



ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

Opportunities, Barriers and Actions for Industrial Demand Response in California

A.T. McKane, M.A. Piette, D. Faulkner, G. Ghatikar, A.
Radspieler Jr., B. Adesola, S. Murtishaw, S. Kiliccote
Environmental Energy Technologies Division

January 2008



Disclaimer

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California.

Acknowledgements

The authors are grateful for the extensive support from numerous individuals who assisted in this project. Special thanks to Mike Gravely and Kristy Chew from the California Energy Commission and Greg Wikler of Global Energy Partners. This work described in this report was coordinated by the Demand Response Research Center and funded by the California Energy Commission, Public Interest Energy Research Program, under Work for Others Contract No.500-03-026 and by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Please cite this report as follows:

McKane, Aimee T., Mary Ann Piette, David Faulkner, Girish Ghatikar, Anthony Radspieler Jr., Bunmi Adesola, Scott Murtishaw and Sila Kiliccote. 2008. *Opportunities, Barriers and Actions for Industrial Demand Response in California*. PIER Industrial/Agricultural/Water End-Use Energy Efficiency Program. CEC-500-2008-XXX.

Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Opportunities, Barriers, and Actions for Industrial Automated Demand Response in California is the year-end report for the Industrial Demand Response Strategic Roadmap Project (Contract No.500-03-026, Task 5.4) conducted by Lawrence Berkeley National Laboratory. The information from this project contributes to PIER's Industrial/Agricultural/Water End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier or contact the Energy Commission at 916-654-4878.

Table of Contents

Preface	iii
Abstract	vi
Executive Summary	1
1.0 Introduction.....	6
1.1. Background and Overview	6
1.2. Program Goals and Objectives	6
1.2.1. Research Scope	8
1.2.2. Benefit to California	9
1.2.3. Report Organization	9
1.2.4. Previous Research	10
1.2.4.1. Industrial Demand Response.....	10
1.2.4.2. Industrial Energy Usage Patterns.....	11
1.3. Terms and Concepts for Industrial Auto-DR Strategies.....	16
2.0 Program Activities	19
2.1. Industrial Demand Response Strategic Research Roadmap	19
2.2. Utility Industrial Integrated Audit Demand Response Database	20
2.2.1. Purpose	20
2.2.2. Data collection methodology.....	20
2.2.3. Taxonomy.....	21
2.2.4. Analysis	23
2.2.5. Recommendations for improved data collection.....	30
2.3. Identification and Analysis of Barriers to Implementation of Industrial Auto-DR	30
2.4. Collaboration on Recruitment and Implementation	33
2.4.1. Site Questionnaire	33
2.4.2. Informational Pieces	33
2.4.3. Implementation	33
2.4.4. Outcomes.....	34
2.5. Scoping Studies.....	36
2.6. Submetering	36
3.0 Key Findings.....	39
4.0 Promising Areas for Future Research.....	43
5.0 Conclusion	45
6.0 References	46
7.0 Glossary.....	48
Appendix A. Industrial Demand Response Strategic Roadmap	
Appendix B. Industrial Demand Response Audit Database Structure	
Appendix C. Industrial Demand Response Audit Database Analyses	
Appendix D. Questions to Add to Integrated Energy Audit Template for Industrial Facilities	
Appendix E. Site Questionnaire	

Appendix F. Fact Sheets
Appendix G. Implementation Examples

List of Tables

Table 1. Electricity Used by California Manufacturing Industries, 2004	13
Table 2. Demand Side Management Framework for Industrial Facilities	16
Table 3. Industrial Demand Response Potential by Plant Type (Top 25 by Average kW)....	24
Table 4. Industrial Demand Response Potential by 4-Digit NAICS (Top 25 by Average kW)	25
Table 5. Comparison by 4-Digit NAICS Category of Top Electricity Consuming Manufacturing Industries and Industrial Demand Response Potential from Audit Database Top 25 Industries by Average kW	26
Table 6. Industrial Demand Response Potential by Shift/Shed Strategy for Production	27
Table 7. Industrial Demand Response Potential by Shift/Shed Strategy for Supporting Systems	27
Table 8. Industrial Demand Response Potential by Technology/Measure.....	29
Table 9. Barriers Analysis of Industrial Demand Response	31
Table 10. 2007 PG&E Auto-DR Participation Profile (industry as a % the total).....	35
Table 11. Auto-DR Program Goals and Results	36
Table 12. Industrial Participants in Sub-Metering Study	38

List of Figures

Figure 1. Discovery Process for Industrial Auto-DR Implementation.....	5
Figure 2. Demand Profile of Various Demand Response Methods in Industrial Facilities ..	17
Figure 3. Generic Automated DR Open-Interface Standard Architecture	19
Figure 4. Industrial Demand Response Audit Database Taxonomy	22
Figure 5. Load Shed Test August 30, 2007.....	34

Abstract

In 2006 the Demand Response Research Center (DRRC) formed an Industrial Demand Response Team to investigate opportunities and barriers to implementation of Automated Demand Response (Auto-DR) systems in California industries. Auto-DR is an open, interoperable communications and technology platform designed to:

- Provide customers with automated, electronic price and reliability signals;
- Provide customers with capability to automate customized DR strategies;
- Automate DR, providing utilities with dispatchable operational capability similar to conventional generation resources.

This research began with a review of previous Auto-DR research on the commercial sector. Implementing Auto-DR in industry presents a number of challenges, both practical and perceived. Some of these include: the variation in loads and processes across and within sectors, resource-dependent loading patterns that are driven by outside factors such as customer orders or time-critical processing (e.g. tomato canning), the perceived lack of control inherent in the term “Auto-DR”, and aversion to risk, especially unscheduled downtime. While industry has demonstrated a willingness to temporarily provide large sheds and shifts to maintain grid reliability and be a good corporate citizen, the drivers for widespread Auto-DR will likely differ. Ultimately, most industrial facilities will balance the real and perceived risks associated with Auto-DR against the potential for economic gain through favorable pricing or incentives. Auto-DR, as with any ongoing industrial activity, will need to function effectively within market structures.

Keywords: Industrial, demand, response, management, automated, DR, auto-DR, shed, shift, peak, load, grid, signal, energy, efficiency

Executive Summary

Overview

In 2006 the Demand Response Research Center (DRRC) formed an Industrial Demand Response Team to investigate opportunities and barriers to implementation of Automated Demand Response (Auto-DR) systems in California industries. Auto-DR is an open, interoperable communications and technology platform designed to:

- Provide customers with automated, electronic price and reliability signals;
- Provide customers with capability to automate customized DR strategies;
- Automate DR, providing utilities with dispatchable operational capability similar to conventional generation resources.

This research began with a review of previous Auto-DR research on the commercial sector. Implementing Auto-DR in industry presents a number of challenges, both practical and perceived. Some of these include: the variation in loads and processes across and within sectors, resource-dependent loading patterns that are driven by outside factors such as customer orders or time-critical processing (e.g. tomato canning), the perceived lack of control inherent in the term “Auto-DR”, and aversion to risk, especially unscheduled downtime. While industry has demonstrated a willingness to temporarily provide large sheds and shifts to maintain grid reliability and be a good corporate citizen, the drivers for widespread Auto-DR will likely differ. Ultimately, most industrial facilities will balance the real and perceived risks associated with Auto-DR against the potential for economic gain through favorable pricing or incentives. Auto-DR, as with any ongoing industrial activity, will need to function effectively within market structures.

Research Goals

The goal of the industrial research is to facilitate deployment of industrial Auto-DR that is economically attractive and technologically feasible. Automation will make DR:

- More visible by providing greater transparency through two-way end-to-end communication of DR signals from end-use customers;
- More repeatable, reliable, and persistent because the automated controls strategies that are “hardened” and pre-programmed into facility’s software and hardware;
- More affordable because automation can help reduce labor costs associated with manual DR strategies initiated by facility staff and can be used for long-term

Key Research Questions

To help frame this research, we formulated five research questions. While much can be learned from the current empirical approach of “learn by doing”, the limited findings from the first year led to questions concerning assumptions about industrial Auto-DR. Although this market is complex, substantial research opportunities exist to target promising sectors and systems to

gain a better understanding of their potential, while also providing a forum to foster and accelerate DR-compatible advances in industrial controls. For its second year of research, the DRRC Industrial Team plans to build on our initial findings and focus the research on answers to the following key questions:

- 1. Where is the potential to shed or shift electricity use in industry?**
 - Which sectors have the greatest potential to shed or shift during peak periods?
 - Have these sectors been active in reliability programs or identified in audits?
- 2. What is the functional capability of specific industries to implement Auto-DR?**
 - What are the control gaps and the associated cost of implementing Auto-DR?
 - Of sectors identified as having Auto-DR potential, which offer the most cost-effective implementation opportunities?
- 3. What are the market trends in industrial controls that support Auto-DR?**
 - Do advances in control technologies make specific sectors or systems attractive candidates for Auto-DR?
 - What are the technology gaps that might benefit from public R&D?
- 4. What are the market and operational barriers to the implementation of reliability and price-responsive industrial DR?**
 - Do industrial energy managers understand economic and societal benefits of DR?
 - What roles do price and incentives have in the decision making process?
 - What are the areas of tension between DR and industrial plant schedules?
- 5. What is the role of industrial Auto-DR in the state's goal to provide reliable and climate-friendly electricity at a reasonable cost to CA consumers?**
 - Is there "migration potential" for DR strategies in promoting industrial load management and energy efficiency in industrial facilities?

Developing a greater understanding of the opportunity for Auto-DR is timely because the market for better controls and facility wide enterprise energy management is immature, but emerging rapidly. Early entries into this market have focused on load management, but these tools and strategies, if DR enabled, hold significant promise for integration into an Auto-DR framework. Similarly, the emergence of higher quality system level network controls provide the missing link to allow improved management of key energy systems, and thus greater opportunities for DR and overall energy efficiency. The complete integration of load management, DR, and energy efficiency across an entire industrial plant may be within reach of many plants within the next decade. Under this scenario, even plants without onsite generation could, under pre-determined conditions, free up electricity to the grid to preserve the system reliability and manage the cost of delivering statewide electricity while maintaining the economic health of their businesses.

The DRRC has outlined a research methodology for implementation of Auto-DR. The potential Auto-DR seems substantial and attainable. Within the next two or three years specific sectors will be targeted with a menu of potential Auto-DR strategies, enabled by the rapid growth of improved industrial controls to support these strategies.

Key Findings in 2007

There appears to be great potential for Auto-DR in industrial facilities. This finding needs to be qualified with further research to understand 1) organizational decision-making processes as they impact DR participation and 2) the role of existing and emerging industrial controls in facilitating participation in Auto-DR, 3) end-use process controls to support reduced service and process control levels during DR events.

Key Finding: Some industrial facilities will shift or shed process load based on financial incentives, not just to protect reliability.

- In certain niche markets, such as industrial gases, electricity is a large proportion of operating costs. As a result, demand management is an integral part of the operating culture with sophisticated controls. For these markets, Auto-DR offers a cost-management opportunity that is integrated into the production schedule
- Shifting a batch process, such as a hammer mill, may be acceptable as an Auto-DR strategy even if it is not be something done on a daily basis.

Key Finding: Auto-DR is compatible with energy efficiency and load management in industrial facilities

- Plants who express interest in Auto-DR are typically already engaged in both energy efficiency and demand management improvements. Auto-DR is another cost-reduction tool, not a replacement for efficiency and demand management.

Key Finding: Many industries have limited controls, especially for supporting or non-core systems that may be suited for Auto-DR. There is an emerging market for demand management and system-level network controls that could allow Auto-DR to be integrated. Discrete controls offer less Auto-DR capability.

Our research identified opportunities for demonstrations or case studies in several areas:

- Adaptation of existing demand management software for Auto-DR applications;
- Minor modification to make network controls for supporting systems DR-enabled;
- Modification of Auto-DR software designed for energy efficiency and load management in data centers;
- Opportunities to “think beyond the plant” by bundling similar Auto-DR shed strategies into a single controls network so that sheds could be “tuned” to actual needs within the scope of individual participation agreements.

Key Finding: The current portfolio of DR programs is confusing, but the availability of financial incentives and technical assistance can make participation attractive.

Industrial facilities are not concerned with DR, since their focus is on core production. The current DR programs and tariffs are so complex that they create challenges. Unless the incentives are substantial, most industries are not willing to study the potential benefits. A simpler approach is needed.

Key Finding: It is possible to define DR shed/shift strategies for specific industries. We can develop preliminary “short lists” for promising sectors to further evaluate their feasibility.

Although the sample size was limited (207 records) and is based on recommended rather than implemented strategies, nine 4-digit NAICS categories were identified as in the top-25 for both large users of manufacturing electricity (Table 1) and DR potential by average kW from the utility integrated audits (Table 4). These categories include:

- Converted Paper Product manufacturing
- Fruit and Vegetable Preserving and Specialty Food Manufacturing
- Basic chemical manufacturing, especially industrial gases
- Dairy Product manufacturing
- Aerospace Product and Parts Manufacturing
- Other Fabricated Metal Product Manufacturing
- Animal Slaughtering and Processing
- Bakeries and Tortilla Manufacturing
- Beverage Manufacturing

Of these, the industrial gas sector appears ready for implementation. Anecdotal evidence from industrial end users indicates that DR opportunities may be found in other industrial sectors. The key research question is “to what extent can and will these facilities accept automation of DR?” The nine sectors listed above were compared against recommendations in other related reports¹. We recommend an initial “short list” of five industrial sectors recommended for further study based on knowledge of these sectors:

- Cold storage
- Data centers and test labs for high tech industries
- Water/wastewater
- Aerospace products
- Beverages, including breweries and wineries

¹ These reports are: Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Demand Response Programs by Quantum Consulting (2006) and Demand Response Analysis and Tool Development for Industrial, Agricultural and Water (IAW) Energy Users by EPRI for the California Energy Commission (2005).

While there is a wide range of potential shift and shed strategies requiring further study, those most frequently identified in the utility integrated audits are:

- For production shifts - conveyors, all systems, pump systems, and electrical;
- For production sheds - all systems (stop production), finishing, process cooling and pump systems;
- For supporting system load shifts - space conditioning, motors, process cooling, and storage; and
- For supporting system load sheds - aerators, multiple systems, electrical, and compressed air.

Future Research

For the second year of research, the DRRC proposes to work with a Technical Advisory Group comprised of representatives from industry and the suppliers and consultants that work with them. This research will be directed toward key research questions outlined above to assist the California Energy Commission (CEC), the California Public Utilities Commission (CPUC), and the investor-owned utilities in more effectively targeting their Auto-DR efforts. Figure 1 below shows a proposed organizational framework.

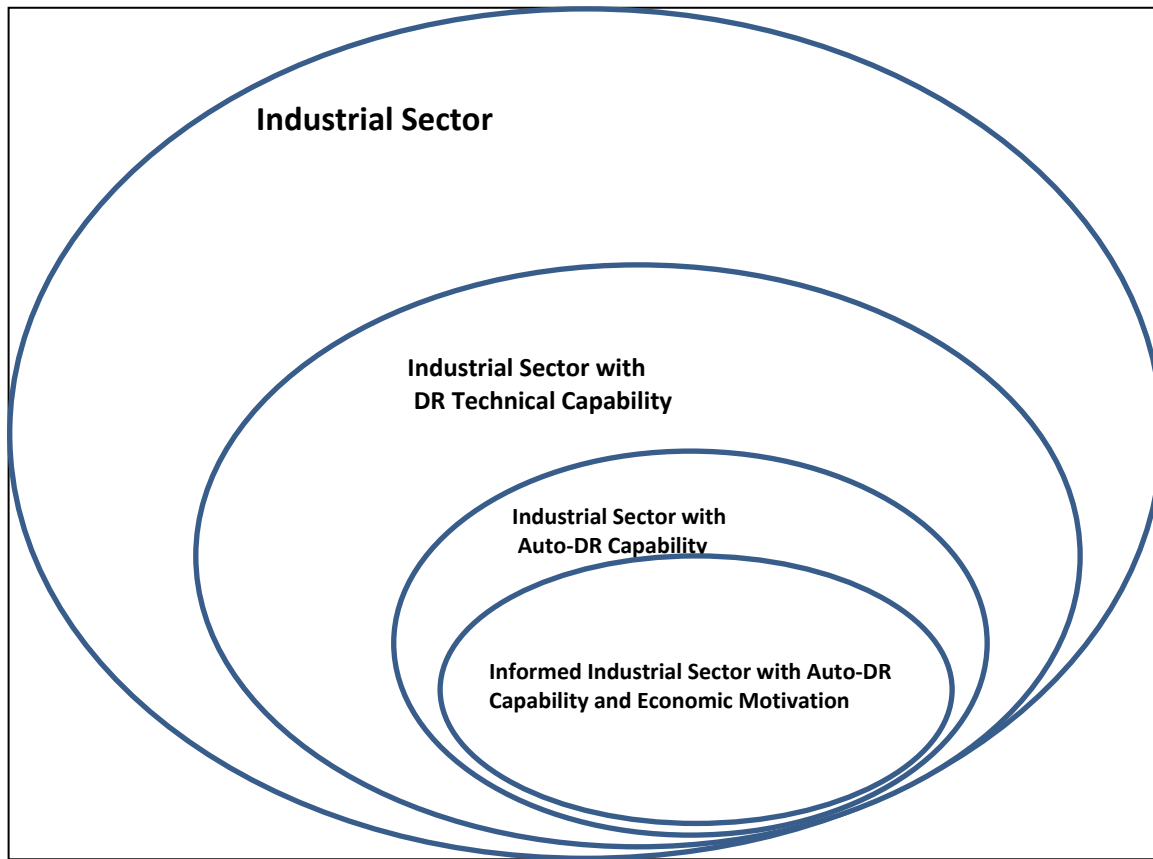


Figure 1. Discovery Process for Industrial Auto-DR Implementation

1.0 Introduction

1.1. Background and Overview

Demand Response (DR) is a set of actions taken to reduce electric loads when contingencies, such as emergencies or congestion, occur that threaten supply-demand balance, and/or market conditions occur that raise electric supply costs. DR programs and tariffs are designed to improve the reliability of the electric grid and to lower the use of electricity during peak times to reduce the total system costs. Automated Demand Response (Auto-DR) is a set of standard, continuous, open communication signals and systems provided over the Internet to allow facilities to automate their demand response with no “human in the loop.”

The Demand Response Research Center (DRRC) at Lawrence Berkeley National Laboratory (LBNL) has tested Auto-DR systems in over 50 commercial buildings over the last four years. Most of the building strategies have focused on lighting, cooling, and ventilation system strategies automated through building Energy Management Control Systems (EMS). Historically, California (CA) industries have participated in a number of DR programs on a manual basis, including day-ahead and day-of programs such as Demand Bidding Program (DBP), Base Interruptible Program (BIP), Capacity Bidding Program (CBP), and Critical Peak Pricing Program (CPP).

Implementing industrial Auto-DR presents a number of challenges, both practical and perceived. Some of these include: the wide variation in loads and processes across sectors and even within sectors, resource-dependent loading patterns that are driven by outside factors such as customer orders or time-critical processing (e.g. tomato canning), the perceived lack of control inherent in the term “Auto-DR”, and aversion to risk, especially unscheduled downtime. In October 2006, an Industrial Demand Response Team was formed at LBNL under the auspices of the DRRC (identified in this report as the DRRC Industrial Team) to investigate opportunities and barriers to implementation of Auto-DR in California Industries. This report represents the results of the first year of research by the team.

1.2. Program Goals and Objectives

The California Energy Commission (CEC) has outlined a reach goal of achieving 448 megawatts (MW) of peak demand reduction (DR) from the industrial sector by 2008². The industrial sector represents 20% of the base electricity peak demand, or approximately 8600 MW. In addition to the opportunities in industrial energy efficiency and demand management, preliminary estimates indicate that 30-40% of industrial loads may be automatic demand response (Auto-DR) candidates³. To date, California’s Auto-DR activity has been focused largely on the commercial buildings sector. While many industrial facilities have participated in reliability and “day ahead” notification programs (1857 MW and 1044 MW, respectively in 2005 – the latest

² CPUC D.04-09-060, AB 32 as cited in California Energy Commission’s PIER Industrial Efficiency Strategic Plan, 2007

³ PIER Demand Response R&D Strategy, Commissioner Geesman Briefing August 24, 2006

date for which a complete evaluation is available), only a small number of industrial sites have participated in other types of DR.⁴

Developing a greater understanding of the magnitude and practical application of Auto-DR is particularly timely. In the past few years, a number of companies have either initiated, or expressed serious interest in, the development of new product offerings designed to provide plant managers with software and hardware tools to more closely manage their energy use in real time. The market for energy management controls or energy enterprise management is still quite immature, but emerging rapidly. Early entries into this market have focused largely on load management, but these same tools and strategies, if DR enabled, hold significant promise for integration into an Auto-DR framework. Similarly, the emergence of higher quality system level network controls provide the missing link that would allow much tighter management of energy end use, and thus both greater opportunities for demand response as well as higher overall energy efficiency. The complete integration of load management, demand response, and energy efficiency across an entire industrial plant may be within reach of many plants within the next decade. These systems will permit the plant of the future to manage electricity, and potentially natural gas, for price and for actual, rather than perceived, demand. Under this scenario, even plants without any onsite generation capability could, under pre-determined conditions, automatically free up electricity to the grid in order to preserve the reliability and/or manage the cost of delivering electricity statewide while maintaining the economic health of their businesses.

Historically, industrial DR programs have engaged facilities to participate in manual or semi-automated demand response largely in response to reliability issues. In its inaugural year, the DRRC Industrial Team began conducting research on strategies for engaging CA industry in Auto-DR, with a particular focus on the practical potential of 1) small, frequent sheds or shifts that could be accommodated without any significant disruption in facility operations and 2) the decision-making strategies that facilities might apply in evaluating the attractiveness of a price-responsive (as opposed to reliability) shed or shift. The research seeks to build on lessons from the successful implementation of DR in the commercial sector as well as knowledge acquired by the CEC, LBNL, and others concerning the energy use patterns and DR potential for California industry.

The goal of the DRRC industrial research is to facilitate deployment of industrial Auto-DR that is economically attractive and technologically feasible. Automating demand response will make DR:

- More visible by providing greater transparency through two-way end-to-end communication that allows Internet tracking of the receipt of DR signals from end-use customers;

⁴ Statewide program participation for industrial and agricultural customers in Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Demand Response Programs, Quantum 2006

- More repeatable, reliable, and persistent because the DR signals trigger fully automated controls strategies that are “hardened” and pre-programmed into facility’s software and hardware;
- More affordable because automation can help reduce labor costs associated with manual DR strategies initiated by facility staff and can be used for long-term benefits.

During the first year of study, the DRRC Industrial Team began to develop the broad outlines of a methodology for successful implementation of Auto-DR. While significantly more work needs to be done, the potential for industrial Auto-DR seems substantial and attainable. We envision a situation within the next two or three years in which specific sectors will be targeted with a menu of potential Auto-DR strategies, enabled by the rapid growth of industrial controls to support these strategies.

1.2.1. Research Scope

The 2006-2007 DR industrial research considered both near-term needs to facilitate industrial Auto-DR for the summer of 2007 and as well as longer term research. This longer-term study is focused on five key research questions.

Key Research Questions

- 1. Where is the potential to shed or shift electricity use in industry?**
 - Which sectors have the greatest potential to shed or shift during peak periods?
 - Have these sectors been active in reliability programs or identified in audits?
- 2. What is the functional capability of specific industries to implement Auto-DR?**
 - What are the control gaps and the associated cost of implementing Auto-DR?
 - Of sectors identified as having Auto-DR potential, which offer the most cost-effective implementation opportunities?
- 3. What are the market trends in industrial controls that support Auto-DR?**
 - Do advances in control technologies make specific sectors or systems attractive candidates for Auto-DR?
 - What are the technology gaps that might benefit from public R&D?
- 4. What are the market and operational barriers to the implementation of reliability and price-responsive industrial DR?**
 - Do industrial energy managers understand economic and societal benefits of DR
 - What roles do price and incentives have in the decision making process?
 - What are the areas of tension between DR and industrial plant schedules?
- 5. What is the role of industrial Auto-DR in the state’s goal to provide reliable and climate-friendly electricity at a reasonable cost to CA consumers?**
 - Is there “migration potential” for DR strategies in promoting industrial load management and energy efficiency in industrial facilities?

Research to date has included:

- A literature search on prior experience (mainly in California and New York) with industry participation in interruptible demand response programs as described in **Section 1.2.4.1**.
- Preliminary analysis of electricity use and electricity use patterns in California industry, as described in **Section 1.2.4.2**
- A draft Industrial Demand Response Strategic Roadmap, as described in **Section 2.1**
- Creation and analysis of the Utility Industrial Integrated Audit Demand Response Database, as described in **Section 2.2**.
- An analysis of the potential barriers to industrial implementation of Auto-DR, including additional insights from 2007 field work, as described in **Section 2.3**
- Collaboration in PG&E territory on Auto-DR recruitment and implementation for the 2007 season, as described in **Section 2.4**
- A summary of the results of scoping studies undertaken to gain a better understanding of sector-specific DR opportunities and barriers in the food processing and semiconductor industries, as described in **Section 2.5**.
- Analysis of sub-metering to monitor DR at six industrial facilities over a period of two years, as described in **Section 2.6**.

1.2.2. Benefit to California

This report provides a summary of research findings to date and plans for future research on industrial demand response. Demand response also holds promise as an attractive enhancement of the control strategies introduced into industrial facilities for load management.⁵ The enhancement of these load management control strategies for *Auto-DR could, in turn, make visible through measurement and analysis, the true energy efficiency potential to be realized in many facilities through cost-effective operational changes.* This integrated approach that optimizes both the timing and amount of electricity to meet production needs describes the energy-efficient California industrial facility of the future.

1.2.3. Report Organization

This section describes the context, rationale, and potential for industrial demand response; program goals and objectives; research scope and key questions; previous research, industrial energy usage patterns, and terms and concepts for industrial Auto-DR strategies.

Section 2 describes the program activities undertaken in the first year, including:

- the industrial demand response roadmap,
- development and analysis of an industrial demand response database from the utility integrated audits,
- identification and analysis of barriers to implementation of Auto-DR,

⁵ Customer actions intended to limit the amount of electricity used at a particular time, particularly to avoid demand charges

- collaboration on recruitment and implementation,
- the results of submetering at selected sites, and
- summary results from scoping studies to date.

Section 3 summarizes key findings from these activities.

Section 4 identifies promising areas for future research.

Section 5 provides conclusions.

Section 6 lists references.

Section 7 provides a glossary of terms

Supporting information is included in the Appendices A-G.

1.2.4. Previous Research

1.2.4.1. Industrial Demand Response

To support the PIER DRRC industrial demand response research tasks and plans, a literature search was conducted to evaluate the key research questions on industrial DR and state of the art knowledge. A complete list is included in Section 6, References. In addition to a number of publications from the DRRC that provided a valuable foundation for this research, a few key studies with relevance to industrial DR are discussed here:

- Quantum Consulting and Summit Blue Consulting. 2006. Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Demand Response Programs, prepared for Southern California Edison Company and Working Group 2 Measurement and Evaluation Committee.

This report includes a good overview of manual industrial DR programs for large nonresidential customers in California, including terminology, participation, barriers, recommendations, and submetering results. Of particular interest is the summary of submetering results, which is analyzed in more depth in Section 2.6.

- EPRI (Electric Power Research Institute), 2005. Demand Response Analysis and Tool Development for Industrial, Agricultural and Water (IAW) Energy Users. Sacramento, CA: California Energy Commission

Using a telephone survey, in-depth interviews were conducted with a small sample of energy managers of the following sectors: cement, electronics, industrial gases, metal casting, petroleum refining, pulp and paper, oil and gas refining, water agencies, agricultural production, and food processing. Key findings include:

1. Reliability is a profoundly more potent motivator than energy cost for DR;
2. The packaging of DR offerings is perceived as inadequate;
3. A business's profit margin can affect their view of economically-driven DR;
4. DR creates a conflict of interest with other energy cost reduction measures;

5. DR that relies on shedding or shifting manufacturing loads is likely to face a stiff, uphill battle.

While acknowledging that additional research is required, the initial results of our first year would seem to support the concept that demand response can actually lead to greater energy efficiency and that industry will, under certain circumstances in selected sectors, voluntarily agree to a production shift or shed. Although much more data is needed, these decisions appear to hinge on the quality of the business proposition versus the risk.

- Goldman, C. and N. Hopper, O. Sezgen, M. Moezzi, R. Bharvirkar, B. Neenan, D. Pratt, P. Cappers, and R. Boisvert. 2004. *Does Real-Time Pricing Deliver Demand Response? A Case Study of Niagara Mohawk's Large Customer RTP Tariff*. LBNL-54974

Examines how Niagara Mohawk (NY) large customers adapted to real time pricing, with government/educational customers the most responsive group, industry second most responsive, and commercial customers, third. A key finding was that while industrial customers have lower responses to day-ahead prices, the New York Independent System Operator DR programs significantly boost industrial participants' price response when events are called. Also of note was the seeming lack of correlation between installation of DR-enabling technology and subsequent program participation.

- York, Dan and Martin Kushler. 2005. *Exploring the Relationship Between Demand Response and Energy Efficiency: A Review of Experience and Discussion of Key Issues*. American Council for an Energy-Efficient Economy, Washington, DC Report # U052.

This report examines the relationship between energy efficiency and demand response (not limited to industrial), especially areas for potential conflict. The authors acknowledge that there is little published research in this area on how demand response affects energy use during off-peak periods as well as energy use and energy efficiency more generally. The report concludes that energy efficiency programs achieve demand reduction at a higher cost than demand response programs, but could be considered as providing baseline levels of peak-demand reduction or "permanent demand response". There is an assumption of loss of service from demand response that is not attributed to energy efficiency. On the other hand, the authors use NYSERDA's programs as evidence that "energy efficiency and demand-response objectives can be combined into a single package." Of interest in this report is the recognition of an as yet unrealized potential for advanced building systems to be used as "an active management tool" – primarily due to the lack of economic incentives and human resources.

1.2.4.2. Industrial Energy Usage Patterns

This section describes preliminary analysis conducted on industrial consumers of electricity by industry type for their potential to participate in demand response (DR) programs, taking into consideration such factors as the share of the total industrial consumption of purchased electricity and what is currently known about the technical or economic potential of these industries to execute DR measures.

A particularly useful document for this work is the California Industrial Existing Construction Energy Efficiency Potential Study CALMAC Study ID: PGE2052.01 (KEMA 2006). This report identifies three types of energy efficiency potential for California industries: technical, economic, and achievable program potential. The data included in this report are helpful in developing an understanding of the energy use patterns and potential for California industry.

Manufacturing Industries

Table 1 ranks all California industries by their consumption of purchased electricity using 2004 data from the California Energy Commission. Information on self-generation is included, but for the purposes of DR, it is the electricity delivered from the grid that matters. The industries have been grouped at the four-digit level of the North American Industrial Classification System (NAICS). Industries have been further disaggregated to the five- or six-digit level for categories that are highly heterogeneous within the four-digit classification or where one specific industry accounts for a particularly large proportion of the four-digit total.

The table also shows an estimate of average MW demand by these industries. The estimate is derived from total consumption using an assumed 24-hour daily production schedule and an 80 percent average capacity utilization factor. This assumption may underestimate the demand of highly seasonal industries, such as wineries and food canning and freezing facilities. The top ten largest users of electricity at the four-digit level are discussed in more detail below. Where relevant, a comparison is made between the results of these analyses and the conclusions of the 2005 report commissioned by the CEC from EPRI.

Table 1. Electricity Used by California Manufacturing Industries, 2004

NAICS Code	NAICS Category	Purchased MWh	Share Mfg Purchased	Self-Gen MWh	Purchased MW ^a
3344	Semiconductors & Electronic Components	2,633,090	8.1%		375.7
334413	Semiconductors & Related	1,792,902	5.5%		255.8
3261	Plastic Products	1,942,201	6.0%		277.1
3241	Petroleum & Coal Products	1,542,391	4.8%	5,212,623	220.1
3251	Basic Chemicals	1,406,927	4.4%	702,408	200.8
32512	Industrial Gases	1,318,637	4.1%	170,465	188.2
3341	Computers & Peripherals	1,199,963	3.7%		171.2
3364	Aerospace Products	1,115,034	3.4%		159.1
336411	Aircraft Manufacturing	460,641	1.4%		65.7
3121	Beverages	1,108,782	3.4%		158.2
31211	Soft Drinks & Ice	307,454	1.0%		43.9
31212	Breweries	261,101	0.8%		37.3
31213	Wineries	531,865	1.6%		75.9
3273	Cement & Concrete	1,096,399	3.4%	131,090	156.4
32731	Cement	732,087	2.3%	131,090	104.5
3115	Dairy Products	1,046,196	3.2%		149.3
311513	Cheese	498,635	1.5%		71.2
3114	Canned & Frozen Foods	912,000	2.8%		130.1
311421	Fruit & Vegetable Canning	389,159	1.2%		55.5
3342	Communication Equipment	943,187	2.9%		134.6
3254	Pharmaceuticals & Medicines	810,562	2.5%		115.7
3345	Navigation & Control Instruments	836,715	2.6%		119.4
3222	Paper Products	752,872	2.3%		107.4
3272	Glass	746,146	2.3%		106.5
3279	Other Nonmetallic Mineral Products	707,426	2.2%		100.9
3231	Printing	705,239	2.2%		100.6
3118	Bakeries & Tortillas	615,210	1.9%		87.8
3323	Structural Metals	578,981	1.8%		82.6
3116	Meat Packing	569,358	1.8%	61,203	81.2
3391	Medical Equipment	515,781	1.6%		73.6
3329	Other Fabricated Metal Products	487,471	1.5%		69.6
3328	Coating & Engraving	400,338	1.2%		57.1
3332	Industrial Machinery	360,654	1.1%		51.5
3119	Other Foods	324,901	1.0%		46.4
3324	Boilers, Tanks, Containers	316,848	1.0%		45.2

^a Assumes 24-hour operation at average 80% plant capacity factor.

The largest industrial user of purchased electricity in California is Semiconductors and Other Electronic Components. The manufacture of semiconductors alone accounts for nearly 70 percent of the four-digit total. Semiconductor and electronic component manufacturing generally runs on a relatively constant annual and time of day production schedule. Semiconductor electricity consumption is dominated by a few large plants in California. Due to the high margin of the products produced, it is unlikely that these facilities would engage in any measures that would affect core production. However, the EPRI report states that portions of loads used for R&D activities (e.g., test runs of new chip designs), selected support loads in manufacturing, and loads that serve administrative areas could be available for curtailment in

response to high prices. The EPRI report further notes that electricity comprises 40 to 60 percent of the operating costs for semiconductor manufacturing. Facility energy managers tend to be knowledgeable and receptive to technical innovation. Anecdotal information collected during 2007 Auto-DR site recruitment appears to support these statements.

The next largest user of purchased electricity at the four-digit level is the manufacture of plastic products. This includes products such as bags, pipes, plastic sheets, foam, and bottles. Energy consumption is fairly evenly distributed through this subsector, except for the largest six-digit subsector, which is All Other Plastic Products. As one of the larger electricity consumers in California, some in-depth assessment of potential DR measures in this industry should be conducted, perhaps in cooperation with the Society of the Plastics Industry, which has previously collaborated with the U.S. Department of Energy on energy efficiency studies.⁶

The largest total user of manufacturing electricity (purchased and self-generated) in California is Petroleum and Coal Products, a sector that is dominated by petroleum refineries and includes more than 1.5 MWh of purchased electricity and 5.2 MWh of self generated electricity. The EPRI report describes petroleum refining as a “fair” candidate for DR, but estimates a DR potential of only 7.6 MW, despite an estimate of over 900 MW of coincident peak demand, which would seem to include on-site generation. However, 7.6 MW is still only 3.5 percent of our estimated demand of 220 MW, and it certainly seems possible that with more in-depth analysis opportunities for greater reductions could be identified.⁷

Basic Chemicals accounts for 4.4 percent of purchased manufacturing electricity, of which Industrial Gases represents the largest share. This sector was rated as a “good” candidate for DR in the EPRI report. The authors point out that industrial gas manufacturers have considerable experience with interruptible rates and can reschedule processes relatively easily. EPRI estimates an achievable curtailable load of 131 MW. While this is based on a higher estimated coincident load of 240 MW, it still represents a very high share of load, about 55 percent. Sheds of this magnitude are supported by the results of the 2007 DRRC Industrial Team collaboration. This is a sizeable DR resource in a concentrated industry where outreach to a relatively small number of energy managers would help to enable a significant DR resource. See Section 2.4 Collaboration for a further discussion of DR experience with this sector.

The fifth largest user of purchased manufacturing electricity is Computers and Peripheral Equipment. Unlike the Semiconductors and Electronic Components industry, this industry is composed of the facilities that assemble components into final products. This industry is included in the broader “electronics industry” categorization used in the EPRI report. As a

⁶ *Improving Energy Efficiency in US Manufacturing Plants*, 2005, prepared by the Society of the Plastics Industry and the U.S. Department of Energy, DOE/GO 102005-2111
http://www1.eere.energy.gov/industry/bestpractices/pdfs/plastics_report.pdf

⁷ A resource for developing a more in-depth understanding is: Worrell, Ernst and Christine Galitsky. 2004. *Profile of the Petroleum Refining Industry in California* prepared for the California Industries of the Future Program. LBNL-55450 <http://ies.lbl.gov/iespubs/55450.pdf>

large user of electricity, this industry also warrants a more in-depth assessment of potential DR measures.

Of the next five largest purchased electricity users, the EPRI report includes all except for Aerospace Products. Electricity consumption is fairly evenly split among the six six-digit level subsectors of Aerospace Products, although Aircraft Manufacturing consumes the largest share at about 40 percent of electricity in this industry. With a limited number of sites to approach and a good track record in energy efficiency, this industry may also represent a promising source DR potential and deserves further research to determine DR amenable loads.⁸

The EPRI report covers the “Cement” portion of Cement & Concrete Products as well as food processing – broadly defined to include fruit and vegetable preservation, dairy products, and beverages. EPRI characterizes cement as a “good” DR candidate with an estimated achievable DR potential of 39 MW based on an estimated coincident peak demand of 212 MW. A cement industry respondent to EPRI’s survey felt that most of the DR potential could be achieved by rescheduling certain electricity-intensive support operations. Anecdotal evidence from the industry would seem to support this statement.

In contrast, EPRI describes the food processing industry as a “fair” candidate for DR. The authors note that these industries are very concerned about interruptions that could result in product spoilage and that survey respondents from this industry indicated that only a small share of this industry’s load would be available for DR. For fruit and vegetable processing, in particular, peak production coincides with statewide peak electricity usage. A scoping study to further assess DR potential in food processing industries is summarized in Section 2.5. However, this study is based on survey results and more basic technical research is needed, particularly for specific subsectors. Based on their relative share of the load, wineries, breweries, and cheese producers should be more intensively targeted for DR research and demonstration. A few wineries have already received DR audits from PG&E contractors and these audits are being analyzed to determine the most promising DR measures.

Cold storage associated with fruit and vegetable processing may also offer DR potential. In addition to the manufacturing industries listed above, refrigerated warehouses consumed another 1,245,811 MWh with 722,988 GWh in the NAICS 4931 category (warehousing and storage) and the rest in NAICS 4244 (grocery wholesale). Due to the relative homogeneity of the technology and the relative ease of implementing DR, utilities should focus on recruiting sites in these sectors. In the section of the 2005 Evaluation Report of DR programs that reviewed the experience with sub-metering of six industrial facilities, adjustment of cold storage was the principal strategy used at four sites (Quantum Consulting, 2006). Two of these sites used this strategy quite successfully, and this would appear to be an easily replicable strategy

⁸ This statement seems to be supported by feedback received from several leading companies in Nov-Dec 2007 as part of the 2009-2020 Statewide Energy Efficiency Strategic Plan process – see the industry sector under <http://www.californiaenergyefficiency.com>

that could contribute significantly to DR in California. A more detailed analysis of which products have the most tolerance for temporary temperature increases and the amount of cold storage space dedicated to those products would help to refine the targeting of facilities in these NAICS codes.

1.3. Terms and Concepts for Industrial Auto-DR Strategies

The demand-side management (DSM) framework is presented in Table 2. Demand Side Management Framework for Industrial Facilities provides three major areas for changing electric loads in industrial buildings: energy efficiency (for steady state load minimization); peak load management (for daily operations); and DR (for event driven dynamic peak load reduction).

Table 2. Demand Side Management Framework for Industrial Facilities

	Demand-Side Management		
	Efficiency and Conservation (Daily)	Peak Load Management (Daily)	Demand Response (Dynamic Event Driven)
Motivation	Utility Bill Savings Environmental Protection	TOU Savings Demand Charge Savings Grid Protection	Price Reliability Emergency Grid Protection
Design	Efficient Production and Support Equipment & Systems	Low Power Design	Dynamic Control Capability for Production and Support Systems
Operations	Integrated Support System Operations Optimized Production System Operations	Demand Limiting Demand Shifting	Demand Shedding Demand Shifting Demand Limiting
Initiation	Local	Local	Remote

- *Energy Efficiency:* Energy efficiency and conservation can lower energy use to provide the same level of service. Driven by the desire for utility bill savings and environmental protection, energy efficiency measures permanently reduce peak load by reducing overall consumption. This is typically done in industrial facilities by installing energy efficient equipment and facilitating efficient operations.
- *Daily Peak Load Management:* Daily peak load management is the practice of operating a facility to reduce time-of-use or peak demand charges. Typical peak load management methods include demand limiting and demand shifting. *Demand limiting* refers to shedding loads when pre-determined peak demand limits are about to be exceeded.

Loads are restored when the demand is sufficiently reduced. This is typically done to flatten the load shape when the pre-determined peak is the monthly peak demand. *Demand shifting* is shifting the loads from peak times to off-peak periods. Figure 2 displays the typical demand profile of an industrial facility employing these methods. While not always the case, notification requirements, workforce considerations, and supplier schedules often result in load shifts at industrial facilities occurring later, rather than earlier, in a 24 hour period.

- *Demand Response*: Demand response refers to the modification of customer electricity usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. Demand response programs may include dynamic pricing and tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control or equipment cycling. DR methods, such as demand limiting and shifting can be utilized when the economics and reliability issues are predicted and communicated to each site in advance. *Demand shedding* is the dynamic temporary reduction, or curtailment of peak load through building services or process load changes.

The bottom row of Table 2 labeled “Initiation” indicates if the activity is a result of a local facility manager motivation or a remote requirement set forth by the facility or an outside entity, such as a utility.

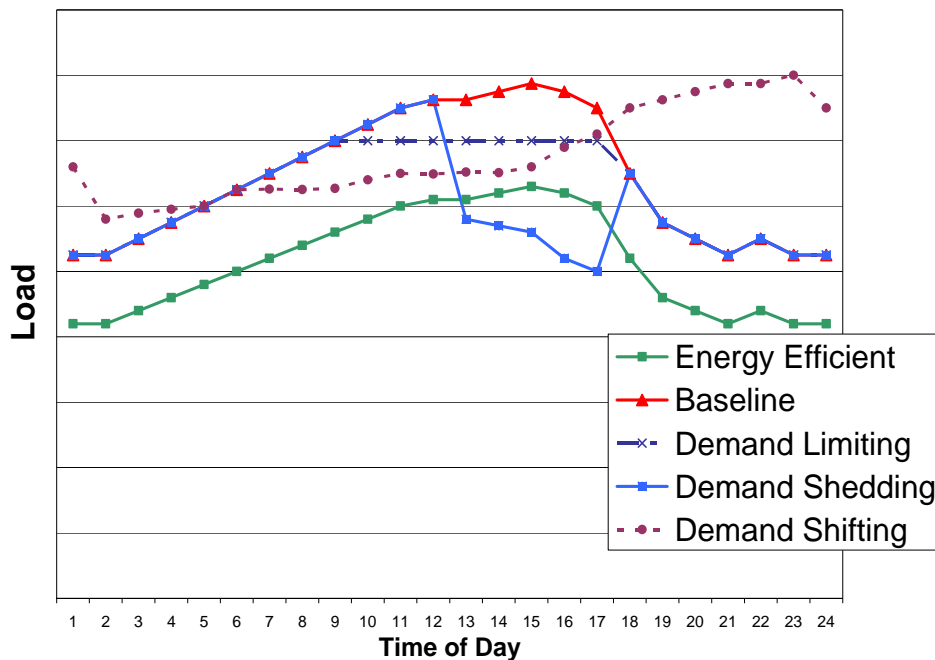


Figure 2. Demand Profile of Various Demand Response Methods in Industrial Facilities

Automated Demand Response (Auto-DR) Technology Overview

The technology used for Auto-DR programs for industrial facilities in 2007 originated from initial conceptual design in 2002 at LBNL. Auto-DR is a fully automated demand response system using Client/Server service oriented architecture (SOA) and is intended to replace labor-intensive manual and semi-automated DR. Before 2007, Auto-DR was primarily used for commercial buildings for HVAC and lighting end-use loads using signals between utilities and customer facilities based on communication technology standards that integrated with third-party proprietary controls and communications software. The essential elements of an Auto-DR system are shown in Figure 3 and include:

- Demand Response Automation Server (DRAS) for Auto-DR based on the interoperable, standard-based architecture using Web Services (WS);
- Client & Logic with Integrated Relay (CLIR) box, WS software client, etc., customized for industry requirements, providing flexibility for participation; and
- Energy Management Control Systems, Energy Information Systems (EMCS/EIS) or other forms of control systems with pre-programmed DR strategies are used within the industry.

Auto-DR systems are built using eXtensible Markup Language (XML) and Simple Object Access Protocol (SOAP) based secure Web Service Oriented Architecture (SOA) for platform-independent, interoperable systems that use low-bandwidth Transmission Control Protocol and Internet Protocol (TCP/IP) Internet connections. This Auto-DR technology has been used for PG&E, SCE CPP and/or DBP Auto-DR programs during 2007 and is scalable to accommodate California's goal of dynamic-pricing and real-time-pricing (RTP) models.

As shown in Figure 3, the steps involved in the Auto-DR process during a DR event are:

1. The Utility or ISO defines DR event and price/mode signals are sent to the DRAS;
2. DR event and price services published on the DRAS;
3. DRAS Clients (CLIR or WS) request real-time event data from the DRAS every minute;
4. Customized pre-programmed DR strategies determine action based on event price/mode;
5. Facility Energy Management Control Systems (EMCS) or related controls carry out load reduction based on DR event signals and strategies.

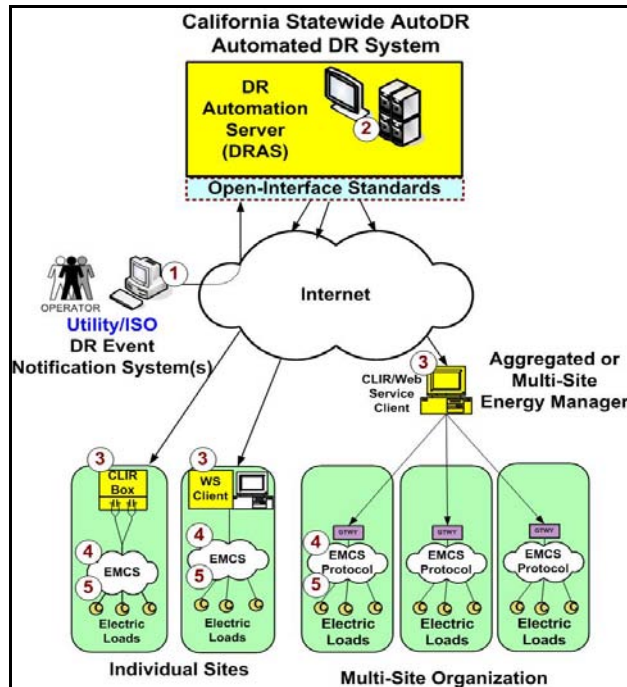


Figure 3. Generic Automated DR Open-Interface Standard Architecture

2.0 Program Activities

2.1. Industrial Demand Response Strategic Research Roadmap

The first task of the Industrial Auto Demand Response Program was to develop an Industrial Demand Response Research Roadmap. The purpose of the roadmap is to provide guidance for research on methods to reduce peak electric demand in the industrial sector through an automated demand response. The roadmap identifies technical, educational and economic barriers to successful industrial Auto-DR and methods for overcoming these barriers. The research combines analysis with empirical results from field experience and theoretical process control. The initial draft Roadmap was informed by several resources, including:

- CEC's Demand Response Analysis and Tool Development for Industrial, Agricultural, and Water (IAW) Energy Users;
- Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Response Programs;
- U.S. DOE Energy Footprints;
- Results of sub-metering demand response demonstration projects;
- Original research by DRRC to begin to characterize California's industrial load by process within each industry by comparing the results of estimated electricity usage and coincident peak demand as described in Section 1.5.2; and
- CEC/PIER Industrial End Use Energy Efficiency strategic planning process.

Initial development included work with CEC staff and the DRRC to synthesize and integrate findings concerning the demand response potential for California industry. The draft report is included in Appendix A.

Future work on the Research Roadmap will include the following additional resources through a Technical Advisory Group:

- Results from ongoing utility-based demand response activities, including Auto-DR implementation experience;
- Input from concerned stakeholders, especially relating to industrial control technologies and strategies; and
- Input from contractors, especially those undertaking sector-specific analyses and studies and DR tool development.

2.2. Utility Industrial Integrated Audit Demand Response Database

2.2.1. Purpose

California's investor-owned utilities (IOUs) have been offering energy efficiency audits to large service sector and industrial customers for many years as part of their demand side management activities. Historically, these audits have focused exclusively on energy efficiency (EE) measures, but increasing interest in demand response has led the IOUs to ask auditors to include information on both EE and DR opportunities. These integrated audits have only recently begun to incorporate DR recommendations, with few audits performed prior to 2005 containing DR recommendations.

The DRRC launched the development of a DR audit database to synthesize findings from the integrated audits across the state. Price-responsive DR strategies are much less developed in the industrial sector due to the heterogeneity of energy uses and the demands of maintaining production schedules. The DR audit database has an initial focus on the integrated audits performed in manufacturing facilities in order to promote greater uptake of DR capacity in the industrial sector. The DR audit database allows researchers at the DRRC to analyze the results according to a variety of criteria such as industry classification, measure type, and utility provider.

2.2.2. Data collection methodology

Due to the confidentiality of the data from the utilities' integrated audits, the DRRC reached an agreement to have a DRRC Industrial Team member review the audits at the utility offices and record notes in a spreadsheet. The subject company names were redacted from the review documents. Using this methodology, DRRC was able to obtain 103 audit records from Pacific Gas & Electric (PG&E), 85 audit records from Southern California Edison (SCE) and 19 records from San Diego Gas and Electric (SDG&E).

2.2.3. Taxonomy

The audit database is designed to structure the integrated audit data to allow analysis for Auto-DR potential by North American Industry Classification System (NAICS) or plant type, by shift or shed strategy for both production and supporting systems, and by technology or measure. This was accomplished by developing a draft structure based on the Team’s industrial energy efficiency and commercial demand response experience. This preliminary structure evolved during a testing and refining process as it was populated with data. The current structure is in Microsoft Access and is sufficiently flexible to be modified for additional categories as the need arises.

There are two main tables: “Audit Info” and “Measure” that are linked together through a one-to-many relationship. Each record (or Audit ID) in the Audit Info table is linked to a maximum of six demand response measures that are listed in the Measure table. A diagram of these relationships is illustrated in Figure 4. A detailed list of database fields can be found in Appendix B.

Since NAICS designations were not provided in the original data, each audit record was evaluated by the Team and assigned a category based on the plant description. Although the energy efficiency data associated with each audit was not disaggregated by measure as part of this initial process, its integrity has been preserved for future disaggregation and analysis, if desired.

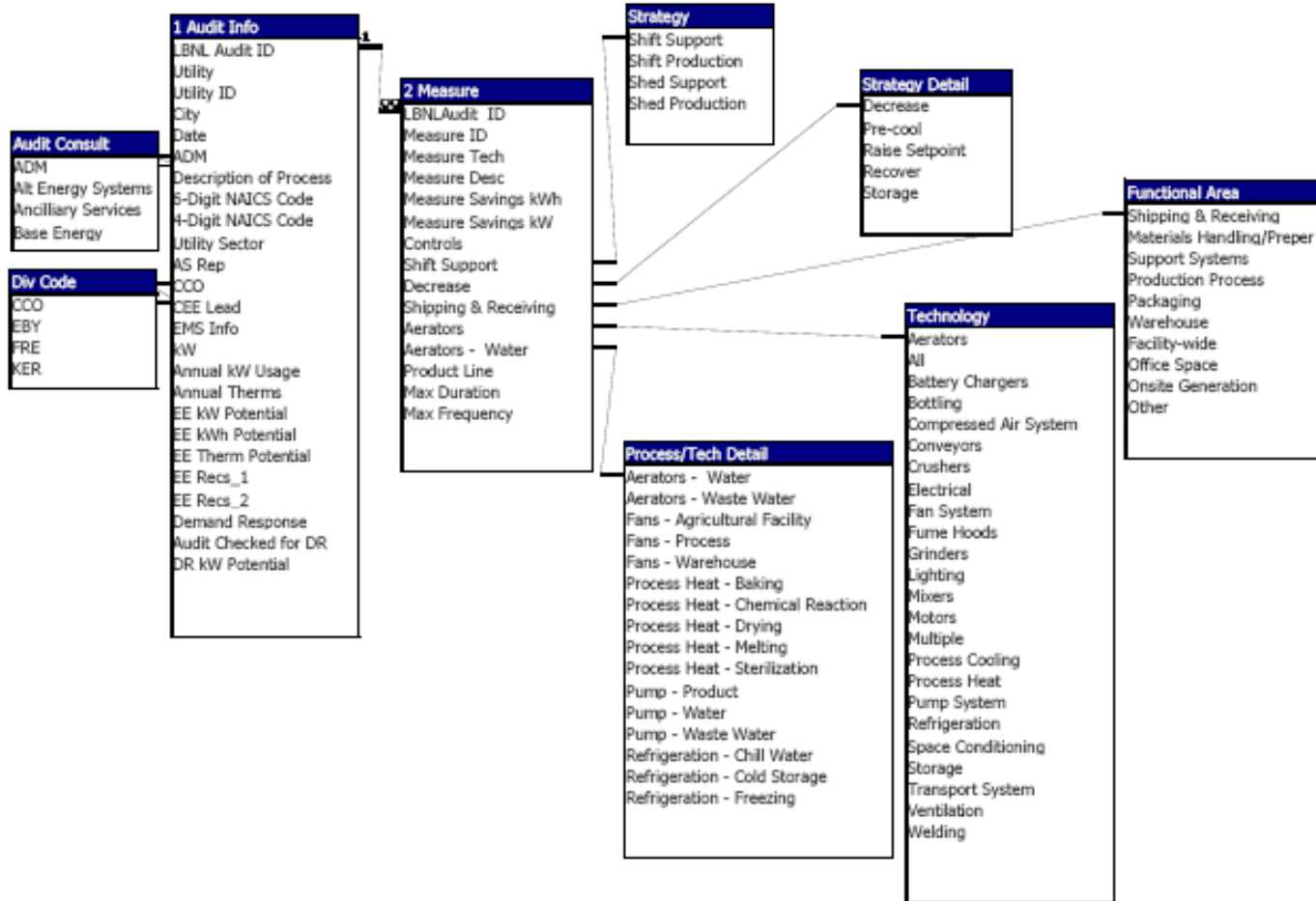


Figure 4. Industrial Demand Response Audit Database Taxonomy

2.2.4. Analysis

Analyses were conducted of the 207 records in the Industrial Demand Response Audit Database. The highlights of these analyses are captured in the series of summary tables in Tables 3-8. A complete version of the data in Table 3 and Table 4 is included in Appendix C.

Table 3 presents the average DR potential by plant type and the sum for each plant type category. Where the sample includes only one plant of that type, the average and sum will be the same. Table 4 uses the 4-digit NAICS categories assigned by plant type to develop a slightly more aggregated picture for the top 25 categories by average kW demand response potential. In Table 5, the NAICS categories in the top 25 by average kW demand response potential for the Industrial Demand Response Audit Database are compared to the top 25 manufacturing industries by electricity use from Table 1. Given the relatively small sample size, there are a significant number of matches – 9 out of 25. These categories may warrant further study.

Leading opportunities for production shifts are conveyors, all systems, pump systems, and electrical. For production sheds, the leading opportunities are all systems (stop production), finishing, process cooling, and pump systems. For supporting systems, the leading opportunities to shift load are space conditioning, motors, process cooling, and storage. The leading shed opportunities are aerators, multiple systems, electrical, and compressed air.

Table 6 identifies and quantifies the production shift/shed potential for specific strategies; Table 7 does the same for supporting systems. In Table 8, the specific technologies involved in the shift and shed strategies are identified.

Table 3. Industrial Demand Response Potential by Plant Type (Top 25 by Average kW); n=207

Sum of DR kW Potential		DR kW Potential		
Description of Process	Total	Description of Process	Sum	Ave
Lumber products, fiber board	3504	Lumber products, fiber board	3504	3504
Federal R&D	2320	Federal R&D	2320	2320
Olive Processing Plant	1979	Olive Processing Plant	1979	1979
Quarrying /processing of mineral rock & sand aggregate	2582	Quarrying /processing of mineral rock & sand aggregate	2582	1291
Envelopes	1133	Envelopes	1133	1133
Milk, water, eggnog, juice	933	Milk, water, eggnog, juice	933	933
Agricultural irrigation	895	Agricultural irrigation	895	895
Aircraft equipment	890	Aircraft equipment	890	890
Industrial gases	1759	Industrial gases	1759	880
Makes PVC pellets or cubes	870	Makes PVC pellets or cubes	870	870
Waffle Food Process	868	Waffle Food Process	868	868
Cotton clean and bale	834	Cotton clean and bale	834	834
Strawberry Processing, Freezing	817	Strawberry Processing, Freezing	817	817
Bakery bread, buns	749	Bakery bread, buns	749	749
Fresh water delivery	733	Fresh water delivery	733	733
Fluid control equipment	657	Fluid control equipment	657	657
Batteries	1750	Batteries	1750	583
Unknown [not identified in audit]	582	Unknown [not identified in audit]	582	582
Distribution warehouse for food products	523	Distribution warehouse for food products	523	523
Ground walnut shells	490	Ground walnut shells	490	490
Fruit drier, processors	449	Fruit drier, processors	449	449
Clay Products, Building Materials	415	Clay Products, Building Materials	415	415
Wastewater treatment plant	791	Wastewater treatment plant	791	396
Poultry Processor	744	Poultry Processor	744	372
Food packaging	326	Food packaging	326	326

Table 4. Industrial Demand Response Potential by 4-Digit NAICS (Top 25 by Average kW); n=207

4-Digit NAICS Code	NAICS Description, 2007	DR kW Potential	
		Sum	Ave
3211	Sawmills and Wood Preservation	3598	1799
2123	Nonmetallic Mineral Mining and Quarrying	2582	1291
3222	Converted Paper Product Manufacturing	1133	1133
5417	Scientific Research and Development Services	2693	898
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	4403	881
3331	Agriculture, Construction, and Mining Machinery Manufacturing	1729	865
3251	Basic Chemical Manufacturing	1868	623
3359	Other Electrical Equipment and Component Manufacturing	1750	583
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Ma	1091	546
4529	Other General Merchandise Stores	523	523
3115	Dairy Product Manufacturing	1011	506
1151	Support Activities for Crop Production	490	490
3364	Aerospace Product and Parts Manufacturing	943	472
3329	Other Fabricated Metal Product Manufacturing	768	384
3116	Animal Slaughtering and Processing	744	372
3149	Other Textile Product Mills	303	303
3312	Steel Product Manufacturing from Purchased Steel	598	299
2213	Water, Sewage and Other Systems	7441	286
3118	Bakeries and Tortilla Manufacturing	1106	277
1121	Cattle Ranching and Farming	1018	255
3121	Beverage Manufacturing	2436	244
3221	Pulp, Paper, and Paperboard Mills	240	240
3271	Clay Product and Refractory Manufacturing	440	220
3339	Other General Purpose Machinery Manufacturing	633	211
4931	Warehousing and Storage	1045	209

Table 5. Comparison by 4-Digit NAICS Category of Top Electricity Consuming Manufacturing Industries and Industrial Demand Response Potential from Audit Database Top 25 Industries by Average kW

Table 1		Table 4	
3344	Semiconductors & Electronics	3211	Sawmills and Wood Preservation
3261	Plastic Products	2123	Nonmetallic Mineral Mining and Quarrying
3241	Petroleum & Coal Products	3222	Converted Paper Product Manufacturing
3251	Basic Chemicals*	5417	Scientific Research and Development Services
3341	Computers & Peripherals	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3364	Aerospace Products	3331	Agriculture, Construction, and Mining Machinery Manufacturing
3121	Beverages	3251	Basic Chemical Manufacturing*
3273	Cement & Concrete	3359	Other Electrical Equipment and Component Manufacturing
3115	Dairy Products	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers & Filaments
3114	Canned & Frozen Foods	4529	Other General Merchandise Stores
3342	Communication Equipment	3115	Dairy Product Manufacturing
3254	Pharmaceuticals & Medicines	1151	Support Activities for Crop Production
3345	Navigation & Control Instruments	3364	Aerospace Product and Parts Manufacturing
3222	Paper Products	3329	Other Fabricated Metal Product Manufacturing
3272	Glass	3116	Animal Slaughtering and Processing
3279	Other Nonmetal Minerals	3149	Other Textile Product Mills
3231	Printing	3312	Steel Product Manufacturing from Purchased Steel
3118	Bakeries & Tortillas	2213	Water, Sewage and Other Systems
3323	Structural Metals	3118	Bakeries and Tortilla Manufacturing
3116	Meat Packing	1121	Cattle Ranching and Farming
3391	Medical Equipment	3121	Beverage Manufacturing
3329	Other Fabricated Metal Products	3221	Pulp, Paper, and Paperboard Mills
3328	Coating & Engraving	3271	Clay Product and Refractory Manufacturing
3332	Industrial Machinery	3339	Other General Purpose Machinery Manufacturing
3119	Other Foods	4931	Warehousing and Storage

* includes industrial gases

Table 6. Industrial Demand Response Potential by Shift/Shed Strategy for Production; n=207

Average of Measure Savings kW		
Strategy	Technology	Total
Shift Production	Conveyors	435
	All	430
	Pump System	304
	Electrical	216
	Crushers	200
	Multiple	166
	Molding	137
	Mixers	136
	Storage	105
	Motors	83
	Process Heat	79
	Compressed Air System	53
	Grinders	51
	Welding	51
	Bottling	28
	Battery Chargers	25
	Transport System	15
	Aerators	8
	Fan System	8
	Packing	7
Shift Production Average		178

Average of Measure Savings kW			
Strategy	Technology	Total	
Shed Production	All	1038	
	Finishing	714	
	Process Cooling	386	
	Pump System	324	
	Space Conditioning	230	
	Multiple	95	
	Process Heat	77	
	Motors	40	
	Molding	24	
	Compressed Air System	19	
	Ventilation	8	
	Shed Production Average		224

Note: The designation “All” for production shift denotes a major change in production operations while the “All” designation for production shed denotes a shutdown.

Table 7. Industrial Demand Response Potential by Shift/Shed Strategy for Supporting Systems; n=207

Average of Measure Savings kW		
Strategy	Technology	Total
Shift Support	Space Conditioning	377
	Motors	167
	Process Cooling	104
	Storage	101
	Pump System	92
	Refrigeration	64
	Compressed Air System	53
	Battery Chargers	35
	Multiple	17
	Grinders	14
	Transport System	14
	Welding	9
	Fan System	6
Shift Support Average		111

Average of Measure Savings kW		
Strategy	Technology	Total
Shed Support	Aerators	539
	Multiple	321
	Electrical	212
	Compressed Air System	165
	Grinders	141
	Fume Hoods	129
	Pump System	113
	Motors	111
	Reverse Osmosis	103
	Storage	99
	Fan System	88
	Packing	59
	Process Heat	41
	Process Cooling	40
	Space Conditioning	38
	Transport System	36
	Battery Chargers	31
	Refrigeration	30
	Lighting	26
	Waste Treatment	21
	Ventilation	15
Vending machine	1	
Shed Support Average		75

Table 8. Industrial Demand Response Potential by Technology/Measure; n=207

Measure Savings kW		
Technology	Sum	Ave
Pump System	9326	141
All	8453	604
Space Conditioning	5449	73
Multiple	4950	138
Compressed Air System	3624	125
Aerators	2163	433
Lighting	2041	26
Process Cooling	1598	89
Motors	1560	92
Process Heat	1264	63
Fan System	984	76
Grinders	908	114
Conveyors	870	435
Electrical	859	215
Storage	804	101
Finishing	714	714
Crushers	600	200
Battery Chargers	437	34
Molding	298	99
Refrigeration	219	44
Bottling	138	28
Mixers	136	136
Fume Hoods	129	129
Reverse Osmosis	103	103
Transport System	101	25
Packing	66	33
Welding	60	30
Ventilation	52	13
Waste Treatment	21	21
Vending machine	1	1
Grand Total	47928	109

2.2.5. Recommendations for improved data collection

As an outcome of collecting and conducting preliminary analyses of PG&E audit, the DRRC Industrial Team met with PG&E to discuss improving the quality of data collected concerning control capabilities for Auto DR in industrial facilities. At PG&E's request, a draft template for additional information was prepared and submitted to for consideration in January 2007. A particular focus of the additional data collection is to increase knowledge of controls capability and shed/shift tolerance. See Appendix D.

2.3. Identification and Analysis of Barriers to Implementation of Industrial Auto-DR

Table 9 lists examples of barriers that impede the adoption of demand response (DR) in the industrial sector. It is composed of three columns: descriptions of the barriers, suggested solutions, and the entities that will need to be involved in implementing those solutions.

The first barrier shown refers simply to the lack of knowledge about DR measures that are feasible in the industrial sector. In contrast to the services sector, large energy consuming end uses in industry are considerably more heterogeneous. DR analysts are beginning to have some sense of practical and effective DR strategies for industrial applications, and sector-specific studies for California have been undertaken for the food processing and hi-tech/biotech sectors. However, DR opportunities in many other industries remain unknown. California's utilities have begun to require energy auditors to include recommendations for DR as well as energy efficiency, and these audits are providing a valuable new source of data for measures that are cross-cutting as well as industry-specific.

The second barrier is that incentives for facilities to participate in DR events are simply not attractive enough to justify much effort, whether staff time or other expenses dedicated to enabling DR. This is particularly true in the industrial sector, where many potential DR measures could result in either production losses or costs increases related to shifting production. The 2005 program evaluation indicated that at current incentive levels the economic DR potential from non-participants is only 280 MW (Quantum Consulting, 2006). The utilities and the California Public Utilities Commission (CPUC) will probably need to redesign the tariff structure of DR programs in order to adequately reward facilities that achieve significant reductions.

The operational barrier describes the fact that industrial customers are sometimes not able to implement measures within the short lead time given by the current notification schedule in the utilities' DR programs. Unlike HVAC or lighting measures, DR strategies with large potential in the industrial sector may require some reorganization of production or shipping schedules. A notification system that gives manufacturers a longer lead time might facilitate certain measures that would otherwise go untapped.

Table 9. Barriers Analysis of Industrial Demand Response

<u>Barrier</u>	<u>Solution</u>	<u>Implementer</u>
Poor Understanding of Technical Potential of Measures in Industry	Subsectoral assessment of DR potential by technology/process	PIER, DRRC
Economic: Insufficient DR Incentives, Revenue Neutrality	Tariff reform	Utilities, CPUC
Operational: Insufficient Time to Adjust Production or Implement Measures	Earlier notification, targeted Auto-DR possible with technical knowledge	Utilities, CPUC
Missed Notification	Improved notification systems, validation, send notifications to multiple contacts, Auto-DR	Utilities, PIER, DRRC
Technical Knowledge at Facilities	Expand DR audits, publication of an Industrial DR Guide, DR training	Utilities, PIER, DRRC, control vendors
Cost-Benefit Evaluation	Research on costs of DR measures (productivity) and DR savings valuation tool	PIER, DRRC, EPRI, trade associations
Facility Staff Time Constraints and Repeatability	Auto-DR	Utilities, PIER, DRRC, control vendors

Missed DR event notifications were a common problem that surfaced for several sites among the submetering case studies in the 2005 Evaluation (Quantum Consulting, 2006). Some facility managers reported that they were often busy or unavailable when notifications were sent. At one submetered site, the 2005 events were missed because notifications were being sent to a staff member who had departed. Greater use of Auto-DR would help overcome this barrier by obviating the need to notify facility staff. Notification systems that automatically alert two or three staff members per site might also help to ensure that events are not missed for these reasons.

The technical knowledge barrier differs from the technical potential barrier in that technical potential concerns the macro policy level while technical knowledge refers to facility-level implementation. Once certain industries and processes have been targeted on the basis of their technical potential, some training for facility managers and possibly controls vendors will still be required to help facility managers understand how to respond to events and integrate DR into their control systems. Technical knowledge about executing DR measures can be enhanced by expanding the number of DR audits, creating DR guides for the most promising measures in targeted sectors, and initiating workshops to provide DR training on successful strategies and the use of various energy management systems to implement measures.

A cost-benefit barrier has been encountered in evaluations of DR programs in that facility managers rarely have a good grasp of the financial implications of participating in DR measures. This relates to the first barrier, because little analysis has been done of the costs of enabling or executing DR measures on industrial processes. Even on the benefit side, facility managers in California have several DR and reliability tariffs to choose from. Few facility managers have been willing to spend the time analyzing these tariffs against their estimated DR potential to determine what benefits will actually accrue to their plants. A beta version of a DR valuation tool has been developed to help users evaluate the benefits of different programs, but it has not yet been widely released. (EPRI, 2005) Finalization and dissemination of the tool might be helpful for facility managers to determine which, if any, DR program makes sense for their companies.

Another finding of the 2005 Evaluation was that staff time constraints were cited as one reason that several facilities did not participate in DR events. Even when facility managers receive notifications, they may be too busy to execute the manual DR strategy. This may be exacerbated by the fact that current incentives may be too low for facility managers to prioritize DR. Automated DR overcomes this barrier by avoiding the need for human action to realize the DR reductions. However, automated DR systems in the industrial sector face their own set of obstacles. They are currently very rare and further technological development, standardization of protocols, and staff training will be required before automated DR becomes widespread in the industrial sector.

This analysis of barriers to industrial DR reveals that seven key obstacles impede greater adoption of DR in industry. The first obstacle necessitates ongoing basic research to identify a portfolio of DR measures that industries can execute with little or no impact on production. The economic, operational, and notification barriers require intervention from the utilities and the

CPUC in order to redesign certain aspects of the DR programs currently offered. The last three barriers all concern the capacity of facility managers to understand DR strategies, evaluate the costs and benefits of DR programs, and execute measures when events are called. Better tools, technical assistance, and development of automated DR technologies would contribute to overcoming these barriers.

2.4. Collaboration on Recruitment and Implementation

From April through September 2007, the DRRC Industrial Team coordinated closely with Global Energy Partners (GEP) in the identification and recruitment of industrial sites for Auto-DR. This coordination included weekly meetings to discuss prospects and to plan joint site visits as needed. During this period, Team members participated in a number of industry meetings, especially at the invitation of the Silicon Valley Leadership Group (SVLG). Several tools were developed by the Team to assist in the recruitment process, including a site questionnaire and two fact sheets on Auto-DR for data centers and industry in general.

2.4.1. Site Questionnaire

The Site Questionnaire was developed by the DRRC Industrial Team in response to a need to have a more structured method for initial data collection from potential Auto-DR candidates. The final product includes useful input from EPRI and is meant to be self-directed. The questionnaire received limited use during the 2007 season because it was completed in July, but is anticipated to provide a better structure for recruitment during the 2008 season. See Appendix E.

2.4.2. Informational Pieces

Two fact sheets were developed by the DRRC Industrial Team for the purpose of communicating the purpose, benefits, and possible strategies for Auto-DR in data centers and in industry more generally. Both fact sheets were used during the 2007 season for this purpose and will be revisited prior to the 2008 season to determine whether additional refinement is needed. See Appendix F for copies of the fact sheets.

2.4.3. Implementation

The implementation process to recruit industrial customers for AutoDR involved identifying and validating the load shed/shift opportunity and estimating the plant technology upgrade. The DRRC Industrial Team coordinated with GEP on a process that included completing a customer participation agreement, scheduling a kick-off meeting, assigning a technical coordinator to implement the technology upgrade, and performing a test to validate the opportunity. The DRRC Industrial Team participated in a number of implementation activities that included weekly conference calls, networking and referrals, developing and maintaining a prospect list, site visits, research and technical review, and training. The weekly conference calls were used to discuss and share information concerning potential industrial sites, the recruitment process, and to refine target sector strategies as experience was gained. In addition to GEP's recruitment efforts, leads were generated through the Team's outreach and coordination to industrial associations, consultants, and others. Members of the Team also participated in and/or hosted PG&E InterAct and Auto-DBP technical coordinator training.

2.4.4. Outcomes

The principle purpose for involvement of the DRRC Industrial Team in the 2007 recruitment activity was to assist GEP in meeting the 15 MW Auto-DR reduction target for PG&E by engaging industry. Another important purpose was to build on the Team’s existing knowledge of what works for Auto-DR in industrial markets.

As the result of this work the DRRC Industrial Team assisted GEP in exceeding their 15 MW goal for Auto-DR through the participation of two industrial sites. The Team worked with GEP to assist them in securing agreements with an industrial gas firm to commit 10 MW to Auto-DR. This production process shed is applicable to other industrial gas facilities within the same company and has generated interest from other industrial gas companies for 2008. A more complete description of this site is included in Appendix G.

Figure 5 shows the electric load shed that occurred on August 30, 2007 when the PG&E automated demand-bidding program was tested. The majority of this load shed came from a large industrial site. The load did not return until the late morning of August 31st, 2007.

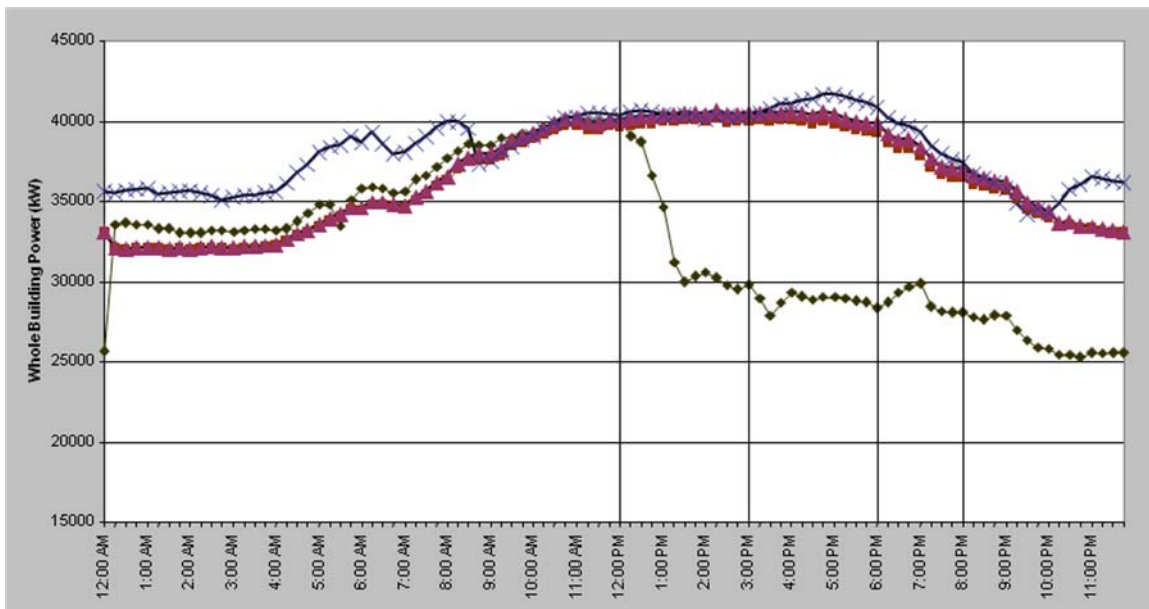


Figure 5. Load Shed Test August 30, 2007

In addition, the DRRC Industrial Team directly recruited a recycling facility for Auto-DR that resulted in a signed agreement for a 5 MW shift. This type of production shift (hammer mill) could be applied to many other industrial facilities that use similar equipment, e.g., such as crushing operations in the mining industry.

Table 10 provides an overview of impact from the participation of specific industrial sectors as a percentage of PG&E’s total Auto-DR demand reduction in 2007. A relatively small percentage of industrial facilities account for 62.5% of the overall demand reduction.

Table 10. 2007 PG&E Auto-DR Participation Profile (industry as a % the total)

Business Type	% Program Participants	% kW Demand Reduction
High Tech	30.2	9.9
Biotechnology	4.8	1.1
Industrial Process	4.8	62.5
Data Center	1.6	3.1

Source: GEP July 2007

It is important to note that although these production sheds and shifts are large and significant, further research into the feasibility of smaller sheds and shifts that do not disrupt production is needed if Auto-DR is to become more widespread in California industry. Most companies simply will not have the ability to affect production to this degree.

The DRRC Industrial Team also focused on data center Auto-DR strategies as potential research demonstrations. Two demonstration sites are under development. The significance of potential in data centers can be summarized as follows:

- Unlike much of the industrial sector, the electricity use of data centers is growing rapidly;
- Servers are grossly underloaded – 10-15% utilization rate is typical, so higher utilization rates would allow servers to be temporarily shut down.

Increased loading of servers can be accomplished through:

- Server consolidation software to increase the loading to 40% or more;
- Virtualization – segregating several tasks within one server;
- Task Prioritization – shutting down low-priority task servers.

The DRRC Team is in discussion with two software vendors on full integration of Auto-DR into their products.

Table 11 shows the 27 MW (18.4 MW plus 8.6 MW) of Auto-DR recruited into the PG&E, SCE, and SDG&E Auto-DR programs. There were no industrial participants in 2006. 50% of the 27 MW are from industrial facilities. As discussed above, the demand reduction as a percent of the total facility load is quite large. The average reduction for three industrial facilities that are currently configured for Auto-DR is 46% with even larger demand reductions of 66% for the 8 sites in process. The industrial facilities are reducing their peak demand in a larger fraction than the commercial buildings. Further research is needed to understand how these large demand reductions perform over time within the demand bid and critical peak pricing programs in which they are configured to participate.

Table 11. Auto-DR Program Goals and Results

	2006	2007 Production	2007 In-Process
1. Accelerate Implementation <ul style="list-style-type: none"> ▪ Commercial participants ▪ Industrial participants ▪ Peak Load Reduction 	13 0 1.1 MW	125 3 18.4 MW	16 8 8.6 MW
3. Expand the role of Technical Providers	none	8 industry participants	
4. Improve DR performance <ul style="list-style-type: none"> ▪ Commercial ▪ Industrial ▪ Aggregate All Participants 	13.0% -- --	19.9% 45.5% 30.7%	12.3% 65.9% 37.4%

2.5. Scoping Studies

Scoping studies were undertaken in 2007 to examine Auto-DR potential in depth in two sectors: food processing and the semiconductor industry.

The food processing study examined DR potential (not limited to Auto-DR), existing levels of participation, experiences, information sources, and use of tools and technologies. The primary means of data gathering was a survey administered to food processing companies. The survey results suggest that opportunities exist to both reduce and shift essential demand (i.e., manufacturing-related demand) and non-essential demand (e.g., office buildings, warehousing, etc.). The primary reasons cited by respondents for enrolling and not participating in DR were plant production schedule constraints, lack of program cost-effectiveness, other priorities, and lack of resources. Of those participating in DR, the primary reasons given were corporate environmental citizenship and economics⁹

The second scoping study, still in development, is designed to produce an operations guide for automating demand response in the semiconductor industry. This guide will be centered around a few key strategies such as process storage for ultra-pure water and cleanroom air velocity reduction.

2.6. Submetering

In 2006 another industrial site was added while two industrial sites stopped participation. Thus in 2007, there were five industrial sites participating in submetering and various DR programs. One of the sites participated in demand-bid pricing (DBP) while the other four were on critical peak pricing (CPP), with one of those on Auto-CPP.

⁹ Lewis, Glen. Unpublished final draft. *Strategies to Increase California Food Processing Industry Demand Response Participation*, prepared for the DRRC and the California Energy Commission, PIER.

In the analysis of the data from the submetered sites, the reader should be aware that the conclusions reached are based on data from three to five readings of various pieces of equipment or groups of equipment, which may not represent the total energy usage at the site. Thus the conclusions below may not be representative of the energy usage and corresponding DR level of participation at the whole site.

The lone site that participated in DBP had 22 events called by its utility. Of those 22 events, there is only clear evidence that this site participated in six events. On the remaining non-participatory event days, the site often used higher total energy. The days in which participation was clearly visible, the reduction was about 20% as compared to previous days.

The remainder of the sites participated in CPP. The one site on Auto-CPP is discussed below. Of the three "manual" CPP sites, two sites show no indication of reducing energy use during events. One site may have actually had higher energy use during some event days.

The single site on "manual" CPP shows decreases in energy use in a refrigeration unit on event days, from 70 kW to 10 kW, but the main building shows an energy increase, from 140 kW to 180 kW. The sum is an energy decrease but not as high as if the refrigeration decrease was not offset by an increase in energy usage in the main building. This one site needs more data analysis to calculate the overall energy savings during event days.

Of the remaining sites that were on CPP, the one site on Auto-CPP showed consistent participation on event days. There was one piece of equipment that used no energy during CPP events during the time period 15:00 to 18:00. The equipment was consistently used immediately before and after the period 15:00 to 18:00. Since the site is on Auto-CPP, this consistent participation is not surprising. But what is surprising is that for about half of the event days, this piece of equipment was off during the time period 15:00 to 18:00 several days before the event. It appears that the Auto-CPP strategy for this piece of equipment was also occasionally used as an energy efficiency measure.

Table 12. Industrial Participants in Sub-Metering Study

Site	Industry	Program	Participation 2004	Participation 2005	Participation 2006	Participation 2007
1	Chem Repackaging	CPP	Yes	Yes	No	No
2	Fruit Proc & Cold Storage	CPP	Yes	Yes	Frequent	Frequent
3	Baking w/ Frzn Storage	CPP	Yes	Yes	Little to none	Little to none
4	Fruit Proc & Cold Storage	DBP	Yes	Yes	Occasional	Occasional
10	Glass	DBP	No	No	Dropped Out	
12	Baking w/ Frzn Storage	DBP	No	No	Dropped Out	
13	Baking	AutoCPP	Not enrolled	Not enrolled	Not enrolled	All June & July dates

Table 12 provides summary information on the six industrial sites. Of the six, two did not participate in any DR events and dropped enrollment by 2006. Three of the four remaining sites that did participate in both years are food-processing plants whose principal DR strategy was to adjust settings of their cold storage units. Site 1 is the only non-food processing plant to participate. This was also the only site to execute a strategy involving multiple measures. An additional site was added to the sub-metering study in 2006, but it was instrumented too late in the summer to record any events. This facility is a large baking operation that is relying on one DR measure to respond to events.

An examination of the sub-metering participants to date reveals that while many valuable lessons have been learned from the sub-metering study (Murtishaw, 2006), its usefulness suffers from three large shortcomings that any future sub-metering should seek to overcome. First, one-third of the selected sites never participated at all. Selected sites need to be carefully vetted to determine that they are very likely to participate in DR events. Second, the sample does not include a broad enough range of California industries. Only one non-food processing facility has been studied to date, and while it is involved in final production of chemicals, it is not an energy-intensive primary producer. If possible, participants should be recruited from among the top nine electricity-consuming manufacturing sectors (see Table 1) to determine strategies that can be repeated by other large consumers of electricity. Third, facilities need to be recruited that can offer a more complex suite of DR measures since one of the principal advantages of sub-metering is to determine which end uses contribute most to the observed curtailments. This is related to the lack of sectoral diversity. Other industries may provide opportunities to quantify DR savings from measures such as pumping, compressed air, grinding, mixing, or conveyance.

3.0 Key Findings

When this research was initiated in October 2006, the actual opportunities for implementing industrial DR in California, especially price-responsive and Auto-DR were unclear. While many industrial facilities have participated in reliability and “day ahead” notification programs (1857 MW and 1044 MW, respectively in 2005)¹⁰, a program goal is to “harden” the industrial response so that it becomes a more reliable resource for managing the cost and supply of electricity. The DRRC had successfully implemented and began commercialization of Auto-DR for commercial buildings, but the industrial sector presented unique challenges – technical, operational, and managerial. While previous analyses (EPRI 2005, KEMA 2007) seem to indicate substantial potential, realizing this potential requires developing a portfolio of approaches, DR strategies, and techniques that both simplify participation and offer clear business value.

One year into this field of study, the DRRC Industrial Team has collected sufficient survey and empirical field data to conclude that *there appears to be great potential for Auto-DR in industrial facilities*. This finding needs to be qualified. Further research is needed to understand 1) organizational decision-making processes as they impact DR participation and 2) the role of existing and emerging industrial controls in contributing to the ability to readily participate in Auto-DR, 3) end-use process control capabilities to support reduced service and process control levels during DR events.

Assumption#1: Industry will not participate in DR programs that pose a threat to operations, such as shift or shed strategies that affect production, unless there is a clear and immediate threat to the reliability of the electric supply system.

Key Finding: *Some industrial facilities will shift or shed process load based on financial incentives, not just to protect reliability.*

- In certain niche markets, such as industrial gases, electricity is a large proportion of operating costs. As a result, demand management is an integral part of the operating culture with sophisticated controls. For these markets, Auto-DR offers a cost-management opportunity that is integrated into the production schedule
- Shifting a batch process, such as a hammer mill, may be acceptable as an Auto-DR strategy even if it is not be something done on a daily basis.

Assumption #2: Industrial demand response competes with industrial energy efficiency for scarce industrial plant resources.

Key Finding: *Auto-DR is compatible with energy efficiency and load management in industrial facilities.*

¹⁰Quantum 2006

- Plants who express interest in Auto-DR are typically already engaged in both energy efficiency and demand management improvements. Auto-DR is another cost-reduction tool, not a replacement for energy efficiency and demand management¹¹.

Assumption #3: Many industrial plants have the control system capabilities necessary to participate in Auto-DR.

Key Finding: *Many industries have limited controls capabilities, especially for supporting or non-core systems that may be suited for Auto-DR¹². There is an emerging market for demand management and system-level network controls that could allow Auto-DR to be integrated. Discrete controls offer less Auto-DR capability.*

Our research identified opportunities for demonstrations or case studies in several areas:

- Adaptation of existing demand management software for Auto-DR applications;
- Minor modification to make network controls for supporting systems DR-enabled;
- Modification of Auto-DR software designed for energy efficiency and load management in data centers;
- Opportunities to “think beyond the plant” by bundling similar Auto-DR shed strategies into a single controls network so that sheds could be “tuned” to actual needs within the scope of individual participation agreements.

Assumption #4: The financial benefits presented by Auto-DR may not be sufficiently attractive for most industries to be worthwhile.

Key Finding: *The current portfolio of DR programs is confusing, but the availability of financial incentives and technical assistance can make participation attractive.*

Industrial facilities are not concerned with DR, since their focus is on core production. The current DR programs and tariffs are so complex that they create challenges. Unless the incentives are substantial, most industries are not willing to study the potential benefits. A simpler approach is needed.

However, if the utility tariffs move toward dynamic pricing, Auto-DR may provide an infrastructure for facility price response for some facilities.¹³

¹¹ Initial findings from the 2009-2020 Statewide Energy Efficiency Plan stakeholder input process seem to support this perspective. See <http://www.californiaenergyefficiency.com/industrial.shtml> for workshop and webcast notes Nov-Dec 2007.

¹² For instance, in an unpublished paper, *Drilling Down Below the Revenue Meter: Understanding Customer Demand Response Strategies through Sub-metering*, John Bidwell of Quantum Consulting describes how “all of the six industrial sites in the sub-metering sample utilized manual controls to activate and control load reductions”.

¹³ Note: for some sectors, such as fruit and vegetable processing, peak production is coincident with peak statewide electricity use. Substantial concerns have been expressed by these industries concerning their structural inability to respond to dynamic pricing during the summer months. Suggestions include

Assumption #5: It should be possible to identify potentially attractive DR shift or shed strategies for specific industrial sectors.

Key Finding: *It is possible to define DR shed/shift strategies for specific industries.. We can develop preliminary “short lists” for promising sectors to further evaluate their feasibility.*

Although the sample size was limited (207 records) and is based on recommended rather than implemented strategies, nine 4-digit NAICS categories were identified as in the top-25 for both large users of manufacturing electricity (Table 1) and DR potential by average kW from the utility integrated audits (Table 4). These categories include:

- Converted Paper Product manufacturing
- Fruit and Vegetable Preserving and Specialty Food Manufacturing
- Basic chemical manufacturing, especially industrial gases
- Dairy Product manufacturing
- Aerospace Product and Parts Manufacturing
- Other Fabricated Metal Product Manufacturing
- Animal Slaughtering and Processing
- Bakeries and Tortilla Manufacturing
- Beverage Manufacturing

Of these, the industrial gas sector appears to be ready for implementation. Anecdotal evidence from industrial end users indicates that demand response opportunities may be found in other industrial sectors. The key research question is “to what extent can and will these facilities accept automation of DR?” The nine sectors listed above were compared against recommendations in other related reports¹⁴: We recommend an initial “short list” of five industrial sectors recommended for further study based on knowledge of these sectors:

- Cold storage
- Data centers and test labs for high tech industries
- Water/wastewater
- Aerospace products

“teaming” with other sectors that have this potential to build greater reliability into the grid without adverse consequences to their operations.

¹⁴ These reports are: *Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Demand Response Programs* by Quantum Consulting (2006) and *Demand Response Analysis and Tool Development for Industrial, Agricultural and Water (IAW) Energy Users* by EPRI for the California Energy Commission (2005).

- Beverages, including breweries and wineries

As previously noted in Section 1.2, refrigerated warehouses are a category worthy of further study. These facilities are attractive due to the relative homogeneity of the technology and the relative ease of implementing DR, as demonstrated in the sub-metering studies in the 2005 Evaluation Report (Quantum Consulting 2006).

Data centers are also an area of significant promise, both due to underutilization of computing assets and the high level of comfort with automated controls. Reliability has an extremely high value for enterprise type data centers, but greater opportunities for Auto-DR can be found in the large number of data centers that are laboratories for testing applications. Unlike many other industries, data centers are an area of great growth in electrical usage, with electricity use projected to rise nationally from an estimated 7 gigawatts (GW) currently to 12 GW by 2011, based on a business as usual scenario.¹⁵ In addition, the industry as a whole is very motivated toward developing a “green” image. Both of these factors contribute to a significant potential for Auto-DR in data centers.

As a comparison, the EPRI study identified cement, electronics, industrial gases, and water agencies as “good” candidates for demand response and metal castings, food processing, petroleum refining, and pulp and paper as “fair” candidates. The Quantum evaluation of 2005 day ahead and reliability demand response programs identifies three clusters of industries as the key participants:

- petroleum, plastic, rubber and chemicals
- mining, metals, stone, glass, and concrete
- electronic, machinery, and fabricated metals.

Other areas of interest include: paper products, plastics, dairy products (cheese), bakeries, cement, and electronics manufacturing.

While there is a wide range of potential shift and shed strategies requiring further study, those most frequently identified in the utility integrated audits are:

- For production shifts, conveyors, all systems, pump systems, and electrical;
- For production sheds, all systems (stop production), finishing, process cooling and pump systems;
- For supporting system load shifts, space conditioning, motors, process cooling, and storage; and
- For supporting system load sheds, aerators, multiple systems, electrical, and compressed air.

¹⁵ U.S. Environmental Protection Agency ENERGY STAR Program. August 2007. *Report to Congress on Server and Data Center Energy Efficiency, Public Law 109-431*

4.0 Promising Areas for Future Research

Referencing back to Section 1.2.1, the Key Research Questions are:

1. **Where is the potential to shed or shift electricity use in industry?**
 - Which sectors have the greatest potential to shed or shift during peak periods?
 - Have these sectors been active in reliability programs or identified in audits?
2. **What is the functional capability of specific industries to implement Auto-DR?**
 - What are the control gaps and the associated cost of implementing Auto-DR?
 - Of sectors identified as having Auto-DR potential, which offer the most cost-effective implementation opportunities?
3. **What are the market trends in industrial controls that support Auto-DR?**
 - Do advances in control technologies make specific sectors or systems attractive candidates for Auto-DR?
 - What are the technology gaps that might benefit from public R&D?
4. **What are the market and operational barriers to the implementation of reliability and price-responsive industrial DR?**
 - Do industrial energy managers understand economic and societal benefits of DR
 - What roles do price and incentives have in the decision making process?
 - What are the areas tension between DR and industrial plant schedules?
5. **What is the role of industrial Auto-DR in the state's goal to provide reliable and climate-friendly electricity at a reasonable cost to CA consumers?**
 - Is there "migration potential" for DR strategies in promoting industrial load management and energy efficiency in industrial facilities?

The first year of research has identified a number of opportunities for additional study that would build on the emerging body of knowledge in this area. Future work of the Industrial Team should consider the following:

1. Form a Technical Advisory comprised of representatives from industry and the suppliers and consultants that serve them to guide the work of the DRRC Industrial Team
2. Examine the issue of controls capability and compatibility
 - Develop a survey of existing industrial control capabilities, to be administered via the web in cooperation with key industrial associations (California Manufacturers and Technology Association, California League of Food Processors, Silicon Valley Leadership Group, etc)
 - Draft a discussion piece describing key control issues for successful implementation of Auto-DR

- Host a workshop of control experts from the demand response, demand management, and industrial system control communities to critique the discussion piece and recommend a path forward
 - Draft a white paper based on outcomes from the critique
 - Host 2-3 workshops with industrial associations to share the outcomes of the controls workshop and further refine the white paper
 - Publish paper on the technical capacity for Auto-DR in CA industry
3. Conduct additional research and develop DR Strategy Guides (initially Refrigerated Warehouses and Data Centers)
 4. Conduct further research on industrial energy use patterns in California, with the goal of identifying specific sheds and shifts in sectors previously identified as showing potential
 5. Investigate opportunities for demonstrations of DR-enabled controls as an integrated feature original equipment manufacturers
 - Compressed air and pumping system networked controls
 - Virtualization/prioritization software for data centers

Although not specifically targeted, some of this research can also be used to enhance the current understanding of industrial management decision-making as it pertains to DR. Finally, a major area for additional research currently outside of the DRRC scope concerns improving program and tariff design to better promote Auto-DR in industry.

For the second year of research, the DRRC proposes to work with a Technical Advisory Group comprised of representatives from industry and the suppliers and consultants that work with them. This research will be directed toward key research questions outlined above to assist the California Energy Commission (CEC), the California Public Utilities Commission (CPUC), and the investor-owned utilities in more effectively targeting their Auto-DR efforts.

5.0 Conclusion

The DRRC Industrial Team research has shown that industrial facilities can be good candidates for demand response and that, under the right conditions, some types of industrial facilities will shift or shed process load based on financial incentives, not just to protect reliability. The DR industrial project also facilitated the initial implementation of the Auto-DR technology in several large industrial facilities. This effort was coordinated with California utilities. While details of the automation controls linkage is proprietary, these installations have shown the CLIR box can be installed with many industrial control infrastructures.

Participation in the 2007 recruitment and implementation also led to the development of several tools (Site Questionnaire, Informational Pieces) that should assist recruitment efforts in future years. The process of developing these tools also enhanced the Team's understanding of the information requirements, potential benefits and barriers for participating in Auto-DR.

In addition, the research required to develop the draft road map and the initial analysis of electricity use in California manufacturing industry was a useful starting point in developing an understanding of industrial DR potential. The analyses of utility demand response audit data built on those efforts. These data have proven useful in beginning to narrow the scope of future study on the types of sheds or shifts that can be effectively automated in specific plant types. From the database, the potential sheds or shifts identified include both production and supporting systems: conveyors, pump systems, process cooling, electrical systems, motors, aerators, and compressed air. These data provide a foundation for further data collection and study that will assist California in targeting specific demand response programs to the most receptive industries. The long-term goal is to develop checklists of potential Auto-DR strategies targeted to specific industries to assist them in working with their utilities to develop an implementation plan.

6.0 References

- Braithwait, Steven and David Armstrong. 2004. *Potential Impact of Real-Time Pricing in California*. Christensen Associates.
- California Energy Commission. 2002. *An Action Plan to Develop More Demand Response in California's Electricity Markets*. Sacramento, CA. P400-020016F
- EPRI (Electric Power Research Institute), 2005. *Demand Response Analysis and Tool Development for Industrial, Agricultural and Water (IAW) Energy Users*. Sacramento, CA: California Energy Commission.
- Ganji, Ahmad. 2007. *Lessons Learned from Energy and Demand Response Audit Projects in California*, presentation at ISA NorCal Tech 2007 Conference, Vallejo, CA
- Goldman, C. and N. Hopper, O. Sezgen, M. Moezzi, R.Bharvirkar, B.Neenan, D.Pratt, P. Cappers, and R.Boisvert. 2004. *Does Real-Time Pricing Deliver Demand Response? A Case Study of Niagara Mohawk's Large Customer RTP Tariff*. LBNL-54974
- Kathan, David. 2006. FERC Staff Report on Demand Response and Advanced Metering. Presentation to NYISO <http://www.ferc.gov/legal/staff-reports/demand-response.pdf>
- KEMA, with assistance from LBNL and Quantum Consulting. May 2006. California Industrial Existing Construction Energy Efficiency Potential Study Final Report to Pacific Gas and Electric Company. CALMAC Study ID: PGE2052.01.
- Kiliccote, S., M.A. Piette, D.S. Watson, G. Hughes. 2006. *Dynamic Controls for Energy Efficiency and Demand Response: Framework Concepts and a New Construction Case Study in New York*, Proceedings, 2006 ACEEE Summer Study on Energy Efficiency in Buildings. LBNL-60615.
- Kiliccote, S., M.A. Piette, D. Hansen. 2006. *Advanced Controls and Communications for Demand Response and Energy Efficiency in Commercial Buildings*, Second Carnegie Mellon Conference in Electric Power Systems: Monitoring, Sensing, Software and Its Valuation for the Changing Electric Power Industry. DRRC Report. LBNL-59337
- Motegi, N., M.A. Piette, D.S. Watson, S. Kiliccote, P. Xu. 2007. *Introduction to Commercial Building Control Strategies and Techniques for Demand Response*, report for the California Energy Commission, PIER. LBNL-59975
- Murtishaw, S, 2006. Summary of Key Lessons from WG2 Submetering Summary, unpublished memo by Scott Murtishaw, Lawrence Berkeley National Laboratory
- Piette, M.A., D. Watson, N. Motegi, S. Kiliccote. 2007. *Automated Critical Peak Pricing Field Tests: 2006 Pilot Program Description and Results*. LBNL-62218.
- Quantum Consulting, 2006. *Evaluation of 2005 Statewide Large Nonresidential Day-Ahead and Reliability Demand Response Programs: Final Report*.
http://www.calmac.org/publications/2006-04-28_WG2_2005_FINAL_REPORT.pdf

Wikler, Greg, Joe Priyanonda, Mary Ann Piette, Sila Kilicote, Grish Ghatikar, June Han, and Dan Hennage. 2007. *Southern California Edison Auto-DR Pilot Program Assessment Report*, Los Angeles, CA Southern California Edison.

York, Dan and Martin Kushler. 2005. *Exploring the Relationship Between Demand Response and Energy Efficiency: A Review of Experience and Discussion of Key Issues*. American Council for an Energy Efficient Economy, Washington, DC Report # U052.

7.0 Glossary

Auto-DR	Automated Demand Response
BIP	Base Interruptible Program
C&I	Commercial and Industrial
CBP	Capacity Bidding Program
CEC	California Energy Commission
CLIR	Client and Logic with Integrated Relay
CPP	Critical Peak Pricing Program
CPR	Critical Project Review
CPUC	California Public Utilities Commission
DBP	Demand Bidding Program
DR	Demand Response
DRAS	Demand Response Automation Server
DRRC	Demand Response Research Center
DSM	Demand Side Management
EE	Energy Efficiency
EIS	Energy Information Systems
EMCS	Energy Management Control Systems
EPRI	Electric Power Research Institute
GEP	Global Energy Partners LLC.
GWh	Gigawatt Hours
HVAC	Heating, Ventilation, and Air-Conditioning
IAW	Industrial, Agricultural, and Water
IOU	Investor-Owned Utilities
ISO	Independent Systems Operator
kWh	Kilowatt Hours
LBNL	Lawrence Berkeley National Laboratory
MWh	Megawatt Hours
NAICS	North American Industrial Classification System
NYSERDA	New York State Energy Research and Development Authority
OpenADR	Open Automated Demand Response
PAC	Project Advisory Committee
PG&E	Pacific Gas and Electric
PIER	Public Interest Energy Research
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RTP	Real-Time Pricing
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SVLG	Silicon Valley Leadership Group
TCP/IP	Transmission Control Protocol and Internet Protocol
U.S. DOE	United States Department of Energy
WS	Web Services
XML	eXtensible Markup Language

Appendix A. Industrial Demand Response Strategic Roadmap



Industrial Demand Response Strategic Roadmap

November 15, 2006 (draft)

**Public Interest Energy Research Program
California Energy Commission**

Research Goals



What are the goals of PIER's industrial demand response research over the next three years (2007-2009)?

1. To conduct research to support the development of a firm demand response resource from California industry for critical peak periods
2. To increase the participation of California industry end users in all types of electricity demand response
3. To investigate options for linking industrial demand response (DR) with energy efficiency (EE) to most effectively use electricity and natural gas in California industry

Knowledge Requirements



What do we need to know to develop a firm demand response from CA industries?

- What types and size of electrical loads are CA industries most likely to be able to shed or shift (technical capability)?
- Which of these electrical loads are CA industries most likely to be willing to shed or shift and by how much (economic interest, amount of DR)?
- Which loads could CA industries subject to an *automated demand response* (AutoDR)? (technical and economic)
- How can demand response programs, especially AutoDR, be structured to offer industry a clear incentive to participate?
 - Commitment lead time, extent of commitment, event notification
 - Firm DR commitment options
 - Enabling technologies
 - Financial incentives

2

Existing Resources



- CA industrial energy use by sector
 - Substantial data on a wide range of sectors
 - Resources include:
 - California Energy Balance database with electricity usage by over 35 industrial sectors
 - Estimates of facility-specific electricity consumption for select large energy users
 - DRRC Demand Response database
- Industrial load types and processes by sector
 - Information varies from limited to fairly detailed, depending on sector
 - Integration of existing research would be very helpful
 - Resources include:
 - Reports such as CEC's Demand Response Analysis and Tool Development for Industrial, Agricultural, and Water (IAW) Energy Users
 - USDOE Energy Footprints
 - USEPA Energy Guides for Industry
 - Data on peak loads disaggregated at the two-digit SIC level by eight different process types
 - LBNL reports on trends and usage patterns of electricity use in CA and industry-specific analyses of energy consumption by several large industries

3

Resources



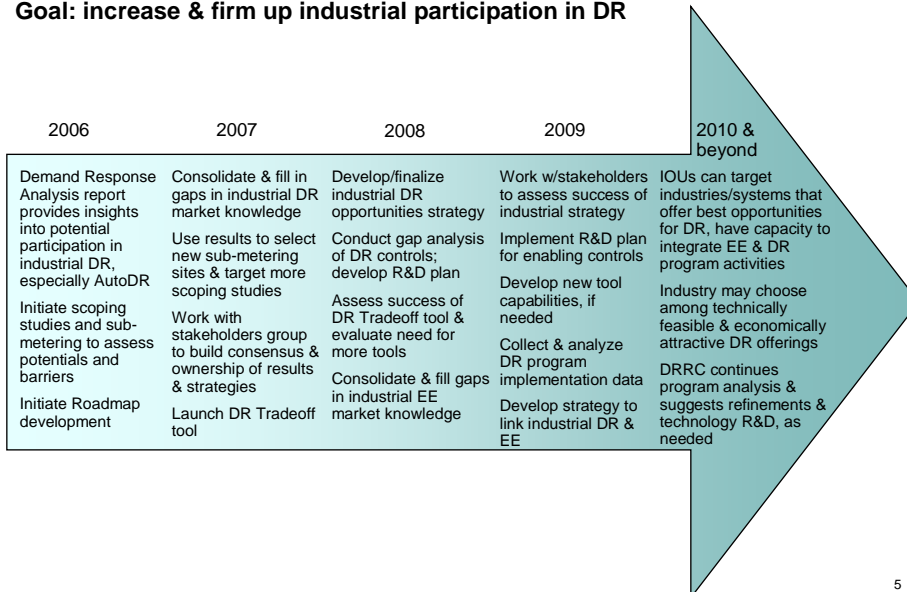
- Industrial loads that industry is likely to agree to shed or shift
 - CA utility programs have experience with industry participation in interruptible demand response, critical peak pricing, demand bidding
 - Targeted research is being conducted for a few sectors
 - Scoping studies now underway for the food processing, high tech, and biotech industries
 - Results of submetering case studies
 - Additional scoping and validation research is needed
 - To target industrial systems and processes found in many plants and/or sectors
 - To identify which systems and processes have the technical potential to be AutoDR candidates
 - To identify the conditions under which a facility with these systems or processes would consider participating in AutoDR

4

Strategic Roadmap

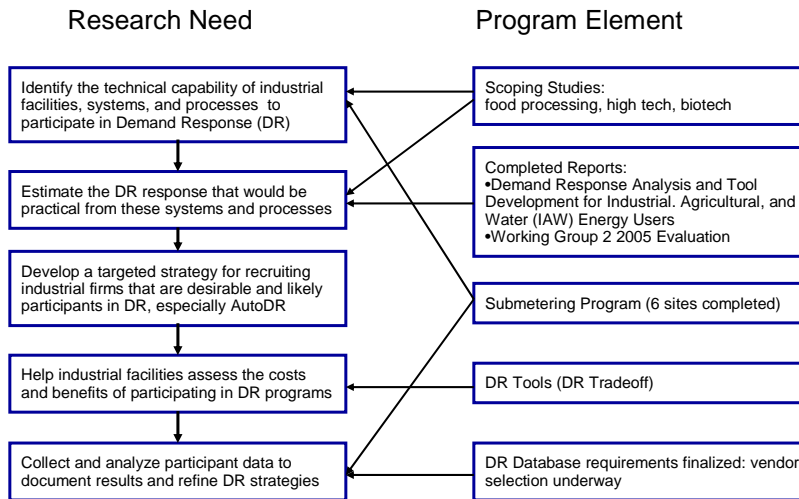


Goal: increase & firm up industrial participation in DR



5

Existing Program Assets



6

Program Asset Details



- **Scoping studies**
Sector-specific studies conducted by industry experts to determine specific DR opportunities in these sectors
- **Completed Reports**
Summaries and evaluations of existing program activities; key findings from a first-order analysis of sector-based opportunities in CA
- **Submetering Program**
Submetered data resulting from installations in industrial facilities participating in DR programs
- **DR Tools**
A basic tool, DR Tradeoff Tool, has been developed that can be used by industrial facilities to evaluate expected savings under different tariff scenarios based on a facility's loads and DR performance
- **DR Database**
Designed as a research tool to collect and analyze DR data from C&I participants. A requirements document has been developed; vendor selection is underway, data is available and ready to load.

7



During 2007, the PIER Industrial DR Research Program Activities will be focused on three major themes:

1. Consolidate and fill in the gaps in industrial DR market knowledge
 - Analyze the results of 3 scoping studies now underway
 - Analyze the results of 6 submetering case studies
 - Integrate existing research on industrial system & process energy use
 - Use the results to target 2-3 additional sectors for scoping studies
 - Conduct plant validation surveys in 6 sectors (36 surveys total)
 - Collect and analyze industrial data from industrial DR participants
2. Test tools and enabling technologies
 - Continue submetering program in 6 more sites
 - Complete testing of the DR Tradeoff Tool

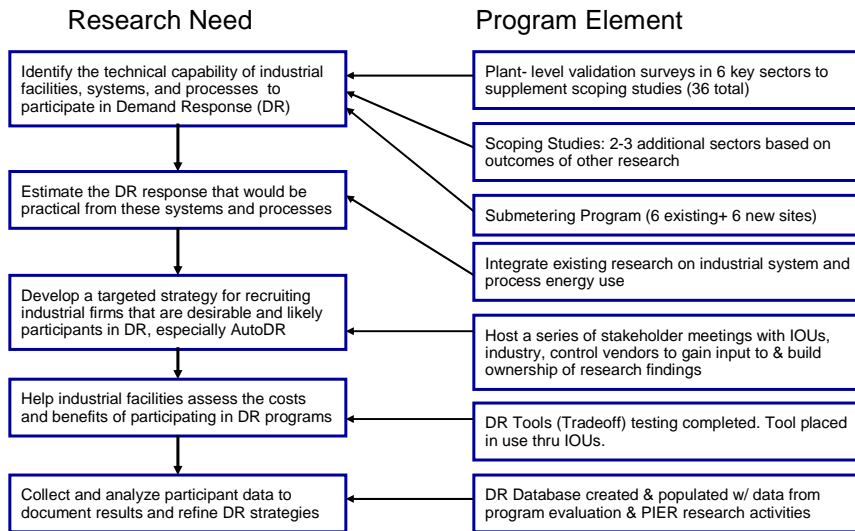
8



3. Work with stakeholders (IOUs, industry, controls vendors) to develop and build ownership for statewide approach to industrial DR
 - Host a series of stakeholder meetings and webcasts
 - Seek to develop consensus on a workable program design(s) for AutoDR
 - Seek to develop consensus on target industries by region
 - Explore synergies between energy efficiency (EE) and DR programs

9

Proposed Program Activities 2007



10

Proposed Program 2008



During 2008, the PIER DR Research Program Activities will be focused on 5 major themes:

1. Integrate data collected and analysis of industrial markets undertaken in 2007 to draft a focused strategy for industrial DR in California
 - Analyze results from 2-3 additional scoping studies, 36 plant validation surveys, 10-12 submetering sites, DR Database, and prior analyses
 - Cross walk results from these analyses with results of industrial system & process energy use
 - Consult with stakeholders (IOUs, industry, control vendors) on the results
 - Develop draft Industrial DR opportunities strategy that considers technical, economic, and managerial factors
2. Work with the CEC and stakeholders to finalize industrial DR opportunities strategy
 - Facilitate stakeholder discussions on industrial DR opportunities strategy
 - Develop a final report that identifies, by industrial sector and system, the most favorable opportunities for DR, especially AutoDR

11

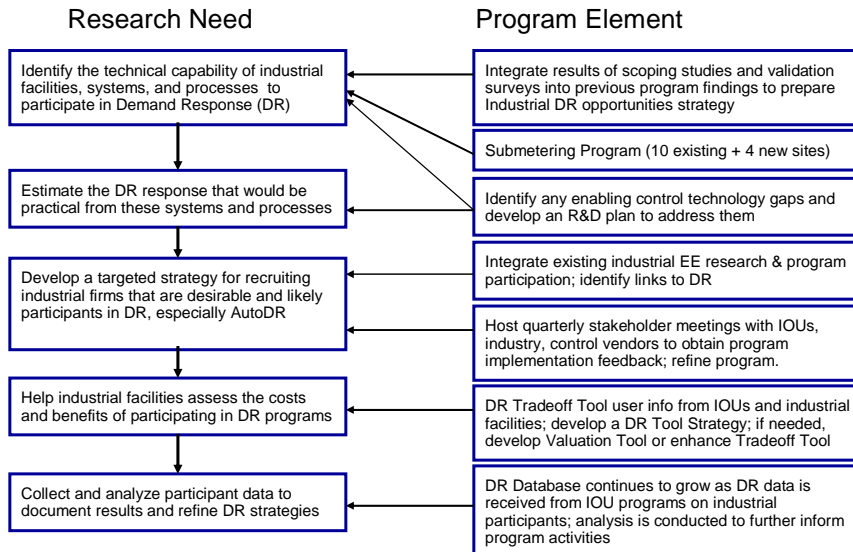
Proposed Program 2008



3. Develop an R&D plan to address enabling control technology gaps for industrial sectors and systems targeted in the DR strategy
 - Work closely with industry and control vendors to distinguish technical gaps from economic gaps (does gap result from lack of technology, lack of cost-effective technology, or other factors unrelated to control technologies?)
 - Develop an R&D plan that identifies categories of technologies that have promise for addressing gaps
 - Conduct an analysis using a stage-gate type approach to determine how and if to invest R&D funds for control technology development
4. Decide on the role and relative importance of DR Tools
 - Determine the uptake and value of the DR Tradeoff Tool
 - Work with stakeholders group to determine if a Valuation Tool should be developed or Tradeoff Tool enhanced
 - Develop an overall strategy for DR Tools that supports ongoing DR efforts and the industrial DR opportunities strategy
5. Consolidate and fill in the gaps in industrial energy efficiency market knowledge needed to link with DR
 - Integrate existing research on industrial system & process energy use
 - Collect and analyze information on industrial energy efficiency program participation at IOUs, CEC, and DOE

12

Proposed Program Activities 2008



13



During 2009, the PIER DR Research Program Activities will be focused on 5 major themes:

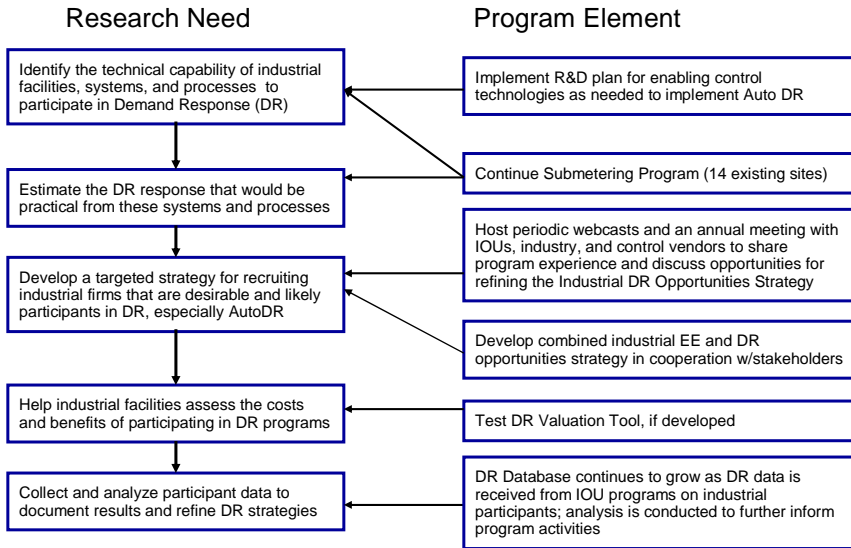
1. Implement R&D Plan for enabling control technologies
 - Develop targeted solicitations for development or enhancement of control technologies to address gaps
 - Use stage-gate process to manage investment of funds and pick the most promising technologies
2. Continue to collect and analyze data from industrial DR experience
 - Use data from DR Database, which includes information from IOU implementation programs, submetering cases, and historical information from 2005 evaluation
 - Analyze use of DR Tools

14



3. Work with stakeholders to determine effectiveness of industrial DR opportunities strategy
 - Provide a forum for sharing information -- on program design, response of industry, successes and barriers
 - Provide results from analysis of DR database
 - Fine-tune research agenda based on feedback from IOUs, industry, control vendors
 - Integrate DR lessons learned into EE programs
4. Work with stakeholders to develop a combined industrial EE and DR opportunities strategy
 - Build on the experience with the DR strategy
 - Facilitate stakeholder discussions
 - Develop a final report that identifies, by industrial sector and system, the most favorable opportunities for a combined EE and DR approach
5. Depending on results from 2008, implement DR Tools strategy
 - Supports ongoing DR efforts and the industrial DR opportunities strategy
 - Focuses on tool development that addresses specific barriers to industrial DR participation

15



Appendix B: Industrial Demand Response Audit Database Structure

The Demand Response audit database is structured around two main tables: “Audit Info” and “Measure” that are linked together in a one to-many relationship. Each record (or Audit ID) in the Audit Info table is linked to a maximum of six demand response measures that are listed in the Measure table.

The Audit Info table contains the following fields:

- Audit ID
- Utility
- Utility ID
- City
- Date of audit
- Audit Consultant
- Description of the process in the plant
- 6 & 4-digit NAICS codes
- Utility Sector (used only for PG&E audits)
- AS Rep (used only for the PG&E audits)
- Div Code (used only for the PG&E audits)
- CEE Lead (used only for the PG&E audits)
- EMS Info (not well populated)
- kW (maximum kW)
- Annual kW
- Annual Therms (not well populated)
- EE kW Potential (not well populated)
- EE kWh Potential (not well populated)
- EE Recommendations (not well populated)
- Descriptions of Demand Response recommendations
- Demand Response Potential kW

The Measure table contains the following fields:

- Audit ID
- Measure ID
- General description of the technologies affected by the demand response
- Specific description of how the technology is modified
- Savings in kWh (not well populated)

- Savings in kW
- Strategy (choices are listed below)
 - Shift Support
 - Shift Production
 - Shed Support
 - Shed Production
- Strategy Detail (choices are listed below)
 - Decrease
 - Pre-cool
 - Raise Setpoint
 - Recover
 - Storage
- Technology (choices are listed below)
 - Aerators
 - All (the whole facility shuts off)
 - Battery chargers
 - Compressed air systems
 - Conveyors
 - Crushers
 - Electrical
 - Fan systems
 - Fume hoods
 - Grinders
 - Lighting
 - Mixers
 - Motors
 - Multiple
 - Process cooling
 - Process heating
 - Pump system
 - Refrigeration
 - Space conditioning
 - Storage
 - Transport system

- Ventilation
- Welding
- Process/Tech Detail (choices are listed below)
 - Aerators – water
 - Aerators –wastewater
 - Fans – agricultural
 - Fans – process
 - Fans – warehouse
 - Process heat – baking
 - Process heat – chemical reaction
 - Process heat – drying
 - Process heat – melting
 - Process heat – sterilization
 - Pump – product
 - Pump – water
 - Pump – wastewater
 - Refrigeration – chilled water
 - Refrigeration – cold storage
 - Refrigeration – freezing
- Max duration (not well populated)

Appendix C: Industrial Demand Response Audit Database Analyses

Industrial Demand Response Potential by Plant Type (complete table)

Sum of DR kW Potential		DR kW Potential		
Description of Process	Total	Description of Process	Sum	Ave
Lumber products, fiber board	3504	Lumber products, fiber board	3504	3504
Federal R&D	2320	Federal R&D	2320	2320
Olive Processing Plant	1979	Olive Processing Plant	1979	1979
Quarrying /processing of mineral rock & sand aggregate	2582	Quarrying /processing of mineral rock & sand aggregate	2582	1291
Envelopes	1133	Envelopes	1133	1133
Milk, water, eggnog, juice	933	Milk, water, eggnog, juice	933	933
Agricultural irrigation	895	Agricultural irrigation	895	895
Aircraft equipment	890	Aircraft equipment	890	890
Industrial gases	1759	Industrial gases	1759	880
Makes PVC pellets or cubes	870	Makes PVC pellets or cubes	870	870
Waffle Food Process	868	Waffle Food Process	868	868
Cotton clean and bale	834	Cotton clean and bale	834	834
Strawberry Processing, Freezing	817	Strawberry Processing, Freezing	817	817
Bakery bread, buns	749	Bakery bread, buns	749	749
Fresh water delivery	733	Fresh water delivery	733	733
Fluid control equipment	657	Fluid control equipment	657	657
Batteries	1750	Batteries	1750	583
Unknown [not identified in audit]	582	Unknown [not identified in audit]	582	582
Distribution warehouse for food products	523	Distribution warehouse for food products	523	523
Ground walnut shells	490	Ground walnut shells	490	490
Fruit drier, processors	449	Fruit drier, processors	449	449
Clay Products, Building Materials	415	Clay Products, Building Materials	415	415
Wastewater treatment plant	791	Wastewater treatment plant	791	396
Poultry Processor	744	Poultry Processor	744	372
Food packaging	326	Food packaging	326	326
Electronics	317	Electronics	317	317
Water delivery	2516	Water delivery	2516	315
Golf course/Country Club	311	Golf course/Country Club	311	311
Pickup bed covers	303	Pickup bed covers	303	303
Coated pipe and rebar	598	Coated pipe and rebar	598	299
Tomato Processing	290	Tomato Processing	290	290
Bottled water	277	Bottled water	277	277
Auto Parts	265	Winery	2153	269
Water reclamation plant	262	Auto Parts	265	265
Wire mesh	261	Water reclamation plant	262	262
Sewage treatment plant	515	Wire mesh	261	261
Dairy	1018	Sewage treatment plant	515	258
Biotech Pharma	252	Dairy	1018	255
Cardboard boxes	240	Biotech Pharma	252	252
Chrome plating	240	Pharmaceuticals	491	246
Skeet shooting targets	237	Cardboard boxes	240	240
Pharmaceuticals and chemicals	235	Chrome plating	240	240
Controls and actuators	234	Refrigerated Warehouse	475	238
Water pumping station, fresh water delivery	2306	Skeet shooting targets	237	237
Frozen Bakery Products	222	Pharmaceuticals and chemicals	235	235
Plastic molding	221	Controls and actuators	234	234
Plastic cases and lights	221	Water pumping station, fresh water delivery	2306	231
Semiconductors and Machine Parts	213	Frozen Bakery Products	222	222
Semiconductors	210	Plastic molding	221	221
Aircraft aluminum sheets	201	Plastic cases and lights	221	221
Refrigerated storage	199	Semiconductors and Machine Parts	213	213
Refrigerated storage	371	Semiconductors	210	210
Seafood canning	184	Aircraft aluminum sheets	201	201
Screen printing	181	Refrigerated storage	199	199
Roofing products	181	Refrigerated storage	371	186
Winery	2153	Seafood canning	184	184
Heat exchangers	173	Screen printing	181	181
Water treatment	173	Roofing products	181	181
Margarine	167	Heat exchangers	173	173
Pharmaceuticals	491	Water treatment	173	173
Medical devices	325	Margarine	167	167
Metal plating, finishing	321	Medical devices	325	163
Metal casting of specialized parts for pumps, plumbing fittings	160	Metal plating, finishing	321	161
Database Software	159	Metal casting of specialized parts for pumps, plumbing fittings	160	160
Plastic packaging material	150	Database Software	159	159
Nails and other fasteners	145	Plastic packaging material	150	150
Reclaimed water pumping station	145	Nails and other fasteners	145	145
Steel tube	138	Reclaimed water pumping station	145	145
PVC Pipe	136	Steel tube	138	138
Offices and data center	127	PVC Pipe	136	136
Biotech Labs	121	Offices and data center	127	127
Metal coating	118	Biotech Labs	121	121
Specialty equip, e.g., carts	114	Metal coating	118	118
Circuit boards	338	Specialty equip, e.g., carts	114	114
Metal heat treating	111	Circuit boards	338	113
Control valves for fluid control	111	Metal heat treating	111	111
Chemicals, Industrial Solvents	109	Control valves for fluid control	111	111
Electronic Devices	108	Chemicals, Industrial Solvents	109	109
Cuts, sands, finishes and glues laminated to wood	106	Electronic Devices	108	108
Hardware store, national chain	105	Cuts, sands, finishes and glues laminated to wood	106	106
Copiers, fax & printers	101	Hardware store, national chain	105	105
Washing, bleaching jeans (pants)	193	Copiers, fax & printers	101	101
lumber products, planed boards	94	Washing, bleaching jeans (pants)	193	97
Bio-Pesticides	85	lumber products, planed boards	94	94
Casting	79	Bio-Pesticides	85	85
Milk Processing, Purified Water	78	Casting	79	79
Toys	76	Milk Processing, Purified Water	78	78
Fasteners	75	Toys	76	76
Metal finishing and plating	75	Fasteners	75	75
Water pumps	73	Metal finishing and plating	75	75
Server Rooms	72	Water pumps	73	73
Sterilized devices	70	Server Rooms	72	72
Refrigerated Warehouse	475	Sterilized devices	70	70
Bakery	135	Bakery	135	68
Office space for industrial gas distributor	61	Office space for industrial gas distributor	61	61
Injection molding	57	Injection molding	57	57
Printing	56	Printing	56	56
Electronics, Printers (also produces software)	54	Electronics, Printers (also produces software)	54	54
Automobile parts	53	Automobile parts	54	54
Aircraft parts	53	Aircraft parts	53	53
Automobile	102	Automobile	102	51
Light manufacturing	41	Light manufacturing	41	41
Golf course watering	32	Golf course watering	32	32
Import and produce ceramic products	25	Import and produce ceramic products	25	25
Metal casting for pumps and plumbing fittings	14	Electronic assembly	28	14
Electronics, LEDs and circuits	14	Metal casting for pumps and plumbing fittings	14	14
Electronic assembly	28	Electronics, LEDs and circuits	14	14
Thermal Plant brewing process, bottling	6	Thermal Plant brewing process, bottling	6	6
Book binding	3	Book binding	3	3
Grand Total	49259	Grand Total	49259	320

Industrial Demand Response Potential by 4-digit NAICS (complete table)

4-Digit NAICS Code	NAICS Description, 2007	DR kW Potential	
		Sum	Ave
3211	Sawmills and Wood Preservation	3598	1799
2123	Nonmetallic Mineral Mining and Quarrying	2582	1291
3222	Converted Paper Product Manufacturing	1133	1133
5417	Scientific Research and Development Services	2693	898
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	4403	881
3331	Agriculture, Construction, and Mining Machinery Manufacturing	1729	865
3251	Basic Chemical Manufacturing	1868	623
3359	Other Electrical Equipment and Component Manufacturing	1750	583
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Ma	1091	546
4529	Other General Merchandise Stores	523	523
3115	Dairy Product Manufacturing	1011	506
1151	Support Activities for Crop Production	490	490
3364	Aerospace Product and Parts Manufacturing	943	472
3329	Other Fabricated Metal Product Manufacturing	768	384
3116	Animal Slaughtering and Processing	744	372
3149	Other Textile Product Mills	303	303
3312	Steel Product Manufacturing from Purchased Steel	598	299
2213	Water, Sewage and Other Systems	7441	286
3118	Bakeries and Tortilla Manufacturing	1106	277
1121	Cattle Ranching and Farming	1018	255
3121	Beverage Manufacturing	2436	244
3221	Pulp, Paper, and Paperboard Mills	240	240
3271	Clay Product and Refractory Manufacturing	440	220
3339	Other General Purpose Machinery Manufacturing	633	211
4931	Warehousing and Storage	1045	209
3326	Spring and Wire Product Manufacturing	406	203
3313	Alumina and Aluminum Production and Processing	201	201
7139	Other Amusement and Recreation Industries	580	193
3254	Pharmaceutical and Medicine Manufacturing	767	192
4244	Grocery and Related Product Merchant Wholesalers	184	184
3241	Petroleum and Coal Products Manufacturing	181	181
3324	Boiler, Tank, and Shipping Container Manufacturing	173	173
3112	Grain and Oilseed Milling	167	167
3345	Navigational, Measuring, Electromedical, and Control Instruments Manuf	325	163
3363	Motor Vehicle Parts Manufacturing	319	160
5112	Software Publishers	159	159
3332	Industrial Machinery Manufacturing	757	151
3328	Coating, Engraving, Heat Treating, and Allied Activities	865	144
3261	Plastics Product Manufacturing	286	143
3311	Iron and Steel Mills and Ferroalloy Manufacturing	138	138
3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	114	114
3212	Veneer, Plywood, and Engineered Wood Product Manufacturing	106	106
4441	Building Material and Supplies Dealers	105	105
3333	Commercial and Service Industry Machinery Manufacturing	101	101
3344	Semiconductor and Other Electronic Component Manufacturing	805	101
3133	Textile and Fabric Finishing and Fabric Coating Mills	193	97
5311	Lessors of Real Estate	188	94
3231	Printing and Related Support Activities	184	92
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	85	85
3315	Foundries	253	84
3399	Other Miscellaneous Manufacturing	76	76
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	75	75
5182	Data Processing, Hosting, and Related Services	72	72
3391	Medical Equipment and Supplies Manufacturing	70	70
3341	Computer and Peripheral Equipment Manufacturing	54	54
3361	Motor Vehicle Manufacturing	102	51
Grand Total		48677	318

Appendix D: Questions to Add to Integrated Energy Audit Template for Industrial Facilities

1) Do you have any process or system that can:

(check all applicable)

_shift to off-peak operation

_shift to a non-critical day

_ temporarily operate differently (e.g. at raised set points, operated at reduced output or using stored energy)

_be interrupted temporarily, from 15 minutes to 8 hours

without having an unacceptable impact on production?

2) In the table below, please check all applicable boxes for functional areas might offer demand response potential:

Functional Area	DR Potential (check all applic)	Potential Duration (in hours)					Potential Frequency								DCS Controls		Required Notice					
		< 2	2	4	6	> 6	times per month				consecutive days				Y	N	1 hr	4 hrs	1 day	> 1 day		
shipping and receiving																						
materials handling/preparation																						
support systems- pumping, compressed air, fans, industrial gas, etc																						
production process																						
packaging																						
warehouse																						
space conditioning																						
lighting																						
onsite generation																						
other:																						

3) Does your facility have a Distributed Control System (DCS) or other automation system? _ yes _ no

If no, what is used to control your industrial processes?

_Manual

_Semi-automatic, such as programmable timer, please describe-

Other, please describe-

4) Assuming advance notification (via phone, text message, pager or e-mail) and “opt-out” option via a Web page, how suitable is your site for automated demand response for some portion of the electric load (i.e., pre-determined loads would shed automatically without staff intervention): (check one).

Suitable for automated demand response.

May be suitable for automated demand response.

Not suitable for automated demand response

Appendix E: Site Questionnaire

Site Questionnaire

Thank you for completing this survey. When completed, please e-mail to cpjoe@gepllc.com or fax to 925.284.3147.

Interviewer	
Date Interviewed	

Contact Information

Name	
Company	
Contact's address	
Phone	
Fax	
E-mail	
Year established	

Site Information – industrial sector (check applicable)

NAICS Code	Industrial Sector	NAICS Code	Industrial Sector
<input type="checkbox"/>	2213 Water and wastewater treatment	<input type="checkbox"/>	3323 Architectural and Structural Metals
<input type="checkbox"/>	3114 Fruit and Vegetable Processing	<input type="checkbox"/>	3328 Coating, Engraving, Heat Treating
<input type="checkbox"/>	3118 Bakeries and Tortillas	<input type="checkbox"/>	3329 Other Fabricated Metals
<input type="checkbox"/>	3121 Beverages	<input type="checkbox"/>	3332 Industrial Machinery
<input type="checkbox"/>	3132, 33,41 Fabric Mills & Textiles	<input type="checkbox"/>	3341 Computers and Peripherals
<input type="checkbox"/>		3342 Communications Equipment	
<input type="checkbox"/>	3222 Converted Paper Products	<input type="checkbox"/>	3344 Semiconductor/Electronics
<input type="checkbox"/>	3231 Printing	<input type="checkbox"/>	3363 Motor Vehicle Parts
<input type="checkbox"/>	3241 Petroleum/Coal	<input type="checkbox"/>	3364 Aerospace
<input type="checkbox"/>	3251 Basic Chemicals	<input type="checkbox"/>	3371- Household & Office Furniture/Fixtures
<input type="checkbox"/>	3254 Pharmaceuticals	<input type="checkbox"/>	
<input type="checkbox"/>	3261 Plastics	<input type="checkbox"/>	4931 Warehousing and Storage
<input type="checkbox"/>	3262 Rubber Products	<input type="checkbox"/>	5182 Data Centers
<input type="checkbox"/>	3273 Cement and Concrete	<input type="checkbox"/>	5622 Waste Treatment and Disposal

Other _____

Site Address	
Number of Employees	
Approx Building Square	

Footage	
Product type (s) manufactured at this site	(1) (2) (3)
Production per year by Product type (Units, lbs, volume)	Product (1): Product (2): Product (3):
Process Type	<input type="checkbox"/> Batch <input type="checkbox"/> Both or Varies <input type="checkbox"/> Continuous
Hours of Operation	<input type="checkbox"/> 1 shift/5 days <input type="checkbox"/> 1 shift/7 days <input type="checkbox"/> 2 shifts/5 days <input type="checkbox"/> 2 shifts/7 days <input type="checkbox"/> 24/7
Scheduled Shutdown	<input type="checkbox"/> Yes <input type="checkbox"/> No If yes, <input type="checkbox"/> during the period from May-Sept <input type="checkbox"/> other _____
Facility Operations	Do you have any of the following onsite: <input type="checkbox"/> wastewater treatment <input type="checkbox"/> data center <input type="checkbox"/> storage for cooling water, industrial gases, or de-ionized water
Outsourced Operations	<input type="checkbox"/> Bldg management <input type="checkbox"/> Production process or service, describe _____ _____ <input type="checkbox"/> Other outsourcing <input type="checkbox"/> No outsourcing

Energy

Utility Company		
Peak load [kW]		
Connected load [kW]		
Approximate breakdown of % load during summer peak (May – Sept)	Production Processes	
	Production Support (Air Compressors, Chilled Water, Water Treatment, Fume Scrubbers, etc) <i>if not known, estimate as part of production</i>	

	Building Equipment (HVAC, Lights, etc.)	
	Other Equipment	

Load Shed Opportunities – General Information

1. Has your site participated in previous DR programs or has your equipment been turned off to reduce energy costs?	Choose one from below	
	Yes <input type="checkbox"/>	If Yes, continue
	<input type="checkbox"/>	If No, go Next Section

2. What equipment was shutdown or throttled back during last year's high demand days?

Equipment / Loads	Method Used to Decrease kW		Automated Load Shed Opportunity Assessment			
	Shut-down	Reduce Load	Can Load be automatically shutdown?	If No, Could kW be decreased if the plant floor was aware of DR event?	Avg kW	Duration
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>		

Note: Automated Demand Response (Auto-DR) is a set of standard, continuous, open communication signals provided over the Internet to allow facilities to automate their demand response with no "human in the loop." The purpose of automating demand response is to make DR more visible, repeatable, reliable, and lower cost by reducing labor costs associated with manual DR strategies initiated by facility staff

If interested in identifying additional kW opportunities, please continue.

Process Equipment

In addition to any previous demand response participation, can any **Process Equipment** be Shutdown or Throttled back for at least 2 consecutive hours between the hours of 12:00PM and 8:00PM, during critical demand days from May 1 thru Oct. 31? Yes No

3. The Auto-DR Hardware is designed communicate a DR event directly to control systems and/or can be used to turn off loads.

Can Auto-DR hardware be allowed to shutdown any process equipment at the start of a DR event?

Yes	<input type="checkbox"/>	If yes, go to 4
No	<input type="checkbox"/>	If no, go to 6

4. List process equipment and estimated kW that can be shutdown or throttled for at least 2 consecutive hours when the Utility calls for a DR event.

Name and Description of Equipment	kW

5. Could all of the process equipment listed above tolerate a demand event on two consecutive days? (Shutdown or throttled for at least two hours on each event day)?

Yes No--list equipment that could not tolerate two consecutive event days:

6. Some process machines can be shutdown as long as the operator has ample time to either clear all material or complete a cycle.

Are there any process machines that could be shutdown if the operator is notified in advance of the DR event?

Yes	<input type="checkbox"/>	If yes, go to 7
No	<input type="checkbox"/>	If no, go to 8

7. List process equipment and estimated kW that can be shut down for at least two consecutive hours with advance notice

Name and Description of Equipment	Kw	Advance Notice Req'd (in hrs)

8. The Auto-DR Hardware, either alone or with a control system, can be used to notify an operator of a pending DR event. Direct notification can lead to a more efficient manual shutdown process, maximizing load shed.

Are there any process machines that could be manually shutdown during a DR event?

Yes	<input type="checkbox"/>	If yes, go to 9
No	<input type="checkbox"/>	If no, go to 10

9. List process equipment and estimated kW that can be shut down with advance notice

Name and Description of Equipment	Kw	Advance Notice Req'd (in hrs)

10. Some companies take advantage of the low cost of power by scheduling manufacturing during the off shifts. (2nd, 3rd or weekend shifts).

Are shifts scheduled based on the price of energy?

Yes No

If not, could this be considered?

Yes No

What is the primary production schedule?

Shift Data				Comments
Shift	1	2	3	
Sun				
Mon				
Tue				
Wed				
Thu				
Fri				
Sat				

Building Equipment

<p>Can any Building Equipment be Shutdown or Throttled back for at least 2 consecutive hours between the hours of 12:00PM and 8:00PM, during 12 DR days from May 1 thru Oct. 31?</p>	
<p>10. Building systems like HVAC and lighting loads have been proven to be a great source of DR load shed opportunity</p>	<p>Are there any buildings that utilize an Energy Management Control System (EMCS) to control temperature?</p> <p style="text-align: center;">Yes <input type="checkbox"/> No <input type="checkbox"/></p> <p style="text-align: center;">If yes, are Lights controlled by the EMCS? Yes <input type="checkbox"/> No <input type="checkbox"/></p> <p>EMCS systems have been paramount in optimizing the efficiency of building systems.</p>
<p>11. Many different strategies have been proven to reduce kW of HVAC systems.</p>	<p>Are there any areas conditioned by an HVAC system that could tolerate a temperature change for a short period of time?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>12. Since DR event occur during high demand time, typically during daylight hours, depending on circuit configurations, lighting fixtures may be another source of load shed opportunity.</p>	<p>Are lighting circuits configured such that the total lumens in an area could be reduced by 25%, 50%, or 75% by isolating lighting circuits?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p> <p>Can certain lighting circuits be turned off during the day without affecting throughput?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>

Backup Power

<p>13. A common solution to maintain throughput during a sustained power interruptions is to power the equipment from a motor-generator and/or mobile air compressor.</p>	<p>Does your site have a backup power source or mobile air compressor?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p> <p>If yes, could the backup system be used during a DR event?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p> <p>If yes, what is the approximate kW? _____</p>
<p>14. If your site has backup power sources, it might be possible to use the Auto-DR hardware to transfer power directly to backup systems.</p>	<p>Does the motor-generator and/or compressed air systems come on-line automatically if a power interruption is detected?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>

Other Equipment

15. Are there any other equipment that could be turned off or throttled back for at least 2 consecutive hours between the times of 12:00PM and 8:00PM, from May 1 thru Oct. 31? Please list potential loads

Name and Description of Equipment	kW

If you have any questions about this survey, please contact Joe Prijyanonda at Global Energy Partners, LLC. He can be reached at 925.284.3780 or at cpjoe@gepllc.com.

Global Energy Partners is located at the following address:

3569 Mt. Diablo Boulevard, Suite 200

Lafayette, California 94549

www.gepllc.com

Appendix F: Fact Sheets



Automated Demand Response (Auto-DR) For Industry Overview

What is being proposed?

Demand Response (DR) is a set of actions taken to reduce electric loads when contingencies, such as emergencies or congestion, occur that threaten supply-demand balance, and/or market conditions occur that raise electric supply costs. Demand response programs and tariffs are designed to improve the reliability of the electric grid and to lower the use of electricity during peak times to reduce the total system costs. Automated Demand Response (Auto-DR) is a set of standard, continuous, open communication signals provided over the Internet to allow facilities to automate their demand response with no “human in the loop.”

Who initiated this idea?

The Demand Response Research Center (DRRC) <<http://drrc.lbl.gov>>, which is sponsored by the California Energy Commission’s (CEC) Public Interest Energy Research (PIER) Program, has been developing standard methods to automate demand response.

The DRRC has tested Auto-DR systems in 40 commercial buildings over the last four years. Most of the building strategies have focused on lighting and cooling system strategies. Previous work has focused on building Energy Management Systems. The DRRC is actively evaluating strategies, techniques, and the application of Auto-DR for industrial facilities.

Why Auto-DR for industry?

In California industry represents 20% of base electricity peak demand, or approximately 8600 MW. Initial estimates indicate that as much as 30-40% of industrial loads may be automatic demand response (Auto-DR) candidates¹.

Automating demand response will make DR more visible, repeatable, reliable, and lower cost:

- More visible because the two-way communication systems allow Internet tracking of the receipt of DR signals from end-use customers.
- More repeatable and reliable because the DR signals trigger fully automated controls strategies that are “hardened” and programmed into software and hardware.
- More affordable because automation can help reduce labor costs associated with manual DR strategies initiated by facility staff.

¹ PIER Demand Response R&D Strategy, Commissioner Geesman Briefing August 24, 2006

Which utility service territories offer Auto-DR programs?

In California, Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E), currently/plan to offer Auto-DR to facilities through their own programs. "Direct-Access¹⁶" industrial facilities customers are also eligible to participate in the DR programs offered within the service territories of these utilities.

What's the value proposition for industry?

Financial

- Lower electricity bills. Reducing energy consumption during high-price periods cuts energy costs.
- Several demand response programs offer financial and other benefits to businesses that can reduce electric load during periods of extreme usage.

Reliability

- Reducing peak energy use helps eliminate exposure to rotating outages.

Environmental

- Cutting electricity is the most environmentally sound way of securing power — reducing use minimizes the need for generation and therefore, the amount of emissions released into the air from the production of electricity.¹⁷

Social

- Your neighborhood will benefit too — lights will stay on, businesses will keep running and people that rely on electrical equipment, often schools and the elderly, will not suffer from power disruptions.

How will Auto-DR work and what will it include?

Auto-DR requires standardized signals between different utilities and industrial facilities based on standardized communication technologies that integrate with third-party proprietary controls and communications software.

The essential elements of an Auto-DR system are shown in the figure below and include:

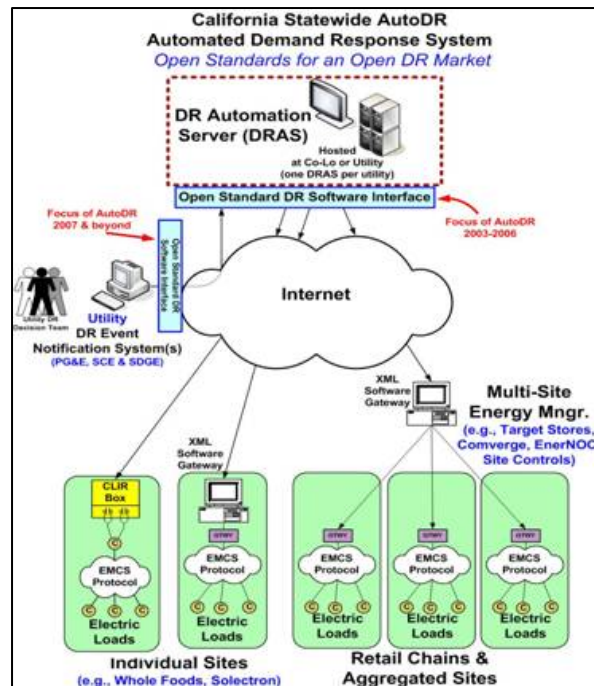
- Demand Response Automation Server (DRAS) for Auto-DR (OpenADR) is based on the interoperable, open-standard architecture using Web Service¹⁸ software system.

¹⁶ Direct Access Customers are those who engage in accessing their energy needs directly with electric service providers such as Calpine, Strategic Energy, etc.

¹⁷ Flex Your Power, http://www.fypower.org/now/demand_resp_faq.html#what_adv. Accessed April 3, 2007

¹⁸ Web services (WS) is a set of modular applications that are self-describing and self-contained that can be easily integrated with other Web services to create objects and processes. WS are built using open Internet standards, thus enabling systems to be constructed and integrated with applications on any platform and programming language.

- Client & Logic with Integrated Relay (CLIR) box, XML software gateway, etc., that fit into individual deployment requirements for a facility and provides flexibility for enrollment.
- Energy Management Control Systems, Energy Information Systems (EMCS/EIS) or other forms of building automation are used for DR strategies within the facility.



What types of programs are available?

Presently the following types programs are offered:

- *Automated Critical Peak Pricing (Auto-CPP)*, offered by PG&E and SCE, is a form of price-responsive demand response that automates the demand response for critical days as part of a critical peak pricing tariff.
 - PG&E: http://www.pge.com/biz/demand_response/critical_peak_pricing
 - SCE: <http://www.sce.com/RebatesandSavings/LargeBusiness/DemandResponse>
- *The Automated Demand Bidding Program (Auto-DBP)*, offered by PG&E, is also a form of price-response that allows participants to provide a bid for a certain load shed level (kW) during a two to 8 hour period.
 - PG&E: http://www.pge.com/biz/demand_response/demand_bidding_program
- *The Automated Capacity Bidding Program (Auto-CBP)*, is currently under consideration by SDG&E, is voluntary and a form of reliability demand response and is based on certain guaranteed monthly payments on an agreed level of bid load reduction at fixed price when requested. It comes w/ more incentives for load reduction during critical peak days in summer.
 - SDG&E: <http://www.sdge.com/drp/glance.shtml>

Who else will be involved?

Private companies subcontracted by utilities to commercialize Auto-DR systems

Industrial energy management experts

Governmental and Non-governmental organizations

What is the process for participation?

The DR programs are different among utilities. For PG&E's Auto-CPP and Auto-DBP programs, participants have to go through an application process subcontracted by PG&E to Global Energy Partners, LLC (GEP) <http://www.gepllc.com>.

Where can I get more specific information about Auto-DR?

- DRRC – <http://drrc.lbl.gov>
- **Flex Your Power** information program provides a summary of voluntary and utility sponsored DR concepts and programs in California:
 - http://www.fypower.org/now/demand_resp.html
 - http://www.fypower.org/now/demand_resp_faq.html
- PG&E Auto-DR program details – <http://www.auto-dr.com> (under construction)
- PG&E DR – <http://www.pge.com/demandresponse/>;
- SCE DR – <http://www.sce.com/RebatesandSavings/LargeBusiness/DemandResponse/>
- SDG&E DR – <http://www.sdge.com/drp/glance.shtml>

Lawrence Berkeley National Laboratory Contact(s)

Aimee T. McKane ATMcKane@lbl.gov 518.782.7002

Anthony Radspieler Jr. ARadspieler@lbl.gov 510.486.2799

<http://drrc.lbl.gov>

Demand Response (DR) and Automated DR (Auto-DR) Strategies for Data Centers

Introduction and Background

The California Energy Commission and the Department of Energy classify data centers as industrial facilities because they are dominated by machine-based energy systems and have industrial energy consumption levels and operation patterns. Specific demand response (DR) strategies are needed for data centers due to their sophisticated controls of environmental conditions, high level of technology implementation, and users' technical knowledge. These make data centers' potential participation in DR participation unique, especially in implementing strategies for automated DR (Auto-DR).

Objectives and Purpose

One purpose of the DRRC's DR initiative for data centers is to identify potential research and control strategies for their participation in Auto-DR. This potential is dependent on the type of controls present in a data center, especially the automation capabilities of its energy management control systems. The type of controls in a facility influences the automation system design to deliver DR event signals from utilities.

Following are participation benefits and some potential strategies for data centers emphasizing on Auto-DR offerings such as Critical Peak Pricing (CPP) and Demand Bid Programs (DBP). Participation benefits vary by the DR and Auto-DR programs offered by California utilities¹⁹, Pacific Gas and Electric²⁰ (PG&E), Southern California Edison²¹ (SCE), and San Diego Gas and Electric²² (SDG&E). DR programs are available for both their firm service customers and direct-access customers in their territories. DR participation involves responding to events during peak summer days (10 to 12 utility-issued events every year, typically lasting 2 to 8 hours).

Benefits from Participation

Financial

- Lower electricity bills from reduced energy consumption from server processing loads during high-price periods on peak event days. Savings can be higher than those in other industries because reducing server loads simultaneously reduces cooling and other equipment loads.
- Financial and technology incentives to reduce load during periods of peak demand.

¹⁹ Auto-DR Programs: <http://www.auto-dr.com/>

²⁰ PG&E: <http://www.pge.com/demandresponse/adrp/>

²¹ SCE: <http://www.sce.com/RebatesandSavings/LargeBusiness/autoDemandResponse.htm>

²² SDG&E: <http://www.sdge.com/business/esc/>

- Economic security resulting from reduced risk of blackouts or brownouts.
- Reduction of data centers' largest operating expense (energy costs) during high-price period(s).

Reliability and Security

- Maintained reliability of electric grids and electricity supply, which can prevent loss of data and revenue and avoid service delays.
- Lowered likelihood of rotating outages and risk of energy crises.

Environmental

- Reduction of peak day consumption decreasing the need for electricity generation and its resulting emissions, including those that contribute to global warming.
- Achievement of the sustainability requirements of the data center industry regarding climate change.

Societal

- Protection of neighborhoods from energy emergencies and safeguarding of people who rely on electrical equipment (often schools and the elderly) from power disruptions.
- Incorporation of DR into corporate social responsibility (CSR) policies and values.

Industry Collaborative Research

- Industrial partners' collaboration to analyze DR and determine optimal response for peak load management, price-responsive systems, and end-use monitoring to provide downstream benefits.

Potential Data Center Specific DR and Auto-DR Strategies

The following table outlines potential strategies for data center DR. These strategies are categorized into two groups: (1) those within the control of the IT department/infrastructure (IT) and (2) those controllable at the facility-level (FL):

- **Tasks prioritization [IT]**

Usage policies for software algorithms can shift low priority and testing-related tasks on event days to non-critical peak times. For example, backups may be run before 12 p.m. or after 6 p.m. Other tasks to shift may include software and related updates, data replication, system upgrades, etc.

- **Load Consolidation and/or Demand shift [IT]**

Most data centers have locations in different grid or climate zones, sometimes in different states and/or geographic locations, as backup during crises. Using existing or custom technologies, faster and efficient temporary migration of loads is possible without much effort. Some strategies are:

- Server consolidation or utilization: capacity analysis and creation of consolidated server-pool to run fewer server(s); enabling technology is presently available.
- Server virtualization: process-load management using virtualization to eliminate redundant server(s); enabling technology is presently available.
- Migration of load to another location; enabling technology is under development.

- **Environmental Conditions and Synergies [IT/FL]**

- Data centers with cooling set-points at or near the minimum requirements for IT equipment may temporarily reduce demand by allowing zone set-point temperatures to rise by a few degrees for a few hours without any adverse effects.
- Data centers with backup reserves such as ice storage or chilled-water storage for cooling may make effective use of these reserves during peak event days.
- Significant reduction of loads is possible through automation and existing technologies. This reduced IT equipment load, when synergized with reduction of accompanying loads such as cooling, lighting, and others, results in efficient management of building zones.

- **Technology Integration [IT]**

Data centers' high-level technology advancement and expert knowledge benefit integration. For example, synchronization of data center software and EMCS using utility DR event notification may be accomplished via the Demand Response Automation Server (DRAS).

LBNL Contact(s)

Girish Ghatikar <GGhatikar@lbl.gov>

Aimee T. McKane <ATMcKane@lbl.gov>

Anthony Radspieler Jr. <ARadspieler@lbl.gov>

Website and Related Activities

<http://drcc.lbl.gov/industrial/>

Appendix G: Implementation Examples



2007 Example of Industrial Auto-DR Application

Industrial Gas Facilities

This industrial gas facility produces compressed industrial gases for bulk distribution. These gases are delivered either via large tanker trucks via direct pipeline. There are about 5 direct pipeline customers, some as far away as 20 miles. The pipeline compressors serving the dedicated pipeline customers are not interruptible. Electricity is their primary cost of production.

At the time of their recruitment into PG&E's Auto-DR program, the facility was already shifting their production to take advantage of PG&E time of use and interruptible rates as well as in response to weather impacts on the efficiency of production. As a result, they were accustomed to shifting processes manually. They participated in non-firm manual DBP last year. As illustrated in the table below, they were able to manually shed from between 4.7 and 16.9 MW from baseline. Their main motivation for participation is cost reduction. Under the non-firm scenario, they were required to fix the amount of load to be shed well in advance of the season. Auto-DR participation in DBP provides this company with a greater range of options – providing a greater level of flexibility of response, while preserving the minimum shed commitment. Auto-DBP, unlike Auto-CPP is non-penalizing for non-participation and allows variable bids.

The large plant can shed about 9 MW from a peak load of approximately 20 MW within an hour from two compressors. There is another smaller plant that can be shut off, shedding about 1 MW. The facilities plan to make up the shed incrementally by optimizing production during off-peak times. The large plant has a very large storage capacity that can be used for this purpose

During the recruitment process, the facility staff expressed some concern about the impact of an Auto DR signal and automation on their production line. In particular, they had security concerns and AutoDR signaling infrastructure and asked about the CLIR physical location, signals, security implementation, etc. Installation and tests were conducted to determine the feasibility of AutoDR. Compatibility between the facility's existing centralized controls (Allen Bradley) and the Auto-DR signal from DRAS was resolved via software programming completed by company engineers brought in from corporate headquarters and LBNL team.

This type of shift can be replicated in other industrial gas facilities.