USING DEMAND-SIDE MANAGEMENT TO SELECT ENERGY EFFICIENT TECHNOLOGIES AND PROGRAMS

Gellings C.W.
Electric Power Research Institute, Palo Alto, California USA

Keywords: demand-side management, energy efficiency, conservation, load management, market transformation

Contents

Summary

Why should demand-side management be of interest? Since the early 1970s, economic, political, social, technological, and resource supply factors have combined to change the energy industry's operating environment and its outlook for the future. Many are faced with staggering capital requirements for new plants, significant fluctuations in demand and energy growth rates, declining financial performance and political or regulatory and consumer concern about rising prices.

While demand-side management is not a cure-all for these difficulties, it does provide for great many additional alternatives. These demand-side alternatives are equally appropriate for consideration by utilities, energy suppliers, energy-service suppliers, and government entities.

For strong load growth, load management and strategic conservation can provide an effective means to reduce or postpone construction of new generating facilities. For others, electrification and deliberate increases in the market share of energy intensive uses can improve the utility load characteristics and optimize asset utilization.

Aside from these rather obvious cases, changing the load shape that an energy system can reduce operating costs. Changes in the load shape can permit adjustments in plant loadings, thus increasing the use of more efficient plants and permitting the use of more domestically abundant and less expensive energy sources.

In the residential sector, cost control/consumer options give the customer some capability to control monthly bills. Many electric customers who had become accustomed to stable prices have seen dramatic increases in their energy bills. In many parts of the world, these upward price trends are expected to continue.

Demand-side alternatives, in particular, cost-control/customer options, give customers a positive signal that there is concern about high energy bills and that they are provided with the means to control future expenditures for energy and energy services.

In addition, implementing demand-side management can lead to greater flexibility in facing rapid change in today's business environment.

While demand-side management is not a panacea for all problems facing the energy industry and its stakeholders, it does provide additional alternatives for meeting the challenges of the future.

1. Introduction

Demand-side management encompasses planning, evaluation, implementation, and monitoring of activities selected from among a wide variety of technical alternatives.

This wide range of alternatives mandates demand-side management be considered in utility, government and regional energy planning processes, as illustrated in Figure 1. Due to the large number of alternatives, however, assessing which alternative is best suited is not a trivial task.

The choice is complicated by the fact that the attractiveness of alternatives is influenced strongly by specific local and regional factors, such as generating mix, expected load growth, capacity expansion plans, load factor, load shapes for average and extreme days, regulatory climate, and reserve margins.

Therefore, it is often inappropriate to transfer these varying specific factors from one area or country to another without appropriate adjustments.

In addition, the success of any alternative depends on the specific combination of marketing activities selected to aid in promoting customer acceptance.

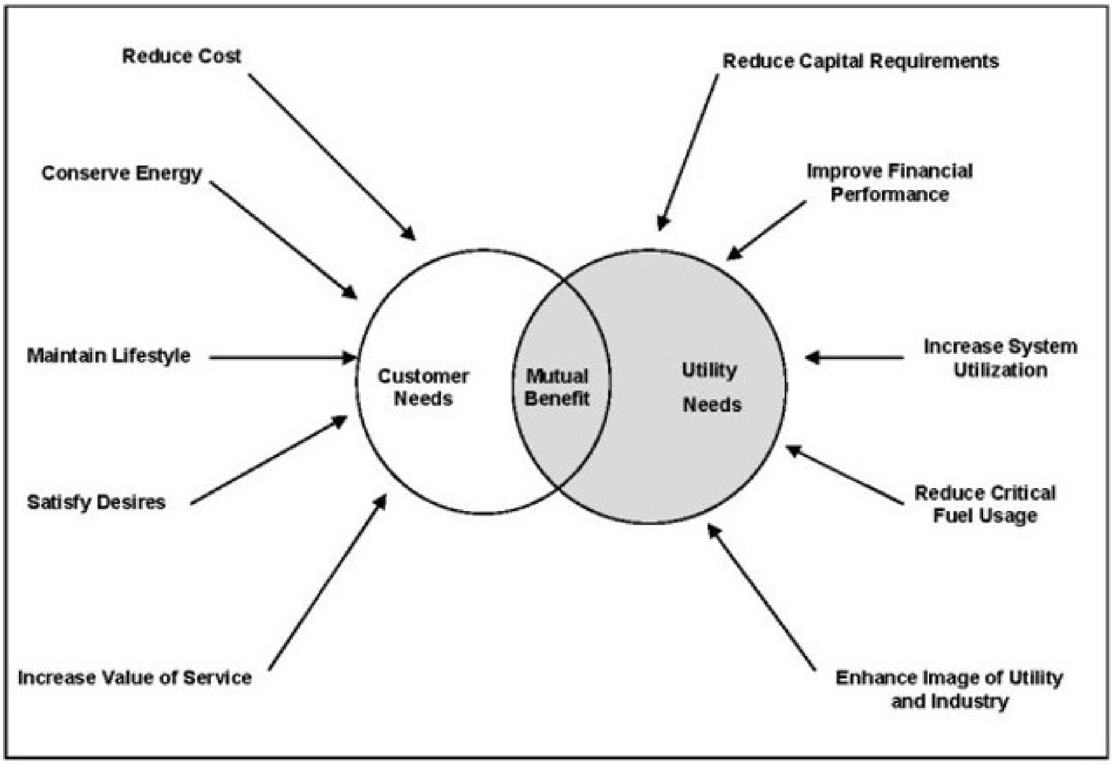

Figure 1. The scope of demand-side management

A large body of research has accumulated about DSM programs, customer reactions to these programs, program impacts, and program costs. This topic focuses on the following questions, which are addressed in the articles and the subarticles that follow:

What is DSM? (see Section 2.2)
How did DSM evolve? (see Section 2.3)
What has been accomplished to date, and at what cost? (see Section 3.2)
What was expected from DSM for the 1990s? (see Section 3.3)
What are the key target market segments for DSM and why? (see Section 3.3)
What is the strategic role of DSM evaluation? (see Section 3.4)

2. Demand-Side Management

2.1. What Is Real

During the 1980s, developed countries saw demand-side management (DSM) transformed rapidly from a start-up activity to a full-blown industry in its own right. DSM became a significant part of integrated resource planning (IRP) strategies that balance cost against risk to meet current and future customer needs. Annual DSM expenditures in the U.S. were measured in billions of dollars, energy savings were measured in billions of kWh, and peak load reductions were stated in thousands of megawatts. Depending on local conditions, energy savings in the U.S. from DSM were projected to be as much as 10% by 2000. Elsewhere in the world, DSM was increasingly viewed as an option to reduce the needs for electric generation capacity.

However, with a few exceptions, other world nations saw DSM as an activity to be pursued by government entities. Few countries have embraced the degree of market intervention still practiced in the United States.

2.2. What is DSM

Demand-side management is the planning and implementation of those activities designed to influence consumer use of energy in ways that will produce desired changes in the time pattern and magnitude of energy. Programs and initiatives falling under the umbrella of demand-side management include load management, new uses, strategic conservation, electrification, distributed generation, and adjustments in the market share of energy-consuming devices and appliances.

Demand-side management includes only those activities that involve a deliberate intervention in the marketplace so as to alter energy use. This intervention has often been hosted by the electric and/or natural gas utility, but can be effected by other energy suppliers, retailers, or government entities. Under this definition, consumer purchases of energy efficient refrigerators as a reaction to the perceived need for conservation would not be classified as demand-side management. On the other hand, a program that encourages consumers to install energy efficient refrigerators, through either incentives or advertising, meets the definition of demand-side management. While this distinction between "naturally" occurring and deliberately induced changes in energy consumption and load shape is at times difficult to make, it is nevertheless important.

Note also that demand-side management extends beyond conservation and load management to include programs designed specifically to modify energy use in both peak and off-peak periods. Thus, demand-side management alternatives warrant consideration by entities or countries such as energy and energy service suppliers with ambitious construction programs, those with high reserve margins, and those facing high marginal costs.

Another important concept to consider in defining demand-side management is that of consumer options to control costs or cost/control consumer options. While demand-side management can include programs designed for all consumers, the term cost control/consumer options has been used to describe certain of those alternatives applicable specifically to the residential class. In this theme, this term refers to those demand-side alternatives that give residential customers the opportunity to control their energy usage and total energy bills.

Cost control/consumer options involve a partnership between the energy and energy service supplier and their designs and offers the program to its customers—but it is the customer who ultimately decides whether or not to participate in the program. Although participation in the program is voluntary, suppliers can offer a wide range of inducements to encourage participation.

2.3. How Did DSM Evolve

The energy shocks of the 1970s had profound impacts on the electric and gas utility industries, impacts that helped give rise to the use of DSM strategies. Sharp increases in fuel prices were accompanied by high inflation and interest rates. Consequently, the cost of building, financing and operating power plants greatly increased. The resulting rate increases were met with unprecedented customer reaction in the form of vocal outcry and changes in energy-use patterns. After years of operating in a stable environment, utilities and other energy suppliers were suddenly presented with high levels of uncertainty concerning two crucial elements of the planning process: projections of costs and customer demand. As resource planning for energy suppliers became more difficult, the consequences of making inaccurate projections became so immense that default and bankruptcy became real possibilities for the first time in the utility industry since the Great Depression.

The rise in electricity process prompted customers to reduce consumption. EPRI estimates that the price-induced reduction, or elasticity, of electricity consumption amounted to a 20% decrease below the level of use that otherwise would have occurred. This effect is generally included in utility forecasting models and is not typically considered part of the effect of DSM programs. In addition to this immediate market price response, the higher prices and increased national attention to energy issues also created a demand for new technologies and energy services.

In short, the abrupt changes in the global energy industry were manifested in several ways:

- Planning energy infrastructure was plagued by the uncertainty of future demand for energy.
- Conservation measures became more attractive to consumers as electricity costs rose.
- Promoting DSM measures became less expensive to some governments and utilities than the generation alternatives in many cases.
- Utilities and governments sought ways to alleviate customer and citizen dissatisfaction by providing service options that offered the opportunity to gain control over electricity bills.

These changes in the energy industry resulting from the shake up in energy supply markets profoundly affected the development of programs designed to impact energy use. At the same time, governments and utilities became more aware of the need to work with customers and communities to maintain the local economic base. All of these changes involved greater interaction with customers and their issues.

The first step in the shift toward a focus was the introduction and evolution of electric and natural gas load management. Load-management programs focus on reducing customer use strategically at the time of high utility-system loads. The goal is to avoid construction of generation, production, and delivery facilities that would be operated for relatively few hours per year and/or costly wholesale purchases when customer loads can be shifted or displaced at a lesser cost. Whereas energy efficiency reduces loads throughout the year, load management targets specific moments and typically has smaller impacts on annual energy usage. Load management programs have been more stable over time than most other customer programs. In many ways, this is the most mature part of DSM activity to date; many utilities have well-developed and significant load management programs.

There are several important components of load management activities, including direct load control (DLC), pricing-based options (interruptible/curtailable rates or seasonal rates), and thermal energy storage. The initial program efforts were hardware-centered and did not sufficiently consider customer needs. The objectives were to identify technologies that worked in peak clipping, valley filling and load shifting and push then into the marketplace. These load management efforts were followed closely by the early interest in "conservation." Again, technology was the driving force of these early conservation programs. Utilities and governments maintained an inventory of energy-saving actions, and they would test hardware options and provide information to customers about possible energy savings from technology adoption.

Instead of using technology or hardware as the driving force behind programs, DSM was the first marketing strategy that specifically promoted a customer focus. Instead of conducting "what-if" studies on individual technologies, DSM allowed an integrated look at technology options, customer needs, and utility considerations.

The DSM framework was initially constructed for two reasons. First, it responded to the need for a logical process to help energy planners optimize the supply–demand interface. Second, it presented a unique marketing tool. The DSM framework was structured to convince supply-side planners that "demand need not be considered as fixed." It packaged the idea of planning both energy supply options and energy demand changes concurrently.

Although EPRI's broad definition of DSM had many merits, it has still not been widely adopted. In the more than 70 integrated resource planning documents reviewed during the research discussed later, not one instance of the use of this broad definition of DSM was apparent. In practice, DSM became an umbrella for increased efficiency, load management and conservation, all with an emphasis on reducing the need for energy. This restricted definition of DSM is used throughout the next chapters.

A corresponding framework and industry consensus has not developed for the remaining group of activities included in the broader concept of DSM. These activities include promotion of new uses of energy to achieve goals such as increased total resource efficiency and increased total factor productivity. We have adopted the term "electrification" to include these actions and others that lead to wider use of electricity. The concept applies equally well to natural gas, oil, and coal.

3. DSM Impacts

Utility industry involvement on the customer side of the meter underwent several serious transformations since the 1970s. In the mid-1970s and early 1980s, full-scale conservation information and load management programs were initiated in the USA and several European countries. It was not until the mid-1980s, however, that USA DSM programs involving the use of the rebates and incentives to promote the purchase of efficient equipment became widespread. Although the exact date is somewhat arbitrary, we will use 1985 to mark the beginning of "modern-day" DSM. The transition toward greater use of utility investments to promote the purchase of high-efficiency equipment implies a growing need to account for the costs and benefits of DSM. By about 1994 this phase ended. What remains today are programs that are largely regulatory driven and represent a far smaller effort than was in place in 1992 when DSM was at its peak. The remainder of this chapter describes efforts to quantify the accomplishments of the industry from 1985 to the middle of 1993. First, in Section 3.1, the components of DSM programs that promote increased efficiency of customer-owned equipment are discussed. The costs and impacts of load-management programs will be treated separately in Section 3.2. Section 3.3 describes the potential for DSM in the United States. These data are not directly transferable to the rest of the world, but they give an order-of-magnitude approximation. In most cases, the industrial results and potential are largely transferable. Commercial and residential results are less transferable unless size of dwelling, weather (with particular emphasis on heating and cooling energy use), appliance holdings, and illumination levels are adjusted.

Sections 3.4, 3.5, 3.6 introduce the concept of evaluating DSM as a resource and assuring continued research and development to improve efficiency.

-
-
-

Bibliography

Electric Power Research Institute (EPRI). (1992). *DSM Process Evaluation: A Guidebook to Current Practice,* TR-100647, 182 pp. Palo Alto, CA: EPRI. [Process evaluations can help utilities to identify problems, fine-tune implementation efforts, and maximize the strategic benefits of demand-side management (DSM) programs. The guidebook is designed to help utilities plan, conduct, and use the results of process evaluations of DSM programs. In particular, this guidebook emphasizes the need for program-specific evaluations that differ in emphasis and approach.]

Electric Power Research Institute (EPRI). (1993). *Principles and Practice of Demand-Side Management,* TR-102556, 144 pp. Palo Alto, CA: EPRI. [This report provides an overview of the demand-side management (DSM) process. It is a guide for the DSM practitioner through the different steps involved in the process, and it provides an introduction to the vast and growing literature on the subject.]

Electric Power Research Institute (EPRI). (1993). *Lessons Learned in Commercial Sector Demand-Side Management,* TR-102551, 100 pp. Palo Alto, CA: EPRI. [The number of utilities offering commercial sector demand-side management (DSM) programs is increasing; and the programs are growing in number, size, scope, and complexity. In fact, DSM has been targeted as one of the most promising areas for delivering needed kilowatthour and kilowatt savings in the future. This report describes the practical lessons of experience from ongoing commercial sector DSM programs. Such lessons can help utilities design and deliver DSM programs at lower cost, with fewer implementation problems and greater customer acceptance.]

Electric Power Research Institute (EPRI). (1993). *"Best Current Practices" in Integrating DSM into T&D Planning: Proceedings from the Second Annual Workshop,* TR-102955, 386 pp. Palo Alto, CA: EPRI. [This workshop was part of a continuing forum for utility representatives. The second in a series, it allowed participants to share their experience and knowledge of locally targeted demand-side management (DSM) programs designed to defer transmission and distribution (T&D) investments. The proceedings documented the lessons utilities have learned that are active in this planning area. It also provided recommendations on "best current practices" for integrating DSM into T&D planning.]

Electric Power Research Institute (EPRI). (1994). *Survey of Innovative Rate Structures*, TR-104491, 36 pp. Palo Alto, CA: EPRI. [This survey provides insight into current innovations in electric rates and how these rates are being implemented by utilities throughout the United States. Detailed examination of the 1095 innovative rates in use by the surveyed utilities provides information on ways in which they are, or may be, used to achieve specific utility goals.]

Electric Power Research Institute (EPRI). (1994). *50 Successful DSM Programs: A Comparative Review of Program Attributes and Data*. The Results Center Profile Series, Profiles 1-50, TR-103463, 60 pp. Palo Alto, CA: EPRI. [Demand-side management (DSM) programs focused on improving customers' energy efficiency have grown rapidly in significance within the U.S. electric power industry. As utilities consider such programs, they need information on the success and shortcomings of other DSM programs for use in the planning process. This report summarizes case studies of 50 DSM programs throughout North America that have successfully overcome innumerable market barriers.]

Electric Power Research Institute (EPRI). (1996). *Persistence Research of DSM Impacts: Methods, Applications, and Selected Findings,* TR-106193, 128 pp. Palo Alto, CA: EPRI. [While this handbook focuses largely on the persistence of demand- side management (DSM) impacts, the methods described can be used to assess the persistence of various utility programs, including innovative pricing, electricity marketing, and power quality services. This handbook provides a resource to help utilities clarify what aspects of persistence they wish to measure, define the scope of the research effort, and establish an appropriate analytical approach to the problem.]

Electric Power Research Institute (EPRI). (1997). *Inventory of Available Methods and Processes for Assessing the Benefits, Costs, and Impacts of Demand-Side Options Benefits, Costs, and Impacts of Demand-Side Options*. Volume 1, TR-108506-V1, 103 pp., Volume 2, TR-108506-V2, 219 pp., Volume 3, TR-108506-V3, 298 pp. Palo Alto, CA,: EPRI. [International experience with demand-side management and integrated planning is revealed in this three-volume series. The first of several reports developed collaboratively with the U.S. Department of Energy and the International Energy Agency, this series compiles information on methods and computer models used in 15 countries to perform integrated planning -- including forecasting techniques, DSM planning, and supply-side planning.]

Biographical Sketch

Clark Gellings' 30-year career in energy spans from hands-on wiring in factories and homes to the design of lighting and energy systems to his invention of "demand-side management" (DSM). Mr. Gellings coined the term DSM and developed the accompanying DSM framework, guidebooks, and models now in use throughout the world. He provides leadership in EPRI, an organization that is second in the world only to the Department of Energy (in dollars) in the development of energy efficiency technologies. Mr. Gellings has demonstrated a unique ability to understand what energy customers want and need and then implement systems to develop and deliver a set of R&D programs to meet the challenge. Among Mr. Gellings' most significant accomplishments is his success in leading a team with an outstanding track record in forging tailored collaborations—alliances among utilities, industry associations, government agencies, and academia—to leverage research and development dollars for the maximum benefit. Mr. Gellings has published 10 books, more than 400 articles, and has presented papers at numerous conferences. Some of his many honors include seven awards in lighting design and the Bernard Price Memorial Lecture Award of the South African Institute of Electrical Engineers. He has been elected a fellow in the Institute of Electrical and Electronics Engineers and the Illuminating Engineering Society of North America. He won the 1992 DSM Achiever of the Year Award of the Association of Energy Engineers for having invented DSM. He has served as an advisor to the U.S. Congress Office of Technical Assessment panel on energy efficiency, and currently serves as a member of the Board of Directors for the California Institute for Energy Efficiency and EPRI PEAC. He is Chairman of the Board of PRIMEN, Inc., and Global Energy Partners, LLC.

Mr. Gellings has received distinguished awards from a number of organizations, including The Illuminating Engineering Society, the Association of Energy Services Professionals, and the South African Institute of Electrical Engineers.

Mr. Gellings is a registered Professional Engineer, a Fellow in the Institute of Electrical and Electronics Engineers (IEEE), a Fellow in the Illuminating Engineering Society (IES), a Vice President of the U.S. National Committee of CIGRE' (International Council on Large Electric Systems), and is active in a number of other organizations. He has degrees in Electrical Engineering, Mechanical Engineering, and Management Science.