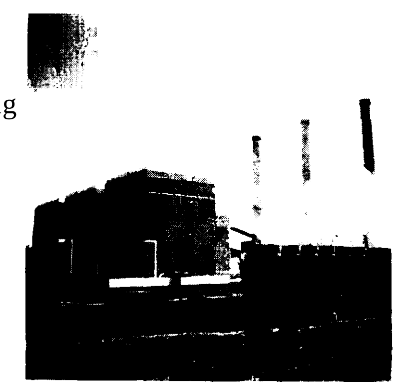
Introduction 1

Energy efficiency offers seemingly glittering promises to all-savings for consumers and utilities, profits for shareholders, improvements in industrial productivity, enhanced international competitiveness, and reduced environmental impacts. The technical opportunities are myriad and potential savings real, but consumers and utilities have so far been slow to invest in the most cost-effective, energy-efficient technologies available. The energy efficiency of buildings, electric equipment, and appliances in use falls far short of what is technically attainable. Energy analysts have attributed this efficiency gap to a variety of market, institutional, technical, and behavioral constraints. Electric utility energy efficiency programs have great potential to narrow this gap and achieve significant. energy savings.

But along with opportunities, greater reliance on energy efficiency as a resource to meet future electricity needs also entails risks—that efficient technologies will not perform as well as promised, that anticipated savings will not be truly cost-effective in practice, and that the costs and benefits of energy-efficiency programs will not be shared equitably among utility customers.

More than 30 States have adopted programs for promoting energy efficiency through utility integrated resource planning (IRP) and demand-side management (DSM) and programs are rapidly being developed and implemented in most of the remaining States (see box l-A). These programs reflect a recognition that increasing the efficiency of energy use by consumers to offset demand growth can be a financially attractive and reliable alternative to the addition of new generating plants. They also reflect a belief by policymakers that tapping the economic and technical resources of electric utilities can be an effective strategy for speeding the adoption of energy-efficient technology in all sectors.



Box I-A-Key Terms

- Energy efficiency refers to the physical performance of specific end uses or energy services such as lighting, heating, cooling, and motor drive. Greater energy efficiency is achieved by replacing, upgrading, or maintaining existing equipment to reduce the amount of energy needed. Energy efficiency is usually measured by the output quantity per unit of energy input (miles per gallon or lumens per watt, for example). Because energy is one of several factors of production (labor, capital, and materials are others), energy efficiency improvements contribute to greater energy productivity and economic efficiency.
- Energy conservation refers to measures taken to reduce energy consumption. Conservation measures include substituting more energy-efficient equipment to produce the same level of energy services with less electricity and changing consumer behavior to cut energy use. The term is sometimes used interchangeably with energy efficiency.
- Demand-Side Management (DSM) refers to utility-led programs intended to affect the timing or amount of customer electricity use. These include energy efficiency programs aimed at reducing the energy needed to serve customer needs and programs that shift electricity demand to reduce peak loads or to make more economic use of utility resources. All utility DSM programs fit into one or both of following: 1) programs affecting the way energy-using equipment is operated, and 2) programs that focus on the installation of improved technologies. A variety of DSM mechanisms are in effect, including audit and information programs, rebates and other consumer financial incentives, direct installation programs, technical assistance, and energy performance contracting.
- Integrated Resource Planning (IRP) is a teohnique used by utilities and State energy regulatory agencies to develop flexible plans for providing reliable and economic electric power supply for customer needs. The process includes explicit comparisons of both supply-and demand-side resource options to meet a range of future electricity demand scenarios. Utility planners compare the lifetime capital and operating costs, availability, reliability, and environmental impacts of the various supply-and demand-side resource options in a consistent manner to develop an overall plan to meet Identified future needs at least cost. There are several competing methodologies for defining what resource chokes constitute "least-coost" mix. The IRP process usually includes public participation and comment and may require approval of State regulators before adoption. After adoption, the plan is used to guide utility chokes in acquiring new resources. IRP is sometimes also referred to as least-cost planning.

SOURCE: Office of Technology Assessment, 1993.

With passage of the Energy Policy Act of 1992, the Federal Government also has adopted a policy favoring expansion of utility IRP and DSM programs and reaffirmed its support for development and commercialization of more energy-efficient technologies.[1]

Efficient use of electricity and changes in the electric power sector will play a vital role in any strategy for achieving a more energy-efficient society. If the threat of global climate change prompts concerted action to reduce carbon emissions, maximizing energy efficiency will be an imperative and a major overhaul of how energy services are provided and paid for will be required on a more accelerated schedule.

This report is part of the Office of Technology Assessment (OTA) ongoing assessment of *U.S. Energy Efficiency: Past Trends and Future Opportunities.* It examines mechanisms for achieving greater energy efficiency through electric utility planning, operations, and regulation. In particular, the report looks at the results of State

[1] Public Law 102486, 106 Stat. 2776, Oct. 24, 1992.

and utility IRP and DSM programs. The report also looks at the influence of State and Federal regulatory policies on utility investments in energy efficiency and presents a range of legislative policy options for encouraging energy efficiency through the electric utility sector.

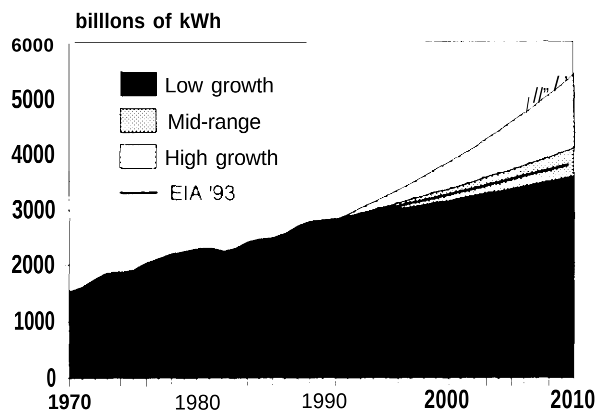
ENERGY AND ELECTRIC UTILITIES

Electric utilities are important as energy users, as providers of vital energy services, and as an economic force in the U.S. economy. Electric utilities are the Nation's biggest purchaser of primary energy supplies-coal, nuclear fuel, gas, and oil. Utility power generation accounted for 36 percent of total primary energy use in the United States or 29.6 quads in 1990.[2]

Energy efficiency improvements have slowed electricity demand growth, but electricity use is still increasing, Energy use for electric power generation as a share of the Nation's energy consumption has been growing-faster than growth in demand for other energy sources and that trend is projected to continue. Electricity demand growth over the past decade has slowed from the high (7 percent/year) annual growth rates that characterized the 1950s and 1960s to an average of 2.3 percent/year in the 1980s.[3]

Projecting future electricity demand is a highly uncertain art-adding to the risks that utilities face in planning and building for the future. Current estimates of 10-year electricity demand growth range from 1 percent to 3.5 per year (see figure l-l). Estimates of new powerplant construction needed to meet this new electricity demand and replace retired units range from 56 to 221 gigawatts (a gigawatt is one billion watts) in addition to the 700 gigawatts already installed.[4]

Figure 1-1—Electricit y Demand Growth, 1970-2010



SOURCES: Office of Technology Assessment, 1993, based on data from U.S. Department of Energy, Energy Information Administration, Annual *Energy Outlook* 7993, DOE/EIA-0383(93) (Washington, DC: U.S. Government Printing Office, January 1993); and Edison Electric Institute, "Meeting Electrcity Needs in the 1990s," September 1991 (briefing paper prepared for the Strategic Planning Executive Advisory Committee by Science Concepts, Inc.).

The U.S. Department of Energy uses a range of about 80 to 100 gigawatts for the new capacity needed by the year 2000--equivalent to construction of up to 100 new 1,000-megawatt coal-fired powerplants.[5] The differences in the estimates of new capacity needs reflect hundreds of billions of dollars in new capital equipment costs to ratepayers.

Efficiency advocates have long maintained that it is often cheaper for ratepayers and better for the environment and society to save energy rather than build new powerplants. This view is now embraced by many utilities, regulators, shareholders, and customers. The energy efficiency

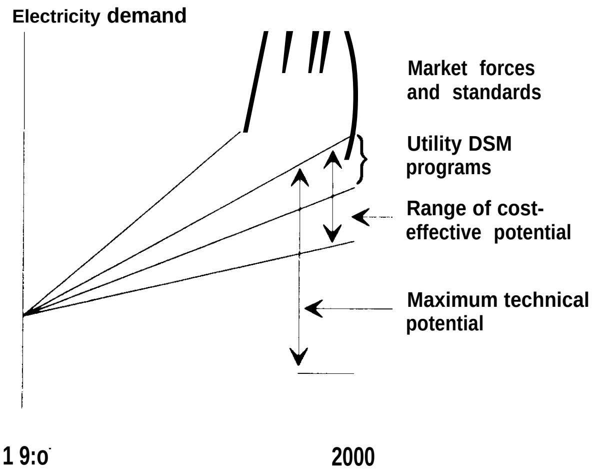
[2] U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1991,* DOE/EIA-0384(9 1) (Washington, DC: U.S. Government Printing Office, July 1992), p. 15, table 5.

[3] Edison Electric Institute, "Meeting Electricity Needs in the 1990s, " September 1991 (briefing paper prepared for the Strategic Planning Executive Advisory Committee by Science Concepts, Inc.).

[4] Ibid.

[5] U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 1993, D0E/EIA-0383(93)* (Washington, *DC:* U.S. Government Printing Office, January 1993).

Figure I-2—impacts of Energy Efficiency Savings



This figure shows the different levels of projected energy savings impacts depending on what measure of energy efficiency is used.

SOURCE: Office of Technology Assessment, 1993, adapted from Barakat & Chamberlin, Inc., Efficient *Electricity Use: Estimates of Maximum Energy Savings,* **EPRI CU-6746 (Palo Alto, CA: Electric Power Research Institute, March 1990).**

strategy is already shaping our future-initial results are promising, but substantial uncertainties remain, and hundreds of billions of dollars are at stake.

FINDINGS

1. There are significant opportunities for cost-effective, energy efficiency savings in all sectors of the economy.

Analyses by OTA and others have consistently found that there are numerous cost-effective opportunities to use electricity more efficiently and to avoid the costs and pollution associated with new powerplant construction and still have the same energy services-warm showers, cold drinks, comfortable surroundings, and a vital economy.[6]

There is general consensus that the most promising technical opportunities for achieving more efficient use of electricity include:

- improvements in the thermal integrity of building shells and envelopes;
- improvements in the efficiency of electric equipment;
- lighting improvements;
- net efficiency gains from shifting energy sources from fossil fuels to electricity (electrification); and
- Optimization of electricity use through better energy management control systems, shifts in time of use, and consumer behavior and preference changes.

Estimates of the amount of cost-effective electricity savings that might be achieved through full adoption of currently available efficiency technologies vary, falling within a range of from 20 to 45 percent of present use by 2000 depending on the study. This wide range in the estimates reflects differing assumptions about technology availability, adoption rates, and cost-effectiveness (see figure 1-2). The high estimates would require replacing much of the entire stock of electricity-using equipment with the most-efficient models available and would require

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[6] *See the* following reports by U.S. Congress, **Office** of **Technology** Assessment: *Energy Technology Choices: Shaping Our Future,* **OTA-E-493** *(Washington DC:* **US. Government** Printing Office, July 1991); *Changing by Degrees: Steps to Reduce Greenhouse Gases, OTA-O-482* (Washington, DC: U.S. Government Printing Office, February 1992); *Energy **Efficiency** in the Federal Government: Government by Good **Example?**,* OTA-E-492 **(Washington,** DC: U.S. Government Printing **Office,** May 1991); *Building Energy **Efficiency**,* **OTA-E-518 (Washington,** DC: U.S. Government Printing Office, May **1992); and** *Industrial Energy **Efficiency**,* **OTA-E-560 (Washington,** DC: U.S. **Government** Printing **Office,** August 1993).

See also: *National **Energy** Strategy: **Powerful** Ideas for America, First Edition 1991/1992* **(Washington,** *DC:* U.S. Government Printing **Office,** February 1991); American Council for an **Energy-Efficient** Economy and New York State Energy Office, *The Achievable Conservation Potential in New York **State from** Utility Demand-Side Management Programs,* Energy Authority Report 9018 (Albany, NY: New York State Energy Research and Development Authority and New York State Energy **Office,** November 1990); **American** Council for an Energy-Efficient Economy et al., *America's Energy Choices: Investing in a Strong Economy and a Clean Environment,* (Cambridge, MA: The Union of Concerned Scientists, 1991): and Arnold **P.** Fickett, Clark W. **Gellings,** and **Amory** B. **Lovins, ''Efficient Use** of **Electricity,''** ***Scientific*** *American,* September 1990, pp. 65-74.

mobilizating of staggering amounts of capital to finance the transition even though it would result in significant long-term savings in energy costs. Even without aggressive retrofitting and replacement of electric equipment, it is projected that present trends in energy efficiency improvements due to energy prices, standards, and technological improvements, coupled with existing utility-sponsored resource planning, conservation, and DSM efforts will result in about a 9 percent reduction in electricity use by 2000 from what it would be without the expected efficiency savings.[7] Utility DSM programs are expected to offset about 14 percent of new electricity demand growth over the next decade.[8]

There is general consensus among energy analysts that we can cut electricity demand growth further and maybe even produce a net reduction in electricity demand over the next several decades. Doing so clearly offers substantial benefits. We believe with wise implementation of cost-effective measures, they likely will outweigh the costs and risks inherent in this strategy.

2. Investments in energy efficient technologies offer significant benefits to electric utilities and the Nation.

Improvements in energy efficiency through the electric utility sector offer the promise of savings for ratepayers and electric utilities, profits for shareholders, and societal benefits to energy security, international competitiveness, and environmental quality. Figure 1-3 illustrates the potential contributions of energy efficient technologies to national interests.

Increasingly, utilities are finding that energy efficiency programs make good business sense.


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A home energy audit in progress.

Investments in energy efficiency through demand-side measures and enhancing the performance of supply-side options can provide reliable, flexible, and lower-cost alternatives to reliance solely on conventional generating options. Efficiency contributes to improved load factors for existing plants, reduces financial risks, and generates good will among customers.[9] In addition, energy efficiency improvements are becoming an important strategy for environmental compliance by reducing emissions and qualifying utilities for additional emissions allowances under the acid rain provisions of Clean Air Act Amendments of 1990. With the growth of State regulatory incentives for DSM investments, utilities are finding that energy efficiency programs offer new profit opportunities.

Improving the energy efficiency of electricity use contributes to greater productivity, lower energy costs overall, and more competitiveness in the international marketplace for U.S. businesses. Moreover, utility DSM investments tend to create more job opportunities for lower-skilled workers

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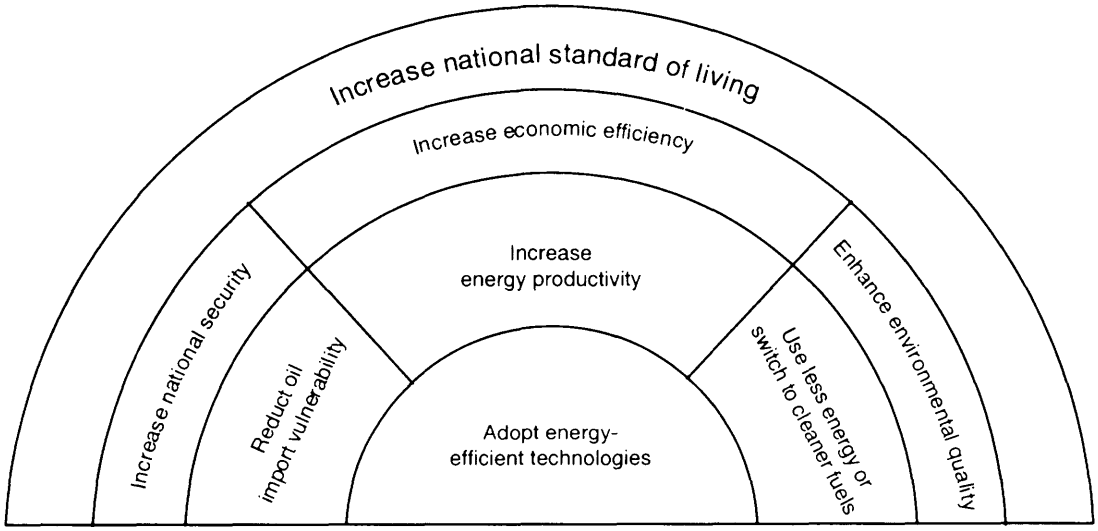
[7] Barakat & Chamberlin, Inc., *Estimating Efficiency Savings Embedded in Electric Utility Forecasts* EPRI CU-6925, *Project 2788*, Final Report (Palo Alto, CA: Electric Power ResearchInstitute, August 1990). Electric Power Research Institute and Edison Electric Institute, *Impact of Demand-Side Management on Future Customer Electricity Demand:* An *Update*, EPRI-CU 6953 (Palo Alto, CA: Electric Power Researc h Institute, September 1990)

[8] Eric Hirst, *Electric Utility DSM-Program Costs and Effects: 1991-2001,* ORNL/CON-364 (Oak Ridge, TN: Oak Ridge National Laboratory, May 1993).

[9] Brent Barker, "Energy Efficiency: Probing the Limits," *EPRI Journal*, March 1992, pp. 14-21.

Figure 1-3-Energy Efficiency and Energy-related National Policy Goals



SOURCE: Office of Technology Assessment, 1993, adapted from Energetics, Inc., Utility Enerrgy *Efficiency Srategies: The Role of Effiency, Productivity,* and *Conservation,* EPRI CU-6272 (Palo Alto, CA: Electrie Power Research Institute, February 1989), p. 2-2.

than construction programs for conventional supply--side generation and transmission additions.[10]

DSM measures also can help reduce our oil import vulnerability. Even though electric utilities today account for less than 5 percent of U.S. oil demand, oil-fried generation remains an important resource in the Northeast, California, Florida, and Hawaii. For utilities in these areas, accelerating the implementation of DSM measures to displace oil-fired generation is a key strategy for responding to potential oil import disruptions.[11]

3. Electric utility energy efficiency programs can produce cost-effective energy savings and help overcome economic, institutional, and behavioral impediments to investment in energy efficient technologies.

The potential of using the electric utilities sector and utility regulation to spur changes in the energy efficiency of America's homes, schools, and workplaces has captured the attention of energy efficiency advocates, utilities, entrepreneurs, State regulators, Federal policymakers, and consumers. Public utilities are well positioned to promote the adoption of more energy-efficient technologies. Their integrated operations, technical expertise, established ties to customers, and familiarity with customer energy use equip them with the technical skill, marketing tools, and information to identify energy-savings opportunities. Their special status as regulated public

10 Howard Geller, John DeCicco, and Skip Laitner, *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies (Washington DC: The American Council* for an Energy-Efficient Economy, October 1992).

11 See U.S. Congress, Office of Technology Assessment, *U.S. Oil Import Vulnerability: The Technical Replacement Capability,* OTA-E-503 (Washington, DC: U.S. Government Printing Office, October 1991), chs. 2 and 3.

utilities offers access to capital, a relatively secure cash flow, and a concomitant responsibility to provide cost-effective and reliable service to their customers. Their regulated status also makes them attractive targets for policy initiatives in pursuing energy efficiency, as it has in improving environmental quality. Utilities are by no means the only entities that can provide energy efficiency investments-the growth of energy service companies and energy management technology companies testify to this. Many of these companies owe much of their market to opportunities created by utility programs and rebates.

Utility efficiency programs can work—providing significant savings and profits for utilities. Energy efficiency and utility demand-side management and conservation efforts have become big business. An estimated $2 billion was invested by utilities in DSM in 1991 and this will grow significantly in years to come.

Initial results have demonstrated that well-designed and implemented utility energy efficiency programs can deliver sustained, reliable, and cost-effective electricity savings. Despite this promise, there have been early disappointments. In many programs, participation rates have been low and actual savings have been well below cost-effective technical potential. In part this is due to the fact that many utility programs are of recent vintage and are still limited in scope. Nevertheless, even the best programs have experienced gaps between technical potential and actual savings. In coming years, utility programs will have to narrow this savings gap and expand the degree of customer participation in order to make energy efficiency the true equal of new generating units and other supply-side options in meeting customer energy needs.

DSM programs entail some risks both in technology and the associated regulatory changes: that the savings will not be as high or as durable as expected, or that consumers will be asked to pay more than necessary to achieve them. DSM programs and IRP methods are evolving to take advantages of lessons learned and to target a broader range of electricity saving opportunities. The challenge is to assure that expanded utility and State programs achieve their goals and that Federal policies support, or at least not frustrate, those objectives.

4. State and Federal Governments will play key roles in overcoming the barriers and constraints to utility energy efficiency investments because of the regulated nature of utilities and government's influence over other sectors of the economy.

States and utilities are already well-advanced in establishing energy efficiency programs. The Federal Government has only limited direct influence over utility resource decisions, demand management programs, and retail operations. Most of these matters are regulated at the State and local level. Yet there is a strong Federal interest in energy efficiency arising from the importance of reliable and economic electric power production to the economy, concerns over the environmental impacts of power generation, and the Federal Government's roles as wholesale power producer, utility regulator, and utility customer.

Our future energy path will be determined by choices made by utilities, consumers, regulators, and government. If we choose to pursue the energy efficiency alternative, success depends on cooperation by utilities, acceptance by consumers, and institutional change. The States and many electric utilities have already moved far ahead of the Federal Government in direct initiatives for more efficient electricity use through the utility sector. There are, however, a number of areas where the Federal Government can make a contribution in encouraging the development and availability of energy-efficient technologies for electric utilities and their customers. Moreover, Federal Government decisions in a number of areas could signicantly affect the success and cost-effectiveness of utility programs and investments.

Federal policy options for encouraging greater energy efficiency through the electric utilities sector are discussed in chapter 2 of this report. The overall strategies include: 1) support for expanded IRP and DSM programs and other State regulatory incentives for utility investment in energy efficiency; 2) continued support for commercializing energy-efficient technologies through tough energy efficiency standards for buildings and equipment; and 3) support for energy efficiency research, development, and technology transfer activities.