AN INTRODUCTION TO DEMAND-SIDE MANAGEMENT: THE BUSINESS OF ENERGY CONSERVATION FOR ELECTRIC UTILITIES

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I. INTRODUCTION

The intent of this handbook is to introduce the reader to business aspects of Demand-side Management (DSM) at electric utilities, define relevant terminology, and direct the reader to more in-depth literature on DSM issues. Geared toward students and those who are new to DSM, this compilation of current literature lays a foundation that will facilitate comprehension of more complex DSM issues.

DSM encompasses a wide variety of actions taken by utilities to modify their customers' energy demand. Among these are programs which:

- reduce energy use (e.g., efficient buildings, equipment and processes);
- redistribute energy demand to spread it more evenly throughout the day (e.g., load shifting, innovative rates), and
- encourage strategic load growth (e.g., electrification programs).

Utilities accomplish such goals by using rebates, audits, loans and free installation of energy-efficient equipment, among other options.

Demand-side management along with supply-side management are components of integrated resource planning (IRP) or least-cost planning (LCP), which is used by power utilities to satisfy energy needs while minimizing costs to the consumer, utility and environment. The appeal of DSM is different for the various parties involved. Through DSM, utilities avoid or delay the expense of building new power plants; can utilize smaller-scale, and therefore more flexible, resources; and build more favorable relationships with the public and regulatory agencies. These attributes reduce resource costs to customers by lowering utility expenses. The flexibility provided by DSM makes the portfolio of resources less sensitive to unanticipated changes in economic growth, fuel prices and power plant construction costs than supply-side resources alone.[1]

Environmentalists seek to lessen pollution and environmental degradation through involvement in DSM. Energy conservationists see DSM as a means to increasing utility commitment to cost-effective energy efficiency.

This handbook focuses on demand-side management that promotes energy conservation and efficiency. More specifically, focus is placed on DSM's business aspects -- those aspects that transform energy conservation and efficiency into viable business decisions with potentially significant impact.

II. HISTORICAL OVERVIEW OF ELECTRIC UTILITIES AND THE DEVELOPMENT OF THE CONCEPT OF DSM

Electricity is an integral component of contemporary civilization. It has been and will continue to be a determining factor in the technological development of society and its economic foundation. This chapter introduces many relevant concepts which will be discussed in more detail in subsequent chapters.

Electric utilities have undergone many changes over their history. The nature of the industry -- capital intensity, vulnerability to fluctuating fuel prices, obligation to provide a service to the public, environmental pressures -- makes for a complex decision-making process, and a sometimes erratic history.

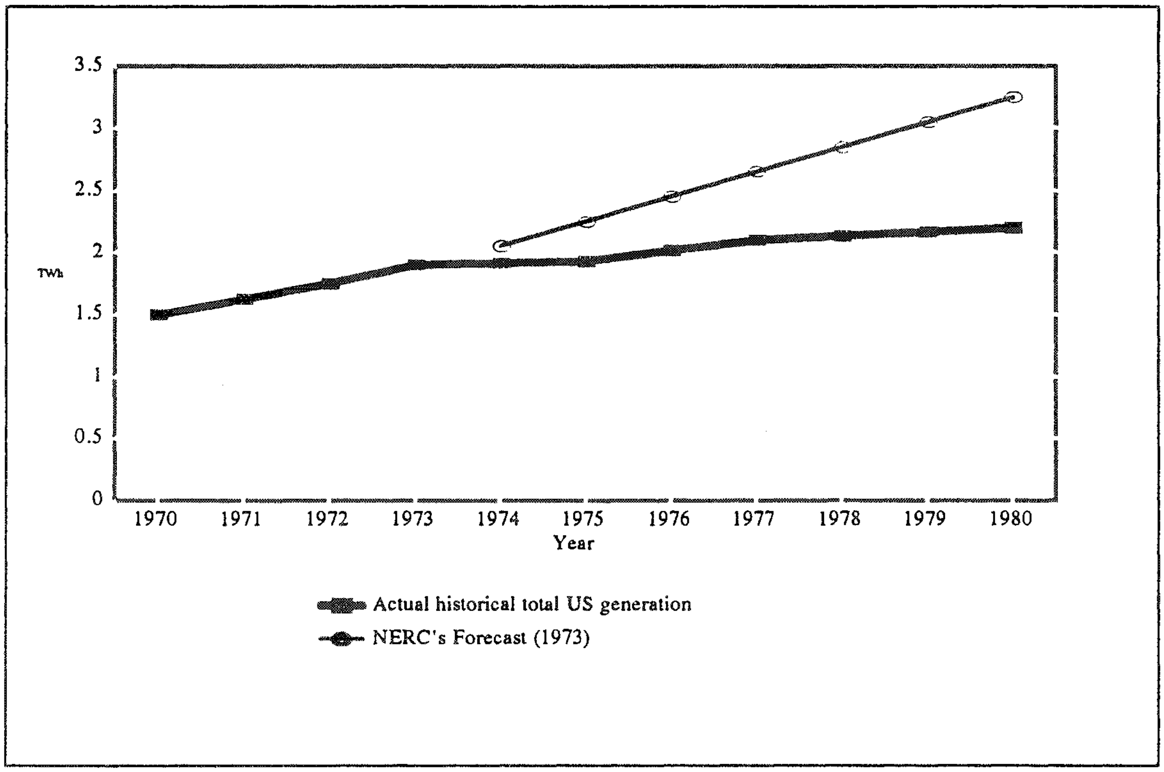
Industry cost structure and regulation have played an important role in shaping the development of the utility industry. In early years of development, falling electricity prices, rising demand and growing profit and productivity effected the character of utilities. This atmosphere created economies of scale, as reflected in the building of larger more efficient plants to serve growing markets at lower costs. Although this growth was capital intensive, these costs were offset by economies of scale and increased market demand. These operating efficiencies stemmed from improved fuel combustion efficiency, potential fuel price reductions for larger quantities purchased and decreased labor requirements.

In order to fund expansion, utilities sold stock to the public. Not only did this strategy provide needed capital, it also created public support for utility growth and consolidation of smaller companies. From these developments grew the utility holding company structure, which was a financial shell encompassing several utilities. These holding companies grew to very large sizes, but were often overvalued relative to the true value of their assets.

Huge losses were incurred in the 1929 stock market crash. This resulted in additional regulatory intervention. Until this time, state and municipal commissions had overseen the industry. The Securities Exchange Commission was then created at the national level to prevent repetition of the financial abuses of the 1920s. In addition, in an attempt to serve the under-served, the government intervened directly in some regions through the formation of electric supply and distribution agencies such as Tennessee Valley Authority (TVA), Bonneville Power Administration (BPA) and Rural Electrification Administration.

The utility industry was considered to be stable as a result of these regulations, which limited competition as well as controlled the worst monopoly abuses. This scenario existed until the 1970s when it was destabilized by effects of the 1973 oil embargo. Utilities' costs for both fuel and new plant construction began to rise quickly; this was compounded by the accompanying rise in the cost to borrow money. Utilities raised rates just to maintain an adequate profit margin to attract investment from potential shareholders. Rates are the ratio between revenue requirements and estimated sales. Thus, rates not only reflect revenue requirements (fixed and variable costs), they also reflect estimated demand. If actual demand falls short of estimates, then the rate will not yield the revenue required to cover all costs. This was the case in the 1970s, when utilities overestimated sales growth. Figure 1 illustrates the shortfall between actual electricity generation and National Electric Reliability Council's (NERC's) 1973 forecast.

Figure 1. Total U.S. Electricity Generation, Actual & Forecasts[2]



This overestimate of demand, along with rising costs resulting from efficiency losses realized by large-scale technologies (e.g., cost overruns on nuclear plants), had serious political ramifications in the form of the appearance of an anti-utility political constituency. Utilities' financial problems were blamed on mismanagement, which led to extensive regulatory proceedings. Public and private agencies fought rate increases, which brought utilities' planning, purchasing and construction decisions under scrutiny. Utility opponents decided that, based on environmental, political and economic grounds, small-scale and independently owned supply alternatives and conservation should replace the industry's traditional economies of scale strategy.

This structural transformation of the electric utility business resulted in the introduction of competition from smaller scale power producers into the arena. The re-emergence of small-scale, independent electricity producers (after 50 years of decline) was furthered by the passage of the Public Utilities Regulatory Policy Act (PURPA) in 1978. PURPA requires utilities to purchase power from Qualifying Facilities (those under the size of 80 MW).[3]

Other legislation passed in the late-1970s also reflected broader acceptance of utilizing energy conservation instead of new energy supplies. The Energy Conservation and Production Act of 1976 required the federal government to establish national energy-conserving building standards. The National Energy Conservation Policy Act of 1978 required large utilities to furnish energy conservation audits for their residential customers. Two years later, Congress passed a federal statute which defined electricity conservation as a "resource" which utilities could buy instead of new electrical generation.[4]

From the 1980s until present, energy conservation/DSM goals have evolved to encompass both economic and environmental issues. Federal and state governmental policies have been the major force promoting conservation through the establishment of financial as well as regulatory inducements for energy efficiency. Initial government programs reacted to rising fuel prices by auditing and weatherizing low-income citizens' homes. Private investment in DSM technologies was encouraged for a limited time period by federal and state tax credits for conservation and renewable resource investments.

Although these programs encouraged considerable activity, federal and state governmental action taken in the area of building codes and appliance efficiency standards has probably been most important.[5] Energy codes, which are usually part of building codes, require many energy-saving measures to be included in new building design. Regulated building components include insulation, windows, and heating, cooling and lighting systems. These codes have been adopted by 36 state governments, as well as many municipalities.[6]

Equipment efficiency standards require that certain equipment (e.g., refrigerators, air conditioners, lamps, and electric motors) exceed a minimum efficiency level in order to be sold. The Federal government, along with states such as California, New York, and Massachusetts, have adopted equipment efficiency standards. Federal standards are covered under two laws: the National Appliance Energy Conservation Act of 1987 (NAECA) and the Energy Policy Act of 1992 (EPAct).[7]

Since the late 1980s, state utility regulatory commissions became increasingly active in promoting conservation through adoption of least-cost Integrated Resource Planning requirements. These requirements strive to create a "level playing field" for DSM as an alternative resource for new energy generation. Such regulations have promoted the evolution of utility energy conservation initiatives over the past twenty years from early programs, which provided consumer education and site-specific design and engineering advice, to current comprehensive programs, designed to facilitate utility purchases of conservation as resources.[8]

The 1990 Clean Air Act Amendments indicate that in the future more environmental costs (externalities) associated with electricity generation will be internalized. Over the next ten years, compliance will cost the industry more than $22 billion, resulting in a 5% price increase (direct compliance cost) in coal burning states.[9]

The most recent relevant legislation is the Energy Policy Act signed into law October 24, 1992. Among its provisions, this law amends PURPA and encourages utilities to implement IRP in order to provide least-cost energy services to its customers. The IRP provisions institute new ratemaking standards which influence states to use ratemaking procedures that encourage utilities to utilize DSM and efficiency measures to fulfill customers' needs.[10] Ratemaking procedures will be discussed in Chapter IV.

All of these regulations have changed the way utilities do business, as reflected in the growth of the adoption of DSM and IRP. IRP has the ability to accommodate new issues, such as: customer service, transmission access, competition (in generation, transmission and customers), and incentive regulation. This attribute has contributed to IRP's rapid evolution into a routinely accepted approach to resource planning in many states.[11] IRP originated as "least cost utility planning" in the 1980s in a few states on the east and west coasts and Wisconsin. By 1989, more than half the states showed at least some progress in implementing IRP.[12] By 1991, 31 states had fully implemented IRP, with an additional 11 states considering it.[13]

IRP has evolved over a short time frame. Beginning as a combination of least cost planning and demand-side management, IRP now addresses more complex issues, including core competitive business activity, risk management and sharing, fuel switching between gas and electric and internalizing environmental externalities.

In addition to growing in breadth and geographic reach, IRP has also spread from investor-owned utilities to non-investor-owned utilities, to regional planning bases and to the natural gas industry. Some believe that this comprehensive approach would be well suited to other industries, such as transportation and health care.[14] IRP can also be adapted to be used in less-developed countries and post-communist countries, most of which suffer from significant environmental damage, capital shortage and energy inefficiency.[15]

DSM/IRP has different advantages for the diverse parties involved. Through DSM, utilities avoid or delay the expense of building new power plants; can utilize smaller-scale, and therefore more flexible, resources; and build more favorable relationships with public regulatory agencies. DSM lessens pollution and environmental degradation and promotes cost-effective energy efficiency. None of this could have been possible without revision of regulatory policies on utilities. Prior to regulatory revision, the "unselling" of electricity (DSM) conflicted with utilities' short-run economic interests. New policy encourages utilities to work towards a least-cost energy strategy, which makes the industry's interests more consistent with those of society.

This change in attitude, synchronizing utility and societal interests, has been reflected in changing terminology: "ratepayers" are now known as "customers" and "intervenors" are now "stakeholders." This new relationship is one of "shared stewardship" rather than "interrupting irritant." Collaboratives of these different interest groups have been organized to design, implement and evaluate DSM programs. The intent of this approach is to make better decisions at less cost than adversarial alternatives, which may involve legal battles with special interest groups.[16]

The electric utility industry has evolved through many stages, experiencing phases of both stability and turmoil. Inexpensive and relatively plentiful fuel sources early on caused the United States to develop in a way that has made us dependent on levels of energy use twice as great as many other industrialized nations.[17] This fact gave utilities power in the past.

In the last 20 years, however, rising and fluctuating fuel prices have effected changes in the structure of utilities. The development of DSM and IRP has added a formerly nonexistent depth and breadth to the utility industry. This trend offers opportunities for both economic and environmental enhancement. DSM and IRP, however, are currently being threatened by retail wheeling.

DSM and the Threat of Retail Wheeling

Most recently, "retail wheeling" or "retail competition" has been the most pressing issue for utilities and DSM advocates alike. "Wheeling" is the transfer of power over transmission facilities owned by a utility that does not produce or sell the transferred power.[18] Retail wheeling would allow retail customers to shop around for the least-cost electricity supply and have it wheeled across existing local electric utility lines. The customer then pays the local utility a retail wheeling rate for transmission and distribution (T&D) services and buys electricity generation service (capacity and energy) from a different supplier. The supplier could be a neighboring electric utility, a non-utility generator (NUG), an electricity broker or a customer's own cogeneration facility located at a different site.[19]

Proponents of retail wheeling -- primarily large industrial customers -- see an opportunity to reduce their costs by taking advantage of lower-priced electricity available from neighboring utilities. In certain areas, this price differential has grown dramatically since 1970. For example, an inter-utility comparison of industrial electricity rates showed that in 1993 low-cost utilities rates were, on average, 34% lower than high-cost neighboring utilities. In 1970 the average rate differential between these same utilities was only 7%. Although DSM and IRP have been blamed for highly varying electricity rates, the largest factor contributing to the dramatic differential seen today is nuclear power -- construction cost overruns and abandoned plants. The high-cost utilities sampled use an average of 28% nuclear power in their generation mix, while the low-cost utilities use an average of only 9% nuclear power.[20] Another factor contributing to rate differentials is excess capacity due to the recession and lower than expected demand for power.[21]

Most of the short-term advantages of retail wheeling would result from shifting existing costs, such as excessive-nuclear plant costs and excess capacity, away from larger industrial customers, leaving the burden of this so-called "stranded investment" on utility shareholders and customers remaining in the system (i.e., residential and small C/I customers). In terms of DSM, retail wheeling would discourage any such spending which could make utilities less competitive by raising electricity rates. Retail wheeling would also discourage integrated resource planning, taking utilities back to the stage when utilities emphasized selling more power, rather than focusing on providing electricity services at least cost.[22]

Retail competition would force utilities to focus on minimizing their rates and on short-term profits rather than on sound long-term planning. Wholesale competition, on the other hand, complements IRP. Wholesale competition was introduced into the electric utility industry around the same time as IRP when it became apparent that economies of scale no longer favored utility construction and environmental impacts of large, centralized plants. PURPA increased competition in the electric utility industry in 1978 by requiring utilities to seek the most competitively-priced energy source from the likes of independent power producers (IPPs). States that have effectively incorporated wholesale competition have reduced utility and consumer costs, diversified resources and lowered consumer risk. In 1992, EPAct expanded on this successful experience by providing wholesale power providers broad access to the transmission grid and appointing the Federal Energy Regulatory Commission (FERC) as the enforcement agency for open transmission.[23]

If wholesale competition is operating well, utilities will already be procuring all cost-effective resources. Although a few customers may find lower rates in the short-term due to the "nuclear versus non-nuclear" phenomenon explained above, it is unlikely that in the long-run retail customers, on the whole, will find less expensive energy supplies through retail wheeling. Thus, the pretext that retail wheeling will have significant long-term economic benefits is unfounded. Retail wheeling would simply shift costs from large industrial customers to residential and commercial customers.[24]

Retail wheeling has been considered in several states and proposed in California and Michigan. If it were decided to experiment with retail wheeling, regulators should strive to implement retail wheeling in ways that advance least-cost energy services and environmental goals, rather than quell energy efficiency efforts. This would involve provisions such as continuation of IRP to determine the optimal mix of resources, funding mechanisms and financial incentives that support utility investment in cost-effective DSM, supply-side cost allocation strategies that are equitable to all customers and promote long-term marginal-cost pricing, and provisions to guarantee attainment of environmental goals.[25]

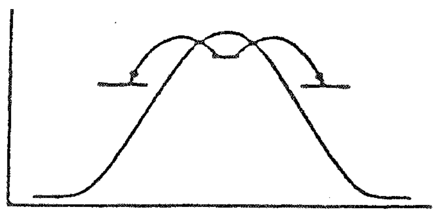
To proceed with retail wheeling without consideration for these issues would be irrational. To quote Cohen and Kihm, "It is indeed ironic that, just at the moment when cost-effective 'pollution prevention' approaches have gained prominence in national, state and corporate policy, we would abandon perhaps the most powerful opportunity available to implement that approach -- in the electric power sector."[26]

In 1994, the threat of retail wheeling appears to be having a chilling effect on utility DSM investments. Fearing a more competitive retail market, some utilities are proposing to cut back their DSM programs and/or minimize rate impacts from these programs. While national spending by utility on DSM doubled between 1990 and 1992,[27] only time will tell if DSM programs will continue to expand or will instead contract.[28]

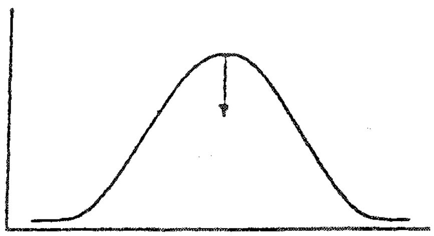
III. DSM PROGRAM CLASSIFICATIONS

Demand-side management includes all activities implemented by utilities to influence customer power consumption. The result of these activities is the alteration of load shape, or time and use of electricity. The common energy conservation load shape changes are pictured and described in Figure 2.

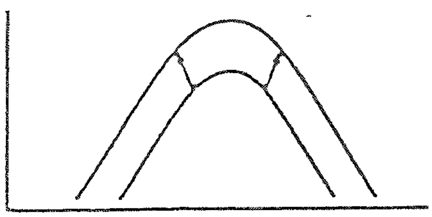
Figure 2. Common Load Shape Changes[29]



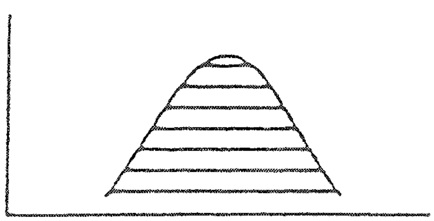
Load Shifting involves shifting certain loads from peak to off-peak periods. Examples: space heating storage, cooling storage, domestic hot water storage.



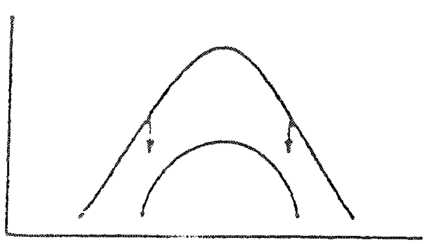
Peak Shaving (Clipping) lowers the peak demand, which accommodates utilities at or near full capacity. Example: direct control of air conditioning units.



Strategic Load Growth increases load through electrification of products or processes served by competing fuels. Examples: heat pumps, electric cars.



Flexible Load Shape increases flexibility of load shape by giving incentives to customers to identify curtailable and interruptible loads. Example: direct control of residential water heaters.



Strategic Conservation utilizes incentives to customers to encourage their lowering overall consumption. Examples: weatherization and efficient appliances.[30]

Most DSM programs are directed at specific subsets of utility customers. Some programs target a certain customer class - a group of customers with similar characteristics, such as level of electricity usage or economic activity. Usual customer classes include residential, commercial, industrial, and other smaller groups, such as agricultural, street and highway lighting, other public authorities, and railroads.[31]

The **residential sector** is often further subdivided by housing type (single-family, multifamily, and mobile home) or by type of electricity use (space heating, water heating). Residential demographics may determine DSM marketing approaches. For example, many utilities have programs that prioritize low-income customers.[32]

The **commercial sector** is broadly defined as businesses which provide services. This sector is subdivided by building type or activity type. The **industrial sector** is defined as businesses which provide products, such as agriculture, manufacturing, construction and mining. This sector is often subdivided by Standard Industrial Classification (SIC) code. Agriculture is sometimes treated as a sector separate from the industrial sector. The **agriculture sector** includes production of crops and livestock, forestry, fishing, hunting and trapping.[33]

DSM programs also vary in the types of services offered to customers:

- **Incentive programs** offer cash or noncash incentives to customers to promote DSM measures. Examples include appliance rebates and zero- or low-interest loans.

- **General information programs** inform customers about DSM options through brochures, bill stuffers, workshops, etc.

- **Site-specific information programs** involve on-site inspection of a customer facility and identification of potential cost-effective DSM actions.

- **Direct-installation programs** involve utility installation of DSM measures, which are often low-cost (e.g., water-heater wraps and compact fluorescent lamps). Often these measures are installed free of charge to participants.

- **Alternative-rate programs** generally attempt to reduce peak demand by offering special rate structures or discounts to customers in return for participation in DSM programs (e.g., residential load control). Large commercial and industrial customers may obtain **interruptible rates**, which offer a discount in return for the customer's agreement to curtail electrical loads during critical peak periods. **Time-of-use rates** may also be used to shift electricity use from on-peak to off-peak times.

- **Fuel-switching programs**, as the name indicates, encourages customers to replace electric appliances with alternatives (e.g., gas).[34]

Many DSM programs combine more than one of these services.

The Association of Demand-Side Management Professionals (ADSMP) defines DSM program types in a different way -- by end-use. For example, program types may include: lighting, space heating, air conditioning, etc.[35]

Table 1 shows the number of electric utilities having different energy end uses and program types by sector in 1992.

Table 1. Number of Electric Utilities Having Different Energy End Uses and Program Types by Sector.[36]

	Residential	Commercial	Industrial
End Uses			
Heating System	359	224	130
Cooling System	360	264	162
Water Heating	412	215	129
Lighting	229	268	190
Building Shell	210	136	97
New Construction	238	148	100
Appliances	168	80	46
Motors	-	150	159
Process Heating	-	47	87
Electrolytics	-	5	26
Other System	44	52	36
Program Types			
Energy Audits	383	298	205
Rebates	347	234	155
Loaning	189	91	58
Other Incentives*	145	102	82
Other	143	102	82

* This category reflects programs that offer cash or noncash awards to electric energy-efficiency deliverers, such as appliance and equipment dealers, building contractors, and architectural and engineering firms, that encourage consumer participation in DSM program and adoption of recommended measures.

IV. INCENTIVES AND DISINCENTIVES OF DSM TO UTILITIES

A range of incentives and disincentives exist for demand-side management programs. Lowering energy demand is usually cost-effective for a utility already at capacity because it can avoid or postpone the need to build expensive new power plants. Until recently, however, this was one of the few business incentives for DSM. Traditional ratemaking formulas link profits to increased sales and prevent utilities from earning a return on their investments in DSM as they do on investments in new power plants.

As regulated monopolies, utilities are allowed to have their prices set at a level which permits recovery of all prudently incurred operating expenses and fixed costs, plus a reasonable rate of return on their rate base. The rate base calculation takes into account their capital investment in power plants, transmission and distribution facilities, meters, trucks, inventory, and working capital, net of depreciation.[37]

Utility profit levels, however, are not fixed, capped, or guaranteed by regulators. State public utility commissions (PUCs) set prices during formal rate cases. The ratesetting process is based on the assumption that the ratio between future costs and sales level will remain constant. The relationship between sales and costs, however, is continually changing. From the time prices are set at a rate case to the time of the next rate case, the utility has an incentive to sell more energy whenever its marginal revenue from the sale of power is greater than its marginal cost to produce and distribute that power.[38]

This simple concept of maximizing sales and profits becomes complex when applied to electric utilities because they provide services in a monopolistic environment in which prices are set by regulators rather than by market forces. Regulators use various approaches to insure that the cost <u>to the utility</u> of producing more power is close to zero. This situation results from the "pass through" of the entire fuel cost and other variable costs directly to the consumer, which, in turn, makes every sale profitable to the utility. Regulators can intervene to lower utility prices if profits rise too much. The utility, however, is not required to refund excessive profits to customers and are therefore motivated to maximize sales between rate cases.[39]

In the past few years many utility commissions have adopted ratemaking reforms to remove these disincentives which penalize utilities when their DSM programs are more successful than projected at the time of the rate case (i.e., sales fall short of projections). Among these ratemaking reforms are:

- decoupling profits from sales,
- lost-revenue adjustments, and
- DSM cost recovery.

"Decoupling," the most important step in removing disincentives, describes a reform plan that breaks the linkage between sales and profits. The most widely known decoupling mechanism is California's 1982 Electric Revenue Adjustment Mechanism (ERAM). ERAM eliminates the conservation disincentive by ensuring that utilities collect their exact authorized base revenue requirement over time, irrespective of fluctuations in sales volume. Over- or under-collections of revenues accrue to a balancing account and are amortized into future rates. As a result, ERAM reduces risk to the utility and stabilizes profits, while promoting productivity and the incentive to cut costs. ERAM does not, however, reward successful conservation programs, it simply tends to make utilities indifferent to conservation.[40] This is not to say that ERAM does not promote conservation, because it does so by creating a more "level playing field" on which conservation can compete on an equal footing with supply-side resources. Once this "level playing field" is established, the inherent economic advantages of conservation have a greater opportunity to be recognized.

ERAM is utilized by most of California's large investor-owned utilities (Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Sierra Pacific Power), and the National Association of Regulatory Utility Commissioners' (NARUC) Energy Conservation Committee has a record of supporting ERAM-type ratemaking reforms.[41]

"Lost revenue adjustments" allow utilities to recover from customers the estimated revenue losses associated with approved DSM measures. The drawback of this approach is that it does not remove the incentive to sell power and therefore does not break the link between sales and profits. Lost revenue adjustments remove disincentives only for readily tracked DSM programs. Without decoupling, improvements in energy efficiency resulting from educational programs, improved prices which induce customers to invest in energy efficiency, or legislation of energy-efficiency standards will continue to reduce utility profits.[42]

"DSM cost recovery," as its name implies, allows for the recovery of the costs of DSM programs. Traditional regulatory practices allow utilities complete recovery of costs incurred in meeting customer energy service demands with <u>supply-side</u> resources, including fuel, purchased power, and new power plant construction. "DSM cost recovery," on terms as favorable as those for supply-side cost recovery, creates a more even "playing field" for investment in conservation.[43]

Removal of disincentives to DSM is only the first step in creating an environment that will foster utility commitment to energy conservation and efficiency. Positive incentives -- monetary rewards or bonuses that utility shareholders may earn based on utility performance in DSM activities -- may be necessary to overcome perceived risk of implementing DSM programs.

Several factors affect the structure of positive incentives. Regulators generally decide first the appropriate amount of incentive and then determine the best mechanism by which to deliver that incentive. Secondly, it is decided whether thresholds must be exceeded before incentives are earned. Some states allow incentives to be earned on the first kWh saved, others require attainment of a threshold level of power savings prior to earning an incentive. A third factor is whether to impose caps that prevent incentives from becoming excessive.

In addition, it must be decided whether incentives are paid on savings projections or on impact evaluation results. Finally, the amount of time over which a bonus is earned is determined.[44]

Incentive mechanisms can reward and/or penalize utility performance in achieving IRP and DSM goals. The structure of incentive programs varies greatly among states, but thus far can be grouped into five categories:

1. shared savings (shared benefits),
2. ROE adjustment - bonus return on equity in rate base,
3. ratebasing - bonus return on ratebased DSM expenditures,
4. mark-up on program expenditures, and
5. bounty - bonus per unit of savings.[45]

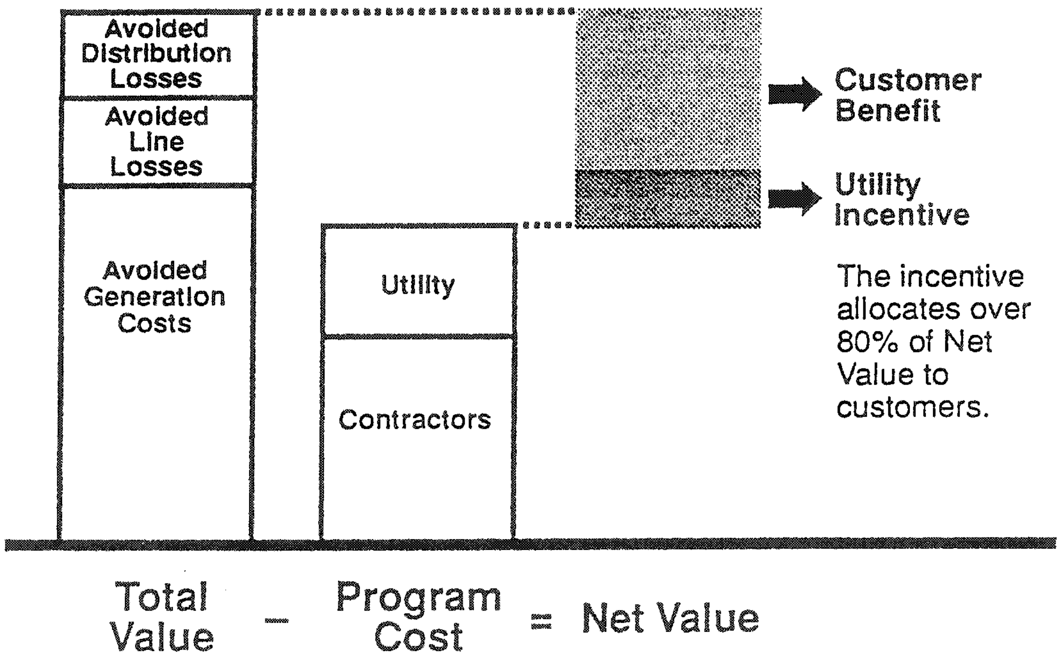
Shared savings incentives allow the benefits of cost effective DSM measures to be shared among customers participating in the DSM program, non-participating customers, and the utility. The participating customers benefit from lowered electricity bills. Utility ratepayers benefit from the utility's reduced cost of providing electric service. The utility retains a portion of the net savings.[46] Utilities with shared savings mechanisms have been allowed to earn from 5% to 20% of net benefits (benefits net of program costs).[47] The method by which net benefits are calculated will affect the dollar amount of the incentive.

To date, the shared savings approach has been the most popular incentive. Shared savings are unique from other incentives because they reward the utility for investing in <u>cost-effective</u> DSM resources, rather than spending revenues collected from customers. A disadvantage of this type of incentive is that it may be difficult to administer because it requires complex measurements and calculations in the evaluation process.

Figure 3 depicts a shared savings mechanism developed through a collaborative process at New England Electric. The incentive structure is based on the difference between the value of conservation and the cost of the conservation. The program allowed the utility's profits to rise by seven percent or more if its 1990 efficiency programs reach targeted levels.

The **ROE (return on equity) adjustment** provides a positive incentive by allowing the utility to increase rates in order to earn a higher return on the equity in their rate base. The amount of bonus return on equity can be calculated by taking into account the utility's level of achievement of conservation goals as well as its ability to accomplish goals cost effectively. Using performance parameters to calculate a bonus promotes maximizing program efficiency goals and tends to minimize program costs.[48]

Figure 3. A Shared Savings Mechanism[49]



Ratebasing in and of itself is not a positive incentive, it is an accounting and cost recovery method which capitalizes utility expenditures rather than expensing them. Capitalizing an expenditure involves adding its value to the asset base and amortizing its cost over the period of its useful life. An expenditure which is expensed is treated as an operating cost in the year incurred, and is recovered concurrently through customer rates, given regulatory commission approval.[50]

When a utility expenditure is ratebased, it is included in the utility's net investment (ratebase), which is used in the ratemaking process. Ratebasing allows a utility to recover the expenditure over the amortized period. Pursuant to regulatory policy, the utility earns a return on the unamortized balance through rates to customers. Thus, the playing field is leveled for supply- and demand-side resources, making utilities indifferent in the choice between the two resource options.[51]

The positive mechanism in regard to ratebasing comes into play when regulators allow utilities to collect a bonus return as a percent of ratebased DSM expenditures. This approach to incentives was one of the first, dating back to a 1980 law passed by Washington state. Bonus return on ratebased DSM expenditures is a weak incentive because it does not consider the utility's DSM performance in determining financial reward. Instead, ratebasing rewards DSM investment, encouraging potential over-investment in ratebase-eligible items, without regard for their conservation efficiency.[52]

"Markup" on DSM program expenditures provides a fixed incentive based on a percentage of program costs. This type of incentive also encourages over-spending on DSM program costs ("goldplating"). Another similarity to ratebasing is that "markup" does not take program performance into consideration when determining financial rewards.[53]

The **"bounty"** incentive mechanism, on the other hand, is a positive incentive which is performance-based as a function of the amount of DSM savings. This mechanism, however, does not take into account the program cost, which could result in compromising cost-effectiveness. As with the shared savings approach, the bounty mechanism may promote "cream skimming," which refers to maximizing incentives and benefits by implementing the least expensive, most effective conservation measures first.[54]

Regulators have experimented with several ways to implement incentives in each category; thus incentives vary widely in the extent to which they encourage DSM. Table 2[55] provides a snapshot summary of 1992 DSM incentive status on a state-by-state basis.

These incentives are intended to make DSM a major profitable activity instead of a public relations ploy or an option attractive only to utilities faced with capacity constraints or high fuel costs. The incentive process is too new to have conclusive evidence of its effectiveness. Although studies show an increase in DSM activity when accompanied by incentives, these studies do not account for confounding variables, such as a utility's need for additional capacity.

The review of incentives so far has identified an important trend in incentive modification. Many commissions deliberately started with generous incentives, expecting to reduce incentives in the future. Commissions have been trying to figure out, through trial and error, how much incentive is just enough to motivate utilities. As commissions revise incentive programs, they are shifting more of the risk toward the utilities without increasing their rewards for success. For example, many recent programs include penalties for below-target performance. Others increase a utility's risk through stricter savings estimation, while reducing rewards at the same time.

To date, the shared savings approach has been the most popular. It is clear, however, that shareholders' incentives across the country are not apt to evolve into one generic mechanism. Wisconsin Public Service Commission (WPSC), for example, has instituted a very different approach to incentives. After experimenting with four types of shareholder incentive mechanisms, WPSC has deemed shareholder incentives to be unnecessary in encouraging utilities to increase DSM activity. Instead, in 1991 WPSC decided to test incentives for non-management utility employees who are in positions to affect realization of DSM benefits. The effect of these employee incentives has not yet been evaluated.

Table 2. US DSM Shareholder Incentives.

State	Shared Savings	ROE Bonus for DSM	Adjustment to Overall Return	Bounty per Unit	Mark up on Expenditures
Arizona	+	-	-	-	-
California	+	-	-	-	+
Colorado	+	-	-	-	-
Connecticut	-	+	-	-	+
DC	+	-	-	-	-
Hawaii	+	+	+	-	+
Idaho	-	-	+	-	-
Indiana	+	-	-	-	-
Iowa	+	-	-	-	-
Kansas	-	+	-	-	-
Maine	+	-	-	-	-
Maryland	+	-	-	-	-
Massachusetts	-	-	-	+	-
Michigan	-	-	+	+	-
Minnesota	+	-	-	+	-
Montana	+	-	-	-	-
New Hampshire	+	-	-	-	-
New Jersey	+	-	-	+	-
New York	+	-	+	-	-
Ohio	+	-	-	-	-
Oregon	+	-	-	-	-
Rhode Island	+	-	-	-	-
Texas	-	-	+	-	-
Vermont	+	-	-	-	-
Washington	-	-	+	+	-

\+ = measure applies
\- = measure does not apply

In contrast to Wisconsin's experience with incentives, California and other states continue to pursue an effective and equitable shareholder incentive mechanism for its utilities. Experience to date indicates that many types of incentive mechanisms can be effective in promoting cost effective DSM programs. The evolution of DSM incentives will differ according to the states' regulatory climate and individual planning needs of each utility.[56]

Critics of DSM believe that the efficient use of energy does not require incentives or subsidies except, perhaps, in some instances in which "barriers to entry" exist, such as with new, unproven technologies. Critics believe that energy efficiency and environmental improvements could be achieved more directly through mechanisms such as energy and pollution taxes, and the commercialization of energy-efficiency services.[57] Theoretically, this may be true, however, difficulties exist with this approach. For example, how does one define the societal cost of pollution and the "acceptable" level of pollution? How would one construct a "fair" energy tax?[58] Perhaps in the future such market mechanisms will be appropriate and sufficient stimuli to maximize energy-efficiency potential; currently, however, significant barriers to entry still exist, thus meriting the consideration of the use of incentives.

V. DEMAND-SIDE BIDDING

One of the more recently developed DSM approaches is demand-side bidding. Bidding involves the use of outside contractors to provide turnkey (readily usable) energy-efficiency services to utilities. These energy service companies (ESCOs) develop a technical approach and marketing program, identify prospective participants, sell the program and perform all engineering, construction and project financing needed to implement efficiency measures.[59] [60]

Payment for these services is usually performance-based -- the ESCO's compensation is typically based on measured reductions in kWh consumption over time, although some are paid a lump sum based on calculated kW reductions. The bidding approach is so named because an auction or "competitive resource procurement" is used to set these payments.[61]

This approach to DSM is attractive to some utilities because it provides convenient access to a range of capabilities that utility customers may not have. It may also enhance the integrity of the program because of the ESCO's long-term contractual relationship and provision of financing, which give the ESCO a vested interest in making the program as successful as possible. One of the major arguments used to justify bidding is that it transfers the risks of DSM to the ESCOs from the ratepayers.

Others have challenged the merits of bidding. A study by McRae et al.[62] shows that DSM bidding programs have some hidden risks. Based on experience with programs at Bonneville Power Authority (BPA), Central Maine Power (CMP), Orange and Rockland (O&R), and Public Service of Colorado (PSCO), the study found that instead of reducing risk, bidding only changes and protracts the type of risk the utility faces. In order for a DSM bidding program to be successful, it must be well designed from the beginning. This requires the utility to be very clear and specific about the type of DSM program it wants. The utility also must decide how to evaluate the caliber of proposals, how it will verify savings for the purpose of compensating the ESCo, and how to safeguard its investment in contract language. In addition, once a contract is signed, the utility's involvement continues in the form of overseeing contracts, evaluating payment requests, confirming installations and measure persistence, and verifying savings performance over a 5-to 15-year period. All of these responsibilities are very time consuming and therefore costly to the utility. This time and cost must be included when calculating the cost/benefit of the program to the utility. Bidding programs are often more expensive than utility-operated DSM programs.

Failure to be less than meticulous in designing and overseeing a bidding program can result in many problems. The McRae et al. study[63] identified hidden risks in the bidding process. The utility is exposed to the risk that "actual" savings are less than the estimated savings for which they are paying. This risk is greater if the bidding contract requires an up-front payment. The utility will always pay for risk, either directly or through a risk premium embedded in a bidder's profit margin. Another hidden risk exists in potential litigation. Bidders have brought legal action against utilities who have disqualified them because the bidder did not meet specifications which the utility neglected to include in the solicitation to bidders. Thus, it is just an illusion that bidding programs transfer risk away from the utility.

Another controversy over bidding is the accusation of ESCO tendencies toward "cream-skimming" (designing and implementing only the lowest cost conservation and load management measures while ignoring other cost-effective opportunities), although some believe that acquiring the lowest cost resources first is not inappropriate.[64]

Bidding may offer an opportunity to, for example, utilities without DSM expertise, who can take advantage of the expertise of others. Now that bidding experience has been documented, utilities considering such programs can learn from this experience and take steps necessary to mitigate the risks involved with bidding programs.[65]

VI. DSM COLLABORATIVES

Historically, the relationship between utilities and regulators has been a rigid one, in the format of a courtroom. This approach precludes real dialogue between regulators, utilities and other interested parties. In the late 1980s, however, the collaborative approach emerged as a constructive alternative. This dialogue-oriented, consensus-building process includes the free flow of ideas and learning how to negotiate effectively with former adversaries, to reorient the corporate culture toward customers and toward market conservation.[66]

A study by Schweitzer and Raab[67] examined nine cases of DSM collaboration involving 24 utilities and approximately 50 nonutility parties (NUPs) in ten states. NUPs were found to include consumer/public advocates, environmental/conservation advocates, large industrial electricity users, state regulatory advocacy staff and state energy officers. In addition, state regulatory advisory staff often acted as observers or facilitators. For perspective, Table 3 indicates the number of collaboratives (out of nine total) in which each party participated:

Table 3. Collaborative Participant Composition

Party	# Collaboratives
Utilities	9
Environmental Advocates	8
Consumer Advocates	7
State Energy Offices	5
State Regulatory Staff	5
Large Electricity Users	4

Often, many groups represented the same general interest, and formed coalitions to strengthen their position. Because NUPs often lacked the resources and expertise necessary to engage in meaningful discussion, the utilities usually paid for the NUPs to hire consultants.

Certain trends in initiation of the collaboratives were observed in this study. In most cases, the collaborative was created, at least in part, as a response to extensive intervention by NUPs on the topic of DSM or as part of a settlement agreement between the utility and NUPs on an issue of contention. In certain instances, the Public Utility Commission (PUC) strongly encouraged or ordered formation of a collaborative. Utility agreement to collaborate on DSM programs may also reflect the utility's own recognition of the benefit of increased DSM investment.

Goals varied among collaboratives in the study. Most often, the joint goal was to design and implement a comprehensive package of cost-effective DSM programs and resolve relevant policy issues. These goals were usually developed at the time of inception of the collaborative and formalized in a Memorandum of Understanding (MOU). Table 4 shows the range of issues addressed, from the least difficult to the most difficult.

Table 4. Spectrum of Issues Addressed by DSM Collaboratives[68]

Least Difficult

1. Identifying potential DSM technologies and inefficient end uses
2. Designing research and development efforts
3. Packaging measures into programs and designing marketing and delivery strategies
4. Screening measures and programs for cost-effective (using previously adopted cost-effectiveness tests)
5. Designing evaluation and monitoring plans
6. Choosing customer incentives for programs
7. Detailing cost-effectiveness tests for measure and program screening (including method for determining long-run avoided cost)
8. Selecting annual budgets for individual DSM programs and overall DSM effort
9. Ratemaking and cost-recovery issues (also in ascending order):
   - A. Allocating DSM expenditures to rate classes
   - B. Expensing vs. amortizing DSM expenditures
   - C. Recouping lost revenues caused by DSM savings
   - D. Other utility incentives (i.e., shared-savings, bounty)
10. Environmental externalities
11. Fuel switching

Most difficult[a]

(a) Other issues that were fairly controversial but not widely discussed among the collaboratives included the role of DSM bidding/performance contracting and the role of load-building programs.

The earliest example of collaboration was in 1988, when the Conservation Law Foundation of New England (CLF), a non-profit environmental law organization, intervened in utility proceedings in Connecticut. After almost two months of collaborative effort, both parties agreed on an unconventional solution to long standing differences regarding efficiency in utility planning. As an alternative to continued litigation, the utility offered to fund CLF and the other intervenors to employ experts in energy efficiency program design to work with company staff to design and monitor such programs.[69]

Subsequently, CLF collaborated with New England Electric and eleven other New England electric and gas utilities to develop innovative efficiency investment strategies. This prompted New England utilities to spend an estimated $200 million in efficiency investments in 1990. The concept has proven popular in California as well. Collaborative efforts among electric utilities, consumers and environmental advocates resulted in a proposal to double 1988 efficiency spending levels, in addition to favorable rate treatment of those efficiency investments.[70]

Two 1994 studies by Oak Ridge National Laboratory (English et al.[71] and Schweitzer et al.[72]) discuss the activities of energy-efficiency advocacy groups (EEAGs) in ten detailed case studies. Many but not all of the case studies involve formal collaboratives. The Schweitzer study makes the following suggestions for EEAGs to maximize results from limited resources:

- follow a multi-year strategic plan that allows time for activities to pay off but is flexible enough to allow change when necessary,

- have a range of expertise on staff (e.g., economists, engineers, lawyers),

- network with other EEAGs, but tailor any ideas to the specific region,

- build coalitions with like-minded groups and ad hoc alliances with organizations with differing opinions (e.g., industry), and

- consider the selective use of litigation.

Based on case study review, research and experience, Raab[73] derived eight principles for designing consensus-building processes to enhance electric utility regulation. He points out that these principles (Table 5) are issues meriting consideration, not formal rules for negotiation settlements.

<u>Table 5. Eight Principles for Consensus Building in Electric Utility Regulation.</u>

1. Initiate consensus building as early as feasible.
2. Include all stakeholders.
3. Secure the PUC's direct involvement whenever possible.
4. Provide adequate resources (e.g., financial assistance for NUPs).
5. Do not exclude contentious or sensitive issues from consensus-building endeavors.
6. Consider assisted negotiation (e.g., facilitation or mediation).
7. Structure consensus-building processes to supplement, not replace, traditional adjudicatory and rulemaking procedures (e.g., technical sessions, advisory committees).
8. Modify traditional procedures to better accommodate consensus-building opportunities (e.g., allowing for adequate time and renegotiation).

Although not all encompassing, these principles are the primary elements needed to improve conventional adjudicatory and rulemaking proceedings. Although improving regulatory procedures does not in and of itself insure better regulation, it does signify an important step in that direction.[74]

VII. MARKETING DSM PROGRAMS

The success of DSM programs is dependent upon the extent to which the market accepts them. Thus, marketing is a critical component in DSM program design. The purpose of marketing a DSM program is to maximize market penetration, which, in turn, will maximize savings.[75]

The **total market** for a particular program is often defined as one of the DSM program sectors discussed earlier (residential, commercial, industrial, agricultural). Utilities commonly classify markets into three types: **new construction, replacement and retrofit.** For a particular program an **eligible market** is established by defining eligibility criteria (e.g., new residential customers with electric space heat). Utility marketing efforts are then focused on a subset of the eligible market, called the **target market.**[76] For example, a utility may elect to concentrate on builders of large subdivisions.

Participation rates reflect the number of program participants as a percentage of the **eligible market.** Participation and eligible markets can be defined in terms of customers, account numbers, meters, or buildings.[77] Participation rate is one of the most critical factors affecting the success of DSM programs. High participation rates are needed to achieve significant savings, and thereby have an impact on a utility's need for new power plants and other resources.[78]

Once a target market has been established, **market potential** can be identified in several ways. **Technical potential** represents the amount of potential savings assuming all electricity-using equipment, buildings, and industrial processes are replaced with the most efficient technology available on the market, regardless of cost. **Economic potential** is the portion of technical potential which is considered cost-effective on the part of specific participant groups. **Market potential** is the part of economic potential which a particular program is expected to attain, taking into account the fact that customers do not always base decisions solely on economic considerations.[79] These marketing definitions are somewhat generic.

Utilities have traditionally had a marketing function; however, marketing DSM exhibits some different characteristics. Utilities are used to selling power and related services to customers. "Unselling" power has been shown to require a different approach.

Some common themes have emerged in reviewing general marketing approaches to making DSM programs successful:

- Market research performed <u>prior</u> to program design allows utilities to understand why and how customers use energy, what motivates customers, and how DSM can be included in a win-win situation for both the utility and customer.

- Financial incentives are most effective if they are high enough to motivate the market, but not so high as to waste funds.

- Customer acceptance of DSM can be enhanced if utilities make customers understand why they are promoting DSM. The absence of this understanding can create reticence and suspicion among customers. Experience has shown that customer acceptance levels rose when they were made aware that DSM participation would delay new power plant construction. In fact, acceptance rose to the point of diminishing the customers' need for financial incentives.

- The importance of DSM in terms of environmental issues is a powerful marketing tool. Environmental responsibility has proven to be a motivating factor not only for residential customers, but also for commercial and industrial customers.

- In terms of promoting energy efficient technologies and products, the development of responsible strategic alliances with trade allies (businesses which sell or influence choices of energy-using equipment, including appliance dealers, architects, and builders) can also be a powerful tool in marketing DSM programs.[80]

- High participation rates can be promoted by approaches including: community-based marketing, personal contact between utility staff/consultants and customers, availability of technical assistance to customers and trade allies, and provision of high-quality services.[81]

More specific marketing observations can be associated with particular customer segments:

- Among **residential customers**, DSM program acceptance has a positive correlation with education and income level. This observation is contraintuitive from an economic standpoint because lower income households can benefit proportionately more from DSM since a greater percentage of their disposable income goes towards utility bills.

- **Small commercial/industrial (C/I) customers** tend to lack expertise in evaluating technical and financial aspects of DSM options, thus requiring special assistance from the utility.

- Utilities can optimize DSM with **large C/I customers** by coinciding DSM offerings with regular maintenance and replacement schedules.

- **Institutional customers** are usually severely constrained financially and are thus very receptive to DSM programs that not only offer incentives but also reduce utility bills.

Table 6 summarizes lessons learned in marketing DSM programs to various customer segments.

Table 6. Summary of Lessons Learned in Marketing DSM Programs[82]

General	Residential	Large Commercial/Industrial
- Perform advance market research	- Recognize importance of life style and convenience factors	- Recognize more formal decision-making process of larger customers
- Develop "pricing strategies for DSM	- Identify correlation between income and education levels and DSM acceptance	- Address "normal" vs. "early" equipment replacement tendencies
- Inform customers _why_ DSM is being promoted	- Segment the market and target DSM program offerings and messages	- Be sensitive to intangible and opportunity costs when promoting DSM to this sector
- Embrace customers' identification with environmental issues		
- Develop strategic alliances with trade allies		- Provide larger C/I customers with information they can use to better manage energy consumption

Institutional	Small Commercial/Industrial
- Recognize hybrid nature of this sector (often they are technically capable, but budget constrained)	- Recognize key differences between "small" and "large" C/I customers when marketing DSM
- Take advantage of multiple facility characteristics of this sector	- Recognize time and expertise limitations of small C/I sector
- Address complex decision processes and approval chains when promoting DSM to this sector	- Consider providing technical and financial assistance to this sector to better promote DSM

Market Transformation

The marketing of energy-efficiency has recently been trending toward market transformation -- the process whereby energy-efficiency innovations are introduced into the marketplace and penetrate a large segment of the eligible market over time. Rather than saving energy on an individual building or customer basis, market transformation attempts to change the whole market for specific products or services so that efficient products or services are the norm and do not need to be promoted with incentives. As compared to conventional programs, this approach has the potential to save more energy at a lower cost because participation rates approach 100% and transformed markets do not require incentives.[83] Market transformation capitalizes on the concept that cost-effective energy-efficiency innovations are feasible in all end-uses given technological progress and rising energy prices in the past two decades. Since it often costs less to save energy than to supply energy, economic productivity and economic efficiency are enhanced as energy efficiency increases. Another advantage of market transformation is that the market does not regress to lower levels of efficiency over time.[84]

The market transformation process, however, is a complex one, involving manufacturers, vendors, architects, builders, contractors, policy-makers, and consumers. Pertinent issues include energy price fluctuations; environmental concerns; market prices, growth rates and competition; technology; and public policy.[85] Because of the nature of market transformation, many policy and program approaches can contribute to a successful strategy:

- research and development (R&D),
- demonstrations and field tests,
- commercialization incentives (e.g., the Super-Efficient Refrigerator Program),
- marketing and consumer education,
- financial incentives,
- voluntary commitments,
- bulk purchases,
- building codes, and
- equipment efficiency standards.[86]

The success of market transformation can be seen in several market segments over the past few decades. For example, the average efficiency of new refrigerators increased by 175% during 1972-1993, the average rated fuel economy of new cars doubled during 1973-1988, and the percent of windows sold with two or more glazings increased from 37% of the market in 1974 to 87% in 1991.[87]

One of the more notable market transformation programs is the Super-Efficient Refrigerator Program (SERP), which was the first program to utilize the "golden carrot" strategy. This strategy uses coordinated utility incentives to overcome market barriers and stimulate development and commercialization of advanced technologies and superior efficiency levels.[88] Through SERP, 25 U.S. utilities offered a $30 million award to the manufacturer that could design the most energy-saving refrigerator that is free of chlorofluorocarbons (CFCs). The award provides the winning manufacturer, Whirlpool Corp., with a subsidy of more than $100 per refrigerator. In return, the refrigerators are delivered to the participating utilities' service territories before it is available to other distributors.[89]

An analysis of eight market transformation case studies by Nadel and Geller[90] made the following conclusions:

- market transformation is viable;
- the best market transformation approach differs on a case-by case basis, depending on technology and market characteristics, including market barriers;
- quality assurance is critical to the market transformation process;
- minimum efficiency standards and building codes often play a critical part in market transformation; and
- due to potential changes in the utility industry, utility commissions and other government agencies need to support and reward utilities (e.g., with recognition or financial incentives) for participating in successful market transformation efforts.

Evaluation approaches need to be developed to assess the success of market transformation initiatives. This is especially important to utilities and government agencies who invest significant resources in market transformation and need to determine the return on their investment. Methods need to be developed and tested to estimate what would have happened to markets in the absence of market transformation. In 1993, evaluation professionals began addressing these issues.[91] [92] Additional work is needed in order for policy-makers to determine how market transformation strategies are performing and how they can perform better.[93]

Developing and implementing market transformation efforts will require extensive coordination and commitment on the part of many organizations. Given the progress to date, however, continued market transformation endeavors can look forward to significant energy savings, economic gains, and environmental benefits resulting from greater energy efficiency.[94]

VIII. FINANCIAL IMPLICATIONS OF DSM

Because energy is such an integral part of our economy, the conservation of energy has myriad financial effects. This chapter examines the effects of DSM on electricity costs and rates (prices), internalizing environmental externalities, and the multiplier effect resulting from DSM.

The cost of a DSM program to a utility typically has three components:

1. a fixed cost ($/year), which includes the program's overall planning, design, and administration;

2. a marketing expense ($/participant), which represents the cost to promote customer participation in the program; and

3. an acquisition charge (cents/kWh), which is the financial incentive paid by the utility for materials and installation required to procure the conservation resource.[95]

All of these cost components are factored into calculating the effect of DSM on electricity costs and prices, which is a significant and controversial issue with utilities and their customers.

The debate centers on whether DSM's primary financial goal should be to reduce the cost to provide electric energy services or to minimize electricity price per kWh. Utilities use various economic tests, which utilize computer modelling techniques, to assess financial viability of DSM programs:

- The **total-resource-cost (TRC) test** evaluates <u>total program costs and savings</u> to the utility and participants, including avoided supply costs based on energy and load reductions.

- The **rate-impact measure (RIM)** calculates the effect of program costs and avoided supply costs on the <u>price of electricity (rate) per kWh</u>.[96]

- The **utility cost test** evaluates <u>the utility's program costs and savings</u> (net benefits and costs of programs based on costs incurred by and revenue requirements of the utility). This test determines if the utility's cost for DSM is less than avoided supply cost.

- The **participant test** measures participants' quantifiable benefits and costs, identifying whether or not the participant is better off with DSM.

- The **societal test** takes the broadest perspective, taking into account the total resource cost as well as external costs and benefits (e.g., environmental impacts).[97]

Using the TRC test to evaluate a DSM program favors minimizing the total cost of electric energy services, whereas using RIM favors minimizing electricity rates. In general, DSM reduces energy service costs but raises electricity rates per kWh. As long as the former is greater than latter, DSM is advantageous for participants. Nonparticipants, however, would suffer from higher rates without benefitting from DSM program savings. On the other side of the argument, favoring the RIM test in evaluating DSM programs may eliminate those programs which can most reduce overall energy service costs.

Regardless of the type of cost test used, debate continues regarding the validity of DSM costs determined by utilities. One of the most notable debates is between Lovins and Joskow.[98] [99] Joskow argues that Lovins' projections of potential savings and their costs are too aggressive because certain administrative costs are ignored, measured savings fall short of "actual" savings, and cost and performance estimates are overly optimistic because they depend on untried technologies with uncertain costs and limited market experience. Lovins explains that the disparity between his cost estimates and Joskow's is due to several factors, including: comparing things that are so different that they cannot be compared at all, differences in accounting conventions, technical inferiority of programs reviewed by Jaskow (resulting in higher costs), and the use of average and high costs in a range of costs so wide as to be practically meaningless. This debate is not surprising given the complexity of the issue, and will surely continue as DSM evolves.

Rate Impact

In many states large industrial customers have complained that Demand-side Management (DSM) programs result in substantial rate increases that put industrial firms at a competitive disadvantage.[100] In a few instances, it has been suggested that DSM programs raise rates for residential customers while primarily benefitting commercial and industrial (C/I) customers. Utilities are also concerned with DSM rate impact in terms of competition for their wholesale and large industrial loads; reducing rates could improve utilities' competitiveness.[101]

These concerns stem primarily from the impact that energy efficiency programs can have on the bills of program nonparticipants. As energy efficiency programs reduce energy use, revenues from energy sales decline. A portion of these revenues are needed to cover utility fixed costs; in order to make up for these lost revenues, rates often must be increased. For energy efficiency program participants, bill reductions resulting from the efficiency improvements generally more than compensate for the rate increase. For nonparticipants, however, rates increase with no offsetting reductions in consumption.

The rate impact of DSM programs is affected not only by the need to recover lost revenues, but also to recover the costs of DSM programs themselves. Impacts on nonparticipants can be exacerbated by program offerings which favor some customer classes over others: the less favored customer classes are likely to be dominated by nonparticipants.

DSM rate impacts, however, are only part of the picture. As mentioned earlier, DSM participant bill reductions usually more than offset increased rates. In order to pass the utility test -- one of the most commonly used cost-effectiveness screening test for DSM programs -- bills must decline for ratepayers as a group, which means bill reductions for program participants are greater than bill increases for nonparticipants. Increasing DSM participation would avail more customers of the benefit of lower bills.

Another part of the picture is environmental issues. DSM programs reduce the amount of electricity generated, thereby reducing power plant emissions. These emissions reductions benefit both participants and nonparticipants. The quantification of these benefits is difficult; however, with increasing clean air requirements, the value of conserving energy will rise. At present, quantification of DSM benefits is understated because environmental externalities are excluded from the picture. Participants and nonparticipants alike benefit from reduced pollution and avoided costs of complying with environmental regulations.

From a study by Pye and Nadel[102] examining rate impact claims, it appears that most claims regarding rate impacts are based on ideology or theory rather than on hard empirical evidence. The study found data from ten existing published and unpublished studies on the rate impacts of DSM programs. "Rate impact" is defined in this study as the percent difference between electricity rates which include DSM in their resource plan as compared to either existing rates or rates which reflect supply-only resource plans (two different approaches are used because use of a single approach would significantly restrict the number of studies available for analysis). Data were collected not only on rate impacts, but also on the level of DSM expenditures by each utility and how utilities recovered DSM expenditures. Nine of the studies reflect actual utility data or forecasts made by or about actual utilities. The remaining study utilizes hypothetical utility data.

The ten studies for which data were found took different approaches in calculating rate impact. To get a true understanding of how DSM affects rates, one should look at rate impacts which fully reflect the costs (including lost revenues) and benefits of ongoing DSM programs as compared to rates which reflect a supply-only resource plan. In this context, certain key variables should be kept in mind when comparing rate impact calculations in the ten studies reviewed:

- Whether DSM costs are expensed or amortized (capitalized, levelized[a], or recovered

[a] The levelized lifetime approach calculates how much rates would change (in real, inflation-adjusted terms) if program costs were amortized over the measure life. It is calculated by dividing the present value of program costs (net of avoided costs), net lost revenues, and DSM incentives by the present value of total sales revenues over the lifetime of DSM measures.

as a deferred expense) affects how quickly these costs appear in electricity rates. Expensed costs are reflected in rates in the year they occur, while amortized costs are spread over several years with the intent of matching the timing of costs with benefits. As a result, the rate impact from amortized DSM costs is more gradual, building as a utility accumulates more years of DSM programs.

- The number of years of DSM expenditures reflected in rates relative to the number of years over which DSM expenditures are recovered is a second consideration. If the number of years of DSM expenditures is less than the period over which they are recovered, only a portion of the long-term rate impacts will be reflected in rates. Also, as DSM continues for many years, lost revenue impacts will continue to increase until the time DSM measures installed in initial years are retired.

- The basis for comparison -- existing rates or supply-only rates -- affects the definition of 'rate impact'. Comparing DSM rates to existing rates indicates rate impact at one point in time but may not reflect fully the avoided supply costs, as would a supply-only rate used as a basis for comparison.

Table 7 presents a summary of these key variables along with the range in rate impact resulting from each study and DSM as a percent of gross revenues.

The disparity in approaches to analyzing rate impact means that comparisons can only be made with great caution and that any conclusions must be considered preliminary. Available data do not allow for the translation of these different approaches into "apples-to-apples" comparable data.

The average ratio of DSM expenditures to gross revenues for this study is approximately 2.5% (for those utilities for which these data were available). For perspective, in a study done by Hirst in 1993[103], only 12% of reporting utilities spent more than 2% of total revenues on DSM programs in 1991. Thus, the utilities in this study are among the more active DSM players; eight fall into the group of 25 utilities with the highest DSM expenditures.[104]

Certain trends can be observed in the body of existing data. Rate impacts for the studies in this sample range from -2.8% to 9.4%, with a median impact of 1.7% and a 90th percentile impact of 5.1% in real terms (net of inflation). Median rate increases were 1.4% for amortized cases and 3.1% for expensed cases. Expensed values are more likely reflective of long-term rate impacts for several reasons. For some amortized values, the number of years of DSM expenditures is less than the amortization period and thus, not all DSM expenses are included in rates. Also, many of the amortized values are levelized, which discounts DSM's costs and benefits over time. As a result, the lower rate impacts in early years are counted more heavily (because they are discounted over fewer years) than rate impacts in later years, which may be higher because the number of years of DSM expenditures approaches and surpasses the amortization period.

Table 7. Rate Impact: Summary of Key Variables and Data for Ten Studies Reviewed.

Study	Yrs. of DSM	Financial Treatment	Range of Rate Impact	DSM Exp. as % Gross Revs.	Base for Comparison
Faruqui & Chamberlin	10-15	levelized/LOM[1]	0.2% - 4.3%	N/A	'92 nat'l avg rate
New York State Dept. of Public Service	2	levelized/LOM[1]	0.2% - 3.7%	.5% - 4.7%	existing rate
	1	expensed[2]	0.7% - 6.2%	.5% - 4.7%	existing rate
New York State Energy Office	18	levelized/LOM[1]	3.2% - 8.0%	1.2% - 3.2%[3]	supply-only rates
	9	expensed	2.6% - 10.2%	1.2% - 3.2%[3]	supply-only rates
Florida Power & Light	28	levelized/LOM[1]	-0.3%	3% - 5%	supply-only rates
	28	expensed	-3.3% - 2.4%	3% - 5%	supply-only rates
Massachusetts	1	95% expensed	0.7% - 9.4%	1.3% - 6.1%	existing rate
Rhode Island	1	expensed	1.5% - 2.6%	2.5% - 3.2%	existing rate
Public Svc. of Indiana	20	amortized / 4 yrs[4]	0.2% - 4.7%	2.8%	existing rate
Detroit Edison	4 - 5	part capitalized (5yrs)/ part expensed	-2.4% - 13%	0.4% - 2.5%	existing rate
Chamberlin, Herman & Wikler	30	levelized/LOM (1)	-2.8% - 8.8%	N/A	existing rate
Hirst	20	capitalized / 15 yrs	-1.1% - 5.0%	N/A	supply-only rate

(1) LOM = life of measure
(2) NYSDPS used the effective annual rate impact approach, which assumes all DSM costs to be expensed.
(3) Reflects DSM spending at 1992 levels
(4) PSI recovers DSM costs as deferred expenses over a 4-year period.

Internalizing Environmental Externalities

Another important issue in analyzing financial implications of DSM programs is the inclusion of environmental costs, or internalizing environmental externalities. Electricity production accounts for two-thirds of the sulfur dioxide, one-third of the nitrogen oxides, and one-third of the carbon dioxide emitted in the United States. The resulting global warming, acid rain, and other environmental degradation are externalities -- costs not reflected in the price paid by customers for electricity.[105]

Integrated Resource Planning addresses externalities not only through DSM but also through non-traditional supply options such as renewable energy sources and cogeneration (the utilization of waste heat produced during the generation of electricity). To date, environmental issues have been incorporated into electric resource planning only at the conceptual level, concerning general methodologies for evaluating environmental impacts, with only limited application of these concepts to actual electric planning analyses.[106]

Bonneville Power Administration has conducted sensitivity analyses, considering several possible operating environments along with various potential strategies. An IRP model was used to quantify various levels of DSM and generation options in order to estimate impact on system cost as well as on average electric rates. Under all scenarios, conservation was found to be a consistently attractive resource when environmental costs and policy credits were taken into consideration. Although aggressive conservation scenarios increased average electricity rates, these effects were offset by cost-effective conservation investments.[107]

Such an IRP model is a useful conceptual tool, however, one must be aware of the wide variance in estimates of the value of externalities. To exemplify this variance, Table 8 compares estimates of externalities from various sources.

Table 8. Externality Costs for Major Air Pollutants Associated with a New Coal Plant[108]

	Massachusetts (Tellus/ESRG)22		NY State		Pace		BPA		California (PG&E)	
Pollutant	$/ton	cents/kWh	$/ton	cents/kWh	$/ton	cents/kWh	$/ton	cents/kWh	$/ton	cents/kWh
CO2	$22	2.44	$1	0.10	$14	1.42	NA	NA	$26	2.67
SO2	$1,500	0.46	$832	0.25	$4,060	2.44	$1,500	0.16	$4,060	2.44
NOx	$6,500	2.01	$1,832	0.55	$1,640	0.50	$844	0.24	$7,105	2.13
Total		4.91		0.90		4.36		0.40		7.24

Notes: Massachusetts assumes heat rate of 10,340 BTU/kWh
BPA assumes heat rate of 10,856 BTU/kWh and low sulfur coal (BPA 1991 planning estimates for area west of Cascades
California assumes heat rate of 10,000 BTU/kWh

The variance in estimation of externality costs is dramatic, with some estimates exceeding others by more than a factor of 20 (e.g., NY State's carbon dioxide @ $1.1/ton versus California's carbon dioxide @ $26/ton). To understand the reasons for such variation, one would have to consider individual state conditions and pollution regulations.

Obviously, much research has been conducted on internalizing externalities. Incorporation of these externalities into wide-spread decision-making will be a major victory for both the environment and the economy.

The Multiplier Effect

One argument often presented in support of DSM programs is that they tend to capture other indirect benefits. One of these indirect benefits is the multiplier effect, which refers to the economic compounding of dollars spent within a community, versus the loss of dollars which pay for imported services. In other words, a dollar saved on imported services or products has the potential of instead being spent within the local economy, thus stimulating the local economy.

In 1986, the Michigan Public Service Commission (MPSC) initiated an analysis, the intent of which was to estimate the amount of state-wide economic impact achieved through the operation of the Michigan Residential Conservation Services (MRCS) Program. Since Michigan is an energy-importing state, money that would have left the state to pay for gas or coal could remain in-state, thus enhancing economic growth through the economic multiplier effect.[109]

MRCS estimated state-specific economic multipliers by examining government and industry-specific information that lists actual annual expenditure patterns for various sectors. Once direct expenditures were determined, the percent of each expenditure that went out-of-state (leakage rate) and the flow of the balance remaining in-state were analyzed.

Output multipliers represent the total amount of economic output for Michigan's economy for a given level of investment. For example, using these multipliers indicates that an additional dollar introduced exogenously into a household would contribute $2.55, on average, to the state's economy. Multipliers were then applied to dollar flows resulting from the MRCS Program. Figure 4 is a flow diagram showing the relationship between all sectors.

The Programs's overall economic effect was then calculated by applying the flow and the multipliers to actual dollars involved in the first five years of the Program, as shown on Table 9[110]. The Program was estimated to have achieved $350 million in direct energy savings at a cost of $235 million. The additional $300 million in indirect economic benefit to Michigan, resulting from the multiplier effect, is a benefit which would not normally be included in a traditional cost-benefit analysis. It demonstrates that the link between DSM and economic growth can be substantial.[111]

Figure 4. Michigan Residential Conservation Services Sectoral Expenditure Flows and Corresponding Economic Output Multipliers[112]

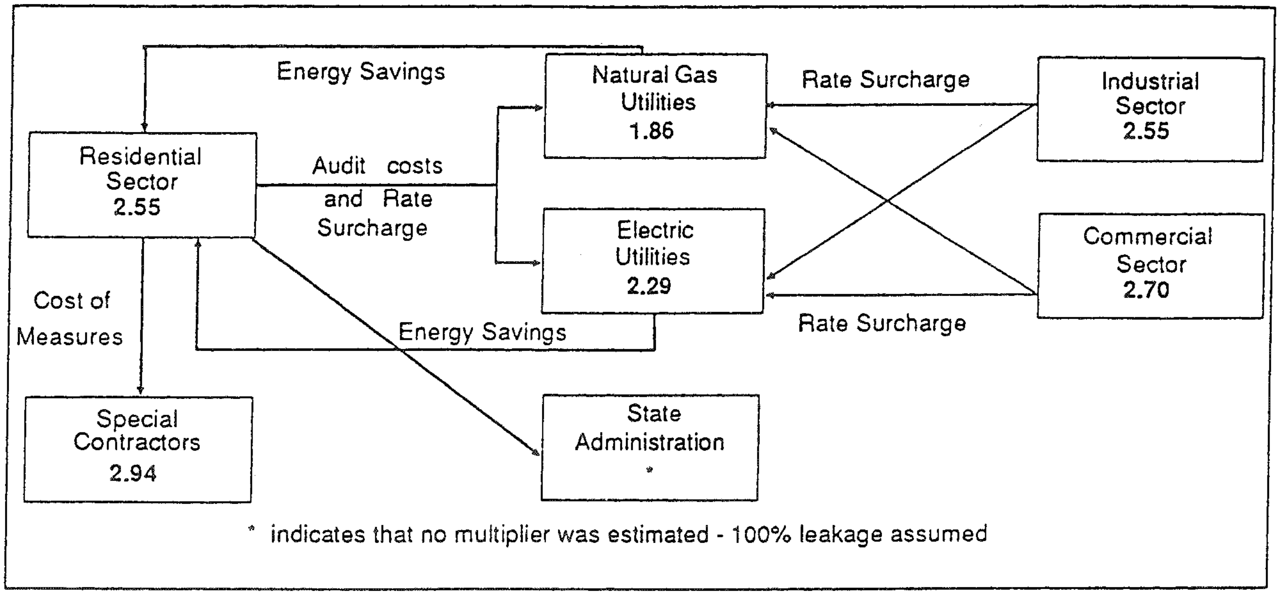


Table 9. Calculations of the MRCS Program's Overall Economic Effect ($1986)

Rate Surcharge:		*Net Economic Gain (Loss)*
Residential to electric utility: ($17,569,000)(-2.55 + 2.29)	=	($4,568,000)
Residential to natural gas utility: ($26,354,000)(-2.55 + 1.86)	=	($18,184,000)
Commercial to electric utility: ($12,032,000)(-2.70 + 2.29)	=	($4,933,000)
Commercial to natural gas utility: ($14,125,000)(-2.55 + 1.86)	=	($11,865,000)
Industrial to electric utility: ($27,267,000)(-2.55 + 2.29)	=	($7,089,000)
Industrial to natural gas utility: ($7,248,000)(-2.55 + 1.86)	=	($5,001,000)
Audit Charge:		
Residential to audit company: ($5,057,000)(-2.55 + 2.94)	=	$1,972.000
Retrofit Charge:		
Residential to contractors: ($5,057,000)(-2.55 + 2.94)	=	$58,862,000
Utility Expenses:		
Electric utility to audit company: ($56,868,000)(-2.29 + 2.94)	=	$36,964,000
Natural gas utility to audit company: ($47,727,000)(-1.86 + 2.94)	=	$51,545,000
Energy Cost Savings:		
Electric utility to residential sector: ($68,596,000)(-2.29 + 2.55)	=	$17,835,000
Natural gas utility to residential sector: $288,767,000)(-1.86 + 2.55)	=	$199,250,000
Administrative Costs of the MPSC:		
Industrial and residential to the MPSC: ($448,000)(-2.55 + 0)	=	($1,142,000)
TOTAL ECONOMIC EFFECT:		$313,646,000

IX. EVALUATION OF DSM PROGRAMS: WHY IT'S NEEDED AND INHERENT DIFFICULTIES

Originally, DSM evaluation was used by management to determine to what degree a DSM program had achieved its objectives. Changes in regulatory policy, however, have placed greater importance on DSM evaluation because evaluation results are often the basis for determining financial incentives to utilities. The combined effects of regulatory scrutiny and financial implications on DSM programs puts significant pressure on evaluators, who now face conflicting objectives from the utility, regulators, and DSM advocates.[113] This problem is currently receiving extensive scrutiny from those involved in all aspects of DSM.

This chapter examines the need for DSM program evaluation, the difficulties inherent in producing accurate, objective evaluations, and the response to these issues by the community of DSM experts.

The Need For Objective DSM Program Evaluation

DSM did not become widely accepted as an alternative energy resource until the late 1980s, when regulatory changes, such as least-cost planning, environmental issues, and incentive mechanisms, were developed. Since that time, regulatory changes have taken place on a state-by-state basis, resulting in a rapid increase in DSM spending, which has created the need for detailed, accurate, objective program evaluation.[114]

DSM program evaluation results are used primarily for four purposes:

1. to justify the level of spending to regulators, stockholders, and customers;

2. to be able to incorporate DSM impacts accurately into future resource planning;

3. to enhance program design and implementation over time to meet customer needs more effectively;[115] and

4. to determine shareholder incentives.

To accomplish these ends, two types of evaluation are utilized. **Impact evaluation** attempts to measure the energy implications (e.g., how many kWh are saved), while **process evaluation** critiques the planning and implementation of a DSM program. Both of these types of evaluation have inherent difficulties and may potentially be compromised by these difficulties and by the nature of their uses and conflicting political and financial objectives.

Difficulties Inherent to Impact Evaluation

Conflicting objectives in DSM evaluation are of particular concern not only because of the nature of the uses of the evaluations, but also because of the nature of what is being measured -- avoided energy demand. While it is straightforward to measure and evaluate electricity delivered to customers and the cost effectiveness of an electricity generator, avoided energy demand cannot be metered. The "bottom line" for DSM is the difference between electricity actually used and electricity which would have been used were it not for the DSM program. It is the latter half of this formula which cannot be measured directly and is therefore inferred.[116]

Avoided energy demand is usually estimated by utility staff. Because estimation procedures have not yet been standardized, results may not be easily interpretable outside of the utility, thus lessening the degree of confidence in such calculations. The use of established social science methods can produce reliable estimates of DSM results, however, with this type of research it must be recognized that certain variables may confound the results. For example, in the case of DSM, impacts differ for the same population over time. This can be due to:

- different characteristics of early participants versus later ones,
- different "base case" equipment stock and customer behavior,
- availability of more efficient appliances, and
- the utility's growing skill in implementation.

Evaluation of DSM is complex because of the human element and the difficulty in isolating changes in energy usage directly attributable to a particular DSM program. One confounding variable in determining direct program effects is "free riders" -- those participants who would have installed, on their own without the subsidy offered through the utility program, the same energy conservation measures as those promoted by the program. In other words, energy savings attributable to free riders would have occurred in absence of the subsidy and should therefore be excluded from the program benefits. A study in Illinois evaluated 20 programs by nine utilities for the period 1984 - 1987. Four program types (rebates, loans, low-income targeted and other audit programs) were considered. Free ridership proportions were estimated to range from 6% to 96%, which indicates the importance of factoring its extent into a DSM evaluation.[117]

"Free drivers," on the other hand, are customers who adopt energy efficiency or conservation measures, but do not participate directly in a DSM program. For example, they may purchase an appliance which qualifies for a rebate, but do not apply for a rebate. These customers contribute nothing to the utility program cost, however the resulting savings or load reduction can sometimes be credited to the program. DSM programs which attempt to alter the market implicitly strive to make everyone a free driver.[118]

Another issue in impact evaluation is the takeback effect, also known as the snapback or rebound effect. All of these terms refer to a reduction in energy savings from efficiency measures resulting from consumers using the money they save from efficiency measures to increase comfort or convenience by operating energy-efficient equipment more intensely. For example, this may take the form of higher temperature settings, increased lighting levels, increased hours of operation, or the purchase of larger units or units with more features. An analysis by Nadel of empirical studies on takeback indicated that takeback is not a widespread phenomenon. Rather, it is a phenomenon limited to several specific end-uses. The study showed: little if any takeback in residential space heating; 10% increase in operating hours of CFLs; 2% increase in plant production levels following industrial efficiency measures; and no takeback for residential water heating.[119]

Currently, a combination of metering, customer survey and computer modeling are felt to provide the most effective approach to DSM evaluation. All of these approaches, however, provide only estimates of DSM impact and should not be interpreted as fact.[120]

Difficulties Inherent to Process Evaluation

It has been argued that DSM process evaluation is more of an art than a science because it is primarily a qualitative, subjective assessment. Research methodology involves collecting people's understanding, perceptions, and opinions based on their own experience, making data subjective. Subjective data are prone to interpretation errors of two opposing types: (1) information may be discredited because it is not scientifically verifiable, and (2) the opinions spoken "the loudest" may be relied upon most heavily ("the squeaky wheel gets the grease").[121]

Another inherent difficulty in conducting process evaluations is the confidentiality of respondents. It is important for evaluation data to be specific, however, in making it specific, the identity of the respondents (either employees or organizations) may be revealed. Because evaluations usually suggest "room for improvement", this could result in an employee's negative ideas getting back to the boss or airing an organization's "dirty laundry" to the public. Generally, employees will not give negative responses regarding a program because they fear punitive reactions from their bosses. Likewise, management will be hesitant to disclose program shortcomings to the utility's regulators, since such weaknesses would reflect poorly on them.[122]

Within an organization, evaluation difficulties may also arise from the fact that because DSM programs are new and still evolving, shifting of activities among departments may occur until the utility learns how to best incorporate DSM into the organization. Such shifting of responsibilities makes it difficult for an evaluator to assess a situation. If a department has grievances against another department or is better able to defend its position, it becomes difficult for an evaluator to understand where weaknesses lie.[123]

Some of these problems may resolve themselves over time. Others are common to research in general and need to be taken into consideration when using evaluations in the decision-making process.

Difficulties Inherent to Program Evaluation in General

Program evaluation, in general, requires an extensive network of supporting tracking and reporting systems, including the following:

- changes in energy savings
- participation information (e.g., audit data, demographics)
- program expenditures
- customer satisfaction
- market data
- merging and development of databases
- documentation on barriers to program implementation and participation
- schedules on: time, budget, and actual program evaluation costs
- consolidated reports for evaluation purposes.[124]

Ideally, evaluations go beyond a "snapshot in time" by employing what is called a "longitudinal" evaluation, which measures the persistence of program impacts. Unfortunately, programs currently in place are designed primarily to track performance for only the first two to three years. It is projected that if the issue of persistence of savings is not addressed, actual savings will fall 20 - 30% short of engineering projections in less than three years. This projection is demonstrated by experience from multi-year evaluations of conservation programs serving single family homes. A recent study by Bonneville Power Administration showed a 25% decline in savings from year one to year three.[125] [126]

The falling off of savings over time is not surprising, considering the myriad opportunities to undermine program savings in comparison to the few program requirements to address the problem. The success of a program depends on the cooperation and follow-through of a variety of people. Using a multi-family program as an example, program success depends on: utility managers and contractors; installation subcontractors; and building owners, managers, residents and maintenance staff. This issue can be addressed when designing DSM programs by including such mechanisms as: incentives for utility contractors and building owners and staff; training and education of maintenance staff and residents; introduction of new technology which assists in maintaining savings; and frequent feedback (e.g., comparative bar charts on monthly bills).[127]

Collaboration between the evaluator and program designer should begin early in the design process to assure long-term program success. The greater the specification of goals and expectations for each party, the easier it will be to measure each party's performance.[128]

An Evaluation Example

An example of evaluation of a DSM program involves Madison Gas and Electric's (MGE) 1988 Energy Conservation Competition Pilot (the Competition). The two key objectives of the Competition were to motivate MGE to improve its conservation efforts in terms of both cost effectiveness and quantity of conservation achieved and to provide an opportunity for energy service companies to design and implement innovative programs. The Public Service Commission of Wisconsin (PSCW), which authorized the program, also intended it to test whether the Competition format was a regulatory strategy which could be applied to other Wisconsin utilities.[129]

Impact evaluation was performed in three service sectors: multi-family, small commercial and industrial (C&I), and large C&I. Building Resource Management Corporation (BRMC), A&C Enercom and Honeywell were chosen as competitors for each service sector, respectively. For each sector, MGE and the competitor were allocated the same amount to spend, totalling approximately $2 million for the entire one year project. This moderate cost approach utilized billing analysis in those facilities where it was appropriate and relied on engineering estimates for other facilities and other impacts (e.g., demand savings) that do not lend themselves to billing analysis. (Note: the data provided on this program reflect evaluation work in progress.)[130]

Competition results found MGE to be the winner in the multifamily and small C&I sectors, while Honeywell prevailed in the large C&I sector. Monitoring of the Competition resulted in a database which contains 3,000 records, including engineering estimates of conservation impacts for each technology installed at each facility. Table 10 shows the top 20 energy conservation measures from a total of 66 technologies. Together, these 20 technologies account for approximately 86% of the $9.4 million in total estimated life-cycle benefits from the Competition.

From a process perspective, Lawrence Berkeley Laboratory (LBL) evaluated the Competition format in terms of its viability as a regulatory strategy, determined areas of improvement for conservation services and assessed the usefulness of the impact accounting methodology. It was found that the Competition not only stimulated MGE to promote innovative energy efficiency programs, it also motivated other utilities to do the same because they wanted to avoid being required to participate in PSCW programs similar to the Competition, which they viewed negatively. The Competition was also found to demonstrate the amount of energy conservation that could be achieved in certain sectors over a given time period, which could be used as a reference for measuring and comparing utility performance in Wisconsin.[131]

Table 10. Madison Gas & Electric's 1988 Energy Conservation Competition Pilot: Top 20 Energy Conservation Measures [a][132]

Rank	Description	Estimated Life-cycle Benefits[b] $	%
1	Low flow showerhead	1,680,600	17.8
2	Night setback thermostat	1,570,378	16.7
3	Equipment Scheduling	664,423	7.0
4	Conversion of constant to variable air volume	357,245	3.8
5	Pipe insulation	336,579	3.6
6	Furnace replacement	314,757	3.3
7	Compact fluorescent fixtures with bulb	309,630	3.3
8	Occupancy sensor	303,057	3.2
9	Retrofit central fans for variable air volume	282,820	3.0
10	High or low pressure sodium fixture	279,643	3.0
11	Metal halide fixture	277,535	2.9
12	Boiler replacement	276,143	2.9
13	Infrared heating	267,877	2.8
14	Air supply upgrade	212,296	2.3
15	Water heating pipe insulation	175,257	1.9
16	Economizers	173,220	1.8
17	Delamping with reflector	165,674	1.8
18	Envelope upgrade	162,032	1.7
19	Boiler hot water reset	152,732	1.6
20	Boiler cut-out	151,332	1.6
Top 20		8,113,231	86.1
All Others		1,313,775	13.9
Total		9,427,006	100.0

[a] Ranked by estimated life-cycle benefits.

[b] Life-cycle benefits are calculated as the present value of lifetime gas and electric energy demand savings, using marginal avoided costs for energy savings, discounted over the estimated life for each technology application using a real (excluding inflation) discount rate.

Budgetary Constraints

Another problem for DSM evaluations is the tendency for utilities to underspend in this area because it has been a low profile activity in the past. Public utility commissions (PUCs) may sometimes intervene to prevent underspending or overspending on evaluation programs. Because we are still in the early stages of the evaluation learning curve, no formula exists to tell a utility or its regulator the correct spending level or methods for DSM evaluation. Experts in the DSM field suggest monitoring and evaluation budgets which comprise at least five to ten percent of a utility's DSM investment.

Intentional Manipulation of Evaluation Research

Another area of potential downfalls in the integrity of DSM evaluation is that of intentional manipulation of evaluation research. Intentional manipulation can occur when an organization pressures the evaluator to skew results towards the organization's goals. These goals may be financial ones or may involve a utility's express desire to either avoid or promote DSM.[133]

An example of the influence of financial goals on evaluations is a proposal by the U.S. Department of Energy (USDOE) to fund DSM programs based on evaluation results. Due to the difficulties in verifying evaluations, it would be easy for utilities to skew program evaluations to reflect greater savings from a DSM program and thus increase their funding from USDOE. Experts recommended to the USDOE that "...tying evaluation results to state funding levels would harm the development of the DSM field and the objectivity of our research during a critical DSM developmental period."[134]

Hall[135] gives examples of how evaluation practices can be skewed:

- choosing evaluation methodologies that favor certain results, or conducting several evaluations and selecting the one that best suits goals (e.g., engineering estimates tend to exaggerate savings levels because they reflect technically achievable savings, not realistically achievable savings);

- selectively choosing the time period during which data are collected (e.g., taking advantage of seasonal temperature changes, or taking advantage of company- or industry-specific fluctuations in consumption);

- choosing sample populations with known opinions or consumption criteria; and

- selectively including, excluding or altering data (e.g., excluding homes which show increased energy consumption following installation of DSM measures).

All of these manipulations would be very difficult and costly to detect. Although Hall feels that evaluation ethics are high, he points out that the pressures to produce results which support organizational goals continue to increase as evaluations become more relied upon as bases for cost recovery of DSM program expenditures.

Approaches to Overcoming Evaluation Difficulties

The problems with DSM evaluation have led DSM experts to consider the need for evaluation standards. After fifteen years of DSM experience, there is surprisingly little standardization of the DSM programs themselves. Although the lack of standardization presents problems in evaluation and comparison of programs, some believe that because DSM program evaluation is in an early phase of evolution, it still involves more art and judgement than science, and that the setting of standards at this stage of evolution could inhibit development of new techniques.[136]

To the extent that evaluation methods are specific to the type of program implemented, standardization of evaluation methods is very difficult. However, certain aspects of evaluation, such as terminology, definitions, and some common elements of methodology, can be standardized, allowing comparison of results of varying evaluation techniques.[137]

Specific efforts to develop standards for DSM evaluation are being pursued by many experts in the field. The International Energy Program Evaluation Conference (IEPEC) and The Topic Committee on Monitoring and Evaluation of the Association of DSM Professionals (ADSMP) are working jointly to develop "guidelines for professional practices" for DSM evaluation techniques.[138]

Along with others in this field, these groups sponsored a survey of DSM evaluation professionals on: the state of development of standards for DSM evaluation, the perceptions of the need for standards, and relevant professional ethics. The survey, which was conducted by The Institute of Technology Assessment, received 46 responses from public utilities, public utility commissions, government agencies, consulting firms, and other related organizations.[139]

Although only 26% of the respondents said their organization had standards, 43% claimed to be developing or considering standards, and 67% felt a need for standards. A definite concern was expressed, however, that any potential standards developed must be broad and flexible so as not to hinder the development of valuable methodologies at this early stage of their evolution. Standards reducing flexibility and creativity of evaluations is only one concern expressed by survey panelists. Other panelists believed that effective methods to evaluate evaluation already exist. Of those who offered comments on this topic, more than half cited organizational or staffing limitations as the reason for making the development of standards prohibitive at this time.[140]

In terms of ethics, 69% expressed problems or potential problems of conflict of interest in evaluating DSM programs. Most indicated that these problems result from pressures for or against program success.[141]

The U.S. Environmental Protection Agency (EPA) is addressing the issue of DSM standards because of its need to enforce provisions of the Clean Air Act. The EPA had Lawrence Berkeley Laboratory (LBL) develop Conservation Verification Protocols (CVP), which will be guidelines for state utility commissioners and boards of municipal utilities to use to verify achievement of conservation savings and sulfur dioxide reductions. CVP are being used by public utilities that are not subject to other regulatory authority.[142]

LBL is developing the CVP with the intent of establishing guidelines that are "strict enough to provide reasonably accurate measurement of savings and yet are easy enough and non-resource intensive enough to actually be used by utilities with very limited DSM staff."[143]

The National Association of Regulatory Utility Commission's (NARUC) Energy Conservation Subcommittee on Conservation Implementation and Performance has also recognized the growing importance of and need for standards in DSM evaluation. In response, it has created standardized definitions, terminology and program format for DSM. The subcommittee is also considering several projects revolving around DSM program evaluation issues and standards.[144]

The New York State Energy R&D Authority and the USDOE have supported the publishing of the Handbook on Evaluation of Utility DSM Programs, prepared by Oak Ridge National Laboratory (ORNL). The topics covered in the handbook were chosen by a committee of regulatory staff, utility staff, environmental advocates and state energy policy planners, and each chapter is written by an expert in that specific area. The handbook addresses the need for providing credible answers to the questions of DSM programs' effect and cost-effectiveness.[145]

A different approach to enhancing the reliability of an evaluation is through the development of databases. One of the recent attempts to define consistent terminology and data reporting formats is the NU-Trak system being developed by the Northwest Power Planning Council in a collaborative process with four Public Utility Commissions, Bonneville Power Administration, and several investor-owned and public power utilities in the region. NU-Trak is gathering data on more than 300 programs. At the national level, Lawrence Berkeley Laboratory (LBL) is developing the Database of Energy Efficiency Programs (DEEP), which collects data that are national in scope at a level of detail that is similar to NU-Trak. The intent of these databases is to provide information on integrated resource planning, program design and implementation experiences.[146]

Because DSM is a relatively new concept in a well-established field, its merits must continually be proven and its process must continually be improved. The expenditure of significant amounts of money on DSM programs needs justification. DSM energy impacts require quantification in order to be factored into financial incentive calculations and future resource planning.

Each of these issues underscores the need for accurate, objective DSM program evaluation. Unfortunately, "the nature of the beast" is such that myriad problems encumber the accomplishment of this goal. First of all, it is difficult to quantify saved energy. In addition, human nature and corporate pressures can work against the integrity of evaluations. The DSM community is responding to these issues by developing evaluation standards. The situation is a dynamic one, continually changing as the entire field of DSM evolves.

It is difficult to make specific recommendations regarding which evaluation methods are best due to the dynamic nature of the DSM field and the broad range of evaluation methods and approaches. Although more uniformity of methods would facilitate comparability among programs, many experts in the field believe that the adoption of more than minimal standardization requirements at this point would limit creative development of better methods.[147] There is, however, a need for coordinated development of methods that focus on reliability, potential bias and sources of inaccuracy. Fels and Keating[148] suggest several desirable features of measurement methods:

- **"transparency,"** to prevent inaccuracies and biases from being hidden within complex methodology,

- **standardization**, as a longer-term goal, to allow comparability across similar programs,

- **attribution**, to separate savings attributable to the program from changes in energy consumption due to other factors, and

- **"truth-seeking,"** to show what actually happened as opposed to what was expected, through a meter-based connection to reality.

Fels and Keating point out that "no single measurement method satisfies all of these criteria for all types of DSM...The most promising evaluation approach is the use of multiple methods...By working together to present an accurate and clear picture of the energy saved by DSM programs, evaluators can play a critical role in providing utilities and regulators with essential information for improving the effectiveness of planned programs."[149]

X. LESSONS LEARNED FROM DSM PROGRAM EXPERIENCE

Implementation of DSM programs has been growing steadily over the past ten years, and program experience has taught many important lessons about ways to structure and promote programs in order achieve significant energy and dollar savings. Nadel[150] (ACEEE) has summarized lessons learned from reviewing the basic types of residential and commercial conservation programs:

- Energy audits designed to assist customers in identifying conservation opportunities usually yield limited energy savings, however, implementation of audit recommendations can be increased by providing post-audit follow-up services and financial incentives.

- Programs can be tailored to fulfill the demands of different niches. For example, rebate programs can successfully promote efficient equipment at a moderate cost to the utility, however these programs tend to reach only a minority of customers and are limited in their ability to promote utilization of more complex systems of equipment.

- Program participation and savings are strongly impacted by marketing strategies and technical/construction support services. Personal one-on-one and intensive community-based marketing strategies have been found to be especially productive. Contractors, equipment dealers, and designers can be helpful in promoting programs. Program design should prioritize customers' needs and ensure understandability.

- All other variables being equal, financial incentives tend to increase program participation and savings. High incentives seem to promote greater savings than moderate incentives, however the difference between the effect of low and moderate incentives may be indistinguishable.

- A significant target for DSM programs is "lost opportunity resources." These resources may include new construction, which provides a one-time opportunity to buy conservation savings at a low cost, or major equipment replacement or building remodeling.

- Engineering estimates for residential retrofit programs often exceed measured savings. This is especially true in areas which use wood or other secondary heat sources. Available data on commercial and new construction programs are limited and show that sometimes engineering estimates exceed savings and sometimes savings exceed engineering estimates. A program can still be cost effective, however, even if savings fall short of estimates.

- A high level of utility commitment to DSM is a major factor in the success of programs.

- Many gaps exist in our knowledge about how to design and operate successful DSM programs. Documentation and evaluation of current programs can provide important information for continued DSM success.

Sioshansi,[151] of the Electric Power Research Institute (EPRI), also makes some observations on DSM experience to date:

- Regulations work, with limits to what they can achieve. For example, appliance efficiency standards, construction codes or labels are a cost-effective way to slowly reduce the number of inefficient products. Rebates and incentives, however, can accelerate the turnover rate by encouraging customers to replace existing appliances with super-efficient ones before the old ones wear out.

- High energy prices/taxes motivate efficiency and reduce or eliminate the need for incentives because the rewards are real and automatic. Energy taxes, however, have certain drawbacks, including penalizing certain sectors of the economy.

- The profit motive is a strong inducement for utilities; however, high incentives increase the likelihood of exaggerated claims.

- Certain basic accounting and reporting standards are needed to determine the true cost-effectiveness of DSM programs.

- "(L)earning by doing really works."

DSM is a relatively young but quickly growing field which can benefit greatly from a continued surveillance of programs and results.

XI. CURRENT AND POTENTIAL ENERGY AND DEMAND SAVINGS

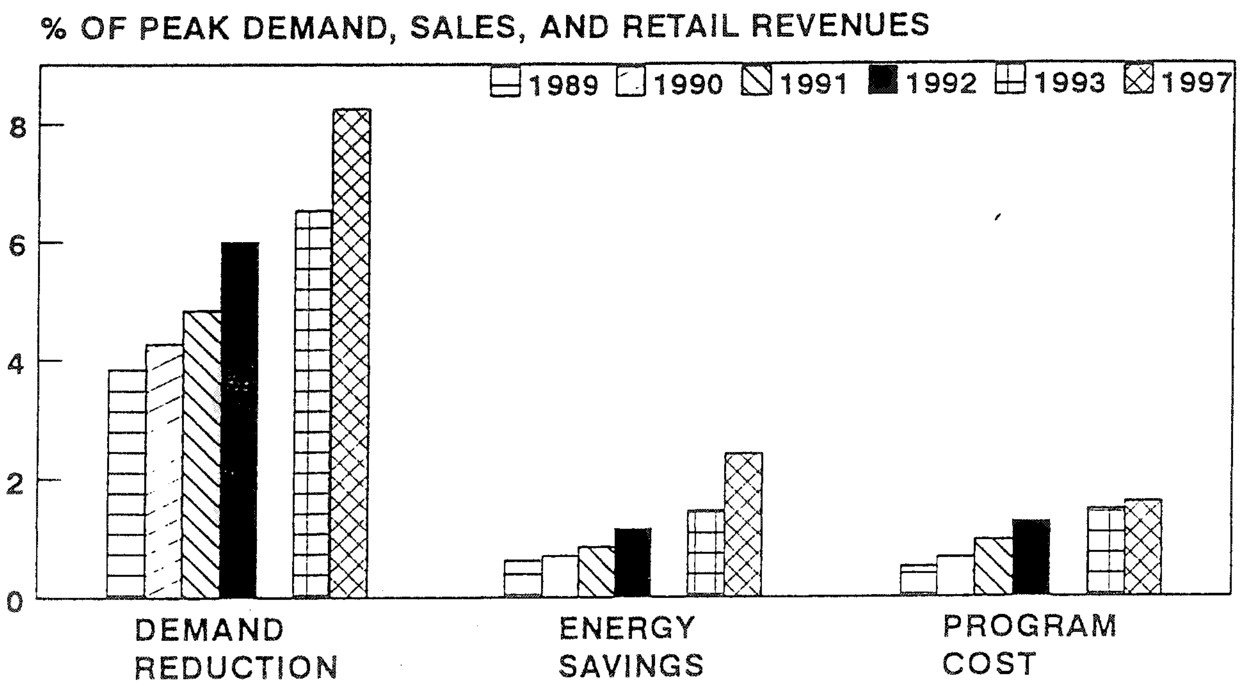
The long-term potential of DSM depends on many important assumptions, such as: the cost and penetration levels of new DSM technologies in different market segments; economic growth, which affects the demand for energy services; energy costs; and the turnover rate of energy-intensive capital stock (e.g., how long inefficient refrigerators will last). As discussed throughout the handbook, it is difficult to isolate the effects of DSM programs from other variables that affect the level of energy consumption and demand. Another source of controversy over estimates of DSM potential is differentiating between "maximum technical potential" (MTP) and achievable potential of DSM.[152] More realistic estimates are those reflecting actual recent experience, although it is important to consider MTP when determining just how much energy and demand savings could be achieved, given adequate resources and support.

A recent (1994) study of current and potential energy savings was completed by Hirst at Oak Ridge National Laboratory (ORNL).[153] The study analyzes DSM program data submitted to the Energy Information Administration (EIA)[154] by all U.S.electric utilities, and provides a comprehensive view of costs and effects of DSM for 1989, 1990, 1991, and 1992, in addition to projections for 1993 and 1997.

In 1992, more than 25% of U.S. utilities ran DSM programs, at a total cost of almost $2.4 billion, or 1.3% of total revenues. These programs saved an estimated 31,800 GWh (1.2%) in energy; and 32,900 MW (6%) in demand. Energy savings are expected to more than double by 1997 (2.5%) and demand reductions are projected to increase to more than 8% of peak demand. Because DSM programs are expected to become more cost effective, DSM spending is projected to increase by only .5 percentage points to 1.8% of revenues. Figure 5 shows DSM-program costs, energy savings, and potential peak-demand reductions for 1989 through 1992 and forecasts for 1993 and 1997.[155]

Other studies have projected savings from DSM further out in time. One such study projects that in 2010 DSM will have reduced electricity generation by 27% and the national energy bill by 18%.[156] Another study estimates that DSM will have reduced projected energy use by 19% by 2010.[157] This represents almost half of the growth in electricity use between 1990 and 2010. The fruition of these and myriad other projections will depend on the many variables referred to in this handbook.

Figure 5. DSM-Program Costs, Energy Savings, and Potential Peak-Demand Reductions for 1989 through 1992 and Forecasts for 1993 and 1997.



DSM has great potential, not only from the standpoint of contributing to a cleaner environment, but also in economic terms. DSM provides new business and employment opportunities in the energy services sector while lowering the cost of energy services. For businesses to fully appreciate and integrate DSM into their strategic planning process, it is critical to provide accurate, objective evaluation of DSM programs. This area is still evolving, but has already provided useful data in terms of energy savings and direct and indirect economic benefits. Clearly, DSM is a substantial business activity for utilities and a viable strategy for pursuing our nation's economic and environmental goals.

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GLOSSARY

The glossary is taken directly from the "Demand-Side Management Planning and Implementation Reference Guide," published by the Association of Demand-Side Management Professionals (ADSMP) in April 1992. The reference guide was prepared by the Program Design and Implementation Committee of ADSMP, chaired by Robert Obeiter, and can be ordered by calling ADSMP at 407-361-0023.

The terminology included in the glossary is much more extensive than that discussed in the handbook, but has been included as a useful tool to go beyond the handbook's introductory level.

GLOSSARY OF DEMAND-SIDE MANAGEMENT TERMS

Absorbent. A material which, due to an affinity for certain substances, extracts one or more such substances from a liquid or gaseous medium with which it contacts and which changes physically or chemically, or both, during the process. Calcium chloride is an example of a solid absorbent, while solutions of lithium chloride, lithium bromide, and ethylene glycols are liquid absorbents.

Absorption. A process of attracting and holding moisture in which the desiccant material undergoes a chemical change. For example, table salt (a desiccant) changes from a solid to a liquid as it absorbs moisture.

Achievable Potential. An estimate of energy savings based on the assumptions that all energy-efficient options will be adopted to the extent that it is cost-effective and possible through utility DSM programs.

Adiabatic process. A thermodynamic process in which no heat is extracted or added to he system.

Administrative Costs. Costs incurred by a utility for program planning, design, marketing, implementation, and evaluation. They include labor-related costs, office supplies and expenses, data processing, and other such costs. They exclude costs of marketing materials and advertising, purchases of equipment for specific programs, and rebates or other incentives.

AFUE. Annual Fuel Utilization Efficiency. AFUE, used to measure the efficiency of gas-fired space heating furnaces, is the ratio of heat delivered to heat input during a year under specified conditions.

Agricultural Sector. Non-residential customers engaged in the production of crops and livestock, forestry, fishing, hunting, or trapping.

Air change. A measure of the rate at which the air in a building is replaced by outside air from infiltration and ventilation; usually described as air changes per hour.

Air conditioner, room. A room air conditioner is a factory-made encased assembly designed as a unit for mounting in a window, through a wall, or as a console. It is designed for free delivery of conditioned air to an enclosed space without ducts.

Air conditioner, unitary. A unitary air conditioner consists of one or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well; where each equipment is provided in more than one assembly, the separated assemblies are designed to be used together.

Air conditioning. The process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution to meet the requirements of the conditioned space.

Air conditioning hours. The number of hours in a 24-hour period in which the temperature exceeded 75°F.

Air conditioning system, central fan. A mechanical indirect system of heating, ventilating or air conditioning in which the air is treated or handled by equipment located outside the rooms served, usually at a central location, and conveyed to and from the rooms by means of a fan and a system of distributing ducts.

Air conditioning system, year round. One which ventilates, heats, and humidifies in winter, and cools and dehumidifies in summer the spaces under construction, and provides the desired degree of air motion and cleanliness. The system includes the following equipment, whether it is located within the structure served or external to it: the refrigeration system and the heat generating system; any piping systems used to convey the heating and cooling media to suitable heat transfer surfaces; pumps, accessories, automatic controls, and interrelated electrical work. The heat transfer portions of the system generally include, as required, preheaters, fan systems of distributing ducts, piping, and necessary means of manual or automatic control

Air diffuser. A circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes, and arranged to promote mixing of primary air with secondary room air.

Alternative Rate Programs. Special rate structure or discount on the customer's electric bill, generally in return for participation in programs aimed at cutting peak demands.

Ampere. The rate of flow of electric current through a conductor.

Annual Effects. Electricity use and demand effects caused by a program's activities in the current year.

Annual Energy Effects. The estimated change in energy use on an average annual basis associated with participation in a program or installation of an efficiency measure. (Note: California collaborative defines this in terms of "the first full year after the installation of a measure" to avoid ambiguity about what year to use.)

Annual Participation. The number of participants who are enrolled in a particular program for a given year.

Appliance Saturation. The number of each of the specific types of household appliances connected to a utility's lines, divided by the total number of residential customers.

ASHRAE. The American Society of Heating, Refrigeration and Air Conditioning Engineers.

ASHRAE 90-75. ASHRAE standard for energy conservation in new building design.

Attrition. Any pattern of customers dropping out of ongoing program (e.g., interruptible rate).

Audit. Analysis of a home, building, or industrial process by an energy engineer to determine ways the customer can improve their energy efficiency.

Automatic Meter Reading System (AMRS). A system capable of reading a meter (watt hour, demand, gas, water or any other type of meter), preparing and conditioning the data and transmitting the accumulated information for the meter location to a central data accumulation device. The communications link may be radio, telephone line, power line carrier, direct cable, or a combination thereof. The data accumulation device will in most cases be a computer.

Avoided Cost. The incremental cost that a utility would incur to produce or purchase an amount of power equivalent to that saved by a DSM measure.

Ballast. One component of a fluorescent fixture or compact fluorescent lamp which controls the voltage and current to the lamp.

Ballast factor. The fractional loss of task illuminance due to use of a ballast other than the standard one.

Base Load Generation. Those generating facilities within a utility system which are operated to the greatest extent possible to maximize system mechanical and thermal efficiency and minimize system operating costs.

Base Load Unit/Station. Units or plants which are designed for nearly continuous operation at or near full capacity to provide all or part of the base load. An electric generation station normally operated to meet all, or part, of the minimum load demand of a power company's system over a given amount of time.

Base Market. The set of customers or technologies against which participation in a program is measured.

Benchmarking. A process for achieving superior performance through rigorous measurement and comparison of operating practices and philosophies in companies recognized as "best-in-class," to identify and incorporate the best practices and to surpass the best-in-class performers.

Benefit-Cost Ratio. The ratio of the value of a DSM measure's energy savings to its installed cost. The energy savings value is based on the utility's avoided cost.

Bidding Program. The utility's issuance of a Request for Proposal (RFP) to acquire demand-side resources. Potential bidders may include energy service companies, installation contractors, material suppliers, customers, and other utilities.

Bill Credit. An incentive in the form of a reduction in a customer's electricity bill.

Blower Door. A diagnostic tool used to test air infiltration rates by either pressurizing or de-pressurizing the building.

Boiler. A device where hot water or steam is generated, usually by burning fuel or using electricity.

Boiler Capacity. The rate of heat output in Btu/HR measured at the boiler outlet at the design inlet, outlet, and rated input.

Booster water heater. Hot water from a primary system is raised to a higher temperature for a particular task (i.e., dishwasher rinse).

Btu - British thermal unit. The amount of energy required to raise the temperature of one pound of pure water by one degree Fahrenheit. One Btu is equal to 3.412 Watt hours, 778 ft-lb and 252 calories.

Btuh heat loss. The amount of heat that escapes, from warmer to colder areas, through walls, ceilings, floors, windows, doors by infiltration in one hour's time.

Building envelope. The walls, doors, windows, and roof that separates the inside of a building from the outside.

Capacity. Usable output of a system or system component in which only losses occurring in the system or component are charged against it.

Capacity, condensing unit. Refrigerating effect in Btuh produced by the difference in total enthalpy between refrigerant liquid leaving the unit and the total enthalpy of the refrigerant vapor entering it. Generally measured in ton or Btuh.

Capacity factor. The ratio of the average operating of an electric power generating unit for a period of time to the capacity rating of the unit during that period.

Capacity, refrigerating. The term refrigerating capacity is used to denote the rate of heat removal from a medium or space to be cooled at stated conditions; refrigerating effect is used to denote heat transfer to or from the refrigerant itself in a refrigerating system.

Capitalized. Equipment or other costs that are considered capital investments to be used over a multi-year period and therefore eligible for inclusion in rate base.

Cash Incentive. An incentive in the form of a rebate or cash payment.

CCF. One hundred cubic feet of natural gas, with a thermal content of 100,000 Btu or one therm.

Central air conditioner. A consumer appliance rated below 65,000 Btu/hour that is powered by single-phase electric current. It consists of a compressor and an air-cooled condenser assembly and an evaporator or cooling coil; designed to provide air cooling, dehumidifying, circulation, and cleaning. The air is treated by equipment at one of more central locations outside the spaces served and conveyed to and from these spaces by means of fans and pumps through ducts and pipes.

Central heating system. A system in which heat is supplied to all areas of a building from a central plant through a network of ducts or pipes,

Central water heater. Hot water generated in one location and piped to points of use. May require recirculating to maintain required temperature at points of use.

CFM (cubic feet per minute). A measure of air flow rate.

CGS. A system of units and measurements comprised of centimeter-gram-second.

Chiller. A device where water is cooled (to 40-50°) for later use in cooling air.

Circuit. A conductor or a system of conductors through which an electric current flows.

Clothes washer. A consumer product designed to clean clothes, utilizing a water solution of soap and/or detergent and mechanical agitation or other movement, and must be one of the following classes: automatic clothes washers, semi-automatic clothes washers, and other clothes washers.

Coefficient of performance, heat pump. Ratio of heating effect produced to the energy supplied, where the heating effect and energy supplied are expressed in the same thermal units.

Coefficient of performance, refrigerating unit. Ratio of the refrigeration produced to the work supplied, where refrigeration and work supplied are expressed in the same thermal units.

Coils. Finned-tube heat changer which heats/cools air flowing over the outside of the tubes by hot/cold water flowing inside the tubes.

Coincident Demand. A customer's demand at the time of a utility's system peak demand.

Coincident Peak. Customer's demand at the time of the utility's system peak.

Cold Deck. The portion of the duct containing the chilled water coil or DX coil. Generally parallel with a bypass deck or hot deck.

Collector efficiency. The output (energy collected) divided by the input (the solar energy falling on the collector surface) within a specified period of time.

Commercial Sector. A group of nonresidential customers that provide services, including retail, wholesale, finance, insurance, and public administrations.

Competitive Bidding. A competitive procurement process for selecting some portion of future electric generating capacity that may include: the publication of a Request for Proposal (RFP) by an electric utility for the purchase of electric generating capacity, electric energy, and/or demand-side management products and services; the submission of bids offering to provide such products and services by multiple would be suppliers; and the selection by the electric utility of one or more winning bids subject to appropriate oversight by a state regulatory commission.

Compression chiller. A refrigeration device which uses mechanical energy input to produce chilled water.

Compressor. A device that increases the pressure of a refrigerant.

Condenser. A vessel or arrangement of pipe or tubing in which a vapor is liquefied by removal of heat.

Condenser, air-cooled refrigerant. A condenser cooled by natural or forced circulation of atmospheric air through it. In refrigeration systems, the component that rejects heat.

Condensing unit. A component of a central air conditioner which is designed to remove the heat absorbed by the refrigerant and to transfer it to the outside environment, and which consists of an outdoor coil, compressor(s), and air moving device.

Conductance, thermal. The time rate of heat flow through a body per unit area from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady conditions. The term is applied to specific bodies or constructions as used, either homogeneous or heterogeneous.

Connected lighting load. The power in watts required by lights when all fixtures are full on throughout the building.

Connection charge. An amount to be paid by a customer in a lump sum, or in installations, for connecting the customer's facilities to the supplier's facilities.

Conservation. The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

Conservation Cost Adjustment (CCA). A means of billing customers to accrue funds to pay for the costs of load management programs as set forth under the Public Utility Regulatory Policies Act of 1978 (PURPA). Utilities defer the cost of building expensive generating capacity by encouraging customers to use energy more efficiently. One means is encouraging customers to purchase energy-efficient appliances and machinery to replace less efficient devices. A common example is when a utility advertises that it will pay customers to convert from resistance electrical heat to heat pumps. The convert greater efficiency of the heat pumps reduces peak demand. Applied over large numbers of customers, the lowered demand allows the utility to avoid expensive construction, which more than pays for the cost of the advertising and the rebates.

Conservation program. A DSM program that attempts to reduce a customer's energy (kWh) consumption over most or all hours of the day.

Constant air volume system. An air conditioning system of the reheat, recool, dual duct or multi-zone type which has fixed air flow rate.

Control group. A group of customer who did not participate in a program who are used to isolate program effects from other factors such as natural conservation.

Convection. Transfer of heat by movement of fluid.

Conventional cooking top. A class of kitchen ranges and ovens which is a household cooking appliance consisting of a horizontal surface containing one or more surface units which include either a gas flame or electric resistance heating.

Conventional oven. A class of kitchen ranges and ovens which is a household cooking appliance consisting of one or more compartments intended for the cooking or heating of food by means of either a gas flame or electric resistance heating. It does not include portable or countertop ovens which use electric resistance heating for the cooking or heating of food and are designed for an electrical supply of approximately 120 volts.

Conventional range. A class of kitchen ranges and ovens which is a household cooking appliance consisting of a conventional cooking top and one or more conventional ovens.

Cooling, evaporative. Involves adiabatic heat exchange between air and a water spray or wetted surface. The water assumes the wet-bulb temperature of the air, which remains constant during its traverse of the exchanger.

Cooling-degree day. The difference between the mean temperature of any day and a base temperature when the mean temperature is greater than the base temperature, with each degree above that temperature equaling one cooling-degree day. For example, if the base temperature is 50°F and the mean temperature for a specific day is 78°F, 28 cooling-degree days to a 50°F base would be accrued.

COP - Coefficient of Performance. The scientifically accepted measure of the heating or cooling performance of any refrigeration machine - heat pump, air conditioner, or refrigerator. It is determined through ARI standardized laboratory testing and provides an indication of steady-state performance. The COP is defined as:

$$\text{COP} = \frac{\text{Heating or (cooling) provided by the system, in Btu}}{\text{Energy consumed by the system, in Btu}} = \quad (6.1)$$

The total heating output of a heat pump includes heat generated by the circulating fan but excludes supplemental resistance heat. Because the COP is a dimensionless measure, the heating and cooling output and energy input must be expressed in the same units. If the output is expressed in the same units. If the output is expressed in Btu, the system energy consumption, typically expressed in watt hours, must be converted to Btu. This is done by multiplying the denominator by the conversion factor 3.4313 Btu/watthour.

COP is more commonly used to measure heating performance than cooling performance and varies with source and sink temperature. Good performance is indicated by a high COP. The higher the COP, the higher the equipment efficiency. The COP is equal to the EER divided by 3.412.

COS - Coefficient of Shading. Ratio of solar radiation passing through a specific glazing system to the solar radiation passing through a single layer of double strength.

Cream skimming. Installing only the lowest cost or easy-to-install DSM measures while ignoring other cost-effective opportunities.

CU - coefficient of utilization. The ratio of light (lumens) from a luminaire received on a work plane, to the lumens emitted by the lamps alone.

Cubic feet per minute (CFM). A measure of air flow rate.

Cumulative effects. The electricity use and demand effects of a program caused by all its participants, from the program's inception through the current year.

Cumulative participation. The sum of the number of participants from the start of a program through the current year.

Curtailable Electric Service Programs. Programs which are designed to reduce a utility's peak load requirements by offering customers substantial rate discounts when service is interrupted during the utility's peak demand period. Most utility programs are targeted at large commercial and industrial customers who pledge a minimum interruptible load level to be curtailed as directed by the utility during electrical emergencies.

Customer (electric). An individual, firm, organization, or other electric utility which purchases electric service at one location under one rate classification, contract, or schedule. If service is supplied to a customer at more than one location, each location shall be counted as a separate customer unless the consumptions are combined before the bill is calculated.

Customer charge. An amount to be paid periodically by a customer for electric service often based upon costs incurred for metering, meter reading, billings, etc., exclusive of demand or energy consumption.

Customer class. A group of customers with similar characteristics, such as economic activity or level of electricity use.

Customer unit. A participating unit that is based on customers, households or buildings, in contract to technology units.

Customers Load Management System. Normally consists of a unidirectional signal system operated by a utility company which upon command from a central control station provides switching signals to turn one or more selected customer appliances off or on in order to improve system load factor by reducing peak load.

Cycle, Carnot. A sequence of reversible processes forming the reversible working cycle of an ideal heat engine of maximum thermal efficiency. It consists of isothermal expansion, adiabatic expansion, isothermal compression, and adiabatic compression to the initial state.

Degree Day. For any one day, when the mean temperature is less than 65 degrees F, there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65 degrees F.

Dehumidification. (1) condensation of water vapor from air by cooling below the dew point; (2) an absorption or absorption device for removing moisture from air.

Dehumidifier. A self-contained, electrically powered, mechanically-refrigerated device designed primarily to decrease the moisture content of the air in an enclosed space; it has a refrigerated surface (evaporator) onto which moisture from the air condenses, a refrigerating system that includes an electric motor, a fan for circulating air, and a drainage arrangement for collecting and/or disposing of the condensate.

Demand. The rate at which electric energy is delivered to or by a system, part of a system, or a piece of equipment. It is expressed in kilowatts, kilovolt amperes or other suitable unit at a given instant or averaged over any designated period of time. The primary source of "Demand" is the power-consuming equipment of the customers.

Annual System Maximum: The greatest demand on an electric system during a prescribed demand interval in a calendar year.

Average: The demand on, or the power output of, an electric system or any of its parts over any interval of time, as determined by dividing the total number of kilowatt hours by the number of units of time in the interval.

Billing: The billing upon which billing to a customer is based, as specified in a rate schedule or contract. It may be based on the contract year, a contract minimum, or a previous maximum and, therefore, does not necessarily coincide with the actual measured demand of the billing period.

Coincident: The sum of two or more demands which occur in the same demand interval.

Instantaneous Peak: The demand at the instant of greater load,usually determined from the readings of indicating or graphic meters.

Integrated: The demand usually determined by an integrating demand meter or by the integration of a load curve. It is the summation of the continuously varying instantaneous demands during a specified demand interval.

Maximum: The greatest demand which occurred during a specified period of time.

Non-Coincident: The sum of two or more individual demands which do not occur in the same demand interval. Meaningful only when considering demands within a limited period of time, such as day, week, month, heating or cooling season, and usually for not more than one year.

Demand Charge. That portion of the charge for electric service based upon the electric capacity (kW or kVa) consumed and billed on the basis of billing demand under an applicable rate schedule.

Demand-Side Management (DSM). The planning, implementation, and monitoring of utility activities designed to influence customer use of electricity in ways that will produce desired changes in a utility's load shape (i.e., changes in the time pattern and magnitude of a utility's load). Utility programs falling under the umbrella of DSM include: load management, new uses of electricity, energy conservation, electrification, customer generation adjustments in market share and innovative rates. DSM includes only those activities that involve a deliberate intervention by the utility to alter the load shape. These changes must produce benefits to both the utility and its customers.

DSM Objectives: Defining broad utility mission and objectives, operational objectives, and load shape objectives.

DSM Alternatives: Identifying the range of available end uses, technologies, and market implementation techniques.

DSM Evaluation and Selection: Identifying and evaluating key customer or market considerations and utility considerations and completing a cost/benefit analysis of these.

DSM Program Implementation: Consisting of pilot and full-scale implementation or execution of the marketing plan.

DSM Program Monitoring: Including measuring the outcomes of program implementation and providing feedback on results.

Department of Energy (DOE). Established in 1977 by the Department of Energy Organization Act to consolidate the major federal energy function into one cabinet-level department that would formulate a comprehensive, balanced national energy policy.

Desiccant. Any absorbent or absorber, liquid or solid, that will remove water or water vapor from a material. In a refrigeration circuit the desiccant should be insoluble in the refrigerant.

Desiccation. Any process for evaporating water or removing water vapor from a material.

Design temperature. Outdoor temperature representing extreme weather conditions; used in sizing heating and cooling equipment.

Direct Installation Program. Utility installation of DSM measures within customers home or business; such programs generally cover low-cost measures, such as water-heater wraps and compact fluorescent lamps.

Dispatchability. The ability of the utility to schedule and control, directly or indirectly, manually or automatically, the DSM measures.

Dispatching. The operating control of an integrated electric system to:

1. Assign generation to specific generating stations and other sources of supply to effect the most reliable and economical supply as the total of the significant area loads rises of falls.

2. Control operations and maintenance of high-voltage lines, substations, and equipment, including the administration of safety procedures.

3. Operate the interconnection.

4. Schedule energy transactions with other interconnected electric utilities.

Diversified Demand. The average load (kW) across a group of customers or end uses.

Diversity. Individual maximum demands in a collection of demands (e.g., electric loads), usually occurring at different intervals. The diversity among customers' demands creates variations among the loads in distribution transformers, feeders, and substations at a given time. A load diversity is the difference between the sum of the maximum of two or more individual loads and the coincident or combined maximum load. It is usually measured in kilowatts.

Diversity factor. The ratio of the sum of the non-coincident maximum demands of a utility's customers or customer classes to the system peak, or maximum coincident demand, of the utility. If all customers maximized their demands at the same time, the diversity factor would equal one. If customers maximized their demands at different times, the diversity factor would be greater than one. Generally, a high diversity factor (i.e., much greater than one) indicates that a utility's load curve is relatively flat. Diversity factor is the reciprocal of coincidence factor.

DOE-2.1. A computer program that simulates the energy consumption of commercial buildings.

Domestic Hot Water. Hot water for domestic or commercial purposes other than comfort heating and industrial processes (ie: hot tap water, showers, etc.)

Double-bundle condenser. Condenser (usually in a refrigeration machine) that contains two separate tube bundles allowing rejection of heat either to the cooling tower or to another building system requiring heat input.

Double glazing. Two panes of glass, usually parallel, with an air space between; used to provide increased thermal and/or sound insulation.

Dropouts. Customers who do not continue to participate in a program, generally applicable to direct load control programs.

Dry bulb temperature. Temperature of air as indicated by a standard thermometer, as contrasted with wet-bulb temperature dependent upon atmospheric humidity.

Dual duct system. An air conditioning system in which there are two air ducts (called decks), one of which is heated and the other cooled. Air of the correct temperature for a particular zone is obtained by mixing varying amounts of each stream.

Duct. A passageway made of sheet metal or other suitable material, not necessarily leak-tight, used for conveying air or other gas at low pressures.

Duty cycling. Periodic cycling off of electrical loads to reduce overall kW demand level and kWh consumption.

Early replacement. Replacement of equipment before it reaches retirement age (sometimes called retrofit).

Early retirement. Equipment that is removed before it reaches normal retirement age but is not replaced.

Economic dispatch. The start-up, shutdown, and allocation of load to individual generating units to effect the most economical production of electricity for customers.

Economic potential. An estimate of energy savings based on the assumption that all energy efficient options will be adopted and all existing equipment will be replaced with the most efficient whenever it is cost-effective to do so, without regard to market acceptance.

Economizer cycle. An automatic control strategy which readjusts outside air to take advantage of cooling effect which may be available there. Can be controlled either by temperature alone (temperature control) or by temperature and humidity (enthalpy control).

Edison Electric Institute (EEI). The association of electric companies. Organized in 1933 and incorporated in 1970, EEI provides a principal forum where electric utility staff exchange information on developments in their business, and maintain liaison between the industry and the federal government. Its officers act as spokesmen for investor-owned electric utility companies on subjects of national interest.

EER - energy efficiency ratio. The ratio of net cooling capacity in Btu/hour to total electric input in watts under designated operating condition. The EER is typically used to measure the efficiency of room air conditioners. The EER is equal to the COP times 3.412 (the number of Btus in a watt).

EF - Energy Factor. A measure of the efficiency of water heaters, it expresses the ratio of daily heat delivered to daily heat input during a year under specified conditions.

Effect, chimney. Tendency of air or gas in a duct or other vertical passage to rise when heated due to its lower density compared to that of the surrounding air or gas; in buildings, tendency toward displacement (caused by the difference in temperature) of internal heated air by unheated outside air due to the difference in density of outside and inside air.

Effect, dehumidifying. Heat removed in reducing the moisture content of air, passing through a dehumidifier, from its entering to its leaving condition.

Effect, heating, compressor (heat pump). RAte of heat delivery by the refrigerant assigned to the compressor in a heat pump system. This equals the product of the mass rate of refrigerant flow produced by the compressor and the difference in specific enthalpies of the refrigerant vapor at thermodynamic state leaving the compressor and saturated liquid refrigerant at the pressure of vapor leaving the compressor.

Effect, humidifying. Latent heat of water vaporization at the average evaporating temperature times the number of pounds of water evaporated per hour in Btuh.

Effect, refrigerating. Rate of heat removal by a refrigerant in a refrigerating system. This equals the product of the mass rate of refrigerant flow in the system and the difference in specific enthalpies of the refrigerant at two designated points in the system or two designated thermodynamic states of the refrigerant. The term refrigerating effect is used to denote heat transfer to or from the refrigerant itself in a refrigeration system, whereas refrigerating capacity denotes the rate of heat removal from a medium or space to be cooled.

Effect, refrigerating, compressor. Rate of heat removal by the refrigerant assigned to the compressor in a refrigerating system. This equals the product of the mass rate of refrigerant flow produced by the compressor and the difference in specific enthalpies of the refrigerant vapor at its thermodynamic state entering the compressor and refrigerant liquid at saturation temperature corresponding to the pressure of the vapor leaving the compressor.

Effect, refrigerating, condensing unit. Rate of heat removal by the refrigerant assigned to the condensing unit in a refrigerating system. This equals the product of the mass rate of refrigerant flow produced by the condensing unit and the difference in the specific enthalpies of the refrigerant vapor entering the unit and the refrigerant liquid leaving the unit.

Effect, total cooling. Difference between the total enthalpy of the dry air and water vapor mixture entering a unit per hour and the total enthalpy of the dry air and water vapor (and water) mixture leaving the unit per hour, in watt (Btuh).

Efficacy. The ratio of light from a lamp to the electrical power used, expressed in lumens per watt (LW).

Efficiency. The amount of energy serv ice delivered by a machine per unit of energy input. For example, if a 400-watt electric motor delivers only 280 watts f mechanical drive power, it has an efficiency of 280/400 = 70%. Under the first law of thermodynamics, this efficiency cannot exceed 100%. The concept is quite general and is not limited to mechanical systems. For example, the efficiency of a light bulb (called its efficacy) may be expressed in the amount of illumination (lumens) delivered per watt of electric power.

The above description is valid under the first law of thermodynamics. Sometimes, an alternative concept based on the second law of thermodynamics is used. This second concept defines efficiency as the ratio of the theoretical minimum energy that is required to accomplish a given task to the energy actually consumes. In using the second law efficiency concept, energy consumption must be measured in units that reflect the quality of the energy involved.

The difference between the first-law and the second-law efficiencies can be illustrated by a concrete examples, provided in Goldemberg et al. (1988). Consider space heating, in which an amount of heat Q is delivered to a building at 30°C by a gas furnace with a first-law efficiency of 60%. The minimum amount of available work W required to provide this heat is that which is required to run an ideal heat pump. If the outdoor temperature is 4°C, then an ideal heat pump would provide Q=12 units of heat for each unit of electricity consumed. If F is the amount of fuel actually consumes by the furnace, then the second-law efficiency is:

$$W/F = (W/Q) \times (Q/F) = (1/12) \times (0.6) = 0.05$$

Thus, while the first law efficiency for a gas furnace (60%) gives the misleading impression that only a modest improvement is possible, the second-law efficiency (5%) correctly indicates a twenty-fold maximum potential gain in theory.

Efficient technologies. State-of-the-art commercially available appliances, equipment, building-shell measures, or industrial processes that improve the end-use efficiency of electricity relative to the existing stock of appliances, equipment, measures, and processes.

Electric central furnace. A furnace designed to supply heat through a system of ducts with air as the heating medium, in which heat is generated by one or more electric resistance heating elements and the heated air is circulated by means of a fan or blower.

Electric clothes dryer. A cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is electricity and the drum and blower(s) are driven by an electric motor(s).

Electric heater. An electric appliance in which heat is generated from electrical energy and dissipated by convection and radiation and includes baseboard electric heater, ceiling electric heaters, floor electric heaters, portable electric heaters, and wall electric heaters.

Electric Power Research Institute (EPRI). Founded in 1972 by the nation's electric utilities to develop and manage a technology program for improving electric power production, distribution and utilization.

Electric refrigerator. A cabinet designed for the refrigerated storage of food at temperatures above 32°F and having a source of refrigeration requiring single phase, alternating current electric energy input only. An electric refrigerator may include a compartment for the freezing and storage of food at temperatures below 32°F, but does not provide a separate low temperature compartment designed for the freezing and storage of food at temperatures below 8°F.

Electric refrigerator-freezer. A cabinet which consists of two or more compartments with at least one of the compartment designed for the refrigerated storage of food at temperatures above 32°F and with at least one of the compartments designed for the freezing and storage of food at temperatures below 8°F, which may be adjusted by the user to a temperature of 0°F or below. The source of refrigeration requires single phase, alternating current electric energy input only.

Electric space heating. Space heating of a dwelling or business establishment or other structure using permanently installed electric heating as the principal source of space heating throughout the entire premises.

Electrification. The term describing emerging electric technologies such as electric vehicles, industrial process heating, and automation. These technologies have the potential for increasing the productivity, contributing to strategic load growth, or facilitating strategic conservation, peak clipping or load shifting. Examples include robotics and industry automation, microwave heating and drain, and freeze concentration of solutions.

Eligibility criteria. Standards that describe the customers who can participate in a utility's DSM program.

Eligible market. The subset of the total market that is allowed to participate in a program based on eligibility criteria.

End-use metering. End-use load are directly measured before and after installation of efficiency measures to identify associated changes.

Energy. The ability or capacity to do work. Energy can be categorized in either stored or transient forms. Stored forms of energy include thermal energy, potential energy, kinetic energy, chemical energy, and nuclear energy. Transient forms include heat and work, mechanical or flow.

Electric energy, measured in kilowatt hours (kWh) is the time-integral of power. In the FPS system, energy is measured in British thermal units (Btu) or foot-pounds.

Energy audit. A review of the customer's electricity and/or gas usage often including recommendations to alter the customer's electric demand or reduce energy usage. An audit usually includes a visit to the customer's facility.

Energy conservation. Refers to the steps that can be taken to reduce energy consumption. It includes encouraging customers to invest in capital improvements (as with improved home insulation or more energy-efficient appliances) and changing energy consumption behavior (e.g., thermostat setback). It is measured by kilowatthours or Btus of energy savings in the past or energy savings potential expected in the future.

Energy costs. Costs, such as fuel, that are related to and vary with energy production or consumption. Energy Efficiency Ratio (EER). A figure of merit of air conditioning or refrigeration performance. The relative efficiency of an appliance in converting primary energy (e.g., electricity) to useful work (such as for cooling in the case of air conditioners) at the rated condition. EER (Btu/kWh) is the Btu per hour output provided by the unit, divided by the watts of electrical power input. The larger the EER, the more efficient the unit.

Energy effects. The changes in aggregate electricity use (kWh/Yr) for customers that participate in a utility DSM program.

Energy Efficiency Program. DSM program aimed at reducing overall electricity consumption (kWh), often without regard for the timing of the program induced savings. Such savings are generally achieved by substituting technically more efficient equipment to produce the same level of end-use services with less electricity.

Energy, electric. As commonly used in the electric utility industry, electric energy means kilowatthours.

Off-Peak Energy supplied during periods of relatively low system demands as specified by the supplier.

On-Peak Energy supplied during periods of relatively low system demands as specified by the supplier.

Primary Energy available from firm power.

Secondary Energy available from non-firm power.

Surplus Energy generated that is beyond the immediate needs of the producing system. This energy is frequently obtained from spinning reserve and sold on an interruptible basis.

Energy management. That part of electric power utility system operation that plans, coordinates, and controls power supply, transmission, distribution, and utilization. Coordination is maintained by management of a power grid of which the utility may be a member, and by effective management within the utility system.

nergy productivity. Refers to the productivity of energy as a factor of production and includes the level f economic value produced per unit of energy input. Energy productivity improvements occur when xisting energy services (e.g., lighting, heating, cooling, motor drive) are made more efficient and when iew, energy-using technologies boost economic efficiency (e.g., telecommunications, iutomation/robotics, information processing).

Engine. A device that transforms energy, especially heat energy, into mechanical work. Among the prime movers, those in which the power originates in a piston and cylinder are classed as engines, while those with purely rotative motion are known as turbines.

Engineering calculations. Calculations of expected changes in energy and loads based on specification of technical performance or efficiency measures and assumptions about operating patterns and conditions. Methods range from simple formulas to complex thermal load simulations.

Enthalpy. A thermodynamic property of a substance defined as the sum of its internal energy plus the quantity Pv/J, where P = pressure of the substance, v = its volume, and J = the mechanical equivalent of heat. Formerly called by the obsolescent names total heat and heat content.

Entropy. A measure of the capacity of a system to undergo spontaneous change, thermodynamically specified by the relationship $dS = dQ/T$, where dS is an infinitesimal change in the measure for a system absorbing an infinitesimal quantity of heat (dQ) at absolute temperature (T).

Environmental Protection Agency (EPA). A federal agency created in 1970 to permit coordinated and effective governmental action for protection of the environment by the systematic abatement and control of pollution through integration of research monitoring, standard setting, and enforcement activities.

Equipment Cost. The cost of equipment the utility purchases directory for a DSM program.

Erg. A very small unit of energy in the metric system. One erg equals approximately 9.5 x 10-11 Btu.

Evaluation. Systematic measurement of the performance of DSM programs.

Evaporator. A heat exchanger which adds heat to a liquid, changing it to a gaseous state (in a refrigeration system it is the component that absorbs heat).

Exhaust. The air deliberately removed from a room, by a fan or otherwise, usually used to eject air contaminants near the source.

Existing buildings. All buildings that are in operation as of the beginning of the current program year.

Expensed. Costs that are treated as current expenses rather than as capital costs; the utility cannot earn a return on expensed costs.

Experiments. Small scale efforts intended to test various concepts and collect information associated with a future DSM program.

Exterior zones. The portions of the building with significant amounts of exterior wall, windows, roofs or exposed floors. Such zones have heating or cooling needs largely dependent upon weather conditions.

Fan Inlet (Vortex) Damper. An air valve placed on the inlet to a fan used to modulate the amount of air, expressed in cubic feet per minute (CFM), delivered by the fan.

Fixed costs. Costs that do not vary with the number of DSM program participants.

Fixture. A complete lighting unit, including one or more lamps and a means for connection to a power source. Many fixtures also include one or more ballasts, and elements to position and protect lamps and distribute their light.

Flexible load shape. Designed to achieve a load shape composed of various components with varying degrees of reliability. In exchange for accepting a lower level of reliability, a customer is typically offered some incentive. A flexible load shape may be achieved through such measures as interruptible loads, pooled or integrated energy management systems, or individual customer load control devices imposing service constraints.

Flue. A passage or channel through which the products of combustion of a domestic fire, boiler, or other furnace are taken to the chimney.

Fluorescent lamp (tube). A low-pressure mercury electric-discharge lamp in which a fluorescing coating of phosphor transforms ultraviolet energy into visible light.

Footcandle. A unit of luminance. One footcandle equals 1 lumen per square foot.

Forced-air furnace. A warm-air furnace equipped with a blower to circulate the air through the furnace and ductwork.

FPS. The British system of units and measurements based on the foot-pound-second system.

Free driver. A customer who takes the same conservation actions as those customers who participated in a utility program, without participating in the program.

Free rider. A customer who receives the benefits of participating in a utility program who would have taken the same conservation actions even if there were no program.

Free service. An incentive in the form of assistance offered by utilities, such as energy audits and maintenance of equipment such as refrigerator or air conditioner tune-up programs.

Freezer. A cabinet designed as a unit for the freezing and storage of food at temperatures of 0°F or below, and having a source of refrigeration requiring single phase, alternating current electric energy input only.

Fuel substitution. The conversion of an end-use from one fuel source to another. For example, replacing an electric hot water heater with a gas fired unit.

Full Scale Program. Programs that are available to all eligible customers within the utility's service area.

Furnace. A device utilizing only single-phase electric current, or single-phase electric current or millivoltage DC current in conjunction with either natural gas, propane, or home heating oil, which is designed to be the principal heating source for the living space of a residence and which is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btus per hour. Every furnace is either an electric central furnace, electric boiler, forced-air central furnace, gravity central furnace, or low pressure steam or hot water boiler. The heat input rate of a furnace is less than 300,000 Btus per hour for electric boilers and low pressure steam or hot water boilers, and is less than 225,000 Btus per hour for forced-air central furnaces, gravity central furnaces, and electric central furnaces.

Gas clothes dryer. A cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is gas and the drum and blower(s) are driven by an electric motor(s).

General Information Programs. A utility's efforts to inform customers about DSM options through such mechanisms as brochures, bill stuffers, TV and radio ads, and workshops.

Gigawatt (GW). One gigawatt equals 1 billion watts, 1 million kilowatts or 1 thousand megawatts.

Gigawatt hour (GWh). One gigawatt hour equals one billion watt hours.

Gross participation. The total number of customers who participated in the program and the measures that they adopted under it. For purposes of comparison, it is often useful to state this in terms of a rate.

Gross program savings. The difference between a customers energy consumption before and after participating in a utility program.

Gross square feet of conditioned floor area. The sum of the enclosed areas of conditioned space on all floors of the building, including basements, mezzanines, and intermediate floor tiers and penthouses, measured from the exterior faces of exterior walls and the centerline of walls separating conditioned and unconditioned spaces of the building.

Heat. The form of energy that is transferred by virtue of a temperature difference.

Heat engine. A mechanism for converting heat energy into mechanical energy, for example, an internal-combustion engine.

Heat exchanger. A device specifically designed to transfer heat between two physically separated fluids.

Heat gain. As applied to HVAC calculations, it is that amount of heat gained by a space from all sources, including people, lights, machines, sunshine, etc. The total heat gain represents the amount of heat that must be removed from a space to maintain indoor comfort conditions.

Heat, latent. Change of enthalpy during a change of state, usually expressed in j/kg (Btu per lb.). With pure substances, latent heat is absorbed or rejected at constant temperature at any pressure.

Heat loss. The sum cooling effect of the building structure when the outdoor temperature is lower than the desired indoor temperature. It represents the amount of heat that must be provided to a space to maintain indoor comfort conditions.

Heat pipe. A heat pipe is sealed, static tube in which a refrigerant transfers heat from one end of the device to the opposite end. The device is installed through adjacent walls of inlet and exhaust ducts, with their opposite ends projecting into each air stream. A temperature difference between the ends of the pipe causes the refrigerant to migrate by capillary action to the warmer end where it evaporates and absorbs heat. It then returns to the cooler end, condenses, and gives up the heat.

Heat pump. An air conditioning unit that reverses itself. By means of a compressor and reversing valve system, a heat-transfer liquid is pumped between the indoor and outdoor units, moving that heat into a building during cold weather and out of it during warm weather.

Heat Pump. A refrigeration machine which is arranged to either heat or cool a building by using heat from the condenser section or by using cooling from the evaporator section.

Heat pump, cooling and heating. A refrigeration system designed to utilize alternately or simultaneously the heat extracted at a low temperature and the heat rejected at a higher temperature for cooling and heating functions respectively.

Heat, sensible. Heat which is associated with a change in temperature; specific heat exchange of temperature; in contrast to a heat interchange in which a change of state (latent heat) occurs.

Heat transfer. Heat can be transferred by three different methods: conduction, convection, and radiation. In conduction, the heat must diffuse through solid materials or through stagnant fluids. According to Fourier's law, the amount of heat transferred through conduction is determined by the area perpendicular to the heat flow, the thickness of the material through which the heat flow is occurring, the conductivity of the material, and the temperature differential between the two materials.

In convection, heat transfer occurs through a carrying medium that travels from the hot to cold regions. Usually, this carrying medium is a fluid in steady motion.

In radiation, heat is transferee by means of radiant wave energy.

Heating-degree day. The difference between the mean temperature of any day and a base temperature when the median temperature is less than the base temperature, with each degree below that temperature equaling one heating-degree day. For example, if the median temperature for a specific day is 35°F and the base is 50°F, 15 heating-degree days to base 50°F would be accrued.

Heating system, high-pressure steam. A steam heating system employing steam at pressures above 15 psig.

Heating system, high-temperature water. A heating system in which water having supply temperatures above 350°F is used as a medium to convey heat from a central boiler, through a piping system, to suitable heat-distributing means.

Heating system, hot water. A heating system in which water having supply temperatures less than 250°F is used as medium to convey heat form a central boiler, through a piping system, to suitable heat-distributing means.

Heating system, low-pressure steam. A steam heating system employing steam at pressures between 0 and 15 psig.

Heating system, medium-temperature water. A heating system in which water having supply temperatures between 250°F and 350°F is used as a medium to convey heat from a central boiler, through a piping system, to suitable heat-distributing means.

Heating system, steam. A heating system in which heat is transferred from the boiler or other source of heat to the heating units by means of steam at, above, or below atmospheric pressure.

Hertz. The number of cycles of alternating current per second, such as 60 Hz.

HID - High Intensity Discharge. High intensity discharge lighting, including mercury vapor, metal halide, and high-pressure sodium light sources.

Horsepower. A unit of power equaling 746 watts, 42.44 Btu/minute, or 550 foot-pounds of work per seconds.

Hot air furnace. A heating unit enclosed in a casing from which warm air is circulated through the building in ducts by gravity convection or by fans.

Household. A person or group of people sharing a dwelling unit.

HP. Horsepower

HPS - High-Pressure Sodium lamp. A high-intensity discharge lamp in which light is produced from sodium gas operating at a partial pressure of about 1.33 x 104 Pa (100 torr). Clear and diffuse-coated lamps are included.

HSPF - Heating Seasonal Performance Factor. Combines the effects of heat pump heating - under a range of weather conditions assumed to be typical of the location or region - with performance losses due to coil frost, defrost, cycling under part-load conditions, and use of supplemental resistance heat during defrost. As such, it is a measure of "dynamic" rather than steady-state performance.
The HSPF is defined as:

$$HSPF = \frac{\text{Total heating provided during season, in Btu}}{\text{Total energy consumed by the system, in watthours}}$$

Computation of the HSPF requires specification of the building heating load as well as the outdoor temperature distribution for the location. These specifications very from building to building and location to location.

Humidifier. A consumer product designed to add moisture into the conditioned air, and which falls into one of the following classes: a central system humidifier or room humidifier.

Humidistat. An instrument which measures humidity and controls a device(s) for maintaining a desired humidity.

Humidity. The water vapor content of the air; may be expressed as specific humidity, relative humidity, absolute humidity, saturation coefficient, or mixing ratio.

Humidity, relative. The ratio of the mole fraction of water vapor present in the air to the mole fraction of water vapor present in saturated air at the same temperature and barometric pressure. Approximately, it equals the ratio of the partial pressure or density of the water vapor in the air to the saturation pressure or density, respectively, of water vapor a the same temperature.

HVAC. Heating, Ventilation, and Air Conditioning.

HVAC system. A system that provides either collectively or individually the processes of comfort heating, ventilation and/or cooling within or associated with a building.

Illuminance. Lighting level, measure in footcandles or lux.

Impact evaluation. Examines the effects of a program, including quantitative documentation of a program's costs and benefits, program participation and measure adoption, performance of DSM technologies, and energy and load impacts.

Incandescence. The self-emission of light energy in the visible spectrum due to the thermal excitation of atoms or molecules.

Incandescent filament (bulb). A lamp in which light is produced by a filament heated to incandescence by an electric current.

Incentive. An award offered to encourage participation in a DSM program and adoption of recommended measures.

Incentive program. Awards (either cash or non-cash) to customers, trade allies, or employees to encourage participation in a DSM program and adoption of recommended measures.

Incentive rate. Some form of reduced commercial or industrial rate generally designed to provide an incentive for targeted businesses to remain in the utility's service territory or to promote business expansion in an economically depressed area of the utility's service territory. Some rates are also targeted at businesses experiencing severe financial difficulties. The rates are usually offered to customer for a fixed period of time.

Incremental cost. The difference in costs, particularly between that of an efficient technology or measure and the alternative standard technology; in some early retirements and retrofits, the full cost of the efficient technology is the incremental cost.

Incremental participation. The number of annual participants in the current year minus the annual participants in the previous year.

Induction. The entrainment of room air by the jet action of a primary air stream discharging from an air outlet.

Induction unit, room air. A factory-made assembly consisting of a cooling coil, or cooling and heating coil, and means for delivering preconditioned air (received under pressure from an external source), mixed with recirculated air by the air-induction process, to the space being conditioned. This device is normally designed for free delivery of air into the space.

Industrial sector. The group of nonresidential customers that provide products, including agriculture, construction, mining,and manufacturing.

Infiltration. The uncontrolled inward air leakage through cracks and joints in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

Innovative Rate. A rate schedule with rats above or below the associated costs of providing service to the customer. A promotional rate establishes a pricing level which permits sales to be made which otherwise would not occur.

Insolation. Solar radiation which is delivered to any place on the surface of the earth directly from the sun; the rate of such radiation per unit of surface.

Instantaneous Technical Potential. An estimate of energy savings based on the assumption that all existing appliances,equipment, building-shell measures, and industrial processes are instantly replaced with the most efficient commercially available units.

Insulation. Any material that provides a high resistance to the flow of heat from one surface to another. The different types include blanket or batt, foam, loose fill, or reflective insulation.

Integrated Engineering Statistical Analysis. Engineering-based estimates are used as explanatory variables in regression analysis of whole customer loads. Parameters verify reasonableness of engineering estimates or identify systematic biases.

Integrated Resource Planning. How much utilities can rely on DSM programs to mitigate need for new supply resources.

Intelligent duty cyclers. Devices containing both microcomputer-based and radio receiver control subcomponents for inhibiting the operation of air conditioning equipment based on sit-specific conditions. The intelligent cycler monitors the on- and off-cycle time intervals of a specific air conditioner under normal, pre-control operation and stores these times in memory. When the device receives a signal to exercise control, it does not allow the on-time to exceed or the off-time to drop below those times stored in memory. The utility may also opt to further reduce load by ordering the device to reduce the on-time by some percentage of the stored on-time.

Interactions of measure adoption. Propensity of customers to purchase certain combinations of measures. For example, customers buy electronic ballast and efficient lamps. This affects the savings from each measure.

Interactive effects. The effect that a change in one end-use's energy consumption has on another end-use's energy consumption. For example, replacing incandescent lamps with compact fluorescents causes a reduction in cooling load.

Interior zones. The portions of the building which do not have significant amounts of exterior surfaces. Such zones have heating or cooling needs (usually cooling only) largely dependent upon internal loads such as lights.

Interruptible electric power. Power made available under agreements which permit curtailment or cessation of delivery by the supplier.

Isentropic. An adjective describing a reversible adiabatic process; a change taking place at constant entropy.

Isothermal. An adjective used to indicate a change taking place at constant temperature.
joule. A unit of energy in the MKS system. One joule equals one watt-second or .738 foot-pounds.

Lamp. A light source, commonly called a bulb or tube.

Latent heat. The quantity of heat required to produce a change in state (e.g., from solid to liquid) at an unchanging temperature level.

LCP - Least -Cost Planning. A utility planning method whereby alternative resource mixes, including demand-side options such as conservation and load management, are evaluated along with traditional supply-side options to determine which of them minimizes the overall cost of service. Cost management is used as the criterion for selecting the resource plan for the utility company.

Lighting area. A room defined by walls and partitions, or an area where a definite usage is planned and is different from the surrounding areas. If more than 75% of perimeter is enclosed (floor-to-ceiling), it must be treated as a separate lighting area under Division 9 of the Standards.

Line losses. Kilowatthours and kilowatts lost in the transmission and distribution lines under specified conditions.

Load Building Programs. A program with the objective of increasing electricity consumption, generally without regard to the timing of the increase.

Load displacement. The increment of customer load measured in megawatts (MW) that is removed from the total customer load served by the utility and is alternatively served by some form of customer electric power generation. Load displacement projects are covered under the companion Non-utility Generator's solicitation.

Load factor. The ratio of the average load in kilowatts supplied, during a designated period, to the peak load occurring during that period.

$$\textit{Load Factor} = \frac{\textit{kWh Supplied in Period}}{\textit{Peak kW in Period x Hours in Period}}$$

Load factor is a measure of efficiency. 100% efficiency would require the continuous use of a given amount of load for every hour of the month.

Load factor. The ratio of the average load in kilowatts supplied during a designated period to the peak or maximum load in kilowatts occurring in that period. Load factor, in percent, also may be derived by multiplying the kilowatthours in the period by 100 and dividing by the product of the maximum demand in kilowatts and the number of hours in the period.

Load forecasts. Predicted demand for electric power. A load forecast may be short-term (e.g., 15 minutes) for system operation purposes, long-term (e.g., 5 to 20 years) for generation planning purposes, or for any range in between. Load forecasts may include peak demand (kW), energy (kWh), reactive power (kVAR), and/or load profile. Forecasts may be made of total system load, transmission load, substation/feeder load, individual customers' loads, and/or appliance loads.

Load management. Economic reduction of electric energy demand during a utility's peak generating periods. Load management differs from conservation in that load management strategies are designed to either reduce or shift demand from on-peak to off-peak times, while conservation strategies may primarily reduce usage over the entire 24-hour period. Motivations for initiating load management include the reduction of capital expenditure, circumvention of capacity limitations, provision for economic dispatch, cost of service reduction, system efficiency improvements, or system reliability improvements. Actions may take the form of normal or emergency procedures. Many utilities encourage load management by offering customers a choice of service options with various price incentives.

Load research. The systematic gathering, recording, and analyzing of data describing utility customers' patterns of energy usage. Types of load research include aggregate load research whereby total electricity usage of a representative sample of customers is recorded and analyzed, end-use load research whereby the energy use of customers' specific end-use equipment is measured and analyzed, and rate load research whereby daily, monthly, and/or seasonal energy use of a sample of customers is used to develop class load profiles.

Load shape. The time-of-use pattern of customer electricity use, generally a 24-hour pattern or an annual (8760-hour) pattern.

Load shape effects. The estimated changes in energy use at specific times during the year. The time periods usually are the same as those of which avoided costs are calculated.

Load shedding. The turning off of electrical loads to limit peak electrical demand.

Load shifting. Involves shifting load from peak to off-peak periods. Popular applications include use of storage water heating, storage space heating, cool storage, and customer load shifts to take advantage of time-of-use or other special rates.

Loss of load probability. A measure of the probability that system demand will exceed capacity during a given period.

Louver. A series of baffles arranged in a geometric pattern that shields a lamp from view at certain angles in order to avoid glare from the bare lamp.

Low-pressure sodium lamp. A discharge lamp in which light is produced form sodium gas operating at a partial pressure of 0.13 to 1.3 Pa (10-3 to 10-2 torr).

Lumen (lm). SI unit of luminous flux. Radiometrically, it is determined from the radiant power. Photometrically, it is the luminous flux emitted within a unit solid angle (one steradian) by a point source having a uniform luminous intensity of one candela.

Luminaire. A complete lighting unit consisting of a lamp, or lamps, together with parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.

Lux (lx). A quantitative unit for measuring illuminance; the illumination on a surface of one meter square, on which there is a uniformly distributed flux of one lumen.

Market potential. An estimate of energy savings that adjusts the economic potential for the likely acceptance of various actions by customers.

Market research. The systematic gathering, recording, and analysis of data about problems relating to the marketing of goods and services. Also called marketing research, it refers to the process of developing information and analyses about customers. Market research includes various subsidiary types of research such as market analysis (a study of the size, location, nature, and characteristics of a specified market), consumer research (a study of consumer attitudes, behavior, reactions, and preferences for goods or services), sales analysis (a study of sales data), and advertising research (a study of the effectiveness of the advertising of goods and services).

Marketing Costs. All costs directly associated with the preparation and implementation of the strategies designed to encourage participation in a program.

Mass. The quantity of matter in a body as measured by the ratio of the force required to produce a unit acceleration to the acceleration.

MCF. One thousand cubic feet of natural gas containing a heat content of 1,000,000 Btu or ten therms (called dekatherm).

Measures. Actions taken by a customer to improve the efficiency or modify the timing of electricity use.

Medium, heating. A solid or fluid, such as water, steam, air or flue gas, used to convey heat from a boiler, furnace, or other heat source, and to deliver it, directly or through a suitable heating device, to a substance or space being heated.

Medium, refrigerating. A solid or fluid, such as a refrigerant, ice, dry ice, or brine, used to absorb heat, either directly or through a suitable refrigerating device, to a substance or space being heated.

Mercury lamp. A high-intensity discharge (HID) lamp in which the major portion of the light is produced by mercury operating at a partial pressure in excess of 1.013 x 105 Pa (1 atmosphere). Includes clear, phosphor coated, and self-ballasted lamps.

Metal halide lamp. A high-intensity discharge (HID) lamp in which the major portion of the light is produce d from metal halides and their products of dissociation - possibly in combination with metallic gases such as mercury. Includes clear and phosphor coated lamps.

Mixing box. A box containing dampers in the hot or cold air stream, mixing the two and delivering the air to a space at a specified temperature.

MKS - Meter-Kilogram-Second. The metric system of units and measurements using meter-kilogram-second.

Monitoring and evaluation costs. The expenditures associated with the collection and analysis of data used to assess program operation and effects.

Multi-zone system. An air conditioning system which functions like a dual duct system, but the mixing takes place at the air handler. A separate duct, carrying air at the correct temperature, goes to each zone.

Net program savings. The estimation of a program's energy and demand savings which are directly attributable to the program.

New construction. New buildings and facilities that are constructed during the current year.

New Construction Program. Programs that affect the design and construction of new residential and commercial buildings and manufacturing facilities; such programs may also include major renovations of existing facilities.

New participants. Customers who participate in a program during the current year and did not participate in the program during the previous year.

Non-cash incentives. Incentives in the form other than rebate or cash payment; may include low-interest loans, reduced equipment costs, bill credits or discounts, merchandise or free services.

Non-coincident demand. Maximum demand of a customer, or customer class, regardless of when it occurs. Generally the non-coincident demand is used as the basis for calculating the demand charge.

Non-coincident maximum demand. Maximum demand of a customer, or customer class, regardless of when it occurs. Generally, the non-coincident maximum demand is used as the basis fore calculating the demand charge.

Non-utility costs. Expenses incurred by customers and trade allies, associated with participation in a DSM program, that are not reimbursed by the utility.

Normal replacement. Replacement of worn-out (and perhaps obsolete) equipment.

Ohm's law. In a given circuit, the amount of current in amperes is equal to the pressure in volts divided by the resistance in Ohms.

$$Current = \frac{(Pressure)\ Volts}{(Resistance)\ Ohms}$$

Operating and maintenance costs. Non-capital, equipment-related costs that continue over the life of the equipment; include fuel costs as well as costs for maintaining and servicing equipment.

Partial participants. Customers who have installed only some of the DSM program measures recommended for their facility.

Participant. The units used by a utility to measure participation in its DSM programs. Such units include customers or households for residential programs, and customers, floor area, or kW-connected for commercial and industrial customers.

Participant costs. Costs associated with participation in a DSM program paid by the customer and not reimbursed by the utility.

Payback. The time period, usually expressed in years, for a conservation investment's cost to equal its energy savings.

Payback period. The time required for the cumulative operational savings of an option (or equipment) to equal the investment cost of that option.

Peak Load. The maximum electrical or thermal load reached during an arbitrary period of time.

Perfluorocarbon Tracer Technology. The use of tracer elements to measure the air infiltration rates within residential and commercial buildings. A number of tracers and capillary absorption tubes are placed within the facility. Natural air infiltration forces the migration of tracers to the capillary absorption tubes. After a set period of time the capillary absorption tubes are analyzed using a gas chromatograph. The level of tracer found within the capillary absorption tube is indicative of the buildings air infiltration rate.

Performance factor. The ratio of the useful output capacity of a system to the input required to obtain it. Units of capacity and input need not be consistent.

Plenum. In suspended ceiling construction, the space between the suspended ceiling and the main structure above. Can serve as a distribution area for heating or cooling systems.

Power. The time-rate at which work is performed, measured in Watts or British thermal units per hour (Btu/hr). Electric power is the product of electric current and electromotive force. In a DC circuit, the current measured in amperes is multiplied by the voltage between the wires to obtain watts. In an AC circuit, since the current and voltage may be out of phase power, also enters the calculation.

Power factor. The ratio of actual power being used in a circuit, expressed in watts or kilowatts (kW), to the power which is apparently being drawn from the line, expressed in voltamperes or kilovoltamperes.

Process evaluation. An independent review of a program's design, delivery and implementation.

Properties, thermodynamic. Basic qualities used in defining the condition of a substance, such as temperature, pressure, volume, enthalpy, entropy.

Psi. Pounds per square inch.

Psig. Pounds per square inch gauge. Measurement of pressure relative to pressure of the surroundings.

Psychrometer. Instrument for measuring relative humidities by means of wet- and dry-bulb temperatures.

Psychrometry. The branch of physics relating to the measurement or determination of atmospheric conditions, particularly regarding the moisture mixed with the air.

R-value. A measure of thermal resistance, equal to the reciprocal of the U-value (measure of thermal conductance). It has units of Fahrenheit degrees times hours times square feet per Btu.

Radiant heating system. A system for heating a room or space by means heated surfaces (such as coils of electricity, hot water, or steam pipes embedded in floors, ceiling, or walls) that provide heat primarily by radiation.

Radiation, thermal (heat). The transmission of energy by means of electromagnetic waves of very long wavelength. Radiant energy of any wavelength may, when absorbed, become thermal energy and result in an increase in the temperature of the absorbing body.

Radiator. A heating unit exposed to view within the room or space to be heated. A radiator transfers heat by radiation to objects within visible range and, by conduction, to the surrounding air which in turn is circulated by natural convection. So-called radiator is also a convector, but he term "radiator" has been established by long usage.

Rebate Program. A conservation or load management program where the utility offers a financial incentive for the installation of energy efficient equipment. Rebates can be offered to customers, installers, or dealers. Rebates are typically either per equipment ($/lamp) or energy/demand based ($/kWh or $/kW).

Recovery capacity. The quantity of water that a water heating system can heat from supply temperature to required temperature in one hour. Expressed in gallons per hour.

Reflectance. The ratio of the light reflected by a surface or medium to the light incident on it.

Reflector. A device used to direct the light from a source by the process of reflection.

Refrigerant. The fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the fluid.

Refrigerating system, absorption-type. A refrigerating system in which refrigeration is effected by evaporating a refrigerant in a heat exchanger (evaporator), resulting vapor then being absorbed by an absorbent medium from which it is subsequently expelled by heating at a higher partial vapor pressure and condensed by cooling in another heat exchanger (condenser).

Refrigerating system, compression-type. A refrigerating system in which the temperature and pressure of gaseous refrigerant are increased by a mechanically operated component. In most cases, the refrigerant undergoes changes of state in the system.

Refrigerating system, direct-expansion. A refrigerating system in which the evaporator is in direct contact with the refrigerated material or space or is located in air-circulating passages communicating with such spaces.

Refrigerating system, mechanical. A refrigerating system employing a mechanical compression device to remove the low pressure refrigerant enclosed in the low pressure side and deliver it to the high pressure side of the system.

Refrigerating system, single-package. A complete factory-made and factory-tested refrigerating system in a suitable frame or enclosure which is fabricated and shipped in one or more sections and in which no refrigerant-containing parts are connected in the field.

Refrigeration cycle. A repetitive thermodynamic process in which a refrigerant absorbs heat from a controlled space at a lower temperature and rejects it elsewhere at a higher temperature. The cycle operates by using power input from an external source. The amount of heat rejected is greater than that taken in by the amount of work required to effect the cycle.

Refrigerator, commercial. A general category referring to any of the many types of refrigerators used commercially. Includes reach-ins, walk-ins, refrigerated display cases, both service and self-service, of all types which are used by business establishments.

Reheat. Adjustment of the set point of a control instrument to a higher or lower value automatically or manually to conserve energy.

Relative humidity. The ratio of water vapor in the air, expressed as a percentage of the maximum amount that the air could hold at the given temperature.

Retrofit. Modifications made to update existing equipment or structures.

Room air conditioner. A device that delivers conditioned air to an enclosed space without the use of ducts; usually mounted in a window or in an opening in a wall, or as a console. Includes a prime source of refrigeration and may include a means for ventilating and heating.

Secondary Measure Adoption. Any measures that customers adopt outside of the program as a direct result of the promotion and incentives. For example, a customer purchases lighting measures beyond the maximum number eligible for a rebate.

SEER - Seasonal Energy Efficiency Ratio. A measure of seasonal cooling efficiency under a range of weather conditions assumed to be typical of the location or DOE region in question, as well as of performance losses due to cycling under part-load operation. The SEER is defined as:

$$SEER = \frac{\text{Total cooling provided during cooling season, Btu}}{\text{Total energy consumed by the system, watthours}}$$

As in the case of the HSPF, the SEER is dependent on the cooling load of the specific building and outdoor temperature distribution, and is a measure of "dynamic" rather than steady-state performance.

SEER contrasts with EER, which measures an instantaneous value at design conditions.

Self selection. The difference between the control group and the participant group as revealed by the participants choosing to participate in a program and the control group choosing not to participate.

Sensible cooling load. The cooling load due to sensible heat gains.

Sensible heat. The heat added to or taken from a body when its temperature is changed.

Setback. The intended depression of the control point by means other than adjustment of the scale setting. An example is thermostat setback.

SIC. Standard Industrial Classification

Single-package air conditioner. A combination of apparatus for room cooling complete in one package; usually consists of compressor, evaporator, condenser, fan motor, and air filter. Requires connection to electric line. Also known as self-contained unit.

Snapback effect. The argument that by undertaking conservation actions, customers perceive a lower (relative) price for energy and, therefore, purchase more of the commodity in terms of comfort or appliance use.

Specular angle. The angle between the perpendicular to the surface and the reflected ray that is numerically equal to the angle of incidence and that lies in the same plane as the incident ray and the perpendicular, but on the opposite side of the perpendicular to the surface.

SPF - Seasonal Performances Factor. Ratio of the useful energy output of a device to the energy input, averaged over the entire heating season.

Split system air conditioner. A system consisting of two or more separate units incorporating the different functions of air conditioning.

Standby loss. The percentage of the total energy stored in the water which is lost each hour from a storage-type water heater.

Statistical analysis. Statistical analysis of whole customers energy or load data to infer changes in consumption associated with adoption of efficient technologies. Methods range from simple before/after comparisons between program treatment and control groups to applications of parametric statistical models (e.g., regression models).

Storm window or other protective window covering. An extra window or sash, usually placed on the outside of an existing window as additional protection against severe weather or to serve as an insulating factor for conversation. Included in this category are protective window coverings such as double-glazed glass, closable shutters, or plastic.

Strategic conservation. Achieved through utility-stimulated programs directed at reducing end/use consumption especially, but not only, during peak period. Not normally considered load management, the change reflects a modification of load shape involving a reduction in sales as well as a change in the pattern of use. In promoting energy conservation, the utility planner must consider what conservation actions would occur naturally and then evaluate the cost effectiveness of possible intended utility programs to accelerate or stimulate those actions.

Strategic load growth. The increase of end-use consumption during certain periods. The result is a general increase in energy sales beyond the valley filling (defined herein) strategy. Strategic load growth may involve increased market share of loads that are, or can be, served by competing fuels, as well as area development.

Summer peak. The greatest load on an electric system during any prescribed demand interval in the summer (or cooling) season, usually between June 1 and September 30.

Supply effects. The direct and indirect effects that the level of program funding has on participation patterns.

Synergism (or Synergistic Effect). A cooperative action of two substances that results in a greater effect than each of the substances could have had acting independently.

System efficiency, water heater. Ratio of the energy (in the form of heated water) delivered at fixtures to the energy supplied to the water at the heater. Losses of energy are due to radiation, convection, and conduction from storage tank and piping.

System, one-pipe. A piping system in which the fluid withdrawn from the supply main passes through a heating or cooling unit and returns to the same supply main.

System, two-pipe. A piping system in which the fluid withdrawn from the supply main passes through a heating or cooling unit to a separate return main.

Tankless water heater. Water heater containing little or no storage and heats water only as required.

Task lighting. Lighting directed to a specific surface, or area, that provides illumination for visual tasks.

Temperature, dry-bulb. The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation.

Temperature, wet-bulb. Thermodynamic wet-bulb temperature is the temperature at which liquid or solid water, by evaporating into air, bring the air to saturation adiabatically at the same temperature. Wet-bulb temperature (without qualification) is the temperature indicated by a wet-bulb psychrometer constructed and used according to specifications.

Therm. A unit of heat, typically associated with natural gas. One therm contains 100,000 Btu and, as there are 1,000 Btu per cubic foot, there are 100 cubic feet of gas per therm.

Thermal balance point. A point of outdoor temperature (e.g., 25°F) at which the heating capacity of a heat pump matches the heating requirements of the building which it heats.

Thermodynamics. The study of energy, its transformations, and its relation to states of matter.

Thermodynamics, laws of. Two laws from the basis of classical thermodynamic principals and underlie many of the efficiency concepts discussed elsewhere in this glossary. These laws have been stated in many different ways. *The first law:* (1) Energy is neither created nor destroyed. The sum of the energy entering a process (potential, kinetic, thermal, chemical, and electrical) must equal the sum of the energy leaving it, even though the proportions may change. This law implies that the efficiency of no energy conversion processes can exceed 100%. (2) When work is expended in generating heat, the quantity of heat produced is proportional to the work expended; and conversely, when heat is employed in the performance of work the quantity of heat which disappears is proportional to the work done (Joule); (3) If a system is caused to change from a initial state to a final state by adiabatic means only, the work done is the same for all adiabatic paths connecting the two states (Zemansky); (4) In any power cycle or refrigeration cycle the next heat absorbed by the working substance is exactly equal to the net work done. *The second law:* (1) It is impossible for a self-acting machine, unaided by any external agency, to convey heat from a body of lower temperature to one of higher temperature (Celsius); (2) It is impossible to derive mechanical work from heat taken from a body unless there is available a body of lower temperature into which the residue not so used may be discharged (Kelvin); (3) It is impossible to construct an engine that, operating in a cycle, will produce no effect other than the extraction of heat from reservoir and the performance of an equivalent amount of work (Zemansky).

Thermograph. An infrared scan that can be used to detect heat loss due to poor insulation.

Thermostat. An instrument which measures temperature and controls device(s) for maintaining a desired temperature.

Three phase. Three separate sources of alternating current so arranged that the peaks of voltage follow each other in a regular, repeating pattern.

Time-of-day pricing. A rate structure that prices electricity at different rates, reflecting the changes in the utility's costs of providing electricity at different times of the day. With time-of-day rates, higher prices are charged during the time when the electric system experiences its peak demand and marginal (incremental) costs are highest. Time-of-day rates price electricity closer to the cost of providing service, sending "better" price signals to customers than non time-of-day rates. These price signals encourage efficient consumption, conservation and shifting of load to times of lower system demand.

Time-of-season pricing. Pricing of service during seasons of the year based on the cost of supplying the service during those seasons.

Ton. A measure of useful space cooling and refrigeration capacity equaling 12,000 Btu per hour or 3516 watts. This denotes the heat absorbing capability of a ton of ice as it melts in one hour.

Tungsten-halogen lamp. A compact, incandescent filament lamp with its initial efficacy essentially maintained over the life of the lamp.

Turbine. A rotary engine actuated by the action or impulse or both of a current of fluid (e.g., water or steam) subject to pressure and usually made with a series of curved vanes on a central rotating spindle.

U-factor. The overall heat transmission coefficient, or quantity of heat in Btu transmitted per hour through one square foot of a building section (wall, roof, window, floor, etc) for each degree F of temperature difference between the air on the warm side and the air on the cold side of the building section.

U-value. A measure of thermal conductance expressed in Btu per hour/square feet/degrees F. It equals the reciprocal of R-value.

Unitary air conditioner. Equipment consisting of one or more factory fabricated assemblies designed to perform the functions of air moving, air cleaning, cooling, and dehumidification; the assemblies usually include a fan, an evaporator, or a cooling coil, and a compressor and condenser in combination; a heating unit may also be included.

Used and useful. A regulatory specification typically used to determine whether an item of "Plant" may be included in a utility's rate base.

Valley filling. The building of off-peak loads. Valley filling may be partially desirable where the long-run incremental cost is less than the average price of electricity. Adding properly priced off-peak load under those circumstances decreases the average price. Valley filling can be accomplished in several ways, one of the most popular of which is new thermal storage (water heating and/or space heating or cooling) that displace loads served by fossil fuels.

Variable air volume. A method used to cool or heat a space or zone by varying the amount of air delivered to that space as conditions change (versus holding the amount of air constant and changing the air temperature).

Variations by attributes, time, and program features. Understanding energy and load impacts by these dimensions is critical for extrapolating effects into the future and applying results for program and integrated resource planning.

VAV - Variable Air Volume. An air conditioning system of the reheat, recool, dual duct or multi-zone type in which the amount of heating or cooling is controlled by changing the air flow rate.

Ventilation. The process of supplying or removing air by natural or mechanical means to or from any space; such air may or may not have been conditioned.

Ventilation air. That portion of supply air which comes from outside plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

Volt. The push that moves electric current through a conductor.

Water heater. An automatically controlled, thermally insulated vessel designed for heating water and storing heated water, which utilizes either oil, gas, or electricity as the fuel or energy source for heating the water, which is designed to produce hot water at a temperature of less than 180°F, and which includes the following products.

(a) "electric water heater" means a water heater which utilizes electricity as the energy source for heating the water, which has a manufacturer's specified energy input rating of 12 kilowatts or less at a voltage no greater than 250 volts, and which has a manufacturer's specified storage capacity of not less than 20 gallons nor more than 120 gallons.

(b) "gas water heater" means a water heater which utilizes gas as the energy source for heating the water, which has a manufacturer's specified energy input rating of 75,000 Btu per hour or less, and which has a manufacturer's specified storage capacity of not less than 20 gallons nor more than 100 gallons.

Watt. A unit of power, named after James Watt, a Scottish engineer. The rate of energy transfer equivalent to one ampere flowing due to an electrical pressure of one volt at unity power factor. One watt is equivalent to approximately 1/746 horsepower, or one joule per second.

Watthour. The total amount of energy used in one hour by a device that requires one watt of power for continuous operation. Electric energy is commonly sold by the kilowatthour (defined herein).

Weatherization. Caulking and weatherstripping to reduce air infiltration.

Wet bulb temperature. The temperature reading obtained from a standard thermometer with its bulb encased in a wick saturated with water at air temperature and exposed to air moving at sufficient velocity to bring fresh samples of air successively to the wick. The thermometer reading drops to a minimum which is dependent on the dry bulb temperature and moisture content of the air.

Winter peak. The greatest load on an electric system during any prescribed demand interval in the winter (or heating) season, usually between December 1 of a calendar year and March 31 of the next calendar year.

Work. In the British foot-pound-second (FPS) system, this is measured in British thermal units. One Btu is equal to 778 foot-pounds, or joules.

Zone. A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.