficiency of electricity use. For example, a study conducted by the Alliance to Save Energy (1991) and others identified cost-effective opportunities to cut electricity use by 7 to 22% between 1991 and 2000.

SHOULD UTILITIES CONTINUE TO DELIVER ENERGY EFFICIENCY?

This report examines the continuing relevance of the historic motivations for electric-utility DSM programs, the reasons that utilities, state public utility commissions (PUCs), federal officials, environmental groups, and others offer in support of these programs. Historic improvements in energy efficiency, coupled with the dramatic increase in competitive pressures facing the electricity and natural gas industries, argue for a new examination of the factors that support such programs.

DSM programs can affect customer electricity use in various ways. The three primary effects of such programs are (l) to improve electric-energy efficiency (i.e., reduce overall electricity use without regard for the timing of program-induced changes); (2) to reduce electricity demand at certain critical times (e.g., when the utility experiences system peaks); and (3) to increase electricity consumption (e.g., through load-building programs that promote beneficial electrification). This report focuses on energy efficiency.

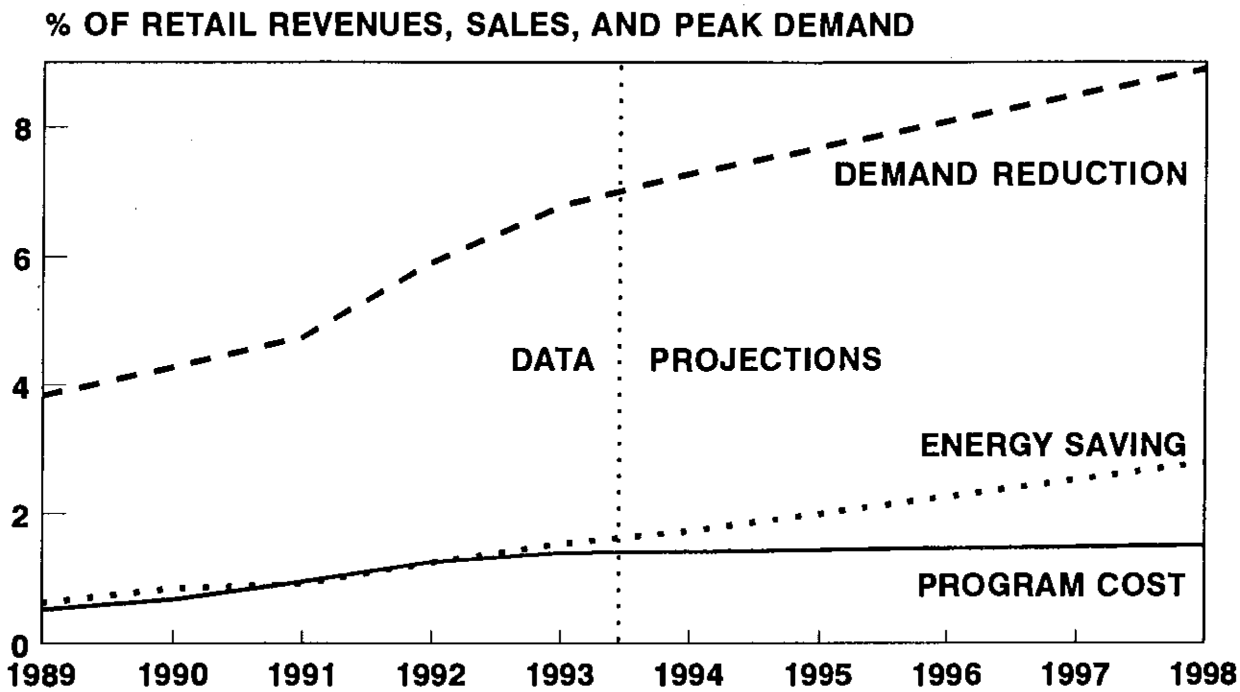

Fig. 1. Costs and effects (energy and demand reductions) of electric-utility DSM programs from 1989 through 1993 and early-1994 projections to 1998.

The electricity industry, for a variety of reasons, is in the midst of a major restructuring. The primary purpose of this restructuring is to increase economic efficiency within the industry. Greater competition and reduced regulation are seen as the key tools to promote economic efficiency, increase customer choices, and lower electricity prices.

These electricity-industry changes are part of a larger trend in the United States and throughout the world. Over the past 10 to 15 years, the U.S. banking, telecommunications, airlines, trucking, and natural gas industries have all been largely restructured. As Peter Bradford (1994), former Chair of the New York Public Service Commission, noted, efforts to introduce competition into monopoly areas have produced consistent results. These results include lower costs, higher productivity, greater customer choice, new technologies and products, greater customer responsiveness, and, as a consequence, no wish to restore regulated monopolies where genuine competition exists. In part, these industry-restructuring efforts are motivated by a general belief that markets do a better job of meeting people's needs than do governments.

Because utility DSM programs are motivated in large part by pressure from PUCs (Schweitzer and Young 1994), restructuring the electricity industry could dramatically affect such programs. For example, Hirst (1994) suggests that under retail wheeling, in which retail customers would be free to choose their electricity supplier, utilities might find it difficult to recover the costs of DSM programs from price-elastic customers. Thus, utilities may focus on programs that are paid for by participating customers, rather than by all customers. Such programs will emphasize peak-demand reductions and beneficial electrification (load building) because, unlike most energy-efficiency programs, these activities do not increase electric rates. If state regulators can no longer mandate utility programs or provide incentives to utility shareholders, utilities may then run programs that focus primarily on customer service rather than on saving energy. York and Cohen (1994) suggest that retail wheeling would "greatly diminish implementation of cost-effective DSM." On the other hand, Cavanagh (1994) asserts that retail wheeling is neither inevitable nor desirable and that PUCs can choose other ways to open electric-service markets to increased competition.

These possible changes lead to important public-policy questions. To what extent would changes in electric-industry structure and regulation reduce DSM-induced energy savings and demand reductions? How would such changes affect the need to build new power plants, transmission lines, and distribution systems? What would be the economic and environmental consequences of such changes? How would less DSM affect the flexibility and diversity of today's electric-power system? What should state regulators do, if anything, to maintain utility investment in DSM? Should other entities carry out such programs?

This report examines these public-policy concerns. We begin, in Chapter 2, by reviewing the historic reasons that the federal government and state PUCs initially encouraged utilities to offer DSM programs to their customers. We then analyze, in subsequent chapters, the relevance of those reasons in 1995. Specifically, Chapters 3 and 4 examine the economic and environmental benefits of DSM; first we review changes in the costs of electricity supply and then we examine the environmental effects of electricity production and transmission. Chapter 5 focuses on the costs of DSM programs.

Chapter 6 examines the barriers to customer adoption of energy-efficiency practices and measures, Chapter 7 discusses the status of government programs aimed at improving efficiency of electricity use, and Chapter 8 discusses likely changes in the electricity industry and the role of PUCs in affecting how competitive forces interact with the public interest regarding future DSM programs. Chapter 9 summarizes the findings of this study.

ORIGINAL REASONS FOR UTILITY DSM PROGRAMS

Although utilities began promoting customer energy efficiency after the 1973 Arab oil embargo, initial efforts dealt primarily with generalized information campaigns, such as advertisements and bill stuffers. Utility efforts became much stronger after passage of the 1978 National Energy Conservation Policy Act, which created the Residential Conservation Service. The Service required utilities to offer onsite energy audits to their residential customers. Among other things, this program encouraged utilities to create, staff, train, and maintain internal organizations devoted to helping customers manage their electricity use.

Government officials, policy analysts, utilities, consumer groups, environmental organizations, and others offered many reasons in the late 1970s and early 1980s to justify state and federal requirements that electric utilities help their customers become more energy efficient. Environmental groups emphasized the adverse environmental effects of electricity production and transmission. State regulators and other government officials saw DSM programs as a way to improve overall economic efficiency by substituting low-cost DSM measures for high-cost supply options. Utilities favored DSM programs because of their customer-service attributes. The various reasons, which largely reflected a view that scarce societal resources were being used inefficiently, included:

- The opportunity to defer construction of new power plants. These plants were expected to take up to a decade to build and to be large, expensive, and polluting. In general, utilities were planning to build primarily large coal-fired power plants at that time.

- Dependence on foreign oil to generate electricity.

- The need to reduce the adverse environmental effects of electricity production and transmission. Electricity production was a major contributor to environmental problems, especially air pollution.

- Distortions in electricity prices. Retail prices, based on embedded costs, were typically below marginal costs (i.e., the cost to build and operate new power plants). Thus, the price signal being sent to consumers told them to overconsume (i.e., underconserve). In addition, most consumers faced prices with no time differentiation. So consumers paid no penalty for consuming electricity during times of system peak (when costs to the utility were much higher than average).

- The need to overcome various market barriers that prevented customers, in all sectors of the economy, from adopting cost-effective energy-efficiency practices and measures.

- The absence of government programs and standards intended to improve the efficiency of electricity use.

- The belief that electric utilities were in a unique position to help their customers improve energy efficiency.

DEFER COSTLY UTILITY SUPPLY RESOURCES AND ADDITIONS

During the 1970s, electricity use grew at an average rate of 4.1%/year. Utilities built larger and larger generating units during that decade, often reaching 1000 MW in size. The average capacity of the new coal units that came online in 1974 and 1975, to illustrate, was almost 600 MW (EIA 1993a).

Because of various environmental, financial, and safety concerns plus slower load growth, it often took utilities a decade or more to complete construction of these large units, especially the nuclear units. Nuclear units ordered in the mid-1960s were completed within five or six years; units ordered in the late 1960s typically took ten years to complete (Kahn 1988). The factors that slowed construction times also increased capital costs. Construction costs for both coal and nuclear plants increased several-fold during the 1970s.

Proponents of utility energy-efficiency programs argued that such programs could defer the need to build some of these power plants. Because of the small unit size and short leadtime for DSM programs, they were expected to provide flexibility to utilities and to reduce their financial risks compared with the large, long-leadtime power plants they would defer.

REDUCE UTILITY RELIANCE ON OIL

Electric-utility use of oil to generate electricity increased steadily after World War II, from 0.4 QBtu in 1949 to 2.1 QBtu in 1970. Utility oil use exceeded 3.0 QBtu each year between 1972 and 1980 (EIA 1993b). Between 1975 and 1980, utilities used oil to generate 14% of their electrical output. Although utility oil use represented only 10% of the nation's oil consumption, concerns about oil imports and oil prices were sufficiently great that many oil-using utilities were converting their plants to burn other fuels. Utility DSM programs were seen as one way to help reduce utility oil use and U.S. dependence on oil imports.

MITIGATE THE ENVIRONMENTAL EFFECTS OF ELECTRICITY USE

Electric utilities are major contributors to environmental problems, especially air pollution. Emissions from power plants account for two-thirds of U.S. SO_2 emissions, one-third of NO_x, and one-third of CO_2 emissions (Ottinger et al. 1990). Compare these air-pollution effects with the nation's electric bill, which amounts to about 3% of GDP.

In addition, exploration and extraction of fuels (e.g., coal mining and oil drilling), fuels transportation, and electricity transmission cause environmental effects. Environmental effects include air pollution (particulate matter, sulfur oxides, nitrogen oxides, and air toxics); water pollution (thermal discharges, chemical and metal discharges, and fish entrainment in power-plant intake pipes); land use; and solid-waste disposal (including nuclear-waste storage). These emissions can affect human health and mortality, visibility, commercial crops and fisheries, other flora and fauna, and manmade structures.

Although federal and state legislation had begun to reduce these environmental effects, as of the late 1970s, many of these environmental costs were not included in the price of electricity. Such unpriced effects are considered externalities, and were thought to account for a nontrivial percentage of the direct costs of electricity. To the extent that DSM programs reduced electricity production and deferred construction of new plants, these environmental costs would be reduced.

ADDRESS MISMATCHES BETWEEN PRICES AND MARGINAL COSTS

Utilities typically assumed, in the late 1970s and early 1980s, that future load growth would be rapid and that this growth would require construction of large coal and nuclear plants. These assumptions led to forecasts of future electricity prices that were much higher than then-current prices. For example, EIA's (1979) forecast of the 1990 price was 33% higher than the actual 1978 price.

This relationship between current and projected electricity prices had two implications for DSM programs. First, to be cost-effective, utility programs had only to deliver energy savings at a cost lower than the avoided costs estimated at that time, which were roughly 7¢/kWh (in 1987 dollars), assuming that future electricity prices reflected long-run marginal costs. Second, the discrepancy between retail electricity prices and avoided costs (6 vs 7¢/kWh) constituted an important market failure. Price signals were encouraging customers to overconsume electricity and to underinvest in energy efficiency. This market failure provided an additional justification for utility DSM programs.

REDUCE MARKET BARRIERS TO ENERGY EFFICIENCY

Until the 1973 Arab oil embargo, energy executives, policy makers, and analysts gave little thought to the human aspects of energy consumption. Particularly in the electric-utility industry, where demand for electricity was doubling every decade, the focus was on expanding capacity fast enough to keep up with demand. To the extent that people thought about electricity use at all, it was primarily as a driver of economic growth and individual prosperity.

By the end of the 1970s, considerable social-science research had been conducted to examine the decision-making processes that households use in selecting energy systems (e.g., new appliances and homes) and in operating existing systems. These analyses showed that energy can be viewed as more than a commodity. The dominant theory of consumer behavior—that consumers act rationally in assessing the costs and benefits of energy alternatives—was deemed inadequate (Stern and Aronson 1984). Analysts used such studies to argue that governments and utilities should help consumers improve energy efficiency.

The research that led to these disparate perspectives on energy decision making identified various factors that inhibited people from adopting what would otherwise be cost-effective, energy-efficiency actions (Hirst and Brown 1990).* Some of these barriers are structural; that is, they affect conditions beyond the control of the individual. Such barriers include:

- Distortions in electricity price caused by differences between prices based on embedded costs and marginal costs, as well as environmental (and other) externalities not included in prices;
- Supply infrastructure limitations, such as lack of availability of energy-efficient products and lack of technicians trained in the installation and servicing of such products;
- Regulation that links utility earnings to increased electricity use;
- Government fiscal and regulatory policies, including those that affect the cost of capital.

Other barriers are behavioral, problems that characterize the energy consumer's decision making. Such barriers include:

- Perceived riskiness of energy-efficiency investments (e.g., the products will not work as well as the traditional ones they replace or the cost of home energy-efficiency improvements will not be reflected in the subsequent sale price);
- Information gaps, the difficulty in obtaining and processing unbiased information about current electricity uses and about energy choices;
- Split incentives (e.g., neither the owner of a building nor the electric-bill-paying tenant has an incentive to install energy-efficient measures);
- Limited access to capital.

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*By "otherwise," we mean what an engineer would calculate on the basis of the incremental cost of the energy-efficiency measure relative to the reduction in operating cost, based on assumptions concerning the lifetime of the action and the consumer's discount rate.

These barriers lead to consumer decisions that weigh capital costs much more heavily than reductions in long-term operating costs, yielding very high implicit discount rates. The difference in real discount rates used in making energy-efficiency investments [ranging from 20 to 100% (Train 1985)] and those used in assessing energy-supply investments (8 to 10%) came to be called the "payback gap." As a consequence of this payback gap, investments in production facilities (e.g., power plants and transmission lines) were much more likely to be made than investments in energy efficiency (e.g., insulation, clock thermostats, and high-efficiency appliances).

COMPLEMENT OTHER POLICIES TO ENCOURAGE EFFICIENCY

During the mid- and late 1970s, the U.S. Congress passed several laws intended to promote energy efficiency. These laws created, as examples, the Energy Extension Service, the State Energy Conservation Program, the Institutional Conservation Program, the Residential Conservation Service Program, and the Weatherization Assistance Program. In part because of the funding provided by these programs, most states created state energy offices. Thus, the late 1970s saw the establishment and development of new institutions aimed at helping consumers to improve energy efficiency.

Federal funding for energy-efficiency programs and research increased from about $100 million a year in 1975 to more than $1 billion a year in 1978, 1979, and 1980 (in 1988 dollars). However, President Reagan, as part of an effort to reduce the size of the federal government, cut energy-efficiency funds by about two-thirds throughout the 1980s. Thus, many programs were stalled just as they were getting off the ground.

A critical element of the National Energy Conservation Policy Act of 1978 mentioned earlier was a requirement for the U.S. Department of Energy (DOE) to establish residential-appliance efficiency standards. However, another element of President Reagan's policies led to DOE issuing a rule for no standards for eight products in 1982. DOE was immediately sued, and an appellate court invalidated DOE's 1982 final rule. The first standards took effect in 1988.

USE THE STRATEGIC POSITION OF ELECTRIC UTILITIES

Motivated by the recognition that DSM was often cheaper than expanding electricity supplies and perhaps by the cutbacks in federal funding, state PUCs began to encourage utilities to expand their roles as institutional supporters of energy efficiency. Stimulated in part by the federal Residential Conservation Service, which began in 1979, state energy offices and PUCs encouraged utilities to expand their energy-efficiency programs. Both the PUCs and the utilities saw DSM as a way to improve customer service and, thereby, to respond to customer complaints about higher electricity prices.

Utilities seemed like a good choice for these programs (Krause and Eto 1988). Utilities, because of the retail monopoly franchise granted by the state, have traditionally been social agents. That is, they often conduct programs that go beyond their narrow economic interests to serve society in general. For example, utilities frequently are active in local economic-development efforts, provide lifeline rates for low-income customers, and offer educational programs in local schools.

Also, electric utilities have long-standing relationships and monthly contacts (i.e., meter reading and billing) with their customers. Utilities have excellent name recognition among their customers and are generally regarded as sources of reliable and credible information. Utilities are in the best position to calculate and capture the electric-system benefits of changes in customer load shapes and levels. Utilities have detailed information about the electricity-use patterns and trends among their customers. And utilities have access to abundant supplies of low-cost capital.

Energy-efficiency and environmental advocates viewed utilities as uniquely qualified to conduct DSM programs because these programs were seen as alternatives to the construction of new power plants. Load-management programs, which focus on reducing demand at the time of system peak, could substitute for the construction of peaking units, such as combustion turbines. Energy-efficiency programs, which focus on reducing overall electricity use, could substitute for coal and nuclear baseload units. DSM programs were expected to deliver savings at costs well below those of the best supply options.

This view of DSM as a resource led, in the mid-1980s, to a new way of utility planning called integrated resource planning (IRP). In IRP, a utility considers a wide range of supply options and DSM programs to meet future customer energy-service needs (Cavanagh 1986; Goldman, Hirst, and Krause 1989). Utilities, under this view of IRP, were expected to secure a portfolio of demand and supply resources that would minimize life-cycle costs of reliable electricity service. This concept led to utility financing of DSM measures, in which the utility would pay some or all of the cost of the measures. Equally important, many states gave utilities financial incentives to improve DSM-program performance. The objective of these regulatory changes was to make the utility's least-cost resource portfolio its most profitable.

Under the IRP paradigm, DSM was often considered an attractive resource for a variety of reasons. The cost to acquire DSM was often lower than the cost of supply options. That is, load-management programs cost less in $/kW than did peaking units, and energy-efficiency programs cost less in ¢/kWh than did baseload units. In addition, DSM programs added diversity to a utility's resource portfolio, making it less vulnerable to sudden changes in load growth, fuel prices, and other factors. Finally, DSM was considered a flexible resource because, compared to most power plants, it is added in small increments.

ELECTRIC-SUPPLY OPTIONS

In this chapter, we examine the continuing merits of four critical early justifications for utility DSM programs: defer expensive sources of generation, reduce dependence on oil, address mismatches between electricity prices and marginal costs, and reduce utility planning uncertainties.

SUPPLY COSTS ARE LOWER TODAY

As noted above, utility and EIA forecasts around 1980 called for continued load growth and construction of many baseload power plants. These forecasts implied substantial increases in real electricity costs and prices (Fig. 2).

During subsequent years, load growth turned out to be slower than expected, utilities built more capacity than needed, natural gas prices fell, and the performance of natural-gas-fired combustion turbines improved. These changes led to a reversal in the relationship between average and forecast electricity prices. The EIA forecasts made in 1986, 1989, and 1995, as examples, showed essentially no increase in future electricity prices (Fig. 2). The latest EIA analysis estimates that the average electricity price in the year 2000 will be 2% lower than the 1993 price and that the average price in 2010 will be only 5% higher than the 1993 price (EIA 1995a).

Typically, today's plans for new generating resources call for gas-fired combustion turbines to meet peaking demands and for gas-fired combined-cycle units to meet baseload demands. Specifically, between 1994 and 2003, utilities plan to add four times as much gas and oil capacity as coal capacity (EIA 1994). The average size of the planned coal units is 406 MW (much less than the nearly 600-MW units added during the mid-1970s), and the average size of the planned gas and oil units is 79 MW. The small unit size and short construction time for gas-fired units add considerable flexibility to utility plans to expand generating capacity.

In addition, nonutility capacity additions between 1994 and 1996 are almost equal to planned utility additions, 15,700 vs 17,800 MW (EIA 1994). The ability to buy power from other utilities or from nonutility generators adds flexibility to a utility's resource portfolio because the purchase contract is not necessarily tied to any particular construction schedule or plant lifetime.

As of 1993, the total (capital plus operating) cost of a combined-cycle unit plus transmission was lower than industrial electricity prices in every region (Baxter and Hirst

1995).* These differences gave industrial customers a strong incentive to obtain power supplies from other sources and to promote retail wheeling.

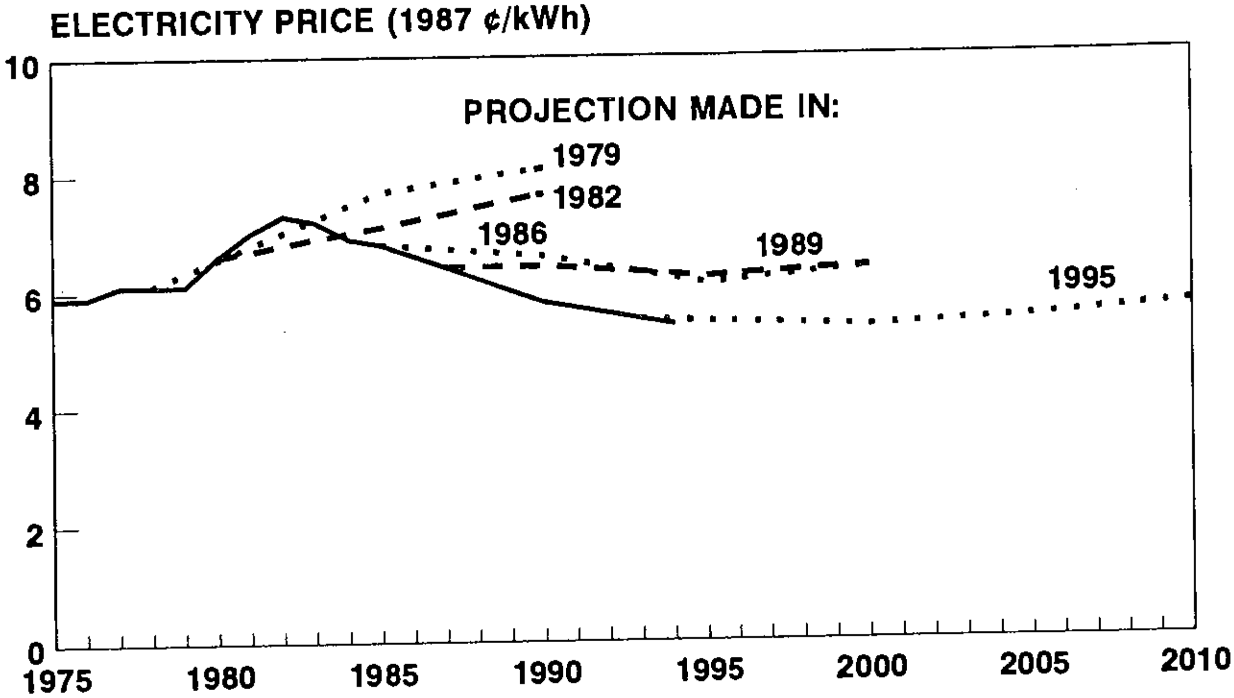

Fig. 2. **EIA projections of U.S. retail electricity price made in 1979, 1982, 1986, 1989, and 1995 compared with actual electricity prices. Prices expressed in 1994 dollars would be 30% higher than the 1987-dollar units shown here.**

OIL DEPENDENCE IS ALSO LOWER

Utility dependence on oil fuel declined substantially during the past 15 years, reaching 3.5% of total generation during the past few years (down from its late-1970s value of 14%). Electric utilities now account for less than 3% of national oil use, far below the late-1970s level of 10%. Thus, the national-security concern about oil imports is much less of an electric-utility issue than it formerly was. Transportation accounts for about two-thirds of U.S. oil use and is therefore the primary contributor to oil imports.

*These combined-cycle costs are based on a real discount rate of 5%, roughly equal to today's utility cost of capital. Discount rates in a competitive electric-generation industry are likely to be much higher to reflect the greater risk to investors. However, even if the discount rate triples to 15%, the total cost of a combined-cycle unit is only 25% higher than with a 5% discount rate. This nonlinearity occurs because operating costs account for roughly two-thirds of the total cost of a combined-cycle unit.

MARGINAL COSTS ARE NOW LOWER THAN ELECTRICITY PRICES

The substantial reductions in electricity prices (in part stimulated by declines in natural gas prices and improvements in combustion-turbine performance) during the past decade led to a reversal in the prior relationship between prices and marginal costs. Thus, one reason for utility DSM programs in the late 1970s—that the prices consumers faced encouraged them to underinvest in energy efficiency—is now gone. Indeed, current prices, because they generally exceed marginal costs, encourage consumers to overinvest in energy efficiency. However, the effects of price signals on consumer behavior are often distorted by various market barriers, as discussed in Chapter 6.

Given the excess capacity that exists today in many regions, short-term avoided costs are often close to the operating costs of existing power plants (on the order of 2.0 to 2.5¢/kWh). Nationwide, operating costs were lower by 3.5% in 1994 than in 1993 (Knutson 1995), probably a consequence of low gas prices and increasing competition. High reserve margins may persist for many years as utilities increasingly offer real-time pricing options to their customers. These options effectively substitute economics (through the price-elasticity effect) for engineering (high reserve margins), which may allow reserve margins to fall with no loss in system reliability. On the other hand, increasing competition may lead to early retirement of some nuclear and fossil units whose variable costs exceed those of the regional wholesale market.

As capacity margins decrease, avoided costs will rise to the full cost of a combined-cycle unit (Fig. 3). Overall, these avoided costs are much lower than the 10¢/kWh (1993 dollars) typically assumed ten years earlier. To be cost-effective, a DSM program must deliver savings at less than 3¢/kWh, based on the assumed avoided costs shown in Fig. 3. Ten years ago, that program needed only to be cheaper than 10¢/kWh.

TODAY'S SUPPLY SYSTEM IS MORE FLEXIBLE AND RESILIENT

Today's capacity additions are environmentally cleaner, smaller in size, inherently more flexible, and take less time to build than the options of 15 years ago. Utilities can build combustion turbines in three or four years. Later, as demand increases, they can add a heat-recovery steam generator to convert the simple-cycle unit to a larger, more efficient combined-cycle unit. If gas prices were to increase dramatically, utilities could probably switch to coal with a coal gasifier. Natural gas is also a much cleaner fuel than coal. To illustrate, the emissions of CO_2 from a gas-fired plant are about half those from a coal-fired plant. And new coal-fired units are much cleaner, on average, than existing coal units. Thus, on virtually all counts, today's supply additions are better than those of a decade ago.

But utilities have more options than those identified above. Utilities can repower existing plants to increase capacity and to extend plant lifetime, and they can purchase power from others. For example, the electric utilities in Maryland plan to rely on purchases from other utilities and from nonutility generators for almost 60% of their supply needs between 1994 and 2008 (Maryland Public Service Commission 1994). Thus, the flexibility and diversity benefits of DSM, which were substantial a decade ago, are now much reduced.

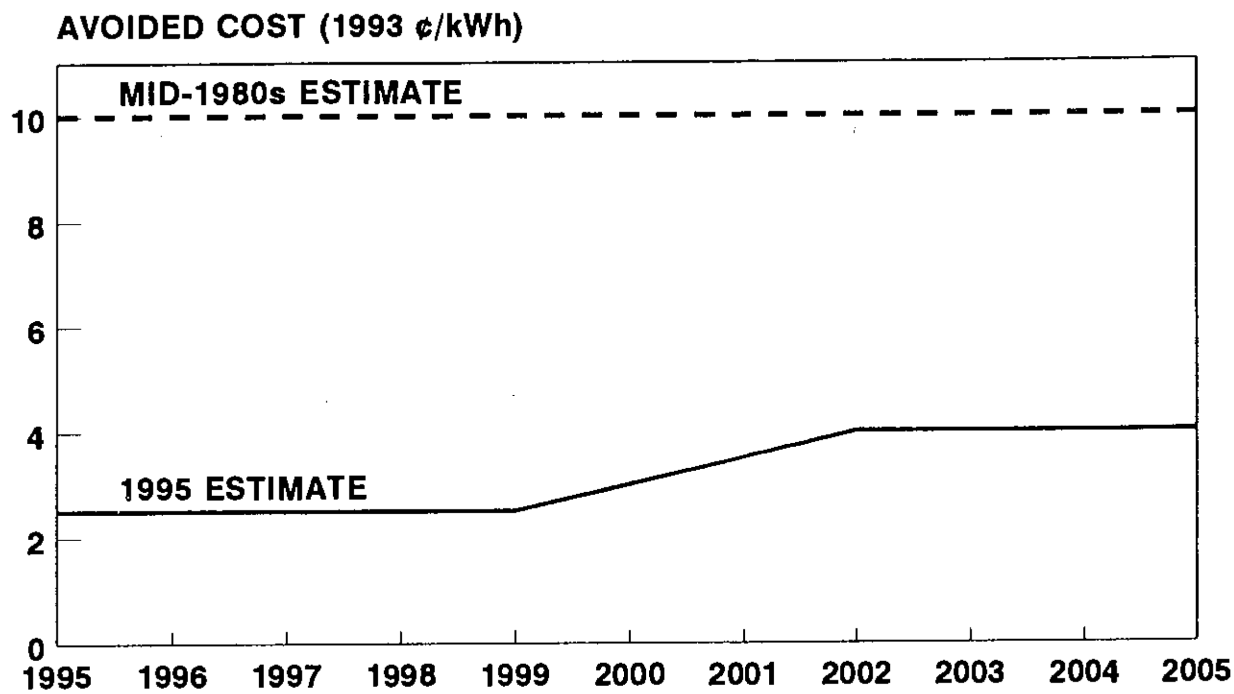

Fig. 3. Schematic showing avoided supply costs as estimated today and a decade ago. The 1995 estimate assumes that no new capacity is needed until around 2000 and that there are no transmission constraints.

SUMMARY

The direct economics of utility supply are dramatically different from what they were 10 to 15 years ago. Because many regions have excess generating capacity, avoided costs for the next few years are likely to be quite low, only slightly above the variable operating cost of power plants. In the midterm, avoided costs are expected to remain below today's prices, because of advances in gas-combustion technologies and low gas prices. Increasing competition in power-supply markets will likely suppress prices further as the inefficiencies associated with a regulated monopoly are weeded out. Growing competition among power suppliers and technological advances are reducing the financial and construction risks that utilities today face relative to those they formerly faced when building large, baseload power plants. Because of these dramatic changes, the economic, diversity, and flexibility benefits of utility DSM programs are generally less today than they were in the past. On the other hand, if natural gas prices increase dramatically or if environmental constraints take new forms of regulation or taxation, supply costs could increase, which would make DSM a more attractive resource.

ENVIRONMENTAL EXTERNALITIES

Many of the important environmental impacts of electricity were historically not part of utility resource-planning and operating decisions. Several factors have changed during the past 10 to 15 years that might affect the environmental benefits of utility DSM programs. First, recent federal and state laws further limit allowable emissions of various pollutants from power plants and transmission lines. Second, utilities, vendors, and DOE have developed improved technologies that reduce these adverse environmental effects. Third, our understanding of the damages caused by these emissions has improved. Fourth, the threat of global warming (especially carbon dioxide emissions) is much clearer now. Finally, our understanding of the effects of DSM programs on utility emissions has increased.

Utility emissions of the major air pollutants *per kWh of production* decreased during the past several years (Fig. 4). On the other hand, total emissions of NO_x and CO_2 grew because of increased electricity consumption (EIA 1993b and 1994).

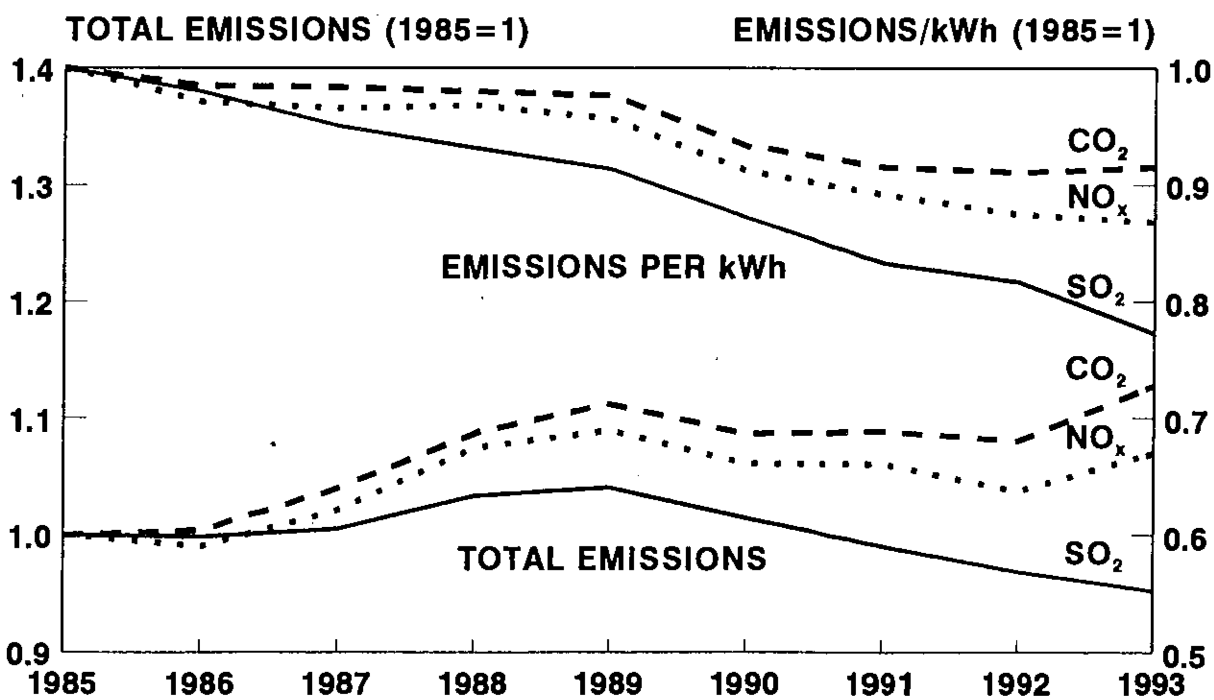

Fig. 4. **Electric-utility emissions of air pollutants from 1985 through 1993. The top curves show emissions per kWh generated, and the bottom curves show total emissions.**

SOME POLLUTION COSTS HAVE BEEN INTERNALIZED

Perhaps the most significant recent environmental legislation to affect electric utilities is the 1990 Clean Air Act Amendments. Title IV of this act limits national emissions of SO_2 in the year 2000 (capped at 8.9 million tons/year) to about half its 1990 value. A key innovative feature of this national limit is the creation of SO_2 allowances. The holder of each allowance is permitted to emit one ton of SO_2 from its facilities. These allowances can be bought and sold, thus encouraging utilities to seek the least-cost ways to meet the national cap. Today, these allowances typically sell for less than $200/ton, far below estimates made a few years ago (Nadel et al. 1994).

In addition to federal legislation, many state PUCs require electric utilities to consider environmental externalities in their resource-planning processes. As of March 1994, 29 states plus the District of Columbia required such consideration (Fang and Galen 1994). Seven of these states (California, Massachusetts,* Minnesota, Nevada, New York, Oregon, and Wisconsin) require utility use of monetized values for various emissions (e.g., Wisconsin's specification of $15/ton of CO_2 emitted). States that require use of environmental externalities generally do not require their use in assessing the continued operation and retirement of existing power plants. This is an important limitation because the environmental damages from existing plants are typically two to three times as much as those from new plants (Koomey 1990).

The monetized values used by these states for each pollutant vary enormously. To illustrate, the values for NO_x range from $69/ton (the Bonneville Power Administration estimate for the east side of the Cascade mountains) up to $31,600/ton (the California PUC estimate for southern California). In part, these estimates vary because the damages caused by some pollutants are quite site-specific (e.g., they depend on population density in the local area and on the particulars of local flora and fauna). In part, these estimates vary because they are based on different methods, in particular the cost-of-control vs damage-function approaches. And they vary because the underlying science is insufficient.

Largely because of limitations in early approaches to estimating environmental damages, two major studies were begun in 1991. One study, conducted at Oak Ridge National Laboratory (ORNL), was sponsored by the Department of Energy and the Commission of the European Communities (Lee 1995a). The second, conducted by RCG/Hagler, Bailly (RCG), was sponsored by several government and utility groups in New York (Rowe et al. 1995).

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*The Massachusetts Supreme Judicial Court in December 1994 struck down the Massachusetts environmental-externality requirements, finding that the Department of Public Utilities exceeded its authority in this area. However, the court endorsed state authority to consider projected costs associated with future environmental taxes or regulation. Recent decisions from the Federal Energy Regulatory Commission also appear to limit state ability to impose environmental-externality requirements on utility-resource decisions.

These two studies suggest that the environmental externalities associated with electricity production at new power plants may be less than was previously thought. For example, ORNL results show that the fuel-cycle externalities for a coal plant located in the Southeast total 0.12¢/kWh. The RCG estimates of the environmental damages from coal-fired power plants located in rural, upstate New York range from 0.08¢/kWh to 0.26¢/kWh (Rowe et al. 1995).

The PUC estimates cited above are typically a factor of ten higher than the ORNL and RCG values (Table 1). Even the RCG numbers for plants sited in New York City (where damages would be unusually high because of the very high population concentration) are much lower than those implied by the monetized externalities adopted by various PUCs.

Table 1. Alternative estimates of environmental externalities exclusive of global climate change from new electric power plants (1992-mills/kWh)

	Pulverized coal	Combined-cycle gas
ORNL study		
Tennessee	1.4	0.2
New Mexico	0.7	0.0
RCG/Hagler, Bailly study		
Upstate, rural New York	2.6	0.2
New York City	4.3	1.7
Earlier estimates		
Nevada	19.0	5.5
New York	11.2	6.9
Oregon	13.9	2.8

Sources: Fang and Galen (1994); Koomey (1990); Lee (1995a); and Rowe et al. (1995).

Caverhill and Chernick (1995) believe that the RCG study "leaves out entire classes of effects and estimates only a portion of other effects." As examples, they estimate the damages from small particulate matter (PM_{10}) and from mercury and other air toxics as orders of magnitude higher than the RCG estimates. The lead authors of the RCG and ORNL studies agree that many externalities were not included in their studies. However, those pollutants were excluded because of insufficient scientific evidence concerning their effects or the belief that the environmental effects from these pollutants are de minimis. The lead authors believe that they neither over- nor underestimated the effects for the pollutants studied. They also note that many experts participated in external reviews of the two studies. Lee (1995b) states that "... the differences between the earlier, and the more recent [ORNL and RCG] studies, are primarily due to three factors: the lower emissions that the more recent studies assume, their lower estimates of health effects due to sulfates, and their decision that the state of the science is too imprecise to justify a specific estimate of the damages from climate change." This disparity in views as well as the large range in values shown in Table 1 demonstrate the uncertainties that remain about the environmental effects of electricity production.

THE THREAT OF GLOBAL WARMING REMAINS

Anthropogenic (i.e., human induced) emissions of greenhouse gases (especially carbon dioxide, but including also methane, nitrous oxides, and chlorofluorocarbons) may alter the Earth's climate. Such changes, if they occur, would radically alter the global environment and its effects on people, plants, and animals.

The scientific community largely concurs on several key issues concerning global warming (Intergovernmental Panel on Climate Change 1994):

- Atmospheric carbon dioxide concentrations are increasing.
- This growth is driven to a large extent by anthropogenic emissions.
- These increases will likely raise global temperatures by 2 to 6^0F some time during the next 50 to 100 years.
- Stabilization of atmospheric CO_2 levels at one to two times today's concentrations can be attained only if global anthropogenic emissions eventually drop substantially below current levels.
- Greenhouse gases have lifetimes that range from ten to several hundred years or more. The extent of global warming is a function of atmospheric concentrations of greenhouse gases. Therefore, climate change is primarily a function of *cumulative* rather than *annual* emissions.
- Key consequences of these temperature increases will probably include higher sea levels leading to inundation of coastal areas; damage to ecosystems; changes in agricultural activities and productivity; spread of infectious tropical diseases; and much greater local and regional climate volatility, including more frequent and more severe thunderstorms, droughts, floods, tornados, and hurricanes.

Recent evidence suggests that the effects of global warming already are being felt (Lashof 1995). According to analyses conducted by the National Weather Service, 1994 was one of the warmest years during the past century. Temperature increases in the Pacific Ocean may have led to an 80% decline in zooplankton volume off the coast of California. An iceberg the size of Rhode Island calved from the Larsen ice shelf in Antarctica, perhaps caused by warming trends. Finally, insurance companies are worried about the high costs they faced from the string of recent natural disasters, including floods, hurricanes, and typhoons.

The United States was one of 155 nations to sign the United Nations Framework Convention on Climate Change in 1992. The U.S. Senate ratified the agreement later that year. And in 1993, the President announced the Climate Change Action Plan, intended to reduce U.S. greenhouse-gas emissions to their 1990 levels by the year 2000 (Clinton and Gore 1993). This plan calls on electric utilities to provide much of those greenhouse-gas reductions.

Climate Challenge is the primary element of the Action Plan that directly involves electric utilities. As of March 1995, 79 utilities, representing more than half of the U.S. electricity generation, had signed agreements with DOE to participate in Climate Challenge (Kane 1995). These utilities plan to cut CO_2 emissions by 160 million metric tons by the year 2000. This reduction accounts for 40% of the total reduction called for in the Climate Change Action Plan. DSM programs account for 18% of the reductions planned in Climate Challenge.

Estimates of CO_2 externalities vary widely (Fang and Galen 1994). The range of values that different PUCs have adopted leads to a range of 1 to 29 mills/kWh for a coal plant and 1 to 12 mills/kWh for a combined-cycle gas plant (Table 2). At the low end of the range, these CO_2 values would roughly double the environmental damages estimated in the ORNL and RCG studies. At the high end of the range, these CO_2 numbers are a factor of ten higher than the damages associated with other emissions (compare Tables 1 and 2). Some PUCs are focusing less on damage costs and more on the financial risks associated with possible future carbon taxes or emissions caps.

Table 2. Estimates of CO_2 externalities from electricity production (1992-mills/kWh)[a]

CO_2 value ($/ton)[b]	Pulverized coal	Combined-cycle gas
1.2	1.4	0.6
24	28.7	12.4

[a]Coal has a CO_2 content of about 2.4 lb/kWh, assuming a heat rate of 10,000 Btu/kWh; and natural gas has a CO_2 content of about 1.0 lb/kWh, assuming a heat rate of 8500 Btu/kWh.

[b]PUC estimates of CO_2 values range from $1.2/ton for New York to $24/ton for Massachusetts (Fang and Galen 1994).

To reduce CO_2 emissions below the 1990 level will require many actions, including use of low-CO_2-emitting power sources (e.g., natural gas and renewables instead of coal), cofiring coal units with natural gas, improvements in fossil-unit efficiencies, offsets (e.g., tree planting and methane capturing from landfills), as well as more energy-efficiency programs. Such actions could be stimulated by direct government mandates. Alternatively, the federal government could shift part of the current tax burden away from employment and income and make up the difference with taxes on greenhouse-gas emissions. The Clinton Administration's inability to implement a Btu tax in 1993 shows the political difficulty in raising taxes, but a campaign framed in terms of tax reallocation and pollution avoidance might succeed. Another possibility is to emulate Title IV of the 1990 Clean Air Act Amendments and establish a national ceiling on greenhouse-gas emissions, with allowances to encourage trading of emissions rights. Finally, the relative merits of reducing greenhouse-gas emissions in the U.S. or in other countries need to be considered.

DSM CAN REDUCE ENVIRONMENTAL DAMAGES

Each kWh saved by a DSM program is a kWh not produced. Each kWh not produced reduces the environmental effects of electricity production. However, the environmental benefits of DSM programs are not necessarily directly proportional to their energy savings. The benefits derive from the particular power plants at which generation is reduced because of the DSM-induced energy savings. In the short run, these power plants are likely to be among the older, dirtier, and less efficient generating units in the utility's resource portfolio.

In the long run, DSM-induced savings defer construction of new, generally cleaner and more efficient generating units.* This deferral may have small, short-term adverse consequences for some pollutants, as illustrated by analysis of the electric systems in New England, southern California, and Colorado. For example, Public Service Company of Colorado (1993) found that DSM programs would defer the conversion of a coal plant to a gas-fired combined-cycle plant. This delay would increase emissions during the two-year delay period, leading to a 1.0% increase in SO_2 emissions during the 20-year analysis period. However, emissions of the other air pollutants would go down when DSM is added to the utility's resource portfolio. For example, these DSM programs would cut CO_2 emissions by 3.5% over the 20-year period.

DSM programs can help a utility meet its environmental goals. The American Council for an Energy-Efficient Economy and PSI Energy analyzed current PSI DSM programs and two sets of expanded programs to the year 2010 (Nadel et al. 1994). By 2010, expanded DSM programs could contribute an additional (beyond what supply options would do) 10 to 20% reduction in SO_2 emissions. Based on the assumed cost of allowances, the environmental benefits of DSM account for more than one-fourth of the projected total DSM benefits. Even in this case, however, the DSM programs contribute proportionately less to SO_2 reductions than to electricity savings, 9.6 vs 12.4%. The difference occurs because new power plants are less polluting than existing ones.

*In principle, a utility will acquire additional generation when the total (capital plus operating) cost of the new generation is less than the operating cost of the existing generation. If DSM decreases the use of an existing generating unit, the economic benefits of acquiring a new unit are correspondingly reduced.

To what extent have utilities used DSM as an environmental-quality strategy? Given the disparities among generating units in their environmental effects, there is no easy way to examine this question. Assume for the moment that use of coal to generate electricity is a reasonable proxy for environmental damages (coal-fired generating units cause much more environmental damage per kWh generated than do other fuels). If environmental quality were a key goal of DSM programs, there would then be a positive correlation between utility coal use and DSM-program electricity savings. However, the opposite is true: the higher the percentage of electricity generation from coal, the lower the percentage of sales reduced by DSM (Hadley and Hirst 1995; EIA 1994). This negative correlation is statistically significant at the 1% level.

These results can be interpreted in two ways. First, they suggest a substantial opportunity to improve environmental quality by expanding DSM programs in coal-using areas. Second, they suggest that environmental quality has not been a primary motivator of utility DSM programs. Coal is used to produce 90% or more of the electricity in Indiana, Kentucky, New Mexico, and Ohio; but DSM cut sales by less than 1% in each of these four states. Also, because coal is an inexpensive fuel, electricity prices in coal-dependent states are generally low, reducing the economic benefits of DSM programs.

SUMMARY

Stricter regulation of power-plant emissions plus recent analyses of the damages associated with such emissions suggest that many of the environmental damages caused by electricity production may be less than we thought several years ago. The ORNL and RCG studies suggest, for example, that the environmental damages, excluding CO_2, from a combined-cycle gas plant are equivalent to only a few percent of the direct capital and operating costs. On the other hand, possible new regulations of air toxics (including lead and mercury), small particulate matter (PM_{10}), and NO_x (especially for areas of ozone nonattainment) could increase the environmental costs of electricity production. And there remains considerable uncertainty and controversy about the extent of the environmental damages from electricity production and transmission.

Whether U.S. society, as reflected by the actions of the federal government, decides to act forcefully to reduce emissions of greenhouse gases is unclear. On one hand, we could decide to wait several years until the science of global warming provides additional answers with fewer uncertainties. On the other hand, we could decide that the potential damages from global warming are so great that we must act now. The effects of legislated or regulated efforts to reduce greenhouse-gas emissions could have large effects on the costs of electricity production, in part because CO_2 is now completely unregulated. DSM could play a modest, but important, role in reducing U.S. CO_2 emissions.

THE COST OF UTILITY DSM PROGRAMS

Chapters 3 and 4 discussed the value of energy-efficiency programs in avoided supply costs and associated environmental damages. This chapter describes the utility industry's experience in delivering energy efficiency through DSM programs. The full societal cost of these programs, based on the measured performance of these programs, should figure centrally in justifications to continue them in the future. We also comment on the impact of these programs on electricity prices, which is increasingly important to utilities.

MEASUREMENTS OF DSM PERFORMANCE ARE IMPROVING

Unlike power plants, for which one can readily measure the energy and demand outputs, measuring the performance of DSM programs is difficult. Such measurement requires a comparison of the energy behaviors of program participants (which can be readily observed) with what that behavior would have been in the absence of the DSM program. The second element cannot be measured because it does not exist; it can only be inferred. Generally, such inferences are based on analysis of energy-use data and other information collected from program participants and nonparticipants.

Nadel and Keating (1991) examined a number of early DSM program evaluations and found that many of them had overestimated savings. Joskow and Marron (1992) identified these and additional accounting inconsistencies in a review of ten utility DSM-program portfolios. They concluded that "the evidence we have suggests that computations based on utility expectations could be understating the actual societal cost by a factor of two or more on average." Given today's lower avoided costs, these findings have been taken by many to suggest that DSM programs are often not cost-effective.

However, utilities have done much to advance the practice of DSM-program evaluation. Today, utilities often base estimates of energy savings on measured energy-use data rather than on engineering estimates as they did several years ago. Utilities are more knowledgeable and sophisticated in their design of comparison groups (used to infer the without-program behavior of participants) and in their use of methods to analyze evaluation data. These data and analytical advances have improved utility ability to estimate well the past and likely future electricity savings from their DSM programs. To illustrate, Brown and Mihlmester (1994) reviewed more than 50 California utility evaluations and found that, on average, measured electricity savings were within 10% of predicted savings. Coakley and Schlegel (1995) examined Massachusetts utility evaluations and found that, on average, measured savings were consistently 80% of predicted savings.

In spite of these improvements in evaluation practice, gaps remain in our knowledge of DSM-program performance. In particular, only limited information is available on program benefits and costs related to (1) the long-term persistence of DSM-program and -measure energy savings; and (2) the effects of market transformation and free drivers (i.e., customers that install measures because of the program but do not participate directly in the program). The first issue would reduce savings, while the second would increase them.

MANY DSM PROGRAMS HAVE BEEN COST-EFFECTIVE

Eto et al. (1994) examined data on 20 commercial/industrial lighting programs. They devoted considerable attention to careful reconciliation of cost and savings data to ensure consistency across programs and inclusion of all costs. They included participant, as well as utility, costs and made consistent adjustments across programs for differences in evaluation methods. Their analysis showed an average cost of conserved electricity (CCE), based on a real discount rate of 5%, of 3.9¢/kWh (Fig. 5). Across programs, the CCE ranged from 1.2 to 7.6¢/kWh. A critical finding from this study was that all 20 programs were cost-effective relative to the utility's estimate of avoided costs at the time each program was operating. In other words, utilities have fielded cost-effective programs across a range of avoided costs.

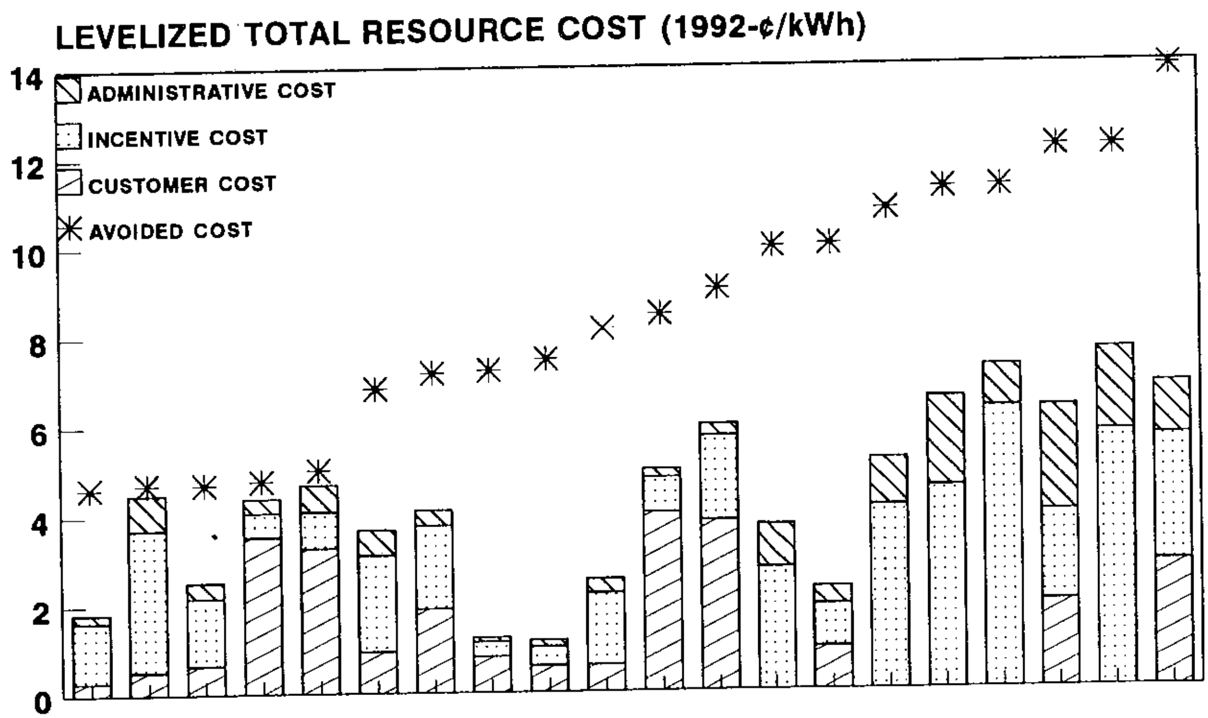

Fig. 5. **The total-resource cost of commercial lighting programs (Eto et al. 1994).**

Goldman and Kito (1994) reviewed costs and benefits for 10 DSM programs in which utilities awarded contracts in response to competitive-bidding solicitations. Total resource costs ranged from 5.4 to 8¢/kWh. Bids aimed at residential customers were more expensive than those aimed at commercial customers (6.2 vs 5.0¢/kWh). In nine of the 10 cases, the CCE was less than the utility's avoided supply cost at the time the program was run.

Since 1990, California's investor-owned utilities have invested about $2 billion in DSM (California PUC 1995b). Utility estimates of the net benefits from this investment exceed $2 billion. Between 1991 and 1994, the resource programs (those intended to provide cost-effective energy and capacity resources) saved electricity at a utility cost of 2.5¢/kWh. Although the benefit-to-cost ratios for these programs declined from year to year, primarily because of lower avoided costs, the direct utility costs also dropped, reflecting the utilities' ability to deliver savings at lower costs.

On the other hand, some utility DSM programs have not been cost-effective. Vine (1995) examined the total cost and measured performance of residential new construction programs. He found that the programs were quite costly, averaging 13¢/kWh. At today's avoided costs, these programs would not be cost-effective. At the same, he points out that accounting for spillover benefits from these programs, which the utilities have found difficult to measure, would reduce these costs.

NATIONAL DSM RESULTS ARE GENERALLY POSITIVE

Although utility DSM measurement and cost-accounting practices differ, it is useful to examine the national data on DSM-program costs and benefits. Utility expenditures on energy-efficiency programs in 1993 saved electricity at a CCE of 3.0¢/kWh, assuming that the measures installed that year last an average of 10 years and the savings are discounted at a real rate of 5% (Hadley and Hirst 1995). These estimates do not include customer contributions to the cost of DSM measures. The comparable figure for 1992 programs is 3.7¢/kWh. This 20% reduction in utility cost may suggest that utility programs are becoming more cost-effective with time but it also likely reflects reductions in utility-paid incentives to customers.

These national averages hide enormous variation across utilities; see solid curve in Fig. 6 (the dashed curve is discussed on the next page). For the 253 utilities that provided complete data to EIA for 1993, utility CCE ranged from 0.4¢/kWh for the cheapest 2% of the savings added that year all the way up to 13.3¢/kWh for the most expensive 2%.* Savings in the middle 80% range from 0.8 to 6.7¢/kWh. Assuming that customer costs add 1¢/kWh on average, these

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*The very low estimates of CCE are probably primarily for information and education programs, for which customers paid most of the measure costs and for which the utilities overestimated savings. The very high estimates of CCE are probably primarily for programs aimed at reducing peak demands but were misclassified as energy-efficiency programs and for programs that included substantial utility payments for the DSM measures. In other words, many of the very low and very high estimates are suspect; therefore the actual variance of total costs is less than implied by Fig. 6.

results suggest that energy-efficiency programs are generally cost-effective relative to long-run marginal costs but not relative to short-run marginal costs (Fig. 3). The results also suggest that some programs are very cost-effective and others are not.

Figure 6 shows how a change in assumed avoided cost can affect the amount of DSM that utilities can cost-effectively acquire. To compute the dashed line, we assumed that customers contribute much more to the programs at the left end of the graph (i.e., those that have a very low utility CCE) than they do to the programs at the right. The graph also shows the amount of energy efficiency that utility DSM programs could have acquired assuming avoided costs of 3.5 or 10.5¢/kWh.* The amount available, based on these 1993 results, at 3.5¢/kWh is 40% of the amount available at 10.5¢/kWh. These results suggest that the amount of cost-effective energy savings that DSM programs can acquire is much less with today's low avoided-supply costs.

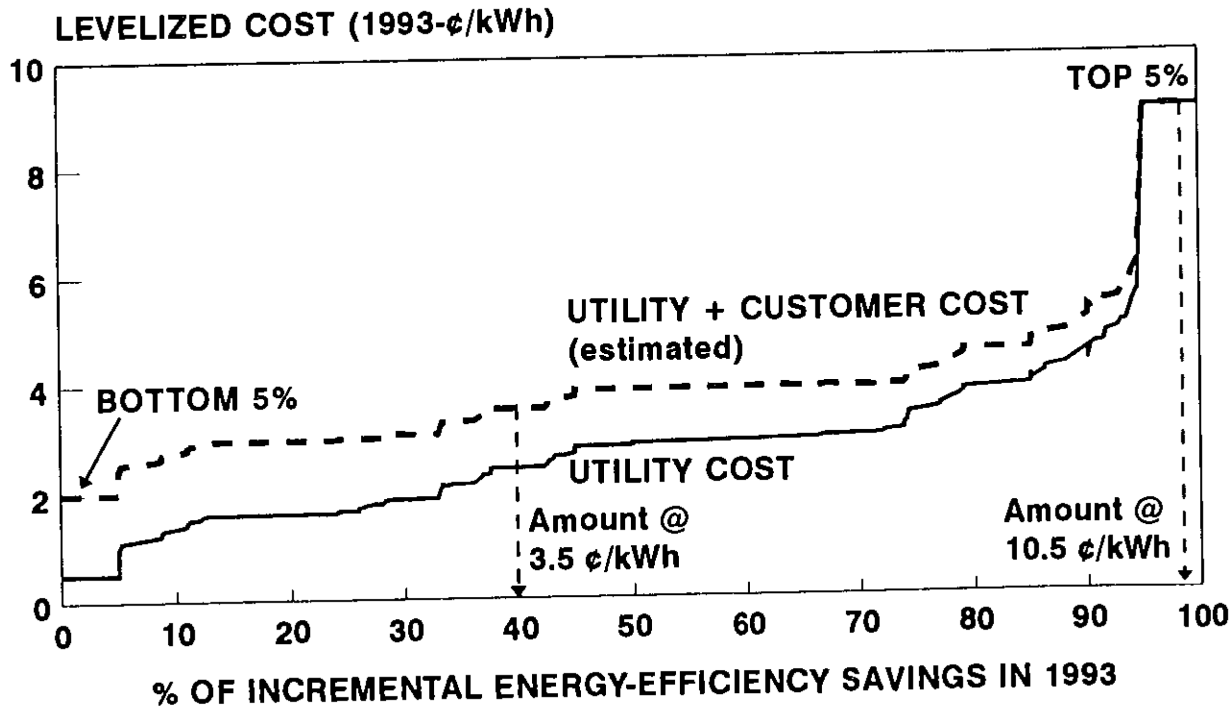

Fig. 6. **Estimated total CCE for utility energy-efficiency programs run in 1993. The dashed lines show how much of the 1993 energy savings would be cost-effective at 3.5 or 10.5¢/kWh.**

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*To reflect avoided transmission and distribution (T&D) costs, we added 0.5¢/kWh to the generation-avoided costs of 3 and 10¢/kWh discussed in Chapter 3 (Fig. 3). T&D accounts for 36% of utility fixed costs, and fixed costs amount to 42% of total revenues (EIA 1994). Normalized by total sales, fixed T&D costs are equivalent to 1.0¢/kWh. We arbitrarily assumed that DSM programs avoid half these fixed costs.

DSM TYPICALLY INCREASES ELECTRICITY PRICES

Cost-effectiveness from a total-resource perspective is one issue. The effects of DSM programs on electricity prices is another. As utilities worry more about competition, they are cutting costs wherever they can, including their DSM budgets. Hirst and Hadley (1994) examined parametrically the rate impacts of DSM programs. Their results suggest that:

- DSM programs typically increase electricity prices (Fig. 7). Although such programs may reduce electric bills, they increase prices slightly over the lifetimes of the measures installed.

- The situation today is different from what it was several years ago. Then, DSM was expected to increase prices for only a few years, after which customers would enjoy both lower bills and prices. The change in expectation is a consequence primarily of reductions in avoided costs (see earlier discussion and Figs. 2 and 3). With avoided costs below average costs, DSM often raises electricity prices.

- The effects of DSM programs on electricity price [probably about 2% on a national basis (Pye and Nadel 1994)] are much less than the effects of other factors, including fuel mix, the capital cost of baseload generation, and purchased-power contracts.

- Utilities can find ways to run DSM programs that cut electricity prices. Reducing DSM-program costs, focusing programs on those areas where large T&D investments could be deferred, timing DSM programs to match avoided costs, and shifting more of the utility's fixed costs from volumetric charges to the monthly customer charge would cut the price increases. Such changes in the structure of retail tariffs are controversial because they raise electric bills for those who use small amounts of electricity and they reduce benefits to customers that improve electric-energy efficiency. On the other hand, such changes may be more consistent with a competitive electricity market, in which prices reflect time-varying, short-term production costs.

Figure 7 shows the results for one hypothetical combination of factors favorable to DSM programs: low program costs, avoidance of substantial T&D costs, high avoided generation costs, and a larger fraction of fixed costs in the monthly customer charge. Because such programs require participants to pay a substantial share of the DSM costs, participation is likely to be lower than in programs where the utility pays for most of the DSM. Because such programs focus on those geographic areas with high avoided T&D costs, the potential to reduce the need for generation (and its attendant pollution) is reduced relative to system-wide programs.

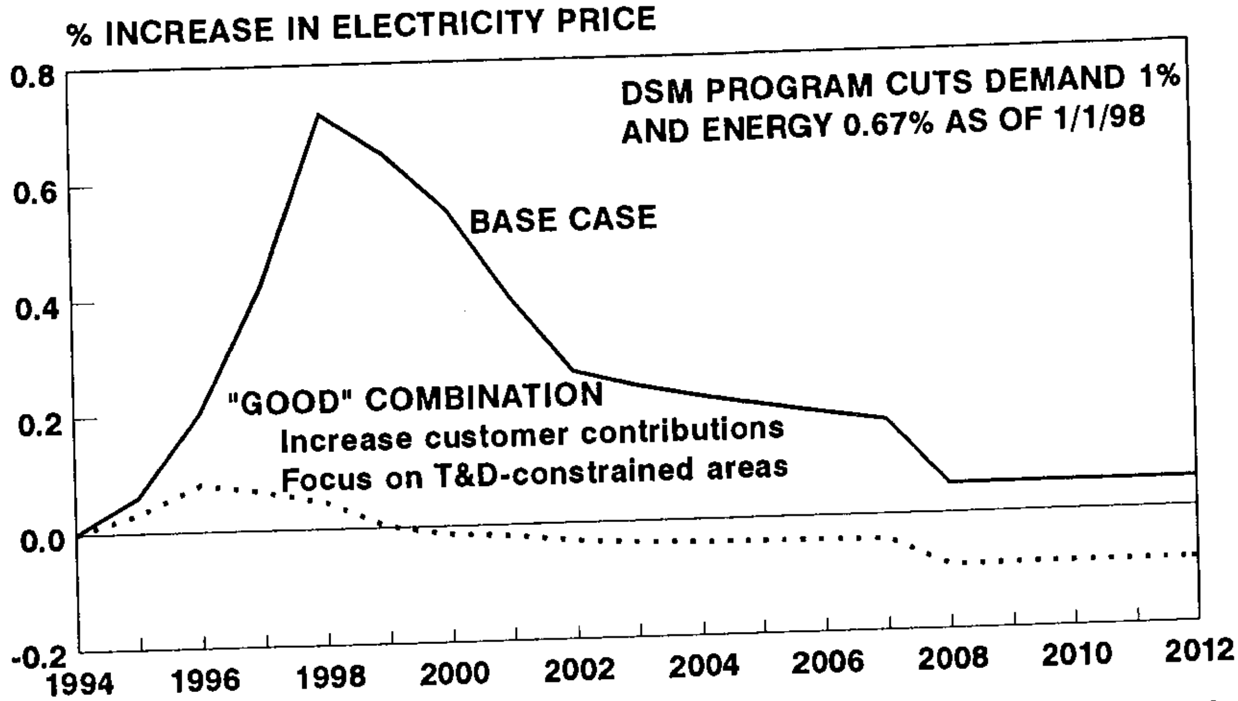

Fig. 7. **Percentage increase in electricity prices caused by the reference DSM program and a "good" combination of factors.**

IMPLICATIONS FOR FUTURE DSM PROGRAMS

The preceding discussions dealt with utility programs as they operated, on average, in the past. Two factors suggest that the future economics of utility DSM may be brighter than indicated above. First, there remains a large potential for cost-effective energy-efficiency improvements. The Electric Power Research Institute estimated a *technical* potential of 24 to 44% of U.S. electricity use (Faruqui et al. 1990). The Alliance to Save Energy (1991) estimated a 7 to 22% *achievable* potential during the 1990s.

Second, many utilities are redesigning their programs to deliver energy savings that are cost-effective at today's avoided supply costs. (Other utilities are reducing the size and scope of their energy-efficiency programs or eliminating them altogether.) These utilities are reducing the rebates they offer customers, replacing rebates with financing options (such as loans), focusing on lost-opportunity resources (e.g., one-time opportunities in new construction and equipment replacement), emphasizing market-transformation programs, and working with governments to adopt stronger building- and appliance-efficiency standards (Geller, Nadel, and Pye 1995). For example, between 1990 and 1992, Wisconsin Electric twice cut the rebate and raised the minimum energy-efficiency ratio for its program aimed at improving the efficiency of new air conditioners. These changes allowed the utility to lower its program costs.

In summary, the evidence presented here suggests that utilities can operate cost-effective DSM programs even at today's low supply costs. However, the amounts of savings feasible at these low supply costs will likely be less than was true several years ago.

THE ENERGY-EFFICIENCY GAP AS A BASIS FOR POLICY

Previous chapters focused on the value of energy efficiency to society as measured by the difference between what efficiency costs and its benefits. We discussed two measures of benefit: (1) the direct economic costs avoided by the utility and (2) the additional savings associated with reduced environmental impacts from avoided electricity production. This chapter focuses on the significance of the difference between the "optimal" and the current level of actual energy-efficiency investments. For some, the difference provides *prima facie* evidence for the existence of imperfections in energy-service markets; the magnitude of the difference is a key rationale for policies to promote increased energy efficiency. For others, the difference is either nonexistent or not large enough to warrant public-policy interventions.

THE EFFICIENCY GAP

The "efficiency gap" refers to the difference between levels of energy-efficiency investments that appear to be cost-effective at today's electricity prices and the lower levels of investment that actually occur. The gap is usually represented graphically with a supply curve of conserved energy (Meier, Wright, and Rosenfeld 1983). A supply curve is a schedule of potential energy savings ordered by the per unit costs of these savings (Fig. 8). Per unit costs are expressed by levelizing the capital cost of the energy-saving investment, net of any changes in nonenergy operating costs, over the lifetime of the measure and dividing by the annual energy savings. The resulting quantity is the CCE discussed earlier. The CCE is compared to the current price of energy, and the quantity of energy savings available below the current price is called the economic potential for energy efficiency or the efficiency gap. Numerous studies to measure this potential have been conducted (e.g., Faruqui et al. 1990; Alliance to Save Energy 1991). All of them have found significant unrealized energy-efficiency opportunities that appear to be cost-effective at today's energy prices.

SIGNIFICANCE OF THE EFFICIENCY GAP

One way to organize a discussion of the efficiency gap is by the academic disciplines from which various perspectives have been articulated. The *technologists'* conservation-supply curves provide an effective analytical tool in arguments for more aggressive energy-efficiency policies. Advocates of these policies claimed that the size of the "gap" showed that there were significant misallocations of resources in energy-service markets. The economic losses implied by the gap provided a key justification for government policies to correct these imperfections. These "market barriers to energy efficiency" included: (1) split incentives; (2) lack of information or misinformation; (3) regulation; (4) market structure; (5) financing; and (6) customs and traditions (Blumstein et al. 1980). The supply-curve approach is a "bottoms-up" analysis focusing on individual energy end uses, technologies, and practices. It is a technology-based approach whose results are expressed in the language of engineering economics.

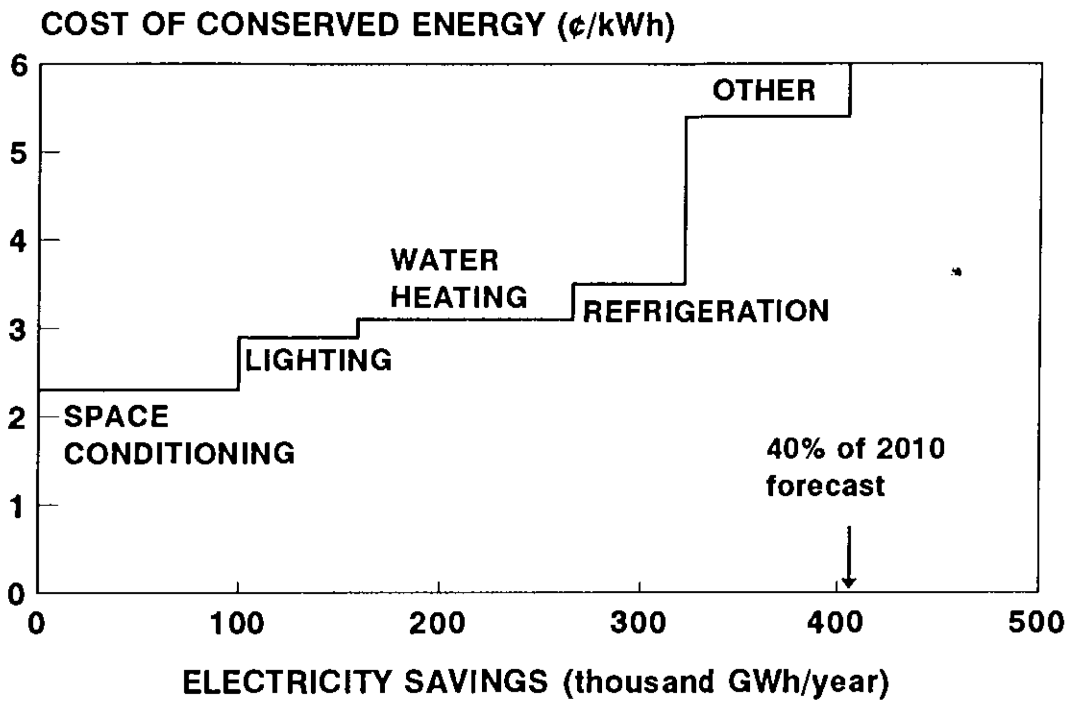

Fig. 8. **Conservation-supply curve showing potential electricity savings in the U.S. residential sector (Koomey et al. 1991).**

Distinct perspectives on the significance of the gap have emerged from formal economic and social-science analyses. The *economists* have done much to clarify the terms of the debate. For example, while all markets exhibit various forms of market barriers, they correctly observe that some are simply examples of the normal workings of markets. That is, some of the technologist's market barriers are no more than the competitive advantage that accrues to and ensures the survival of firms operating in competitive markets, while others are simply the unavoidable "friction" of real-world institutions and transactions. Market failures, on the other hand, represent substantial misallocations of resources that stem from apparently intractable features of certain markets. Market failures include: (1) externalities, which are benefits or costs resulting from but not solely borne by participants in a particular transaction (e.g., the environmental externalities discussed in Chapter 4); (2) public goods, whose benefits cannot be captured adequately by individual participants in markets; and (3) imperfect information, which represents incomplete or differential levels of knowledge by participants to a transaction (Rothkopf and Fisher 1989). Only substantial misallocations of resources justify government interventions.

Thus, much of the debate over energy-efficiency policies depends on whether a market barrier is a market failure or a feature of a "normal" competitive market. Much of the confusion, according to economists, is that early conservation supply curves used incomplete accounting. That is, the efficiency gap results primarily from failures by technologists to account for "hidden costs" in their analyses. These costs consist of omitted transaction costs and changes in the amenities provided by efficiency measures. For example, it takes time, effort, and money to identify and arrange for the installation of energy-efficiency measures; if the "hassle" is too great, it is not worth the effort. In addition, supply curves fail to recognize legitimate differences in consumer perceptions about the riskiness of energy-efficiency investments.

In the simplest form, this line of critique holds that proper accounting of hidden costs and differences in risk profiles eliminate the efficiency gap (Ruff 1988). More sophisticated versions hold that these factors account for most of the difference between the technologist's assessment and current practice such that the resulting mismatches imply only a small efficiency gap, which is not large enough to warrant government intervention (Sutherland 1991).

The "value test" is a recent attempt to incorporate direct and hidden costs and benefits explicitly (Chamberlin and Herman 1993; Braithwait and Caves 1994; and Hobbs 1991). Proponents of the value test argue that it provides a more comprehensive measure of cost-effectiveness than either the total-resource-cost test (which reflects the technologist's perspective) or the rate-impact measure (which reflects the economist's perspective). The value test can, in principle, capture the "hidden benefits" of energy-efficiency measures, such as reduced maintenance, improved productivity, and other amenities.

Figure 9 illustrates the relationship between stylized characterizations of the positions of the economists and the technologists (Jaffe and Stavins 1994). The left side of the figure compares the technologist's concept of an economic energy-efficiency potential to the economist's concept. While economists support government interventions to eliminate market *failures* in energy-efficiency markets (externalities, public goods, and imperfect information), they do not support the technologist's advocacy of government intervention to eliminate the market *barriers* associated with high discount rates, inertia, and heterogeneity. Furthermore, both technologists and economists stop short of advocating government intervention to eliminate *all* market failures under a very broad definition of energy markets; eliminating these would lead to an even higher hypothetical potential.

The costs of intervention are considered on the right of Fig. 9. Eliminating those that can be eliminated at reasonable costs raises the economic potential to the "narrow social optimum," which is defined as the economic potential that intervention can capture at costs lower than the benefits provided. A higher "true social optimum" is justified by adding additional environmental-externality benefits to the equation.

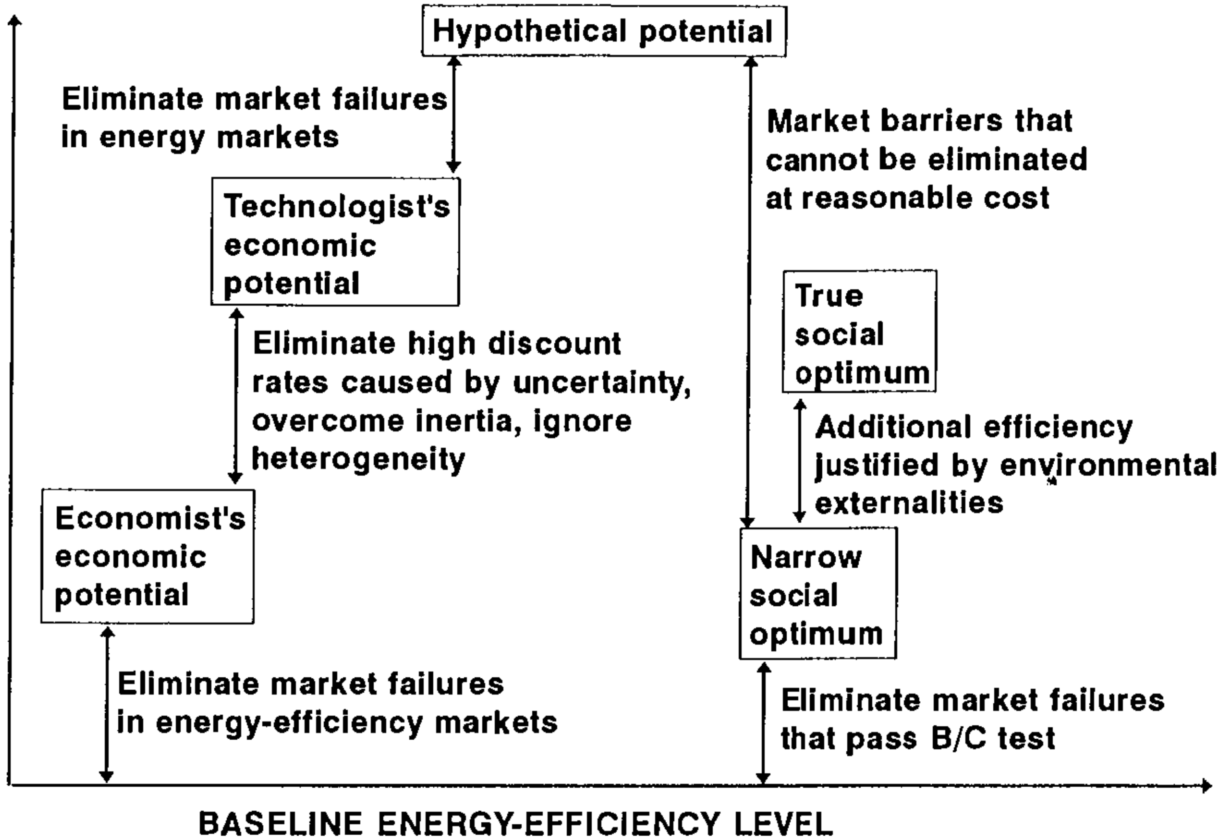

Fig. 9. Alternative views of the energy-efficiency gap (Jaffe and Stavins 1994).

Fieldwork conducted by *behavioral scientists* reveals a substantial amount of misinformation about energy use (Kempton and Montgomery 1982). Even in the presence of accurate information, they have discovered a variety of noneconomic rationales that appear to explain failures to pursue energy-efficiency activities that are acknowledged to be cost-effective (Wilk and Wilhite 1985). Behavioral scientists have, thus, begun to articulate the nature of the economists' hidden costs and risk-taking propensities. For example, behavioral scientists have argued that energy use (and, hence, energy-efficiency opportunities) is but one attribute of the multiattribute products, services, and human activities that have energy-use implications. To illustrate, Stern and Aronson (1984) offered five views of the individual as an energy user (Table 3).

The recognition that there are additional costs and benefits associated with energy efficiency beyond those traditionally included in conservation-supply-curve analyses has shifted the debate away from reliance on the price of electricity, avoided cost, or avoided-cost-plus-externalities as the relevant measure of the level up to which energy-efficiency opportunities should be pursued. Previously, energy service was considered to be a single product that could be provided by different combinations of energy and capital. Advocating increased energy efficiency required demonstrating that social welfare was increased through the substitution of (typically) capital-intensive energy-efficiency measures for increased energy use. Now, under a more sophisticated concept of social welfare, changes in the energy service or amenity and transaction costs must also be considered. In this framework, the policy function is the maximization of social welfare, not simply increases in efficiency under a static conception of the amenity being delivered.

Table 3. Five views of the individual as energy consumer

View	Implications
Investor	Economic rationality, in which consumers trade off capital and operating costs to minimize life-cycle costs
Consumer	Energy provides necessities and pleasures
Member of social group	Energy behaviors strongly affected by what friends and neighbors do
Personal values	Energy behaviors affected by self-image and values (e.g., environmental ethic)
Problem avoider	Minimize inconvenience and disruptions, therefore take few actions

Source: Stern and Aronson (1984).

Acknowledging the primacy of social-welfare maximization as the objective of public policy has important consequences for energy-efficiency advocates. For example, economists point out that the costs of intervention must be considered alongside potential benefits. If the efficiency gap was small and the intervention costs were large, then social welfare would be reduced by intervention and, therefore, should not be pursued. This concept recognizes that regulation is neither perfect nor free. More dramatically, it is, in principle, possible to maximize welfare through decreased energy efficiency (because of increases in efficiency in other parts of the economy) or through increased energy use (through gains in nonenergy sectors).

EVIDENCE FOR MARKET FAILURES AND INTERVENTION COSTS

Formulating experiments and analyses to estimate the size of these often noneconomic quantities, however, is enormously difficult. There are significant methodological challenges to articulating testable hypotheses and avoiding outcomes driven primarily by assumption or methodology. For example, early conclusions reached by behavioral scientists suggested that consumers were not behaving "rationally," as traditionally defined by reference to the actions of a utility-maximizing economic agent. Much of the work conducted subsequent to this apparent challenge has only served to clarify in what sense an action can be said to be rational (Sanstad and Howarth 1994). As currently formulated, then, the notion of rationality cannot be confirmed. It is a methodological presumption that is basic to economic analyses of human behavior.

To date, only a few studies have used a stricter framework of what constitutes evidence for or against a particular market failure and on what the effects of intervention have been. Koomey and Sanstad (1994) compare efficient core-coil ballasts for fluorescent lamps with standard ballasts, high-efficiency with other refrigerators, Energy Star computers with other personal computers, and televisions with and without standby power. In each case, they show that the more efficient technology is cost-effective, provides service equal to or better than the less efficient alternative, is commercially available, but is not widely adopted.

Turning to utility DSM programs, two studies examined the same programs using a broader framework than the traditional economic tests suggest. Herman and Hicks (1994) applied the value test to three utility DSM programs, all of which were cost-effective under the total-resource-cost test. The programs remained cost-effective under the value test, although the results were less positive when they accounted for changes in amenity and transaction costs. They did not, however, consider any hidden benefits, such as spillover effects. Levine and Sonnenblick (1994) examined process-evaluation results from one of the same programs to examine spillover directly. They found that the program reduced consumer reluctance to pursue additional energy-efficiency activities independent of the utility's DSM program.

POLICY IMPLICATIONS

Our discussion traced the evolution of a debate that is very much alive today. We summarize the current status of the debate as follows:

- Obstacles to energy-efficiency investments are widespread.
- Some market barriers cause resources to be misallocated and therefore justify government intervention, but other barriers do not.
- The costs and cost-effectiveness of government actions must be considered in the decision to intervene.
- The limited evidence available from utility DSM programs supports a finding of program cost-effectiveness under broader measures of societal cost-effectiveness.

Perhaps the most important practical contribution of the debate on energy efficiency has been a deeper understanding of the existence and magnitude of the obstacles to energy efficiency. This improved understanding can provide the basis for deciding on whether and, if so, how governments should intervene in energy-service markets. We next assess the capabilities of standards and codes, and utilities and energy-service companies (ESCOs) as potential future instruments of these interventions.

GOVERNMENT ENERGY-EFFICIENCY STANDARDS AND CODES

Previous chapters considered various factors underlying the rationale for energy-efficiency policies. To the extent that these factors justify intervention in end-use markets, we need to consider available intervention options. This chapter focuses on the role that government standards and codes play in improving energy efficiency. For some, standards and codes substitute for other forms of intervention, such as utility DSM programs. It is therefore critical to assess this claim in considering future utility programs.

COST-EFFECTIVENESS OF NATIONAL STANDARDS AND CODES

The 1978 National Energy Conservation Policy Act required the Department of Energy to promulgate standards for various types of residential appliances and equipment. In 1982, the Department issued "no standard" standards. In 1987, Congress passed the National Appliance Energy Conservation Act, which established standards and timetables for updates. The 1988 amendments to the 1987 act added fluorescent-lighting ballasts to the list of products for which DOE sets standards. The Energy Policy Act of 1992 (EPAct) (U.S. Congress 1992) added several items to the list for which DOE must set standards. The residential electrical products covered by national efficiency standards include: refrigerators, refrigerator/freezers, freezers, dishwashers, clothes washers, water heaters, central air conditioners and heat pumps, furnaces, televisions, kitchen ranges and ovens, clothes dryers, room air conditioners, fluorescent-lamp ballasts, and swimming-pool heaters. EPAct added several commercial products to this list, including: packaged air conditioning and heating equipment, water heaters, motors, certain lamps, and some plumbing products.

Measured in direct economic terms, standards have been tremendously successful (Fig. 10). LBNL (1994) estimated that residential appliance standards have already saved consumers $1.9 billion. Ultimately, these standards will save consumers $58 billion. The ratio of total benefits to costs is 2.5. LBNL estimates that past and likely future appliance and equipment standards will cut residential electricity use by 7% by the year 2015, about 80,000 GWh annually and 21,000 MW (McMahon, Turiel, and Geller 1995).

In addition to strengthening federal appliance and building standards, EPAct strengthened state building codes for residential and commercial construction. EPAct requires states to review their residential building codes to determine whether they should be revised to meet or exceed the 1992 Model Energy Code. Similarly, EPAct requires states to review their commercial building codes for compliance with ASHRAE 90.10-1989. These provisions will provide additional electricity savings for buildings that are heated or cooled with electricity. By the year 2000, these building codes should cut electricity use in residential and commercial buildings by 14,000 GWh (Geller and Nadel 1993).

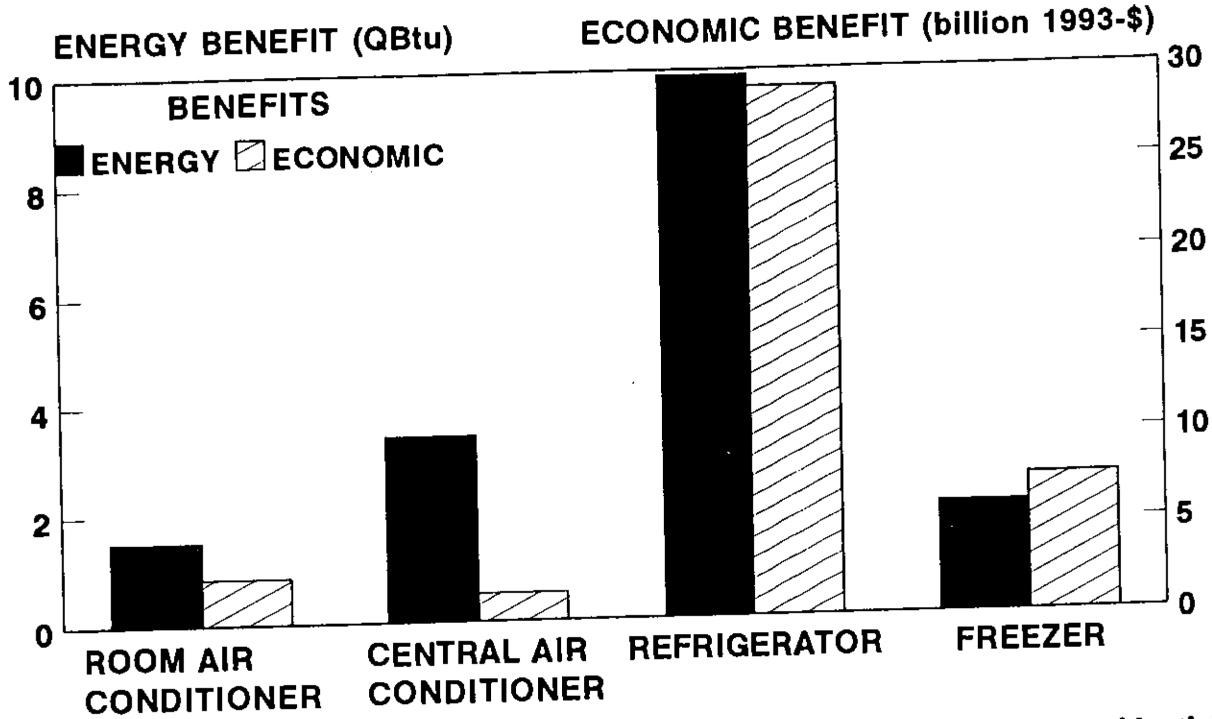

Fig. 10. The energy and economic benefits of U.S. standards for some residential appliances.

Together, appliance and building standards are expected to reduce U.S. electricity use in the year 2000 by 3%. This expected savings is comparable to that expected from electric-utility DSM programs (Hadley and Hirst 1995).

DO STANDARDS AND CODES SUBSTITUTE FOR DSM PROGRAMS?

The success of appliance and equipment standards and building codes as energy-efficiency policies has important implications for future utility DSM programs. Standards and codes can interact with utility programs in a variety of ways. They can: (1) replace the need for DSM programs; (2) work synergistically with DSM programs to enhance the performance of both; and (3) provide a basis for DSM programs targeted to energy-efficiency opportunities not appropriate for standards or codes.

In assessing the relative merits of standards and codes vs utility programs, it is important to consider both economic and political implications of each option. From an economic perspective, that issue is simply one of the relative societal costs of standards and codes vs DSM programs. In today's political climate, which favors market-based policies, the political legitimacy of standards and codes vs DSM programs cannot be ignored. Standards and codes are mandatory requirements and reflect a command-and-control approach to implementing government policies. Utility DSM programs, by contrast, are voluntary (although not necessarily for the implementing utility).

From an economic perspective, standards and codes are superior public-policy instruments to overcome market failures and to reduce underinvestment in energy efficiency if they can produce desired outcomes at lower cost than alternative policy options (e.g., utility DSM programs or fuel taxes). The historic, low administrative costs of federal appliance standards suggests that they are highly cost-effective for many residential appliances.

The efficacy of standards and codes, however, depends on the types of decisions they affect and their effectiveness in influencing these decisions. For example, building codes target new-construction choices whose consequences are long-lived. But, experience shows that compliance with building codes is uneven. In discussing the relative merits of standards and codes, these elements must be considered.

Standards and codes can be designed to pursue two distinct objectives. Traditionally, they have been used to eliminate the worst products and practices. In addition, in some cases, product standards have been set at levels that lead markets to higher efficiencies through technology forcing. For example, compare the 1990 and 1993 national refrigerator standards to the refrigerator models available in 1989 and 1993 (Fig. 11). While the 1990 standard eliminated almost half of the models available in 1989, no model in 1989 met the then upcoming 1993 standard. However, by the time the 1993 standard came into effect, all models met or exceeded the standard.

DSM programs often share these objectives. Thus, in principle, DSM programs and standards could be substitutes for one another. Whether they are, in fact, substitutes depends on two questions. First, do standards and codes exist for the energy end uses addressed by DSM programs? Second, to the extent they do not, what is the likelihood of future enactment of such standards and codes? The answer to this second question probably depends less on economics than it does on the political legitimacy (public preferences) for "carrots" over "sticks" as the appropriate form for public policies. The answer (based on the discussion in the previous chapter) also depends on the types of market barriers the policies are intended to overcome.

Recent experience suggests that there are important synergies between standards and codes and utility DSM programs. For example, Geller and Nadel (1994) argue that certain utility programs are critical to the future evolution of standards and codes. Working from a conceptual model of product introduction, commercialization, and ultimately codification through standards and codes, they believe that utility programs aimed at the early commercialization of advanced technologies, such as the super-efficient refrigerator program (L'Ecuyer et al. 1992), are critical for updating future standards.

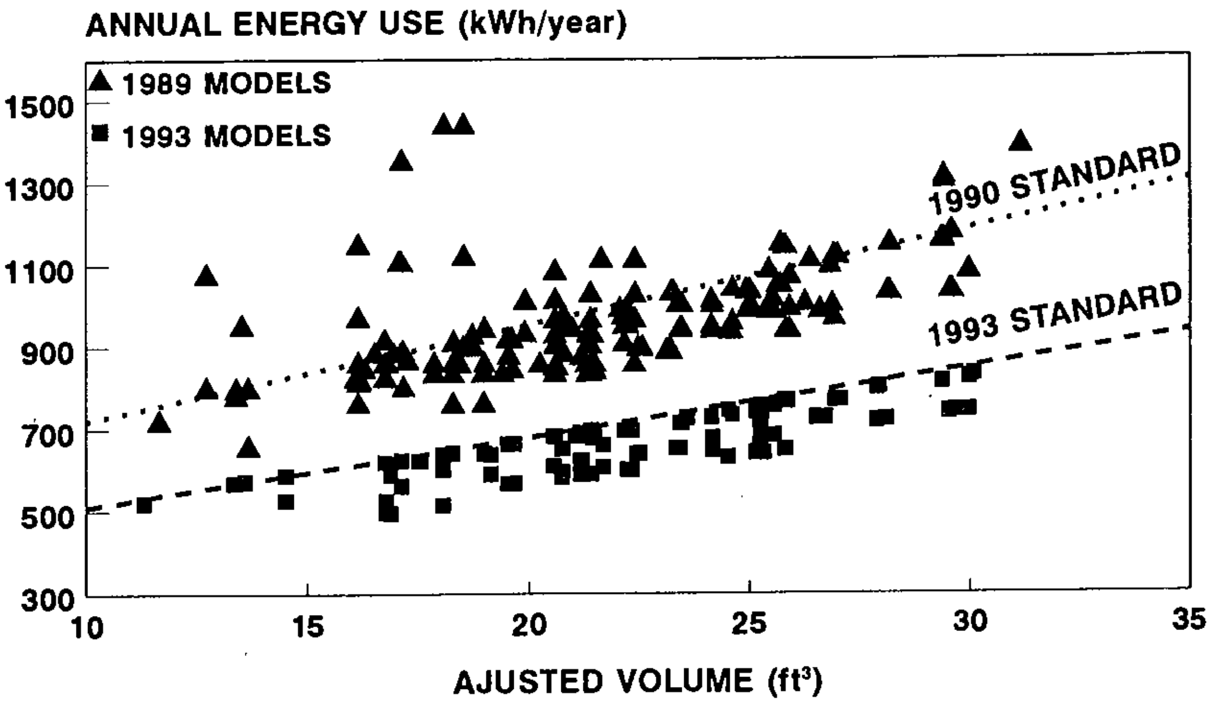

Fig. 11. Comparison of annual electricity use for different top-mounted refrigerator-freezers with automatic defrost sold in 1989 or 1993 with the 1990 and 1993 federal energy-efficiency standards.

In the construction of new buildings, recent experience also documents the important role that utility DSM programs play in the enforcement of standards and education of the building-construction community. States differ significantly in the stringency of building codes; and within states, there are wide disparities in code enforcement and compliance. Utility new-construction programs have undoubtedly played a role in improving this situation (Caulfield and Lee 1994).

Passage and enforcement of building codes in the Pacific Northwest was a cooperative effort of many parties, including the Northwest Power Planning Council, the Bonneville Power Administration, other electric utilities, state agencies, and builders. Although the Council proposed Model Conservation Standards in the early 1980s, it took several years for Washington and Oregon to pass legislation implementing these standards. During that time, Bonneville and other utilities spent "over $100 million on demonstration programs, early code adoption efforts, utility marketing programs, and a host of training and education efforts" (Madison, Usibelli, and Harris 1994). This effort paid off in a very cost-effective way in Washington: the utility CCE for the entire code effort was less than 0.3¢/kWh and the total societal cost was only 2.0¢/kWh.

Nadel (1992) describes seven ways that utility DSM programs can work synergistically with building codes: (1) development of linkages between code requirements and eligibility levels for utility new-construction programs, (2) utility promotion of new code levels before they become mandatory, (3) utility promotion of efficient technologies and practices to lay the foundation for code updates, (4) utility advocacy for stronger code levels, (5) utility-sponsored training for code inspectors and building designers on code requirements and ways to meet code requirements, (6) utility financial assistance to state and local governments for energy-code enforcement efforts, and (7) utility hook-up requirements or fees based on code requirements.

Pragmatism must temper the criterion of selecting between standards and DSM programs solely on the basis of costs. Building-code compliance and builder training can all be improved by either the government or by utilities. The political reality in most states, however, is that, given limited resources, code officials focus primarily on health and safety compliance, while energy-efficiency codes are given less attention. In this situation, the issue is whether the extra costs of utility involvement to train code officials are acceptable. As long as the programs are cost-effective, they should be pursued because it is not realistic to assume that standards and codes will be met automatically, even in the presence of limited enforcement (Baylon 1994).

Several classes of energy-efficiency opportunities are either not appropriate or not amenable for incorporation into standards or codes. These opportunities are potential candidates for utility DSM programs or other energy-efficiency policies. For energy-efficiency opportunities characterized by both low stock turnover and rapid technological progress (such as lighting equipment and space-conditioning systems), early retirement of existing equipment may be warranted. Similarly, better operation and maintenance practices represent a class of efficiency opportunities that do not involve the purchase or replacement of equipment. It is difficult to imagine how these opportunities could be captured by standards or codes. Hence, both may be good candidates not only for utility-run DSM programs but for other types of energy-efficiency policies, as well.

SUMMARY

Economic considerations should figure prominently in determining whether standards are preferable to DSM programs or other energy-efficiency policy. However, economic considerations must be tempered by recognition of the pragmatic and political realities of what can be expected from either governments or utilities. We identified important synergies among different energy-efficiency policies. Exploiting these opportunities requires both a deeper understanding of the market barriers to energy efficiency and a detailed understanding of institutional capabilities of the various instruments of public policies. In the next chapter, we examine the future role of utilities as delivery agents of energy efficiency.

FUTURE UTILITY ROLES IN DELIVERING ENERGY EFFICIENCY

Today's electric utilities face unprecedented competitive pressures from new entrants on the generation side of the business and from customers seeking to bypass them to purchase directly from other sources of power. These pressures will lead to dramatic changes in the future structure and regulation of the electricity industry. Many people are concerned about the continuing role of utility delivery of various energy-related public policies, ranging from low-income assistance programs to research and development to energy-efficiency programs (Tonn, Hirst, and Bauer 1995). In this chapter, we consider the likely effects of the competitive pressures faced by utilities on their future role in delivering energy efficiency and the decisions that PUCs will make to influence this role.

Although the structure and regulation of wholesale competition will likely affect the scope and scale of utility DSM programs, it is the prospect of widespread retail competition (often in the form of pressures for retail wheeling) that will have the greatest impact on the future of utility DSM programs (York and Cohen 1994). For example, many utilities are already reducing DSM-program budgets based on the prospect—not the existence—of retail wheeling. It is, therefore, useful to discuss future utility roles in delivering energy efficiency around the four key issues that retail competition raises for utility DSM programs:

- the utility's obligation to serve and the role that obligation implies for a utility in resource planning and acquisition on behalf of retail customers,
- the future structure of the electricity industry and the forms of regulation that are employed for the remaining monopoly functions,
- the implications on energy efficiency of the current transformation of DSM programs from an emphasis on resource value to customer value, and
- the likely enduring advantages of utilities in delivering energy efficiency vs the anti-competitiveness issues that may arise for new entrants seeking to deliver these services.

THE OBLIGATION TO SERVE AND THE MONOPOLY FRANCHISE

Utility involvement in delivering energy efficiency as a least-cost resource alternative is based on the long-standing regulatory compact between a regulated utility and its PUC. In return for price regulation and an obligation to serve all customers on a nondiscriminatory basis, the utility is granted a monopoly franchise for the provision of least-cost electric service to all customers in a defined geographic area. Thus, the obligation to serve means that the utility assumes a resource-portfolio-management function (planning, acquisition, and operation) on behalf of its customers. This obligation is the primary rationale for requiring a utility to acquire energy efficiency whenever it costs less than supply options.

When retail wheeling relieves a utility from its obligation to serve certain customers, it also relieves the utility from its obligation to acquire resources for these customers using this least-cost-planning principle. Thus, a critical threshold question for the future of utility energy-efficiency programs is the pervasiveness of the pressures for retail wheeling and the prospects for the elimination of the retail-monopoly franchise.

Pressure for retail wheeling exists where customers perceive that there are off-system purchases available at costs lower than current retail rates. These conditions are most prevalent in the northeast, California, southwest, and parts of the midwest (Baxter and Hirst 1995). In other parts of the country, however, retail rates are only slightly higher than market prices and, as a consequence, the pressures for retail wheeling are much less. At the same time, while the pressures for retail wheeling may be less in other parts of country, so too are the economic rationales for energy-efficiency resources (i.e., because avoided supply costs are low).

In those areas where the pressures for retail wheeling are greatest, the outcomes are uncertain. Many utilities are offering rate discounts to their largest and most price-sensitive customers, thereby reducing the incentive for these customers to seek off-system sources of supply. In these situations, the monopoly franchise may be preserved.

Similarly, in the transition to full retail access by all customers, some customers will remain with their local utility and call on it for the traditional resource-portfolio-management functions. Hence, the utility will retain a "core" group of customers for whom it will retain the obligation to serve. This distinction is already well-established for natural gas local distribution companies; most customers (although not the majority of gas use) remain core customers.

Where the obligation to serve remains, the conditions under which pursuit of DSM as a least-cost-resource option is appropriate are unaffected. However, the size of the energy-efficiency resource available to the utility may be less than it is today for two reasons. First, only part of the utility's former load will remain with core customers. Second, the avoided supply costs against which DSM must compete will likely be lower than they would be without competition.

RESOURCE-VALUE VS CUSTOMER-VALUE DSM PROGRAMS

The introduction of retail competition changes the definition of "utilities" in a fundamental way. In a world where no entity has an obligation to serve, utilities will be regulated distribution companies with an obligation only to *connect* all customers to the electric grid. In such a world, we expect to see two kinds of utility response, likely taking place in parallel. First, these distribution utilities can be expected to cut costs wherever possible because the marketability of their product (defined for the moment as kWh) will be determined by market conditions; not by their embedded costs.

Second, at some point, production efficiencies will be combined with strategies to differentiate and market distinct utility products and services. Energy-efficiency services will likely play an important part in many utilities' future product offerings. Put simply, utilities will offer DSM services wherever marginal revenue from those activities exceeds marginal costs. Newcomb (1994) describes a variety of innovative DSM roles that utilities will be motivated to pursue in a more competitive environment.

Thus, at the retail end of the business, the nature of a utility's DSM programs will change from their traditional emphasis on resource value to an emphasis on customer value. Utilities will have strong motivation to run such programs, the costs of which are borne primarily by program participants.* Hence, we see little danger of DSM programs disappearing. However, because energy-efficiency measures are not intrinsically separable into either resource-value or customer-value, the implications of these changes on the need for additional energy-efficiency policies is not obvious. Many believe, for example, that customer-value DSM programs will not emphasize energy efficiency to the extent that resource-value DSM programs have in the past.

ALIGNING PRIVATE AND PUBLIC INTERESTS

The previous discussion deliberately blurred the distinction between the regulated and nonregulated aspects of the utility's retail business activities. However, regulation will exist in a world of retail competition. While regulated utilities with only an obligation to connect may no longer have explicit generation-resource-planning responsibilities, regulatory policies will continue to influence the resource-related decisions (primarily expansion and operation of the local distribution system) made by the regulated firm.

Under traditional rate-of-return regulation, utilities face significant financial disincentives to activities that reduce short-term sales growth. Nadel, Reid, and Wolcott (1992) explored this basic tension between the private financial objectives of a utility and the societal objectives of PUCs. All else equal, a regulated utility will seek to maximize its returns within the PUC regulations. If these regulations successfully align a utility's private interests with those of society, socially beneficial DSM will be pursued. With retail competition, the prospect of gaining or losing market share adds another factor to consider in achieving this alignment.

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*In other words, these programs will satisfy the rate-impact measure. In general, today's DSM programs are paid for by all customers and are required to satisfy the total-resource-cost test, but not necessarily the rate-impact measure.

Competitive pressures also manifest themselves in concerns over the continuing importance of traditional forms of regulation based on the rate of return. Interest in forms of rate regulation that more closely mimic competitive markets is growing. Performance-based regulation holds the promise of creating a basis for rate setting that is linked explicitly to market-based pricing principles. However, some forms of performance-based regulation, notably price caps, provide explicit incentives for a utility to increase sales (Marcus and Gruenich 1994). Other forms, such as revenue caps (Eto, Stoft, and Belden 1994; Hirst 1993), total energy cost indices (Lowery 1993), or bill indices (Moskovitz 1992), may be more conducive to utility delivery of energy efficiency.

With full retail competition, T&D will likely remain regulated monopolies. If the form of regulation does not discriminate against energy efficiency when it is the least-cost option, distribution utilities are likely to provide energy-efficiency services, in particular those that defer the addition of more expensive distribution-system facilities. The major avoided capital cost for distribution utilities is substation upgrades (Rosenbloom and Eto 1986). Thus, DSM will be targeted to specific geographic areas within the service territory (Orans et al. 1992). The load-shape objectives of these programs, moreover, will be local-area coincident-peak reductions. Thus, DSM programs will be narrower in geographic scope and will focus more on demand reductions (and less on overall energy savings) than do today's programs.

UTILITIES AS INSTRUMENTS OF PUBLIC POLICY

The critical outstanding issue for public policy is that with no entity retaining an obligation to serve, society would, by default, rely on the market to perform the formerly integrated generation, transmission, distribution, and demand-side planning functions. The unregulated retail businesses will provide energy-efficiency services through "customer-value" DSM programs, and regulated distribution utilities will provide energy-efficiency services based on the economics of local-area distribution systems, given the form of PUC regulation chosen. However, some believe that, in view of the failures in today's energy-service markets, an important role will remain for government policies. In this section, we introduce a framework for evaluating utilities as instruments of these policies.

An institution (e.g., regulated distribution utilities or unregulated ESCOs) represents an appropriate instrument to carry out public policies, if it has superior delivery capabilities for these policies. These capabilities must be considered in light of the objectives of the policies and the cost of implementing them.

Early proponents of utility DSM programs alleged several incumbent advantages offered by utilities as institutions for improving energy efficiency. Access to customer billing information, lower marketing costs, billing systems for the collection of fees, the ability to pool risks, access to low-cost capital,* and name recognition were among the advantages commonly cited. Unfortunately, quantification of these advantages has not been conducted, although there have been limited comparisons of utility vs ESCO performance (Goldman and Kito 1994; Vine, deBuen, and Goldman 1992).

Hence, more study is needed of these purported benefits with special attention to consideration of whether, if they exist, they can be expected to persist in a future with a very different electric-industry structure. The outlines of this study are clear; LBNL and ORNL are engaged in just such a research project this year. To begin, a disaggregated approach is required to compare the performance of utilities, ESCOs, and codes/standards in addressing energy-efficiency market failures. The approach should take into explicit account all the stages in an energy-efficiency transaction (e.g., marketing, project development, financing, construction or implementation, quality assurance, and savings verification), because each entity will likely not offer significant advantages for every element. For example, anecdotal evidence suggests that ESCOs have been more successful than utilities in bundling energy-efficiency opportunities into complete packages of energy services, including financing, that are more attractive to customers than individually marketed and priced services of which energy efficiency is only one. While other, similarly anecdotal evidence suggests that utility billing systems provide a powerful and proven method for collections from customers.

We would expect the findings to differ according to the particular energy-efficiency opportunity, end use, and market sector under examination. For example, ESCOs have had some success in pursuing efficiency in the institutional sector, which often lacks the technical expertise to identify such opportunities, has severe capital constraints, and employs decision-making processes that are ill-suited to linking energy cost savings to the capital budgeting process (Geller, Nadel, and Pye 1995). At the same time, some ESCOs have had difficulties "getting in the front-door" without assistance from the host utility, while others, such as Johnson Controls and Honeywell, tend not to work through utility programs.

What will likely emerge from this line of inquiry will be a deeper understanding of the factors leading to suboptimal investments in particular energy-service markets. This understanding should lead to a comparative assessment of the current and likely future strengths and weaknesses of various approaches for addressing them. Hybrid strategies drawing selectively on the strengths of each will likely develop to pursue available options in a more strategic and disaggregated fashion than previously considered.

At the same time, future public policies must balance the comparative advantages of utilities (as institutions) vs the potential for anticompetitive effects that may hinder the

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*Competition may reduce utility access to low-cost capital. Already, financial analysts are rating utility stocks and bonds as much more risky than they did a few years ago (Cohen et al. 1994). These changes suggest that utilities will have to maintain higher equity ratios, pay higher interest rates on their bonds, and provide a higher return on equity. All these changes will raise utility cost of capital.

development of the ESCO infrastructure. Evidence to date suggests that these advantages may be significant (Goldman, Kito, and Moezzi 1995), hence the anticompetitiveness issues raised by utility participation in these markets cannot be ignored.

For example, regulators may determine that utilities, without an obligation to serve, have no role in pursuing energy-efficiency opportunities not directly consistent with their private business interests. In this extreme case, the role of the utility may simply be to collect a wires charge to support third-party development of the energy-services infrastructure. The California Working Group (1995), created to provide the California PUC with options to preserve important public-policy goals in the face of restructuring, postulated the creation of an independent nonprofit state consortium for just this purpose. The California PUC (1995a), in its proposed restructuring order, identified two types of DSM programs. Energy-efficiency programs that focus on market transformation should be supported with customer funds and overseen by the PUC; customer-service programs should be funded by shareholders and remain unregulated.

EMERGING DSM-POLICY ISSUES

The basic question for future public policies is the extent to which market-based outcomes will reflect societal interests. Future PUC decisions will implicitly or explicitly create the conditions that will answer this question. Four regulatory policy issues figure centrally in this process:

- Will regulated utilities (in the limit, simply the distribution business) have planning and operating incentives embedded in rate-setting formulas or processes that are consistent with the public interest in energy efficiency?

- What criteria will PUCs use to review utility-proposed use of ratepayers funds for DSM programs if the primary purpose of these programs is customer value rather than resource value? Which programs should be funded by utility shareholders rather than by customers?

- Will regulatory efforts to check market-power abuses by utilities or their subsidiaries operating in energy-service markets help these markets mature and become fully competitive?

- To the extent that markets, rather than vertically integrated utilities, make end-use and supply-resource choices, how, if at all, will PUCs ensure consistency of these choices with the public interest? How will inconsistencies in these choices be addressed?

CONCLUSIONS

During the past 15 years, the electricity industry has changed in many ways. These changes include the use of different fuels and technologies to generate electricity, the application of different technologies and practices to reduce power-plant emissions, the use of different methods to regulate utility planning and rates, declines in electricity prices, and a reversal in the relationship between electricity prices and avoided costs. In addition, the electricity industry is now in the midst of a major transition from a vertically integrated, cost-of-service, retail-monopoly-franchise, regulated industry to one that is less regulated and more competitive. The specifics of the endpoint are not yet known.

All these changes, not surprisingly, affect the rationale for and benefits of utility DSM programs (Table 4). While the principles that underlie DSM programs are unchanged—improve economic efficiency and reduce the environmental impacts of the electric system—the magnitudes are different. For example, it still makes sense for distribution utilities with an obligation to serve to acquire DSM resources when they are less expensive than the supply alternatives. However, the amounts of DSM that meet this objective and the definitions of "less expensive" and "utilities" are different today than they were several years ago.

Because avoided costs are far below what they were 10 to 15 years ago, the amount of DSM that utilities can cost-effectively acquire is likely much less. However, some utilities have demonstrated an ability to modify their DSM programs to obtain cost-effective savings even as avoided supply costs declined. Thus, given the right incentives, utilities should be able to acquire cost-effective DSM resources in the future.

The benefits of energy-efficiency improvements in reducing the environmental impacts of electricity production continue to be controversial. On the one hand, new power plants are much cleaner than are older units. On the other hand, reducing greenhouse-gas emissions (of which carbon dioxide is the major contributor) may turn out to be extremely important; CO_2 is now not regulated. Two major, recent studies show much smaller values of the environmental damages associated with electricity production than those estimated a few years earlier. We do not know whether these studies are more accurate than earlier ones, reflect recent improvements in the design of new power plants, or reflect the uncertainties about environmental damages.

Likewise, the existence and importance of market barriers to customer adoption of energy-efficiency actions continue to be hotly debated. Clearly, one major market failure no longer exists: retail electricity prices are now well above marginal costs. Fifteen years ago, prices were below marginal costs; that price signal encouraged customers to underinvest in energy efficiency.

Government building codes and appliance standards, which generally were nonexistent 15 years ago, are having a substantial effect on energy efficiency. However, these government programs and utility DSM programs can work synergistically to yield greater energy-efficiency improvements at lower cost than could occur with either type of program alone.

Finally, changes in the electricity industry will surely change—but not eliminate—DSM programs. As market forces play a stronger role in electricity markets, time- and location-dependent prices will send powerful signals to consumers that will encourage energy savings at certain times and places when and where electricity is expensive to produce and deliver. In addition, the existence of futures markets in electricity will make it easier for private companies to market energy-efficiency services. Utilities themselves will increasingly use DSM as customer-service programs to maintain and build market share. And regulators and utilities may agree that utilities should continue to run energy-efficiency programs for utility core customers.

The DSM programs of the future may be characterized by the following:

- The "utility" of the future will likely be a distribution entity regulated by the state PUC, as generation becomes unregulated and separated from distribution and customer services.

- Participating customers will generally pay for most of the energy-efficiency products and services they receive.

- These services will focus on improving customer comfort, convenience, and productivity, as well as on saving electricity.

- Many utilities and other suppliers will use energy services (including energy efficiency) as an important marketing tool to retain existing customers and to gain new customers.

- Utilities, to reduce the cost of their DSM programs, will continue to seek partnerships with other entities (e.g., with governments in promoting energy-efficiency standards and with manufacturers in encouraging market transformation).

- New technologies, including information systems, will play a key role in delivering energy-efficiency services. This information will instruct customers on the amounts of electricity used for different end uses, advise them of the timing of their electricity use, and encourage more use of time-differentiated electricity pricing.

Table 4. **Past and current status of factors that justify utility DSM programs**

Issue	Late 1970s situation	Current situation	Possible future situation
Electric supply options	Large, expensive, long-leadtime coal and nuclear plants	Smaller, inexpensive, cleaner, short-leadtime natural-gas plants; much excess capacity	Competitive markets may keep electricity prices low for many years
Avoided costs	Higher than prices	Lower than retail electricity prices	
Utility oil use	10% of U.S. oil use	3% of U.S. oil use	Likely to remain low
Environmental effects	Substantial; externalities thought to be ~1/4 of direct costs	New power plants (especially gas-fired ones) much cleaner than old units, but continued uncertainty about environmental effects	Possible stricter limits on NO_x, small particulates, air toxics, and, especially, carbon dioxide
Market failures and barriers	Thought to be very important obstacles to adoption of cost-effective DSM measures	Continued controversy about the existence and importance of market failures and market barriers	
Other energy-efficiency programs	Federal and state programs just beginning	Federal appliance and equipment standards, state building codes, plus other programs have major effects on electricity use. Utility DSM programs and government codes and standards interact in productive ways.	
Role of electric utilities	Uniquely positioned to offer advice and financial assistance to customers	Competition concerns lead utilities to reduce DSM programs paid for by all customers	PUCs may use nonbypassable fee on distribution system to pay for DSM

In conclusion, reports predicting the end of DSM are premature. However, it is naive to articulate any future for DSM without clear reference to the assumptions about future industry structure, regulation, and public policies. Regulation of the utility industry is changing, it is not disappearing. Utility interest in energy efficiency is also changing, but not likely to disappear either. To the extent there remain socially beneficial energy-efficiency opportunities that regulated utilities are uniquely poised to capture, there will be justification for public policies to ensure that they are captured.

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