Market Transformation Lessons Learned from An Automated Demand Response Test in Summer and Fall of 2003

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ABSTRACT

A recent test to enable a fully automated demand response in large facilities has revealed several lessons that are important to consider for a wider application of Demand Response (DR). The automated demand response test used a web-based technology to provide a signal to energy users to reduce simultaneously reduce electric loads. The test simulated possible future system toallow energy users to implement pre-programmed strategies to reduce electric loads on the electric grid. The automated demand response system works by using the existing Energy Information Systems (EIS) and Energy Management and Control Systems (EMCS) at the sites. The six facilities recruited for the test differ in their organizational characteristics. Although these organizations are all serving diverse purposes and customers, they share some underlying common characteristics that make their simultaneous study worthwhile from a market transformation perspective. These organizations contract out a major part of their technical building operating systems. Control systems and energy management systems are proprietary. Their systems do not easily interact with one another. This paper examines lessons learned concerning the organizational culture of the participants. The participants were large institutions run by a bureaucracies. The high level of outsourcing controls services complicates their understanding of their control technologies, which are at the heart of enabling demand response. The participants expressed a sense of altruism toward demand response, recognizing it is a likely and worthwhile activity fostered by state agencies.

Introduction and Background

A recent test to demonstrate an Automated Demand Response (Auto-DR) system in California has revealed several lessons that are important to consider for a wider application of a regional or statewide Demand Response Program. **Manual demand response** involves a labor-intensive approach such as turning off lights or equipment. **Semi-automated response** involves the use of controls for load shedding, with a person initiating a pre-programmed load shedding strategy. **Fully automated demand response (Auto-DR)** does not involve human intervention, but is initiated at a home, building, or facility through receipt of an external communications signal. The automated DR system in this test used web-based technology to provide a signal to six different Energy Information System (EIS) (Piette et al, 2004, Watson et al, 2004). The signal triggered the EIS to send a message to the Energy Management Control System (EMCS) that had been pre-programmed to initiate an electric demand shedding strategy. The Auto-DR system was built using existing technology at the sites.

Demand Response (DR) is a set of activities to reduce or shift electricity use to improve the electric grid reliability, manage electricity costs, and ensure that customers receive signals that encourage load reduction during times when the electric grid is near its capacity. The two

main drivers for widespread demand responsiveness are the prevention of future electricity crises and the reduction of electricity prices. Additional goals for price responsiveness include equity through cost of service pricing, and customer control of electricity usage and bills. The technology developed and evaluated in this study could be used to support numerous forms of DR programs and tariffs.

The two main drivers for widespread demand responsiveness are the prevention of future electricity crises and the reduction of average electricity prices and price volatility. Additional goals for price responsiveness include equity, through cost of service pricing, and customer control of electricity usage and bills. Demand response has been identified as an important element of the State of California's Energy Action Plan, which was developed by the California Energy Commission (CEC), California Public Utilities Commission (CPUC), and Consumer Power and Conservation Financing Authority (CPA). The CEC's 2003 Integrated Energy Policy Report also advocates DR (Docket No. 02-IEP-1).

The basic concept of the project was to perform a two-week test of fully automated DR for four to six facilities. The test consisted of providing a single fictitious continuous electric price signal to each facility. The price was designed to encourage the participants to participate in a demand response strategy that had a larger electric load shed with higher electric prices. The technology used for the communications is known as eXtensive Markup Language (XML) combined with "web services" were used to present the price signal to the clients in a way that was common to all participants. The client's control and communications systems at each site were programmed to check the latest electricity price published by a common price server. The client then passed the signal onto the building control system, which automatically acted upon that signal. All of the facilities used existing commercially available Energy Information Systems (EIS) and Energy Management and Control Systems (EMCS) for the test (Motegi et al, 2003). These systems were programmed to automatically begin shedding demand when the fictitious electric price rose from $10 cents/kWh to $30 cents/kWh and then again when the second stage price signal increased to $75 cents/kWh. Five sites participated in the test. The test kept the test prices elevated for 3 hours. Fully automated sheds at all five sites occurred on November 19, 2004, providing up to about 0.5 MW of the 5 MW of aggregated electric load.

As part of the research, LBNL developed a detailed description of the control and communications infrastructure at each site. In a related effort and to prepare for the test, LBNL developed measurement plans at each site to measure both the whole-facility electric load shed, and component electric load shed. The control and communications systems developed for the test were also used to measure the sheds. A series of methods to measure the sheds were developed based on the available measurements. Non-energy changes in building services were also evaluated at several sites. Extensive interviews of the test participants were conducted to evaluate any disruptions that took place as a result of the test, and to understand the technical requirements for the technology implementation, and other perspectives on DR

The Auto-DR test was sponsored by the California Energy Commission's Public Interest Energy Research Program.. The primary purpose of the test was to evaluate control and communications systems in large facilities and to test the hypothesis that the receipt of a signal to initiate an automated demand response system is technically feasible. One outcome of the study is information about the likely users of Auto-DR systems and their organizational capabilities in implement demand response. The information on the organizational capabilities is reported in this paper. In each of these large facilities, the core business is not energy management and the

energy management team gets little attention from top managers unless things go wrong. Each of these organizations operates through a complex bureaucracy that can seem impenetrable at times. All of the facilities are operated with extensive outsourcing of control and service activities, which removes the management from the first level of understanding of the problems they encounter in energy systems they own. The facility managers have had some technical understanding of DR since they all participated in earlier tests.

All of the participants volunteered to participate in the study for altruistic reasons, that is to help find solutions to California's energy problems, and to gain knowledge about their own control and communications technologies. They provided technical support, plus access to sites and vendors. Their efforts reveal preliminary findings regarding organizational and technical barriers to the implementation of a wider scale program. Lessons learned in the implementation of such tests often fail to report the organization's response to the introduction of new technologies. This paper will describe some of the organizational impediments and suggest ways that future research can be conducted to examine some of the barriers further. It will also discuss briefly the manager's concerns with demand response and help define a strategic vision for interacting with similar organizations and their DR technologies.

The methodology section briefly describes the research methodology. The organizational research was not the primary goal of the research and was intended to be unobtrusive. Results are consequently preliminary and further organizational research will need to be done.

Methodology

The Auto-DR test focused on evaluating control and communications systems. The facility managers were asked to help implement changes to existing technology, but the business decisions were hypothetical. This means that the Auto-DR test helped evaluate the capabilities of new technology, but provided only minimal information about organizational behavior. The managers' organizations did not receive direct economic benefits from participating. The Auto-DR response that they responded to was hypothetical and limited.

The methodology to collect information on organizational behavior included telephone interviews, some on site interviews; observations during meetings, and reports from the project team members who were assisting with the technology and demand shed measurements. The research was conducted as Participant Action Research, that is, the technical and organizational researchers were both observing and directing (O'Brien, 1998). Participant Action Research is a widely used method in sociological studies and involves having the researchers observe the people while joining in with their activities. The research team was closely involved with helping solve technical problems as they arose and had first hand knowledge of owner problems. The technical researchers sent email copies of notes and status of the job to all the team members to keep them informed. The research team was involved in project management tasks including checking on schedules and making sure the managers understood the test.

The Auto-DR test participants were not selected because they were innovators. Innovators constitute between 1-2% of all users and are known for being venturesome and willing to pursue technology for its own sake (Rogers, 1995). They are unconcerned with costs and undaunted by failures. Innovators are a useful category of users for technical researchers, since they have skills that can advance the technology. The managers in this test are closer to the adopter category of Early Adopters, these managers are more cautious but not fearful of new

technology. They pursue new technology because it looks promising and they recognize that change is possible. This type of manager investigates possible changes carefully with the view of making better future decisions for their organization. Early adopters are very useful for organizational research since the continue to work within the parameters of their organizations rules and norms.

The selection criteria for the test considered issues such as the type of building, ownership, type of EMCS and EIS, type of end-use loads, and previous experience in DR programs. A further underlying motivation for selecting these particular organizations is their size. Specifically, the size of their portfolios would offer good future opportunities for larger scale energy shedding and the existence of an automated demand response would offer flexibility and advantage to the grid operators.

The institutional owners represent several classes of buildings. They manage university buildings, grocery stores in a chain, financial services, state and federal office buildings (Table 1). For the purposes of future full-scale automated demand response programs these owners are first users whose participation will reveal not only their technical issues, but also organizational and business issues that can encourage or imperil Auto-DR program as a resource. The diversity of the use, ownership, and management methods reflected a good cross section of large facility owners.

Table 1. Facilities Involved in Auto-DR Test

Type of Business	Ownership	Facilities Managed By
Retail Supermarket Chain	Private	Corporate staff manages through regional staff, outsourced controls and most HVAC outsourced
Pharmaceutical Research	Private	Large private staff managed by company employees, outsourced controls
Public University	Public	Large government employee staff, outsourced controls
Government Office Building	Public	Large government employee staff, outsourced controls
Government Postal Facility	Public	Large government employee staff, outsourced controls
Large Bank	Private	Third party property manager provides engineering staff, outsourced controls.

At the close of the project, managers were only asked if they thought they project was successful and if they would do it again. A detailed organizational study was not done as these facility managers and this study is a preliminary analysis of how these organizations respond to DR. Future work is needed to explore these issues in greater detail.

Another conceptual paradigms that is useful for understanding the users seen in this test is that of the lead user. Lead users are organizations that are an extremely valuable cluster of customers and potential customers who can contribute to identification of future opportunities and evaluation of emerging technologies (von Hippel, 1988). Understanding these users can provide richness of information relatively efficiently. Von Hippel defines lead users as those who exhibit the following two characteristics.

- They face the needs that will be general in the market place, but face them months or years before the bulk of that marketplace encounters them
- They are positioned to benefit significantly by obtaining a solution to those needs

We discuss how the lead user concept provides insights into the organizational culture of the Auto-DR test participants. One of the challenges of this research is that we learned about the organizational response to the Auto-DR technology developed in the test. It is unclear how to generalize from the test research to broader DR programs, however some of the issues we discuss below are universal to both Auto-DR and DR in general.

Results

This section describes observations regarding organizational findings, along with customs and practices of large facility managers. Readers interested in the technical findings should refer to the full technical report (Piette et al, 2004). In some sense all of these organizations were innovative because of their role in acquiring state-of-the-art technology that they use for energy management and DR although they are not as fearless as true innovators. Some part of the infrastructure was already in place to enact the demand response test. The institutions selected for the study were not intended to form the basis for a formal case study analysis of organizational behavior. The facilities, however, did represent a good cross-section of the potential Auto-DR market for large facilities. Large facilities are managed by a complex system of organizations. To an outsider, these organizations can be dauntingly large especially when trying to approach them for the introduction of new innovations. Everyone in the organization has well defined job responsibilities and is busy. The routine responsibilities keep them busy handling day-to-day operations of the facilities.

Lead Users

To help the leader users understand what was required for the test, the researchers prepared a Memorandum of Understanding (MOU), which carefully described the technical aspects of the Auto-DR test. The researchers followed up the MOU with telephone calls that urged, convinced, suggested and encouraged the idea that some form of an Auto-DR Program would likely be seen in California's future. A mature Auto-DR program will need to define the system requirements in a specification so that users can understand what is provided and what is expected. The MOUs were defined the requirements for participation in the Auto-DR test, and may be useful in the development of the specifications for a mature program.

Unlike many studies with lead users, these lead users did not self identify themselves as potential lead users of an Auto-DR program. From conversations with the users it was clear that they had not formerly thought in any detail about the idea of an Auto-DR program. Most were familiar with the meaning of demand response, but were uncertain how a real Auto-DR program would be applied to their operations.

Getting participation in the project was not easy since the facility managers needed to be persuaded that it was in their long-term interests to participate. The research team explained the concept that the Auto-DR control and communications technologies could provide a valuable public service to shed loads at peak times. The facility managers were told that they might be asked to automatically shed in the future, or that greater levels of automation might help them reduce their electricity costs if prices were dynamic in the future. The researchers told them that the knowledge gained in this project might allow them to take advantage of future DR programs to reduce their electricity costs.

At some time in the project outreach calls, four of the potential study sites decided not to participate and had to be resold the concept. One of the participant's vendor problems caused them to drop out of the study when their company was in an acquisition. Reasons for not wanting to participate may be easy to understand, but are restated here for those not familiar with this type of test. The program is exploratory, conceptual, complicated and may include some unknown costs. The benefit is not clear and the individuals in the organization at this level are not risk takers. The primary motivation these lead users offered for their willingness to undertake the test was their desire to be good citizens (altruistic motivations) and a weak secondary reason was their desire to be on top of a new trend in energy purchasing (business forecasting, cautious risk aversion).

Government Testing

There is some reluctance by busy managers to get involved with large government sponsored studies. Government's role in conceptual testing is not a well-understood phenomenon despite the large amount of government sponsorship of such tests. Some research shows that the role of government is often at odds with the primary motive of most companies, that is, to make a profit. (Sabel, et al, 1987). Government testing often leads to regulations and complications that industries would rather avoid. But, government has a role here in serving the "public good" and all of the lead users appeared to accept that role.

During the course of questioning prior to participating in the Demand Response Program, the participants were all asked how they would feel about a program that was simple for the gird operator to implement. The system operator would shut down parts of the grid when there was insufficient energy.

"What do you think of a system that will shut your facility down entirely from time to time when there is not enough energy to serve the entire grid?

As expected, each participant reacted with horror to this suggestion. In fact, this is the situation they face now. Large parts of the electric grid have shutdown when energy demand exceeds capacity. When they come to this realization, these lead users are willing to accept that the government research can play an important role in providing polices and programs to assist insolving the problem of balancing energy capacity against demand.

Although government's role in conceptual testing is often unclear, a major study compared the US model and German model of government sponsorship of conceptual testing. (Sabel, et al, 1987). This study revealed that policies to promote shifts in technology or innovation were unsuccessful unless the government simultaneously encourages or at least allows the effected industries to reorganize themselves to take advantage of innovations. Further, in cases where large-scale action is required to accomplish some public "good", it may be necessary for the bonds of competition and collusion to be weakened so that sharing of information is possible. As representatives of the citizens, government can guide the development of concepts that are good for industry and good for the citizens. The government can act as an intermediary and effectively lead innovations that enhance both sectors if the goals are not set too high and the purposes sufficiently compelling (Sabel, et al, 1987). From the perspective of these lead users, both criterions were met in this test. They were not asked to do too much and they accepted the role of the researchers' study of Auto-DR because the purpose was sufficiently important to them.

Large Facility Lead Users Share Characteristics

Owners of the institutions we studied share common characteristics. They are large and operate as entities whose organizational boundary edges are far apart. Some members of the institution spend almost all of their professional lives dealing only with other members of that institution. The core business or goals of the institution are clear to all participants and members are valued who can do routine things efficiently – deliver mail, process federal operations, conduct financial services, prepare and graduate students, deliver groceries, conduct long term testing of products. From previous research, we had an entry point of contact provided for these organizations; nevertheless, the site coordination was not easy. Putting aside for the moment the complexity issues that arise from the out sourced technology that is located at a distance from other technologies, there were still problems. Since there is no Auto-DR program in existence for these companies to develop an organizational response to, no one in these organizations is responsible for implementing the program.

The institutions' primary focus is to do something over and over again with low transaction costs and high efficiency. Each day, buildings are operated, bills get paid, and the air conditioning runs at is a level of service that is below the top management radar unless something goes wrong. The mid-level management personnel within these bureaucracies value optimizing and managing routine functions efficiently and without fuss.

The researchers explained the Auto-DR test to the potential participants. At one site an early response was the statement from the manager that he was not responsible for that decision or action. They offered the name of a peer in another department or area that they thought provided a better fit. Of course, the responsibilities did not fit into any department, and we were found ourselves cast back and forth between individuals in the company. An Auto-DR test is complex and the inability to find someone to "own" it was an impediment to the research program.

It is useful to know that a bureaucracy operates the institutions in this study. Bureaucracy is often used as a pejorative epithet in common usage and is meant to define mindless over-conformity and rule-encumbered inefficiency. The term bureaucrat is used here as used by Weber (Weber, 1947, quoted in Scott 1987). A bureaucracy is an organization of extremely high efficiency that focuses on doing routine things well. Combining the word bureaucracy with institution seems to call to mind particularly strong prejudices in the minds of most readers. But this is not necessarily so. Whether their core business is financial services, producing undergraduates, delivering the mail, distributing groceries or providing drugs to a heavily regulated marketplace, the institutions in this study share common characteristics. They do a workmanlike, quality job at their core business and it is the shared goal of every member of the bureaucracy to make the operations more efficient. Further understanding of these bureaucracies is necessary for a successful mature Auto-DR system.

When the main purpose of an organization is well known understood by all the participants and optimized routine functions are the expected and desired outcome of every manager's job, even worthwhile innocuous innovations may fail to thrive. The Auto-DR test has the managers ceding some control over their facilities to machines they do not fully understand. Innovations such as Auto-DR that may imperil the core goals of the institutional bureaucracies are certain to cause anxiety to responsible managers.

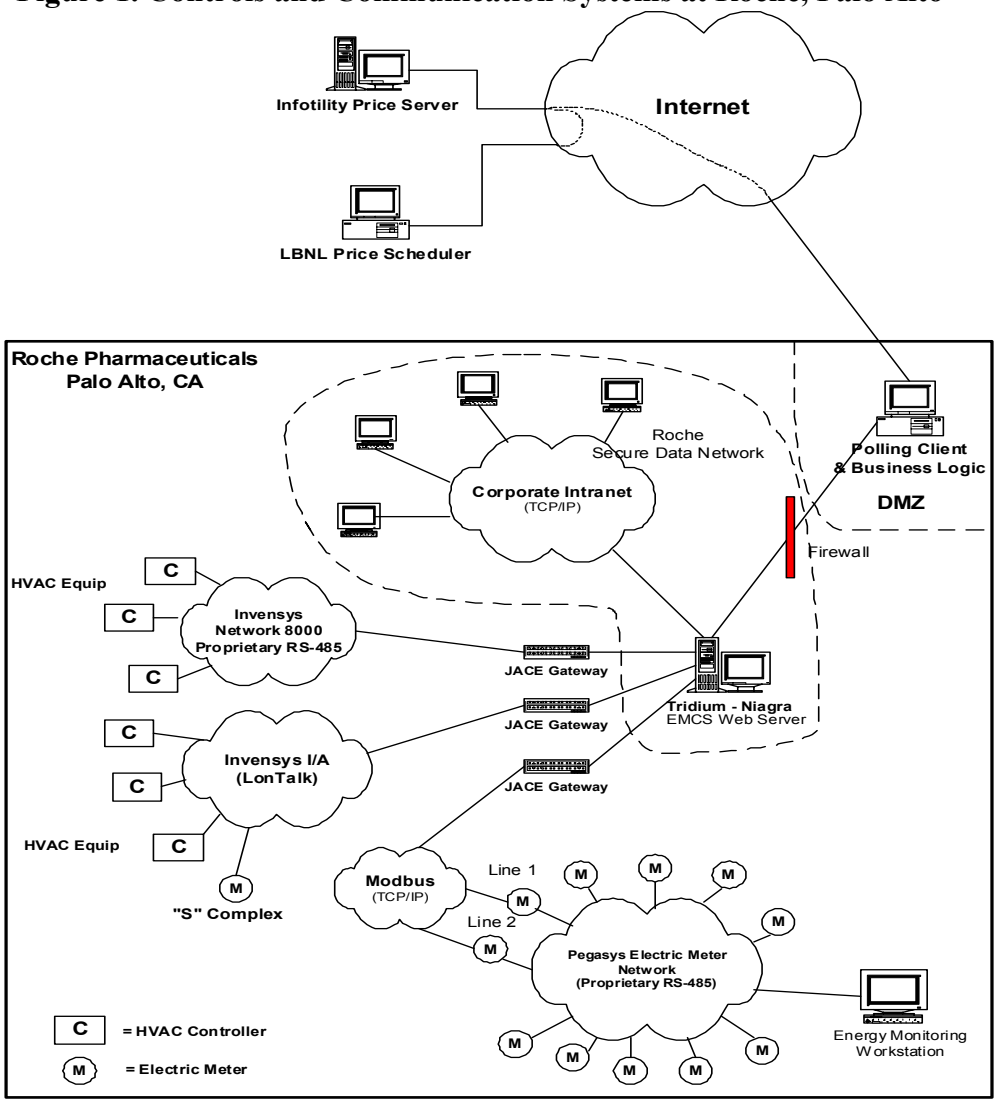
Problems from Outsourcing of Technology

Large institutional organizations managed by a professional bureaucracy share many common problems. The widespread use of outsourcing of electronic control technology has the specific knowledge required implement an Auto-DR test located outside the company. The size of the organizations and organizational emphasis on routine already provides a difficult to overcome organizational culture. The outsourcing of the controls technology along with the adoption of control technologies over time, the fact that the enabling technologies are located at some distance from each other and the complexity of the systems makes implementation of changes to the controls technology difficult.

Again, an impediment now widespread in these large institutions is that the knowledge about many technical functions is now outsourced to specialty vendors and subcontractors. Related to this is the fact that these specialty companies are in the business of selling services to the institution and while their opinion is valued, it is often discounted as sales talk. The CEC's support and LBNL's leadership can overcome some of the prejudices that the owner's representative may feel about engaging in the test, but it is not a solution for a long term DR program.

An example of the complexity of the outsourcing situation is shown by the complexity of the control and communications systems in Figure 1 (Piette et al, May 2004). The system diagrams were developed to understand the complex inter-relationships between the outsourced technology and the new Auto-DR system. Such diagrams of the systems did not exist prior to the research team's analysis of the control and metering systems. The figure shows the price scheduler and the price server developed by the LBNL research team and Infotility. The complexity of system is challenging. Facility Managers may require significant technical assistance to develop DR strategies. Again, the typical mid-level manager at these organizations did not get involved with all of the details of the technology for the Auto-DR study. In fact, it is not easy for them to estimate cost or extent of the work to be done to support such research. They require technical assistance to enable automated DR of the type developing in this research. Questions remain regarding how much assistance is needed of manual or semi-automated DR as well. The research team undertook an intermediary role between the outsourced technology vendor and mid level management. This is not a condition of this test only. Any large-scale implementation of such technology will have to adapt to these conditions and provide knowledge and leadership assistance if it is to be successful.

Figure 1. Controls and Communication Systems at Roche, Palo Alto



Recommendations for Future Research

The role of the intermediary was partially developed on this project and the discussion below describes the organizational "assistance" the research team undertook to accomplish the Auto-DR test. It is not clear how much assistance will be needed on future Demand Response tests, including larger tests with more participants. However, it appears that significant technical assistance may be needed for certain market segments. Further research is needed to evaluate such needs.

Large facilities generally are built over time. Although there it is not intentional or desired, many of the control and communications systems accrete technology over time. That is, additional features are added and layered on to existing systems controls in a messy fashion. This messiness is a leading cause of the technical support needed. The systems are unique, with multiple layers of legacy systems that suffer from the obscurity and use of proprietary hardware and software. The research team spent considerable time deciphering the layers (Piette, et. al.

2004). It is likely that similar complex systems will be found to be at future sites too. We must determine how to deal with this complexity if we are to have future success adapting commercial systems to contain Auto-DR capabilities.

A traditional problem with large, complex systems is that they may be so intricate that it is difficult to know if they are operating correctly. Although, this is partially a condition that could be corrected by good commissioning, commissioning alone is not the complete answer. The "science" of how things fundamentally operate is being lost to many technology users. As older operators retire and new operators come on board that do not really understand the systems they operate, more problems are likely to occur. The training of the operators may be the most difficult and most important need for implementation of a long-term program. Specifically, it may be valuable to provide local experts who understand how an automatic demand response system is supposed to work. In the short term, technical assistance from the research team may include debugging and testing, but this is not a long-term solution. The institution must "learn" and be able to provide an adaptation to the Auto-DR need or the systems will not be adopted.

Providing electricity is a complex endeavor. Making sure that every customer has power and that it is delivered in a routine and safe way is a tremendous accomplishment of modern civilization. But the provision of energy services has relied in the past on a paradigm that is changing. Good energy services today imply not merely getting the energy to the right place, safely and without interruption, but new public goals of peak shedding and demand responsiveness. The existing industry organization does not presently support these goals and although there is universal agreement among the six participants that these programs are necessary, they cannot provide the leadership to solve the problem. Industrial users at these lead user sites, accept the role of government-sponsored research in developing a solution.

There are few industries and institutions that do not have lead users. But in the case of demand response programs, the lead users may not self identify themselves. They do not have real demand response programs to study yet. Their technology is cumbersome and values safety and security of information over demand responsiveness. It will be important for the researchers to target clusters of lead users and educate them about the long term likelihood of demand response programs and help mid-level managers to guide their cumbersome bureaucracies towards participation in these programs.

Future research is needed to further engage DR participants as lead users so that they can become part of the extended demand response research team. They should be encouraged to share the burden of investments in new technologies and systems to support DR, but costs will need to be low in the initial stages of the research until the DR programs have been proven to be valued. There may be a value in conducting long-term research that provides ongoing technical assistance to these facility and energy managers. Such projects could assist them in understanding their current technology in relation to future demand response program.

Although the exact technical nature of automation in future DR programs is unclear, there is a need to identify and undertake education of these and related institutions to help improve understanding possible technologies. Large institutional owners with formal bureaucracies will not be able to respond to adoption of advanced technologies in a single season unless they have some previous knowledge about DR technologies can identify within their organizations a responsible participant. The potential participants are low level actors in their overall organizations. To make the DR programs successful in getting things done in these organizations it is critical that we are able to diagnose the relative power of the various participants and

comprehend the patterns of interdependence. One needs to know and understand not only the game, but also the players (Pfeffer, 1992).

One approach to institutional owners is to work up through the knowledgeable vendor and controls suppliers rather than down from the institutional owner. Generally, control equipment sales to a facility are done through the owner or owner's operator. In this case, future researchers may want to work with trusted vendors who can help the facility managers understand how demand response would work in their facilities with their equipment. Owners who fully understand their outsourced technologies are rare, but an educated vendor can enact the change more easily by educating the owners. Further, an educated vendor can supply the essential information on cost that the midlevel managers need in order to get permission to participate. Vendors may also be able to supply the names and departments of the individuals who should be approached so that a relationship can be developed.

Acknowledgements

The authors are grateful for the extensive support from Ron Hofmann, a consultant to the California Energy Commission, Laurie ten Hope (CEC), Gaymond Yee (CIEE), George Hernandez (James Ruben Associates), and Karen Herter (LBNL), Joe Desmond and Nicolas Kardas (Infotility), and numerous individuals from the participated sites. This project was supported by the California Energy Commission's Public Interest Energy Research Program and by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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