The Contribution of Energy Efficiency to the Reliability of the U.S. Electric System

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ABSTRACT

This paper examines the role of energy efficiency in enhancing electric system reliability. In many states that have enacted utility restructuring legislation, and thus far in Congress, energy efficiency advocates have had trouble convincing legislators of the connection between end-use efficiency and system reliability, and thereby persuading them to include support for end-use efficiency programs in restructuring legislation. Most often the small "wires charge" proposed as a means of funding such programs has often been labeled a "new tax." Meanwhile, the prospect of interstate competition and retail customer choice has led utilities to slash spending on energy efficiency and other demand-side management programs. The foregone energy savings and demand reductions have contributed to declining reserve generation capacity margins, a trend that North American Electric Reliability Council (NERC) forecasts show continuing through 2008.

The authors contend that end-use energy efficiency programs can make a very substantial, cost-effective contribution to electric system reliability over the next decade by reducing both the national base load and regional and local peak loads on the electric system. We do not contend that energy efficiency can completely eliminate the need for any new generation capacity or enhancements to the transmission and distribution network, but that energy efficiency can cost-effectively and significantly reduce the need for both while providing a much-needed margin of insurance against the uncertainties inherent in the utility industry's transition to competition. Since the most oft-cited reason for electric utility restructuring is to save consumers money, policymakers should not fail to include support for end-use efficiency programs in restructuring legislation.

Introduction: The Historic Role of Energy Efficiency

Energy efficiency has long been a national public policy priority, and has made a substantial contribution to the nation's energy supply, thereby "lightening the load" on our electricity generation, transmission, and distribution system. Analysis by the Alliance to Save Energy, illustrated in Figure 1 (Alliance, 1998) reveals that energy efficiency - the energy saved by efficiency improvements implemented between 1973 and 1998 – made energy efficiency the nation's second largest source of energy (and largest domestic resource) by 1998. This analysis accounted for changes in energy intensity due to structural changes in the economy, such as a decline in energy-intensive industries and the increasing share of the nation's Gross Domestic Product (GDP) derived from services. While steep increases in energy prices were undoubtedly a strong driver for improvements in energy efficiency, many of the gains were purposeful, policy-driven, and accomplished through targeted research and development and technology deployment programs.

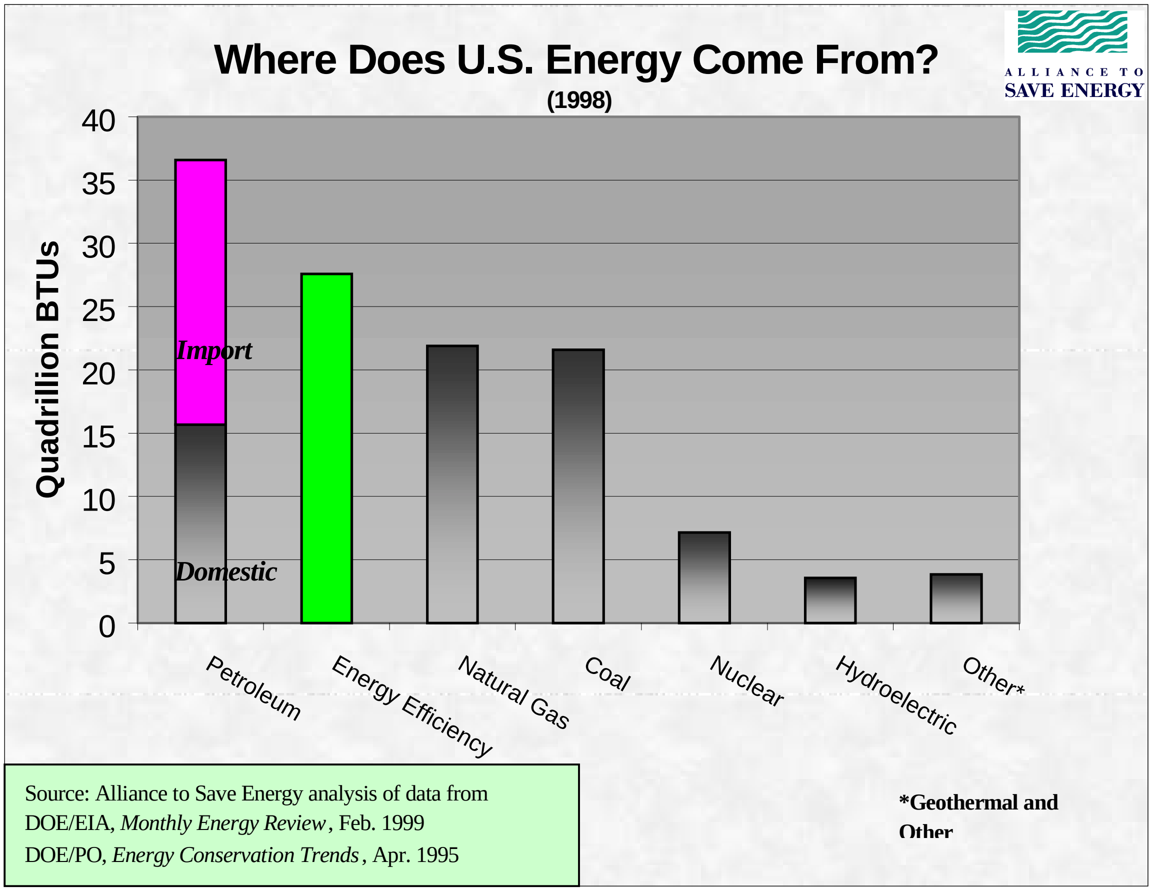


Figure 1. Sources of Primary Energy in the U.S. Economy, 1998

The rise of energy efficiency as a policy objective dates back to the 1970's, when increasing electricity demand, higher capital costs, and rising electricity prices led to heightened public awareness of the need to moderate energy use with conservation efforts. Three federal laws enacted in the 1970s laid the groundwork for the various demand-reduction and load-management strategies that collectively became known as demand-side management (DSM). These were the Energy Policy and Conservation Act of 1975 (EPCA), the Energy Conservation and Production Act of 1976 (ECPA), and the National Energy Conservation Policy Act of 1978 (NECPA). Also starting in the '70s, as state regulators began increasingly scrutinizing the cost-effectiveness of new capacity investments brought before them by regulated utilities requesting cost recovery plus a profit, the concept of "least-cost planning" was born. Least-cost planning asserted that it was often more cost-effective to help customers reduce their energy demand through more efficient technology and better energy management practices than to build new power plants.[1]

[1] For an excellent history of the rise of demand-side management and least-cost planning in electric utility regulatory policy, see Joseph Eto, 1996: *The Past, Present, and Future of U.S. Demand-Side Management Programs.* LBNL-39931. Berkeley, CA: Lawrence Berkeley National Laboratory.

The late 1980's saw a growing number of states adopt least-cost planning regulations, with the consequence that utility DSM budgets grew rapidly from 1989 to 1993. In 1990, the U.S. Energy Information Administration began formally tracking these expenditures in its annual survey of utility operations. From 1989 to 1993, utility spending on DSM tripled, rising from $0.9 billion in 1989 to $2.7 billion in 1993. Along with program expenditures, utilities also reported the energy saved and the actual and potential peak demand reductions due to their programs, broken down by program category, so that energy savings and peak load reductions attributable to energy efficiency[2], as opposed to load management, can be identified. Figure 2 (Energy Information Administration, 1997 and 1998) shows that the contribution of energy efficiency in both areas grew substantially, increasing from 32.3 billion kWh and 6.9 thousand MW in 1992 to nearly 60 billion kWh and over 14.2 thousand MW in 1996.

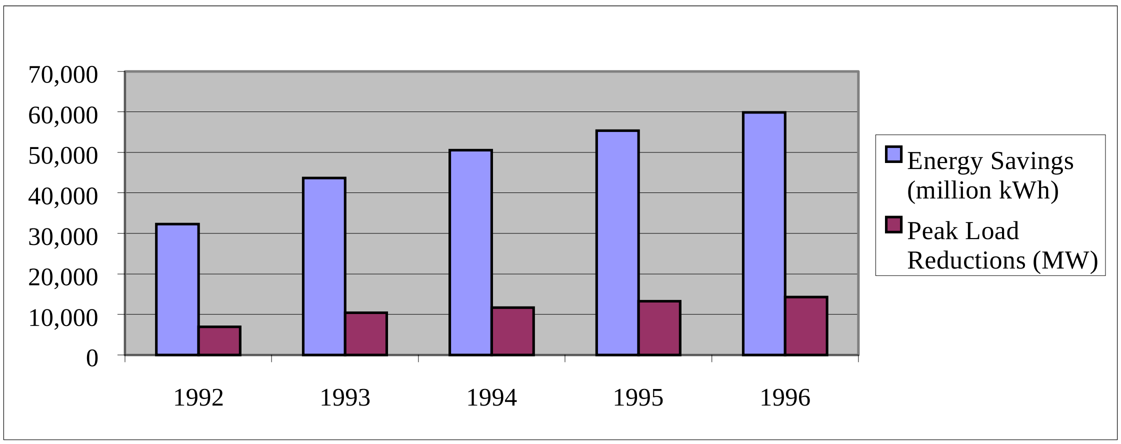


Figure 2. Energy Savings and Peak Load Reductions from Energy Efficiency in Utility-Sponsored DSM Programs, 1992-1996

The Nature and Costs of Electric System Reliability

The North American Electric Reliability Council's definition of reliability encompasses two concepts: adequacy and security. Adequacy is defined as "the ability of the system to supply the aggregate electric power and energy requirements of the consumers at all times," while security means "the ability of the system to withstand sudden disturbances." While outages can be described in terms of number, frequency, duration, and amount of load (or numbers of customers) affected, of much greater importance, although much more difficult to quantify, are the economic consequences of any interruption(s) in electric service. (SEAB 1998) As the nation moves slowly but

[2] DSM programs are designed to achieve two basic objectives: energy efficiency and load management. Energy efficiency is primarily achieved through programs that reduce overall energy consumption of specific end-use devices and systems by promoting high-efficiency equipment and building design. By their nature, energy efficiency programs typically reduce energy consumption over many hours during the year, including at times of peak demand. Load management programs on the other hand, are designed to achieve load reductions; primarily implemented at times of peak load. Peak load reduction programs may have little effect on total energy consumption.

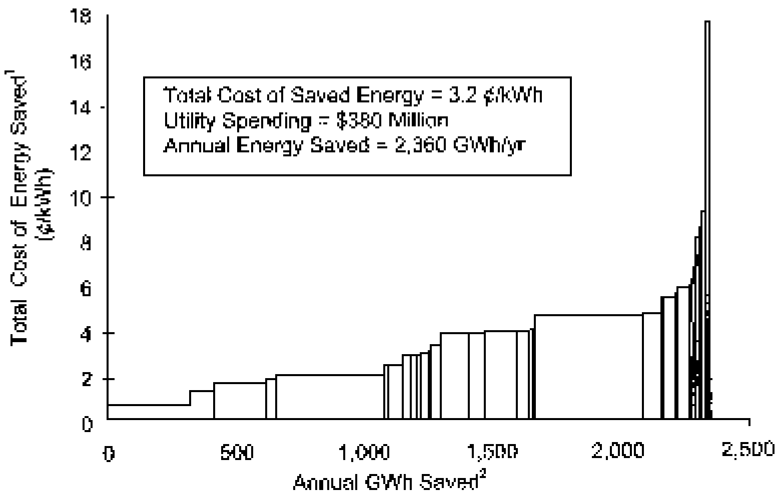
surely toward embracing competition in the market for electricity, it is important to remember that electric system reliability is, in many respects, a classic "public good." By the laws of physics, the essential attributes of electric service – adequacy, voltage, and frequency – are available (or not) to all interconnected users simultaneously. Like the textbook examples of lighthouses and national defense, most aspects of electric system reliability are provided to everyone or to no one. The costs of maintaining and ensuring system reliability are therefore most properly borne by all users of the electric system, the general public. Therefore, one important goal of public policies governing how the system is run and how its operating costs are allocated, which are established by a hierarchy of entities from the U.S. Congress on down, should be to ensure that these costs are minimized.

Energy Efficiency Cost-Effectively Saves Energy and Reduces Peak Demand

As described earlier, utility sponsored DSM programs came about because energy efficiency advocates demonstrated and state regulators realized that saving energy could be less expensive than producing it (Lovins 1976, SERI 1981). Although the performance of utilities varied widely in the cost-effectiveness of their design and administration of energy efficiency programs, several rigorous studies showed that overall, they were cost-effective. EIA analysis of utility reported 1994 data on DSM programs showed that the mean utility cost for energy efficiency programs fell to 2.9 cents per kWh saved, and a number of utilities were able to achieve substantial energy savings at costs below 2 cents per kWh saved (EIA 1994). Although some analysts cast doubt on these figures, arguing that variances in utility accounting, measurement, and reporting practices can vary widely and that in some cases, customer costs were not included in reported program costs, a thorough examination of 40 of the largest U.S. utility commercial-sector DSM programs verified the initial findings of cost-effectiveness (Eto, Kito, Shown, and Sonnenblick 1995). This study accounted for all customer costs and all overhead and administrative expenses, including financial incentives paid to utilities as well as the cost of measuring savings. It also examined the savings evaluation methods used by utilities and found that the choice of method did not introduce a statistically significant bias in the results. On average, DSM programs were found to have saved energy at a cost of 3.2 cents per kWh and that, on average, they were highly cost effective when compared to the original avoided costs used by utilities when designing the programs. The range of program costs and the energy saved by those programs are illustrated by Figure 3 below.

Moreover, evaluation of energy efficiency program costs on the basis of the average cost-per kWh of energy saved can dramatically understate the value of the peak demand reductions delivered by those programs. Demand reductions avoid the monetary (and environmental) costs of generation *on the margin*. An individual customer that reduces demand receives the private benefit of reduced energy bills, but since the market-clearing price for delivered energy at any time is a function of overall system demand, individual load reductions reduce this price, providing monetary benefits to all (Ferguson 1999). A situation that occurred in the Pennsylvania-New Jersey-Maryland (PJM) power pool on July 6, 1999 illustrates this phenomena very well. PJM's load that day reached an all-time high, and as a consequence, it deployed its active load management program to reduce demand during the mid-day hours. The program cut demand by an average of 1%

during nine peak-load hours. Because electricity prices reached $920/MWh during these hours, this demand reduction cut electricity costs by $10 million. (Were it not for these demand reductions, electricity prices would have been even higher!) This $920/MWh price was 20 times higher than the average price in PJM between June and September, 1999 (Hirst 2000).



Source: Eto et al. 1995

[1] The total cost of energy saved includes installation of energy-efficiency measures (including net customer-paid costs) and all utility administration costs (including marketing, overhead, measurement, and shareholder incentives). Costs are levelized using a 5% real discount rate and divided by annual energy savings.

[2] Programs are arranged in ascending order of cost. The "width" of each program represents program size as represented by annual energy savings.

Figure 3. The Cost of the Largest Utility Commercial Sector DSM Programs 1992

By "Lightening the Load" Energy Efficiency Has Enhanced Reliability

Energy efficiency, by reducing demand, unquestionably contributes to system reliability, primarily in terms of supply adequacy. Quite simply, energy efficiency measures implemented within a particular service area or region can reduce both the base load, the amount of energy required to be supplied to that area or region, as well as the peak power demand. The contribution of energy efficiency measures to reducing base or peak load depends on the technologies targeted: lighting and refrigeration efficiency, for example, would reduce base load, while air conditioner efficiency gains would help reduce summertime peak load. (Of course, any reduction in base load reduces the "height" of the peak load.) Thus, energy efficiency measures in the aggregate help to maintain adequate margins of generation supply adequacy.

Furthermore, efficiency can also contribute to the security aspect of reliability, at the level of local transmission and distribution networks. The well-publicized outages of the summer of 1999 in both New York and Chicago were caused by failures and weaknesses in the distribution system, not generation supply inadequacy. The thermal failures in distribution transformers and feeder cables were the result of high, sustained peak demand, demand that could have been mitigated by more aggressive end-use efficiency programs in those areas. Thus, to the degree that energy efficiency reduces the load and stress induced on various points in the power distribution network, it also can enhance the security of the system by decreasing the likelihood of failures at those points in the system.

The Onset of State-by-State Utility Restructuring Has Brought Reliability Problems, Exacerbated by Steep Cuts in Utility-Sponsored Energy Efficiency Programs

Passage of the Energy Policy Act of 1992, which broadened the scope of competition in the wholesale electricity generation market and opened the door for states to institute "customer choice" retail electricity market competition, clouded the future for the traditional vertically integrated monopoly utilities. Utilities' investment in new generation facilities slowed, as it became unclear whether such investments would be economic given the expected downward pressure on retail prices from competition. By the latter part of the '90's, many regions of the country began experiencing reliability problems as a result of continued demand growth, particularly at peak, and customers felt the capacity crunch by way of blackouts, power quality fluctuations, and wholesale market price spikes:

- August 10, 1996: a multi-state blackout in the West interrupted 30,000 MW of load to 7.5 million customers, some for as long as nine hours.
- July, 1998: Public Service Co. of Colorado was forced to institute rolling brownouts following an annual peak demand increase of 10%
- August, 1998: Prices reached $999/Mwh in the Pennsylvania-New Jersey-Maryland (PJM) power exchange; the New England ISO issued a systemwide power watch; New York Power Pool members were asked to request conservation measures from customers; in the Midwest, Detroit Edison and Consumers Energy asked customers to cut back, while UtiliCorp United, Kansas City Power & Light and Interstate Power all ordered interruptions for interruptible customers. In California, SDG&E set a new system peak and called for conservation measures, while the California ISO declared a Stage 2 Emergency when operating reserves fell below 5%.
- The summer of 1999 saw major outages hit New York City, Chicago, and New Orleans.

The conventional and predominant response to the nation's current capacity/ demand crunch has been a focus on the construction of new power plants and major transmission lines. National policmakers have failed to recognize the direct consequences of utilities' extensive cutbacks in their energy efficiency programs since 1993. These foregone energy savings and peak demand reductions have greatly exacerbated the current capacity crunch.[3] Hence, policymakers have completely overlooked the potential of energy efficiency programs to reduce load growth and mitigate peak demand, and thereby enhance system reliability.

As shown in Figure 4 below, (EIA 1997 and 1998), utility-sponsored DSM program spending peaked in 1993 at $2.7 billion and declined by 46% to about $1.4 billion in 1998.

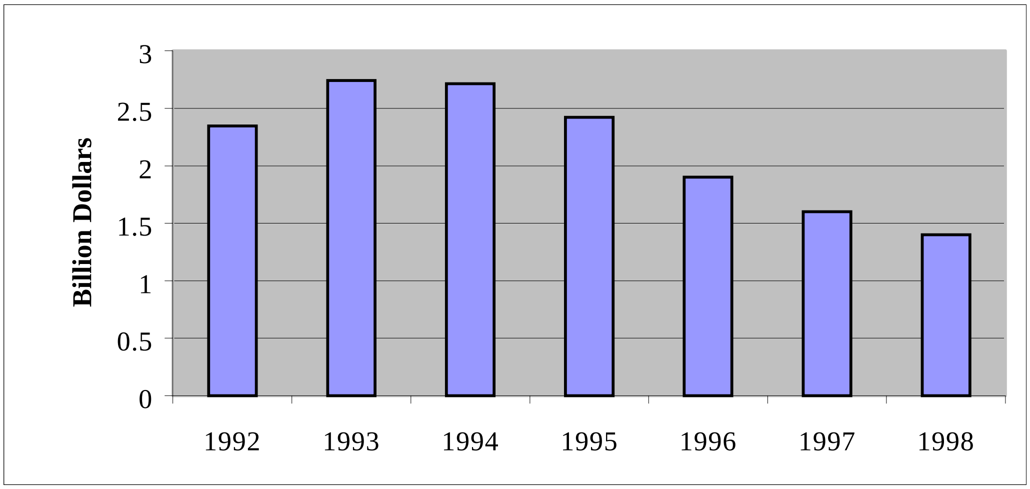


Figure 4. Utility Demand-Side Management Program Spending

Figure 5 (EIA 1997 and 1998) shows that the energy savings and peak demand reductions from the energy efficiency component of those programs peaked in 1996. Rather than continuing to increase, as was projected in '96, they declined considerably through 1998, the last year for which data are available.

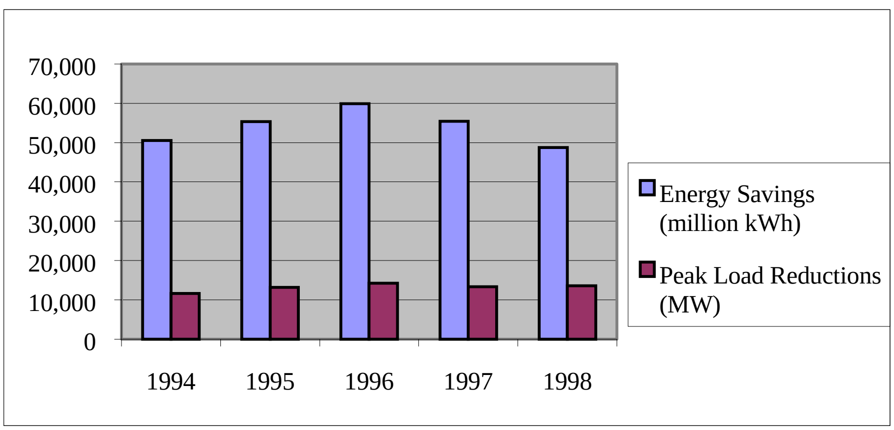


Figure 5. Energy Savings and Peak Load Reductions from Energy Efficiency in Utility-Sponsored DSM Programs

Energy Efficiency is "Least-Cost Reliability Insurance"

Of course, electric system reliability problems are highly temporal and geographically distinct in scope. They can be fleeting, only occurring during a couple of

[3] For a detailed analysis of the foregone energy savings and cost to consumers from utility cuts in energy efficiency programs from 1993 to 1997, see Coequyt et al, 1998. *Unplugged: How Power Companies Have Abandoned Energy Efficiency Programs*. Washington, DC: Environmental Working Group.

hours and days per year. Analysis of aggregate numbers cannot indicate exactly how much and when energy efficiency did or could have enhanced reliability, and by how much. Such an analysis would be extremely complex and require detailed modeling of the real-time peak power demand curves at the nation's several wholesale power exchanges, which is well beyond the scope of this paper and the resources of the authors.

That proviso aside, the aggregate numbers in Table 1 (EIA 1999) show that overall, peak demand reductions from energy efficiency in the years 1994-1998 amounted to between 1.99 and 2.31 percent of total U.S. non-coincidental peak load in each of those years.

Table 1. Peak load reductions from energy efficiency as a percentage of non-coincidental peak load

	1994	1995	1996	1997	1998
Peak Load Reductions	11,662	13,212	14,243	13,326	13,591
Non-coincidental Peak Load	585,844	620,871	616,790	660,293	669,069
Peak Load Reductions from Energy Efficiency as a Percentage of Non-coincidental Peak Load	1.99%	2.13%	2.31%	2.02%	2.03%

In its 1998 *Reliability Assessment 1998-2007*, the North American Electric Reliability Council (NERC) projected that the total net internal demand for summer 2001 of the three continental U.S. Interconnections (Eastern, Western, and ERCOT) would equal 700,283 MW. NERC also projected total capacity additions of 27,770 MW by 2001. In 1997, U.S. electric utilities in their reports to the Energy Information Administration on DSM programs had projected actual peak demand reductions from the energy efficiency component of their programs totaling 17,771 MW. If all three projections hold true, energy efficiency in 2001 could contribute load reductions amounting to over 2.5 percent of total net internal demand, account for over 15 percent of the interconnections' total projected capacity margin, and "supply" 64% of projected capacity additions. Unfortunately, the projection was wishful thinking – as shown above, illustrated by Figure 5, utility spending on energy efficiency programs had long since peaked at $2.7 billion in 1993, and peak demand reduction from energy efficiency were trending downward – just 13,591 in 1998 (the last year for which data are available).

The U.S. Department of Energy's (DOE) "Power Outage Study Team," composed of DOE professionals, scientists from many of DOE's national laboratories, and professors from several of the nation's leading university electrical engineering programs, examined the causes of eight major outages and power disturbances across the country during the summer of 1999 and made recommendations for improving reliability. In its report, the POST team recognized the connection between energy efficiency and reliability, and included among its twelve recommendations the explicit call to "Encourage energy efficiency as a means for enhancing reliability." (Carrier et al, 2000). In particular, the POST study recommended that the federal government "work with state governments to support development and implementation of cost-effective energy efficiency programs," and "expand existing federal programs to promote energy efficiency."

Uncertainty is the Watchword for the Next Decade

The transition of the utility industry to competition in the generation and retailing sectors of the electricity market brings with it inherent uncertainties. The institutions and traditions that served to assure reliability and the smooth functioning of bulk power markets are undergoing profound change. In fact, the Secretary of Energy Advisory Board Task Force stated in 1998, "[we] believe that the primary challenges to bulk-power system reliability are presented by the transition itself, rather than by the end state of competition." Under regulation, utilities planned for and built power plants to meet a predetermined reserve generation capacity criterion, and were assured of recovering costs plus a profit margin through the regulatory rate-setting process. Under competition, markets – composed of electric generating businesses, investors, and consumers – will decide which supplies will be needed and economical. These decisions will be made on the basis of trends in market prices and projected revenues from the sale of electricity relative to the construction and operating costs of the unit in question (SEAB 1998). The ability of markets to accurately forecast future demand and potential revenues and translate those into timely investments in supply capability is uncertain. In addition, the North American Electric Reliability Council (NERC), in its report, "Reliability Assessment 1998-2007," predicted that there will be less coordination, or at the very least it will take significantly longer to coordinate, needed additions to generation capacity with the additions to transmission capacity to support it. All of this will take place against a backdrop of steadily rising demand for energy, increases in peak demand, and declining reserve generation capacity margins, as illustrated by the graphs in Figure 6 below (North American Electric Reliability Council, 1998):

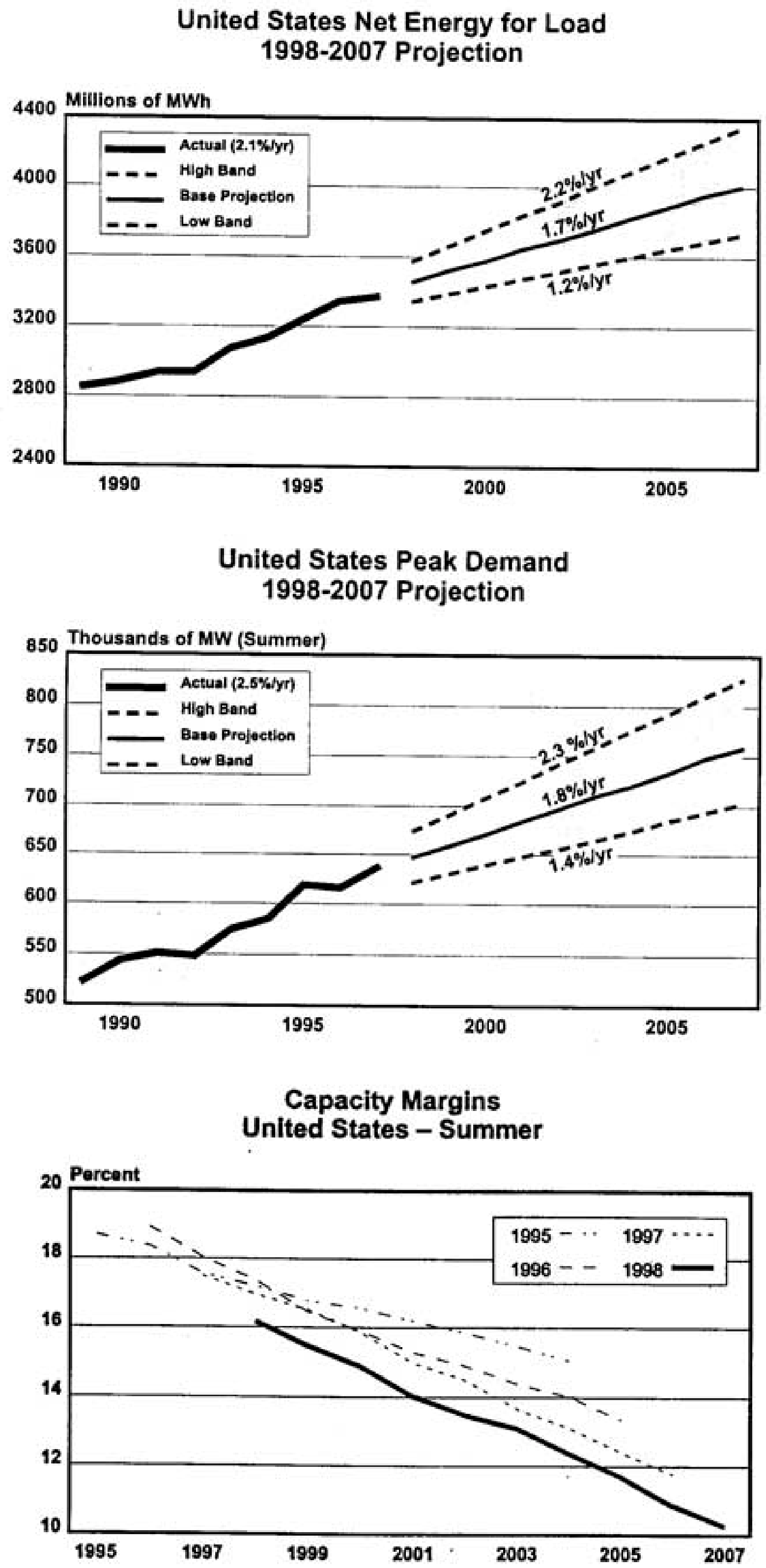


Figure 6. Projections of United States Net Energy for Load, Summer Peak Demand, and Summer Capacity Margins

Conclusion

Congress, in considering federal electric utility restructuring legislation, must recognize that in a competitive environment, none of the entities succeeding the vertically integrated regulated monopoly utility has a financial incentive to promote cost-effective energy efficiency for the benefit of customers, the environment, or overall grid reliability. In light of the NERC forecasts and the explicit recommendations of the DOE's POST Report, any legislation enacted by Congress, either a comprehensive utility restructuring bill or a so-called 'reliability bill,' should include provisions to strengthen, rather than allow the continued erosion of, funding devoted to energy efficiency programs. These programs serve a vital public interest, enhancing reliability by helping temper rising demand from our growing economy, while at the same time serving private interests, saving the businesses, public institutions, and individual consumers that implement energy efficiency measures money on their utility bills. Energy efficiency programs should be considered at a minimum to be "least-cost reliability insurance" that is well worth investing in. While the evidence suggests that the private energy services market will continue to emerge, with energy service companies (many spun off from formerly vertically integrated utilities) competing to provide their customers -- primarily the larger entities in the commercial and industrial sectors -- maximum-value energy services, individual consumers and small businesses will likely be underserved in this regard. It is therefore in the public interest to continue to fund programs aimed at capturing, for their contribution to reliability and other public benefits, the cost-effective energy savings and peak demand reductions available through energy efficiency programs. Furthermore, the purpose of energy efficiency programs is entirely consistent with the basic goal of utility restructuring – to lower customers' electric bills. For these reasons, Congress should not fail to include in federal utility restructuring legislation a non-bypassable funding mechanism applicable to all electricity generated or sold throughout the country specifically to provide continued support for energy efficiency programs.

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Summary:

This paper argues that policymakers should appreciate and provide a means to fund energy efficiency programs as “least-cost reliability insurance” in legislation to restructure the electric utility industry.