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ABSTRACT
Industrial demand side management (DSM) programs, though not as developed or widely implemented as residential and commercial programs, hold the promise of significant energy savings—savings that will benefit industrial firms, utilities and the environment. This paper is a synopsis of a larger research report, *Industrial Demand Side Management: A Status Report*, prepared for the U.S. Department of Energy. The report provides an overview of and rationale for DSM programs. Benefits and barriers are described, and data from the Manufacturing Energy Consumption Survey are used to estimate potential electricity savings from industrial energy efficiency measures. Overcoming difficulties to effective program implementation is worthwhile, since rough estimates indicate a substantial potential for electricity savings. The report categorizes types of DSM programs, presents several examples of each type, and explores elements of successful programs. Two in-depth case studies (of Boise Cascade and of Eli Lilly and Company) illustrate two types of effective DSM programs. Interviews with staff from state public utility commissions indicate the current thinking about the status and future of industrial DSM programs. Finally, the research report also includes a comprehensive bibliography, a description of technical assistance programs, and an example of a methodology for evaluating potential or actual savings from projects.

1.0 INTRODUCTION
Demand side management (DSM) is the implementation by electric and natural gas utilities of any number of energy efficiency measures aimed at altering the level and timing of energy demand in the service territory of the utility company. The Office of Technology Assessment estimates 154 utilities are conducting 417 industrial sector DSM programs.[1] Utilities take such measures primarily to reduce the need to construct new power plants. However, DSM programs also produce many other benefits for both the utility and the public—for example, reduced pollution and decreased use of natural resources (e.g., the coal and natural gas consumed during power production, as well as the water used). Industrial DSM programs have demonstrated they can overcome obstacles to achieve substantial energy savings.[a]

In 1991, the industrial sector consumed about 820 billion kWh of electricity, about one-third of all electricity sold in the United States. The remaining potential energy savings in industry is considered by some to be the last major DSM resource still untapped by utilities. Based on electricity demand values from the Manufacturing Energy Consumption Survey and estimates of potential savings in various end uses, savings on the order of 100 to 200 billion kWh are projected in manufacturing. Electricity for motors is by far the largest end-use application in manufacturing, accounting for as much as two-thirds of total use. Lighting, another major potential source of savings, accounts for about 6% of total manufacturing use. Within manufacturing, the chemicals, primary metals, and pulp and paper industries together account for over half of all electricity use.

2.0 PERSPECTIVES ON INDUSTRIAL DSM: BENEFITS AND IMPEDIMENTS
Several factors encourage utilities to formulate industrial DSM programs. DSM programs defer the need to construct new power plants and help utilities retain industrial customers by increasing efficiency services. DSM programs help utilities achieve environmental benefits; indeed, non-energy benefits are often achieved via energy

(a) In the research report and in this paper, "industry" refers to those firms that utilities define as industrial customers, which are primarily U.S. manufacturing firms and larger (>50 kW) commercial firms, as well as mines, agricultural firms, and construction firms.

efficiency. Additionally, utilities experience positive public relations benefits by implementing DSM programs. However, there are also impediments to implementing these programs at utilities.

A variety of factors come together to produce barriers that must be overcome in implementing industrial DSM programs. The opponents of DSM are against cross-subsidization between customer classes in DSM cost allocations, are skeptical because of utilities' lack of experience in industrial energy efficiency measures, and are concerned over capital constraints that are a financial barrier to investing in energy efficiency. Many companies have indicated that various constraints have kept them from DSM participation, perhaps not realizing that returns on investment can reach 300%.[2]

Additionally, the industrial sector is very complex, and utilities have limited experience dealing in detail with industrial facilities and equipment. Energy savings from industrial DSM programs are difficult to estimate in advance, leading to uncertainty in program design and difficulty in obtaining program approval. Utilities face considerable uncertainty about the future, especially in the face of the potential restructuring of the industry and the introduction of retail wheeling of power. Under some future restructuring scenarios, DSM programs might not serve utilities' principal business needs.

Smooth and effective implementation of energy efficiency improvements can be hindered on the industrial side by a decision-making process that pits energy-saving projects against more obviously profitable ones. Although the added incentives provided by utility DSM programs should encourage industrial firms to adopt energy-saving measures, some industrial firms have a generally negative view towards DSM and may, in fact, believe DSM programs increase their electricity prices and give energy efficiency assistance to their competitors. In addition, the time required for installation of energy efficiency measures can disrupt production facilities. Utilities, too, face barriers, principally in not being knowledgeable enough about their customers' processes to design customized programs or to accurately estimate and measure savings. Overcoming difficulties to effective program implementation is worthwhile, however, given that rough estimates indicate a substantial potential for electricity savings.

A program that can overcome the impediments described above[3] is likely to be

- **customized** to meet industrial customer needs
- **easy** for the utility to implement
- **management-friendly**, minimizing staff time
- **minimal in its disruption** to industrial operations
- **attuned to the industrial decision-making process**
- **equitable** in terms of rate structure
- **trusted to reduce the customer's perceived risk**
- **measured** by the utility, using sound measurement techniques
- **expert** in its treatment of the intricacies of particular industries.

Equipment upgrades targeted at reducing energy consumption are a natural component of an industrial DSM program. However, because of the interrelationship of energy use, environmental effects, and operating costs, the most important opportunities for industrial DSM may reside in efforts to work together with industrial customers to improve their overall efficiency and competitive position. Such efforts may be especially important in helping to retain load from industrial plants that would otherwise cease operations or relocate.[a] Even under a scenario in

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(a) An example of such an effort involved a Sealtest plant in the Northeast that was in danger of closing. The plant was one of the parent company's least efficient; to reduce costs, the plant had cut back to a four-day work week, but further cuts were necessary. A partnership developed among Boston Edison, the Massachusetts Division of Energy Resources, and the parent company, together with a refrigeration engineering firm and a firm that conducted a comprehensive energy efficiency study. The efforts of the team resulted in comprehensive changes to plant equipment that reduced operating costs by approximately 30% and substantially improved the product.[4]

which retail wheeling was prevalent across the United States, the best way for utilities to retain markets likely would be an aggressive program to work with industrial customers as industrial partners, helping to make their use of electricity an efficient and holistic endeavor and a financial success.

3.0 INDUSTRIAL ELECTRICITY USE AND POTENTIAL ELECTRICITY SAVINGS

Unfortunately, no general review of electricity savings can predict the type or magnitude of savings that could be achieved at any particular plant. The industrial sector is too diverse for such predictions. Manufacturing firms range from those that transform raw materials into more refined forms, such as the primary metals and petroleum-refining industries, to those that produce highly finished products, such as the food processing, pharmaceuticals, and electronics industries. Industrial firms vary greatly not only in the outputs they produce, but in how they produce them: even two plants producing identical outputs can use different processes; even two plants using identical processes can use different vintages and types of equipment. Hence, successful DSM programs recognize the need for personal attention to individual customers and their particular industrial operations.

Some industrial DSM programs are similar to commercial DSM programs in their focus on a few standard technologies such as motors; lighting; and heating, ventilation, and air-conditioning (HVAC) systems. Motor drive represents a large fraction of industrial energy use and is a fruitful target for industrial DSM programs. Lighting programs can also yield significant energy savings and may provide a way to build industrial customer confidence in a utility's DSM activities.[5] However, such programs do not address a large source of potential electricity savings that resides in process upgrades that may be specific to an industry or customer. Such process-specific measures also have the potential for benefits other than energy savings alone, which, depending on the customer and the particular operation, may make them more attractive than projects that save energy only. For example, a project that upgrades an industrial process to use process waste and byproducts for their materials or energy value may not only reduce energy use but also reduce waste handling, treatment, and disposal costs.[1] Because environmental costs have become an increasingly large component of industrial capital and operating expenditures, projects with both energy and environmental benefits and concomitant cost savings may be of particular interest to industrial managers.

Table 1 shows the fraction of costs devoted to energy and the overall energy intensity (in terms of energy cost per thousand dollars of shipments) for the four most energy-intensive industries. (The standard industrial classification [SIC] numbering is the nomenclature used for classifying industrial processes.)

The importance of energy costs to some industries is more evident below the 2-digit SIC level. Table 2 lists some of the highly energy-intensive sub-industries within the industries listed in Table 1. For the energy-intensive industries listed in Table 2, energy efficiency improvements may be the key to success of a firm. A DSM program may be the first step to achieving that success.

Table 1. Energy-Intensive Manufacturing Industries[6]

Industry	Energy Cost as a Fraction of All Operating Costs (%)	Energy Cost per Thousand Dollars of Shipments ($)
SIC 26 Paper	5.0	42.6
SIC 28 Chemicals	4.6	32.1
SIC 32 Stone/Clay/Glass	6.8	56.7
SIC 33 Primary Metals	6.0	57.7
Average for all Manufacturing	2.5	19.6

Table 2. Energy Intensive Manufacturing Sub-Industries[6]

Industry		Energy Cost as a Fraction of All Operating Costs (%)	Energy Cost per Thousand Dollars of Shipments ($)
SIC 262	Paper Mills	9.0	83.2
SIC 263	Paperboard Mills	9.5	87.0
SIC 281	Industrial Inorganic Chemicals	13.6	103.7
SIC 2812	Chlor-Alkali	22.4	199.9
SIC 2813	Industrial Gases	29.4	236.2
SIC 324	Cement, Hydraulic	21.4	204.8
SIC 3334	Primary Aluminum	19.7	228.9

4.0 UTILITY DSM EXPERIENCE WITH INDUSTRIAL CUSTOMERS

Designing and implementing a successful industrial DSM program involves a number of important choices and issues to be resolved if efficiency goals are to be achieved. As utilities change the way they operate, they need to be more prepared for and aware of customer needs. Finding the right combination of DSM program features, services, and delivery mechanisms is one secret of success.

Successful programs vary widely because they are attuned to the specific needs and interests of particular industries and companies, because rate structures and business climates differ from state to state and region to region, and because individuals with unique skills are typically catalysts in applying DSM programs in particular circumstances. At Boise Cascade, for example, a highly specific process improvement (in treatment of waste water from recycled products) was adopted for a number of reasons: because the new system reduced levels of environmentally regulated waste; because it reduced electricity use; and because the utility provided an acquisition payment to reduce the first cost and, thus, the payback period. At another manufacturing company, Eli Lilly and Company, management is environmentally conscious enough to encourage continuing improvements in energy efficiency; with the added advantage of a comprehensive set of DSM program options from its utility, such improvements meet Lilly's criteria for investments. Table 3 lists 12 types of programs and briefly describes the features, strengths, and weaknesses associated with each.

4.1 Assistance from Federal and State and Private Organizations

Several sources of industrial DSM or energy efficiency assistance are available in addition to those programs offered solely by utilities. Certain federal and state agencies, as well as other nonprofit organizations, offer assistance to industrial entities and the utilities that serve them. The programs offered are designed to help organizations increase the energy efficiency of their industrial processes and facilities. These programs also serve as a resource for organizations and utilities in implementing industrial DSM plans. In Table 4, several programs are listed by program name, sponsor (funding agency), and type of assistance provided.

4.2 Program Experience

The review of current industrial DSM programs reveals the general shift of industrial DSM programs from primarily a focus on finances to an emphasis on multifaceted service to respond to the energy efficiency needs of the industrial customer. After wholesale customers, industrial customers are the largest potential for load loss; therefore, industrial customers are a focus of concern for utilities and their future.[7] The successful industrial DSM programs have services and delivery mechanisms that were tailored to the needs of the industrial customer. In some cases, such as Southern California Edison, the intense competition and diversity of industry leads to programs that aggressively seek to meet the needs of every industrial customer. The solution for Southern California Edison is not the only solution. The variety of programs is quickly growing as the complexity and awareness of industrial needs grows and as the market opens up. Utilities are combining different services and financing mechanisms in DSM programs to find the optimal combination of motivation for the industrial firm and financial commitment by both the industrial firm and the utility.

Table 3. Types of Utility Industrial DSM Programs

Program Type	Description	Weakness	Strength
Rebates (financial)	A utility pays a rebate to the industrial firm for investment in DSM measures.	A utility must continue to pay as long as it wants to continue the DSM measures.	The rebate is the most popular program type. It involves the least expense for the *industrial firm.*
Loan (financial)	Utilities create easy ways for industrial firms to acquire loans.	This program has limited appeal to industrial firms that can get normal loans from banks.	This program especially helps capital-poor industrial firms, which would otherwise not be able to afford up-front costs.
Shared Savings (financial)	The industrial firm receives incentive to invest in efficiency and then shares its energy savings with the utility to pay back (part of) the incentive.	These programs involve extensive data collection to administer and figure savings.	The utility is able to recover more of its costs.
Leasing (financial)	The utility buys energy-efficient equipment and leases it to the industrial firm.	This approach may be costly to the utility if the lease is terminated before the equipment is paid for.	Some of the risk to the industrial firm trying efficient equipment is taken away.
Dedicated Allocation of DSM Funds (financial)	A fund for DSM programs is split among a group of industrial firms.	A high potential exists for free riders when everyone is given funding.	Industrial firms can depend on a certain amount of money to encourage efficiency.
Incentives to Hire Energy Managers (financial)	The utility guarantees that a manager will pay for herself in savings or the utility will make up the difference.	The program is costly and savings are difficult to assess in a mutually agreeable way.	It motivates the industrial to move on its *own* programming and measures.
Market Pull Programs (financial)	Vendor and customer incentives are used to make the market more energy efficient.	The utility pays more up-front to pull the market.	The utility may eventually taper off and even discontinue the incentives.
Information Only (education)	The utility offers information on efficiency to industrial firms.	Measuring actual savings is difficult.	The cost is relatively low.
Bidding (technical assistance)	The utility requests bids for another company to operate an efficiency program.	Utilities are having difficulty determining when bidding is appropriate.	Theoretically, bidding provides for the real market price of programs.
Comprehensive One-Stop Services (technical assistance)	The utility provides for and guides audit and program implementation.	It is costly to the utility in time and money.	The industrial firm enjoys individualized service.
Subscription Services (technical assistance)	A breakdown of services and costs is provided and the industrial firm chooses the services it wants.	The industrial firm may opt out of DSM and efficiency entirely.	The industrial firm is confident about services it is getting and paying for.
Brokering (technical assistance)	A third party encourages efficiency.	It can be more difficult to deal with two parties instead of just the one industrial firm.	The third party may actually facilitate coordinating the action of many industrial firms to provide for the whole.

Table 4. *Sources of Industrial Energy Efficiency Assistance*

Program Name	Funding Sponsor	Type of Assistance
Energy Analysis and Diagnostic Centers	US Department of Energy	Energy audits and technical assistance
Manufacturing Extension Partnership	National Institute of Standards and Technology	Technical assistance
Energy Star Showcase Buildings	US Environmental Protection Agency	Technical information
Green Lights Program	US Environmental Protection Agency	Financial assistance
Energy Efficiency and Renewable Energy Clearinghouse (EREC)	US Department of Energy	Technical information
DSM Pocket Guidebook for Industrial Technologies	US Department of Energy	Technical information
National Industrial Competitiveness through Energy, Environment, and Economics (NICE[3])	US Department of Energy & US Environmental Protection Agency	Financial assistance and technical information
Pinch Technology	Electric Power Research Institute	Computer software/technical information
Global, Automated Urban Government Energy System	Public Technology, Inc.	Computer software
The Chicago Energy Management Cooperative	Public Technology, Inc.	Technical assistance
Lighting Research Center	Rennselaer Polytechnic Institute	Technical assistance
Industrial Extension Service	North Carolina State University	Technical assistance
Energy Savings Plan Program	Bonneville Power Administration	Financial assistance
Integrated Resources Research Program	New York State Energy Research & Development Authority	Technical information and forecasting tools
Industrial Energy Efficiency and Economic Development Program	New York State Energy Research & Development Authority	Technical assistance
Flexible Technical Assistance Program	New York State Energy Office	Technical assistance
Customer Technology Application Center	Southern California Edison	Technical assistance
Electric Ideas Clearinghouse	Washington State Energy Office	Technical assistance
Regional Energy Efficiency Initiative	Southern California Edison, Southern California Gas Company, The Irvine Company, and the California Energy Commission	Technical assistance
Innovative Concepts Program	US Department of Energy	Financial assistance and research
Energy Related Inventions Program	US Department of Energy	Financial assistance and research
Federal Energy Management Program	US Department of Energy	Research/technical assistance
Metal Melting & Processing Applications Development	Electric Power Research Institute	Research
Nonmetals Technology Development	Electric Power Research Institute	Research
R&D Applications Center for Materials Fabrication	Electric Power Research Institute	Research
Industrial Program Technical Analysis & Planning Support	Electric Power Research Institute	Research
Establishment of an EPRI Pulp & Paper Office	Electric Power Research Institute	Research
Electricity Use & the Environment	Electric Power Research Institute	Research
EPRI Partnership for Industrial Competitiveness	Electric Power Research Institute	Technical information

Comprehensive one-stop services illustrate a change in utilities' use of industrial DSM. The shift from solely financial to more service-oriented programs is a response to the coming of competition. Industrial DSM programs of the future are likely to continue this change to treating utility kWh sales as a service, instead of a commodity. Industry's perception of energy efficiency benefits may also be expected to change as energy saving benefits are further demonstrated. Common traits among successful programs that seem to give strength to programs are mentioned frequently in the literature. The most frequently cited features of successful programs include[3]

- customer focus
- marketing techniques
- program flexibility
- financial incentives
- program analysis and evaluation
- partnerships.

In addition, the programs offering the larger financial incentives have above-average participation and savings.

5.0 CASE STUDIES

Case studies are presented for two companies that have implemented industrial DSM programs: Boise Cascade Corporation and Eli Lilly and Company. They illustrate how the process and outcomes were affected by the industrial characteristics and/or the successful DSM program features listed above.

5.1 Boise Cascade's West Tacoma Mill

Boise Cascade Corporation's West Tacoma Mill illustrates the key effect a utility DSM program can have on the decisions an industrial firm makes to remain competitive and to comply with environmental regulations. The director of technical and environmental affairs of Boise Cascade's West Tacoma Mill parlayed a utility DSM program's incentive into a mechanism to reduce the risk in adopting new technology to treat the waste water of a new newsprint recycling plant. Boise Cascade will save almost 7 million kWh annually as the result of a single project. In addition, the energy manager expects to save another 50 to 56 million kWh per year in his plant as a result of investing in options identified in a comprehensive audit just completed. The case study also describes the competitive environment faced by the newsprint operation, the utility industrial DSM program of Bonneville Power Administration, the role of Tacoma City Light, and the newsprint recycling and production process.

5.2 Eli Lilly and Company

Laboratories of Eli Lilly and Company illustrate how an active corporate energy engineering staff can leverage technical assistance and incentives of a utility DSM program to help meet corporate energy efficiency and competitiveness goals. Staff of Lilly's Energy Engineering Technical Center used utility DSM programs to enhance the energy efficiency of its main offices, a technical center, a toxicology testing plant, and two major production facilities in the state of Indiana.

For Eli Lilly and Company, the average savings over the last 3 years for just three of its plants is over 8 million kWh. For the three years 1992-94, savings now total 24 million kWh, and the company expects to achieve such savings yearly for at least the next ten years. If Lilly meets its goal, it will have achieved savings of over 100 million kWh by then.

5.3 Case Study Discussion

The case studies illustrate several points. First, and most obvious, these DSM programs resulted in savings of electricity. Second, energy efficiency savings in an industrial manufacturing environment is almost always tied to production and related processes. These case studies show that electricity savings in industry go far beyond simple lighting and high-efficiency motor retrofits. Third, both case studies show the great importance of auditing a facility to look for all opportunities—equipment efficiency, as well as process improvement. Both case study firms discovered potential savings and energy efficiency projects they either had not known about or had not had the time to identify themselves without outside assistance and encouragement. Fourth, commitment by either top management or an individual is a crucial requirement for successful utility DSM programs.

6.0 REVIEW OF REGULATORY ISSUES

State public utility commissions (PUCs) are responsible for overseeing utility industrial DSM programs within integrated resource planning (IRP) and other energy efficiency promotion activities. While PUC regulation of utility DSM programs varies from state to state, regulatory oversight usually includes review and approval of the DSM program design, implementation and evaluation processes. PUCs are often required to review all expenses incurred by a utility for DSM and to grant cost recovery only for those expenses judged to be prudent. PUCs have often initiated energy efficiency investments by utilities. It is in the state regulatory forum that issues surrounding industrial DSM programs, such as environmental externalities and retail wheeling, are resolved.

6.1 Interviews with PUC Staff

Researchers interviewed PUC staff in 10 states: Utah, California, Minnesota, Texas, Massachusetts, New York, Pennsylvania, Iowa, Wisconsin, and Georgia. Interviews included a discussion of industrial DSM program status, accounts of successful or failed programs, stakeholder views, DSM cost recovery issues, the future of industrial DSM, and the potential for federal and state roles in encouraging industrial energy efficiency.

Several points of agreement were evident among all ten PUC staff interviewed. All have active industrial DSM programs in place. The benefits to utilities are load retention and load management, and the benefits to industrial customers are in reduced cost of energy. All regulators mentioned that industrial companies object to sharing the cost of utility DSM programs for other customer classes and other industrial customers. A few states are moving toward subscription or optional DSM cost-sharing schemes and performance-based incentives. Successful programs noted by PUC staff used an innovative and usually comprehensive approach and had significant non-energy benefits. All but one indicated the future of DSM to be in greater customer service orientation. Retail wheeling is not uniformly seen as inevitable. The estimated effects of retail wheeling are perceived differently by utilities and industrial customers, but not consistently. Most PUC staff interviewed thought retail wheeling would jeopardize rates and services now enjoyed by core customers. PUC staff most often recommended that federal and state energy offices promote industrial energy efficiency through demonstration projects in their states.

6.2 The Future of Industrial DSM Programs

The future of industrial DSM is widely reported by PUC staff interviewed to be moving toward comprehensive programs, that is, programs that include rebates or other financial incentives for some prescriptive measures, such as lighting or motors, and performance measures, as described in a custom-designed efficiency upgrade. This view of the future also assumes that electricity will be marketed less like a commodity and more like a service, even in the event that retail wheeling becomes a reality. Any prognostications regarding industrial DSM programs necessarily include the likely effects of retail wheeling.

Performance-based rate-making, that is, the use of conservation incentives, will become more widespread, increasing the likelihood of more service-oriented efficiency programs. On the other side of this issue are PUC staff in California and elsewhere, who believe that if retail wheeling becomes a reality, utilities will eliminate industrial DSM programs in a effort to maintain the lowest possible costs. Equity considerations will emerge as the effects on core customers and others become known. Energy efficiency investments by industrial customers are expected to increase as the benefits in energy savings and economic productivity are demonstrated. PUC staff in several states look forward to increasing these projects to educate industrial customers and utilities in their states. In addition, federal support was encouraged in the areas of equipment efficiency standards, standard labels for motors, and training regarding engineering energy audits.

7.0 CONCLUSION

A number of very desirable benefits are associated with industrial DSM. In addition to the benefits to utilities and their industrial customers discussed above, society as a whole benefits from the reduced environmental stress and from the potential for a stable industrial base (with the concomitant employment opportunities) that energy efficiency improvements may encourage. Many public interest groups (i.e., non-government organizations) commend utility efforts to initiate industrial DSM programs.

Industrial partnering with utilities for DSM can be an incentive to change technologies, processes, and practices, all of which make the company more profitable. This partnering can substantially change the economics of installing energy efficiency measures. For some industries, DSM can increase economic competitiveness. By participating in utility DSM programs, Boise Cascade Corporation expects to save $133,000/year on electricity bills, and Eli Lilly and Company will save approximately $1 million over the next three years. For utilities, industrial DSM can help defer or obviate the need to construct additional generation (kW), transmission and distribution capacity, while helping them meet environmental regulations, keep their industrial customers, and improve their load factor and their public image.

Industrial DSM programs have gained substantial experience in overcoming the obstacles to energy and economic efficiency. Effective industrial DSM programs combine energy awareness, personal attention from decision-makers, the ability to couple energy savings with other benefits (such as process improvements), appropriate program vehicles, and the expertise to analyze and apply custom solutions. Though the mix of attributes may be difficult to orchestrate, successes provide benefits to all immediate participants and to the nation.

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