Lecture 7: Demand Side Management

7.1 Introduction:

Definition

"Demand-side management is the planning, implementation, and monitoring of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the 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 demand-side management include: load management, new uses, strategic conservation, electrification, customer generation, and adjustments in market share (Gellings 1984–1988)."

Demand-Side Management Embraces The Following Critical Components Of Energy Planning:

1. Demand-side management *will influence customer use*. Any program intended to influence the customer's use of energy is considered demand-side management.
2. Demand-side management *must achieve selected objectives*. To constitute a desired load-shape change, the program must further the achievement of selected objectives; that is, it must result in reductions in average rates, improvements in customer satisfaction, achievement of reliability targets, etc.
3. Demand-side management *will be evaluated against non-demand-side management alternatives*. The concept also requires that selected demand-side management programs further these objectives to at least as great an extent as non-demand-side management alternatives, such as generating units, purchased power, or supply-side storage devices. In other words, it requires that demand-side management alternatives be compared to supply-side alternatives. It is at this stage of evaluation that demand-side management becomes part of the integrated resource planning process.
4. Demand-side management *identifies how customers will respond*. Demand-side management is pragmatically oriented. Normative programs (we ought to do this) do not bring about the desired; positive efforts (if we do this that will happen) are required. Thus, demand-side management encompasses a process that identifies how customers will respond not how they should respond.

5. Demand-side management *value is influenced by load shape*. Finally, this definition of demand-side management focuses upon the load shape. This implies an evaluation process that examines the value of programs according to how they influence costs and benefits throughout the day, week, month, and year.

7.2 Demand-Side Management and Integrated Resource Planning

A very important part of the demand-side management process involves the consistent evaluation of demand-side to supply-side alternatives and vice versa. This approach is referred to as *integrated resource planning.* For demand-side management to be a viable resource option, it has to compete with traditional supply-side options.

7.3 Demand-Side Management Programs

A variety of programs have been implemented since the introduction of demand-side management in the early 1980s.

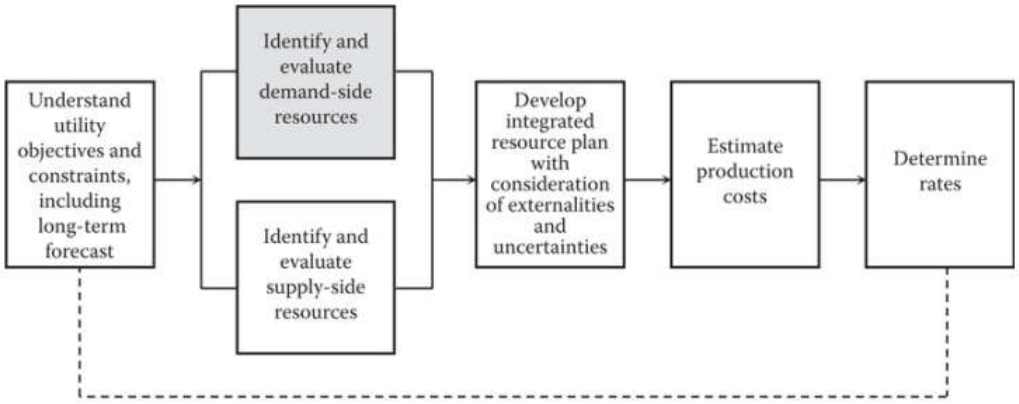


Figure 7.1. How demand-side management fits into integrated resource planning.

7.3.1 Elements of the Demand-Side Management Planning Framework

Set objectives: The first step in demand-side management planning is to establish overall organizational objectives. These strategic objectives are quite broad and generally include examples such as conserving energy resources, reducing peak demand (thereby deferring need to build new power plants), decreasing greenhouse gas emissions, reducing dependence on foreign imports, improving cash flow, increasing earnings, and improving customer and employee relations. In this level of the formal planning process, the planner needs to operationalize broad

objectives to guide policymakers to specific actions. It is at this operational level or tactical level that demand-side management alternatives should be examined and evaluated. For example, an examination of capital investment requirements may show periods of high investment needs. Postponing the need for new construction through a demand-side management program may reduce investment needs and stabilize the financial future of an energy company, or a utility and its state or country.

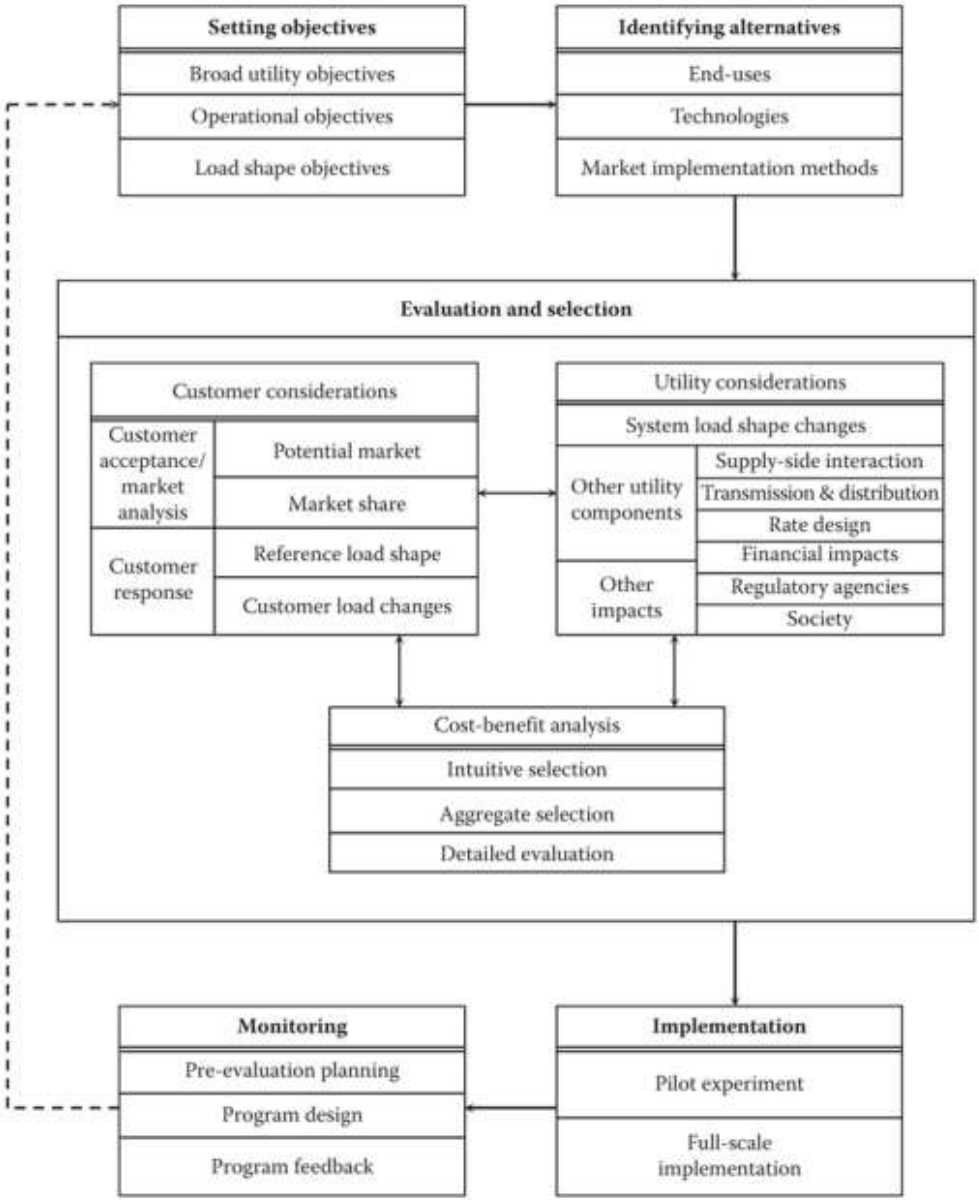
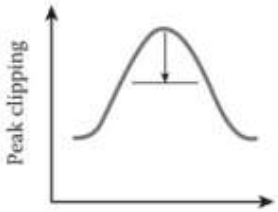


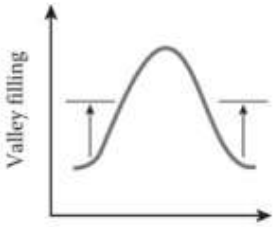
Figure 7.2 Elements of the demand-side management planning framework.

1. *Identify alternatives:* The second step is to identify alternatives. The first dimension of this step involves identifying the appropriate end-uses whose peak load and energy consumption characteristics generally match the requirements of the load-shape objectives established in the previous step. In general, each end-use (e.g., residential space heating, commercial lighting) exhibits typical and predictable demand or load patterns. The extent to which load pattern modification can be accommodated by a given end-use is one factor used to select an end-use for demand-side management. The second dimension of demand-side management alternatives involves choosing appropriate technology alternatives for each target end-use. This process should consider the suitability of the technology for satisfying the load-shape objective.
2. *Evaluate and select program(s):* The third step balances customer considerations, supplier considerations, and cost/benefit analyses to identify the most viable demand side management alternative(s) to pursue. Although customers and suppliers act independently to alter the pattern of demand, the concept of demand-side management implies a supplier/customer relationship that produces mutually beneficial results. To achieve that mutual benefit, suppliers must carefully consider such factors as the manner in which the activity will affect the patterns and amount of demand (load shape), the methods available for obtaining customer participation, and the likely magnitudes of costs and benefits to both supplier and customer prior to attempting implementation.
3. *Implement program(s):* The fourth step is to implement the program(s), which takes place in several stages. As a first step, a high level, demand-side management project team should be created with representation from the various departments and organizations, and with the overall control and responsibility for the implementation process. It is important for implementers to establish clear directives for the project team, including a written scope of responsibility, project team goals and time frame.
4. *Monitor program(s):* The fifth step is to monitor the program(s). The ultimate goal of the monitoring process is to identify deviations from expected performance and to improve both existing and planned demand-side management programs. Monitoring and evaluation processes can also serve as a primary source of information on customer behavior and system impacts, foster advanced planning and organization within a demand-side management program, and provide management with the means of examining demand-side management programs as they develop.

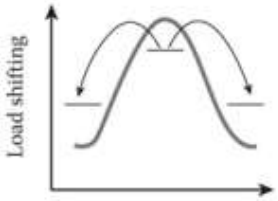
Peak clipping—or the reduction of the system peak loads, embodies one of the classic forms of load management and is now commonly referred to as *demand response*. Peak clipping is generally considered as the reduction of peak load by using time-based rate options or incentive-based strategies, with or without enabling technologies. While many utilities consider this as a means to reduce peaking capacity or capacity purchases and consider strategies only during the most probable days and times of system peak, these strategies can be used to reduce operating cost and dependence on critical fuels by economic dispatch.



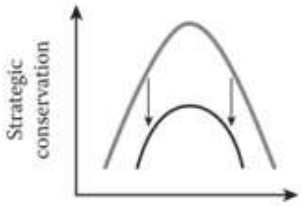
Valley filling—is the second classic form of load management and applies to both gas and electric systems. Valley filling encompasses building off-peak loads. This may be particularly desirable where the long-run incremental cost is less than the average price of energy. Adding properly priced off-peak load under those circumstances decreases the average price. Valley filling can be accomplished in several ways, one of the most popular of which displaces loads served by fossil fuels with electric loads that are operated during off-peak periods (e.g., water heating and/or space heating).



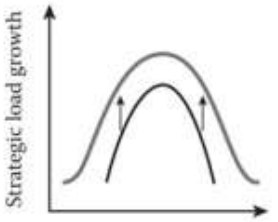
Load shifting—is the last classic form of load management and also applies to both gas and electric systems. This involves shifting load from on-peak to off-peak periods. Popular applications include use of storage water heating, storage space heating, coolness storage (the most common type of thermal energy storage), and customer load shifts. The load shift from storage devices involves displacing what would have been conventional appliances.



Strategic conservation—is the load-shape change that results from programs directed at end-use consumption. Not normally considered load management, the change reflects a modification of the load shape involving a reduction in consumption as well as a change in the pattern of use. In employing energy conservation, the planner must consider what conservation actions would occur naturally and then evaluate the cost-effectiveness of possible intended programs to accelerate or stimulate those actions. Examples include weatherization and appliance efficiency improvement.



Strategic load growth—is the load-shape change that refers to a general increase in sales beyond the valley filling described previously. Load growth may involve increased market share of loads that are or can be, served by competing fuels, as well as economic development. Load growth may include electrification. Electrification is the term being employed to describe the new emerging electric technologies surrounding electric vehicles, industrial process heating, and automation. These have a potential for increasing the electric energy intensity of the industrial sector. This rise in intensity may be motivated by reduction in the use of fossil fuels and raw materials resulting in improved overall productivity.



Flexible load shape—is a concept related to electric system reliability, a planning constraint. Once the anticipated load shape, including demand-side activities, is forecast over some horizon, the power supply planner studies the final optimum supply-side options. Among the many criteria he or she uses is reliability. Load shape can be flexible—if customers are presented with options as to the variations in quality of service that they are willing to allow in exchange for various incentives. The program involved can be variations of interruptible or curtailable load; concepts of pooled, integrated energy management systems; or individual customer load control devices offering service constraints.

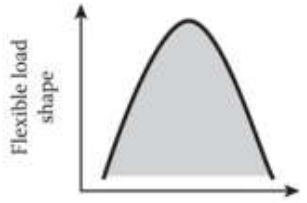


Figure 7.3.Six generic load-shape objectives that can be considered during demand-side management planning.

7.3.2 Targeted End-Use Sectors/Building Types

The three broad categories of end-use sectors targeted for demand-side management programs are residential, commercial, and industrial. Each of these broad categories includes several subsectors. In some cases, the program will be designed for one or more broad sectors; in other cases, it may be designed for a specific subsector. For example, the residential sector can be divided into several subsectors including single family homes, multifamily homes, mobile homes, low-income homes, etc.

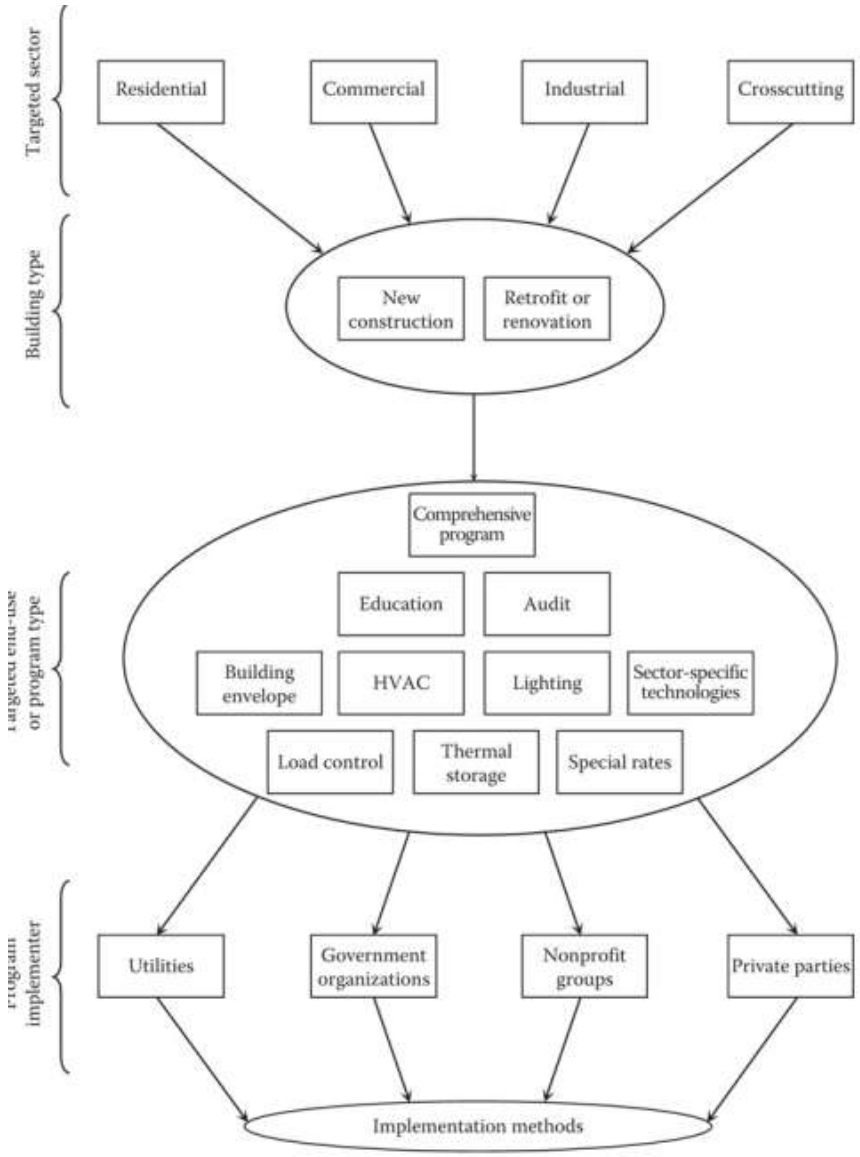


Figure 7.4. Relationship between end-use sectors, building types, end-use programs, and program implementers.

7.3.3 Targeted End-Use Technologies/Program Types

Some programs are comprehensive, and crossover between end use technologies. Other programs target specific end-use equipment, such as lighting, air conditioners, dishwashers, etc. Still others target load control measures, such as demand response programs whereby customers temporarily curtail loads in response to peak demand events or programs that permanently shift loads to off-peak hours (e.g., via thermal energy storage).

7.3.4 Program Implementers

Implementers of demand-side management programs are often utilities. However, other possible implementers include government organizations, nonprofit groups, private parties, or a collaboration of several entities. Utilities and governments, in particular, have a special interest in influencing customers' demand—treating it not as fate but as choice—in order to provide better service at lower cost while increasing their own profits and reducing their business risks. Energy planners can choose from a wide range of market push and pull methods designed to influence consumer adoption and reduce barriers.

7.3.5 Implementation Methods

Among the most important dimension in the characterization of demand-side alternatives is the selection of the appropriate market implementation methods. Planners and policy makers can select from a variety of methods for influencing customer adoption and acceptance of demand side management programs.

The methods can be broadly classified into six categories.

1. ***Customer education****:* Many energy suppliers and governments have relied on some form of customer education to promote general customer awareness of programs. Websites, brochures, bill inserts, information packets, clearinghouses, educational curricula, and direct mailings are widely used. Customer education is the most basic of the market implementation methods available and should be used in conjunction with one or more other market implementation method for maximum effectiveness.
2. ***Direct customer contact****:* Direct customer contact techniques refer to face-to-face communication between the customer and an energy supplier or government representative

to encourage greater customer acceptance of programs. Energy suppliers have for some time employed marketing and customer service representatives to provide advice on appliance choice and operation, sizing of heating/cooling systems, lighting design, and even home economics. Direct customer contact can be accomplished through energy audits, specific program services (e.g., equipment servicing), store fronts where information and devices are displayed, workshops, exhibits, on-site inspection, etc. A major advantage of these methods is that they allow the implementer to obtain feedback from the consumer, thus providing an opportunity to identify and respond to major customer concerns. They also enable more personalized marketing, and can be useful in communicating interest in and concern for controlling energy costs.

3. ***Trade ally cooperation****:* Trade ally cooperation and support can contribute significantly to the success of many demand-side management programs. A trade ally is defined as any organization that can influence the transactions between the supplier and its customers or between implementers and consumers. Key trade ally groups include home builders and contractors, local chapters of professional societies, technology/product trade groups, trade associations, and associations representing wholesalers and retailers of appliances and energy consuming devices. Depending on the type of trade ally organization, a wide range of services are performed, including development of standards and procedures, technology transfer, training, certification, marketing/sales, installation, maintenance, and repair.
4. ***Advertising and promotion****:* Energy suppliers and government energy entities have used a variety of advertising and promotional techniques. Advertising uses various media to communicate a message to customers in order to inform or persuade them. Advertising media applicable to demand-side management programs include the Internet, radio, television, magazines, newspapers, outdoor advertising and point-of-purchase advertising. Promotion usually includes activities to support advertising, such as press releases, personal selling, displays, demonstrations, coupons, and contest/awards.
5. ***Alternative pricing****:* Pricing as a market-influencing factor generally performs three functions: (a) transfers to producers and consumers information regarding the cost or value of products and services being provided, (b) provides incentives to use the most efficient production and consumption methods, and (c) determines who can afford how much of a product. These three functions are closely interrelated. Alternative pricing, through

innovative schemes can be an important implementation technique for utilities promoting demand-side options. A major advantage of alternative pricing programs over some other types of implementation techniques is that the supplier has little or no cash outlay. The customer receives a financial incentive, but over a period of years, so that the implementer can provide the incentives as it receives the benefits.

6. ***Direct incentives****:* Direct incentives are used to increase short-term market penetration of a cost control/customer option by reducing the net cash outlay required for equipment purchase or by reducing the payback period (i.e., increasing the rate of return) to make the investment more attractive. Incentives also reduce customer resistance to options without proven performance histories or options that involve extensive modifications to the building or the customer's lifestyle. Direct incentives include cash grants, rebates, buyback programs, billing credits, and low-interest or no-interest loans. One additional type of direct incentive is the offer of free, or very heavily, subsidized, equipment installation or maintenance in exchange for participation. Such arrangements may cost the supplier more than the direct benefits from the energy or demand impact, but can expedite customer recruitment, and allow the collection of valuable empirical performance data.

The selection of the individual market implementation method or mix of methods depends on a number of factors, including the following:

1. Prior experience with similar programs.
2. Existing market penetration.
3. The receptivity of policy makers and regulatory authorities.
4. The estimated program benefits and costs to suppliers and customers.
5. Stage of buyer readiness.
6. Barriers to implementation.

Some of the most innovative demand-side marketing programs started as pilot programs to gauge consumer acceptance and evaluate program design before large-scale implementation. The objective of the market implementation methods is to influence the marketplace and to change the customer behavior. The key question for planners and policy makers is the selection of the market implementation method(s) to obtain the desired customer acceptance and response. Customer acceptance refers to customer willingness to participate in a market implementation program,

customer decisions to adopt the desired fuel/appliance choice and efficiency, and behavior change as encouraged by the supplier, or state. Customer response is the actual load-shape change that results from customer action, combined with the characteristics of the devices and systems being used. Customer acceptance and responses are influenced by the demographic characteristics of the customer, income, knowledge, and awareness of the technologies and programs available, and decision criteria, such as cash flow and perceived benefits and costs, as well as attitudes and motivations.

TABLE 7.2 Examples of Market Implementation Methods

Market Implementation Method	Illustrative Objective	Examples
Customer education	• Increase customer awareness of programs • Increase perceived value of energy services	• Websites • Bill inserts • Brochures • Information packets • Displays • Clearinghouses • Direct mailings
Direct customer contact	• Through face-to-face communication, encourage greater customer acceptance and response to programs	• Energy audits • Direct installation • Store fronts • Workshops/energy clinics • Exhibits/displays • Inspection services
Trade ally cooperation (i.e., architects, engineers, appliance dealers, heating/cooling contractors)	• Increase capability in marketing and implementing programs • Obtain support and technical advice on customer adoption of demand-side technologies	• Cooperative advertising and marketing • Training • Certification • Selected product sales/service
Advertising and promotion	• Increase public awareness of new programs • Influence customer response	• Mass media (Internet, radio, TV, and newspaper) • Point-of-purchase advertising
Alternative pricing	• Provide customers with pricing signals that reflect real economic costs and encourage the desired market response	• Demand rates • Time-of-use rates • Real-time pricing • Critical peak pricing • Off-peak rates • Seasonal rates • Inverted rates • Variable levels of service • Promotional rates • Conservation rates
Direct incentives	• Reduce up-front purchase price and risk of demand-side technologies to the customer • Increase short-term market penetration • Provide incentives to employees to promote demand-side management programs	• Low- or no-interest loan • Cash grants • Subsidized installation/modification • Rebates • Buyback programs • Rewards to employees for successful marketing of demand-side management programs

7.3.6 Characteristics of Successful Programs.

TABLE 7.3 Synthesis of Key Challenges and Success Factors for Selected Energy Efficiency and Load Management Programs.

Program Type	Key Challenges	Key Success Factors
Residential conservation	• Technology developments • Easy access to pay stations	• Enhancing customer knowledge and control over their consumption
Residential lighting	• Low customer motivation, especially if electricity prices are low • Utility resource allocation toward marketing and outreach efforts • Overcome customer experience or perception of poor quality products • CFL disposal issues	• Aggressive customer awareness and outreach efforts • Strong publicity campaigns • Leverage ENERGY STAR® brand • Build and maintain relationships with manufacturers and retailers
Residential load management	• Obtain customer trust to install equipment • Address customer complaints unrelated to the program • Low level of customer motivation if electricity prices are low	• Simple program design • Widespread customer awareness and outreach efforts • Establish system reliability • Maintain continuity in customer participation • Build strong customer relationships • Provide customer choice and control on electricity usage
Residential new construction	• Generate interest in the program by all parties • Maintain consistency with builders and energy raters	• ENERGY STAR name recognition • Build and maintain relationships with builders and raters
Low income	• Build customer trust and confidence • Rapid turnaround in contractor workforce responsible for delivery	• Deliver nonenergy benefits, such as comfort and safety • Engender participant trust through program stability and continuity • Successful education and outreach efforts • Partner with community-based organizations for effective delivery

C&I energy efficiency	• Incorporate flexible incentives to fit different customer requirements, while keeping program design simple	• Simplicity in program design • Strong financial incentives • Keep customer's financial bottom-line in mind • Strong customer relationships/ maintaining close contact with customers directly and through contractors
C&I new construction	• Generate interest from designers, builders, and owners • Shortage of qualified staff	• Build broad awareness • Start with a pilot program and expand • Staff development and training • Flexible approach • Full energy simulation capability
C&I retrofit	• Need to conform to new/ increased codes and standards • Interactions with regulators	• Flexibility in accommodating different measures • Stakeholder collaborative process in designing programs • Highly skilled utility staff • Contractor capacity building • Contractor–customer relationships
C&I niche	• Accommodate industry requirements • Obtain customer interest for participation • Differences in using the new technology	• Target niche, high-growth industries • Dynamic program design to fit market requirements • Form partnerships and collaborations with related groups • Integrate energy efficiency into customers' business strategies • Achieve more than just the energy benefits
Small business	• Develop web-based delivery infrastructure • Bring vendors up to speed	• Make program participation as simple as possible • Build a strong network of vendors

Source: Wikler.G.et al., Best practices in energy efficiency and load management programs, 1016383, EPRI, Palo Alto, CA, 2008.

7.3.6.1 Key *Elements of Program Design*

- Maintain simplicity in program design
- Design incentive structure to fit customer requirements
- Maintain flexibility in program design to accommodate measures
- Maintain dynamism in program design to fit market requirements in specific industries

- Develop sound performance tracking mechanisms
- Incorporate customer choice and control features in program design
- Ensure resource allocation is commensurate with program tasks
- Obtain stakeholder support right at the design stage
- Maintain high quality of products
- Establish program branding
- Undertake program improvements over time

7.3.6.1. Key Elements of Program Delivery

- Foster trade ally relationships and partnerships
- Undertake contractor capacity building efforts
- Build networks and alliances with other relevant parties and groups
- Undertake program publicity campaigns
- Establish strong customer education and outreach efforts
- Foster utility–customer relationships
- Coordinate with other utilities and program administrators
- Build customer–contractor relationships
- Maintain strong in-house capabilities
- Integrate energy efficiency into customer's business strategy
- Deliver nonenergy benefits
- Maintain consistency over time
- Enhance program delivery through collaborative efforts.

7.4 Conclusion

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 utilities 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 and the environment. While demand side

management is not a cure-all for these difficulties, it does provide for a great many additional alternatives that have myriad nonenergy benefits as well as the more obvious energy-related benefits. These demand-side alternatives are equally appropriate for consideration by utilities, energy suppliers, energy-service suppliers, and government entities.

Implementation of demand-side measures not only benefits the implementing organization by influencing load characteristics, delaying the need for new energy resources, and in general improving resource value, but also provides benefits to customers such as reduced energy bills and/or improved performance from new technological options. In addition, society as a whole receives economic, environmental, and national security benefits. For example, since demand side management programs can postpone the need for new power plants, the costs and emissions associated with fossil-fueled electricity generation are avoided. Demand-side management programs also tend to generate more jobs and expenditures within the regions where the programs are implemented, boosting local economies. Moreover, demand-side management programs can help reduce a country's dependence on foreign oil imports, improving national security. Demand-side management alternatives will continue to hold an important role in resource planning in many countries, and will be a critical element in the pursuit of a sustainable energy future.