



**CALIFORNIA
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**Demand Response Research Plan to Reflect the
Needs of the California Independent System
Operator**

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**DEMAND RESPONSE RESEARCH PLAN TO REFLECT THE NEEDS OF THE
CALIFORNIA INDEPENDENT SYSTEM OPERATOR**

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January 2004
CERTS—Load as a Resource

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IMPORTANT CONCEPTS AND REPORT OVERVIEW

This document presents a research plan to increase the use of demand response and enhance power system reliability. This research plan is based only upon interviews and discussions with California Independent System Operator (CAISO) staff. The following concepts need to be defined and clarified before the research plan is discussed.

1. Demand elasticity exists when some customers elect to reduce consumption of a particular commodity during periods of high price. When the demand for the commodity is reduced in response to high price, the demand is considered to be elastic. In the following report, we describe a **level 1** response. **This is the elastic response of customer demand to the price of electric power.** The customer response is autonomous; that is, the customer independently makes their own decision about when and how to reduce their consumption.

The level 1 elastic response may take two forms. It may be a simple response where the load is automatically curtailed when price reaches a point that is established by a **tariff**, or it may be a more complex response that allows the customer to bid a curtailment price trigger. The simple response may be a basic retail tariff, and it will be called the **level 1 (tariff)** elastic response. The more complex form, in which the customer can bid its own price trigger, may be transacted over the internet or some other low-cost communication system; it will be called a **level 1 (bid)** elastic response. Both the **level 1 (tariff)** and the **level 1 (bid)** response are forms of demand elasticity, because the customer has elected to respond to price. In this report, we will simply refer to elastic load as the **level 1** response unless it is important to distinguish between a simple retail tariff and a more complex system that allows the customer to bid a curtailment price trigger. In that case, we will refer to **level 1 (tariff)** or **level 1 (bid)**.

The communication of the price to the customer is assumed to be automated. The automation of the response may involve a customer deciding on a price at which a load(s) is to be turned off. The customer may also bid a price level at which it would allow the load turned off. When the price reaches that level, the load is automatically turned off. The bid or tariff may be handled by proxy, e.g., a smart thermostat. The **level 1** response is to provide demand elasticity.

2. Dispatched demand response means that the CAISO has determined that, because of system conditions, it needs to drop load in a certain area to provide reliability services. The CAISO issues a control signal that turns off the load. This is the dispatched or **level 2** response. **These loads are turned off by the CAISO to provide reliability services including ancillary services when and where the CAISO determines they are needed.** The customers submit bids for loads they are willing to have turned off, but the CAISO makes the decision as to when and where to turn them off, and they are under the CAISO's direct control. The **level 2** response is to provide reliability services under the control of the CAISO. The

CAISO must have an extremely high confidence level in the direct dispatched load control method.

3. The load forecast is the prediction of net load for specific locations and specific times. The load forecast will be a highly accurate statistical analysis and will include the effect of the level 1 response as well as the weather and other conditions. The CAISO must have an extremely high confidence level in the statistical load forecast.

The primary goal in the development of this research agenda for demand response is to accurately reflect the concerns and needs of the CAISO. To accomplish this, two brainstorming meetings were held at the CAISO offices in Folsom, California, and a series of telephone interviews were conducted with CAISO staff.

Five recurring **themes** emerged in these conversations.

- Though there has been relatively little success with demand response programs to date, ISO personnel believe that responsive load has the *potential* to be a significant resource to increase reliability and mitigate price volatility.
- Demand response must be location-specific to have real value.
- Demand response programs must not increase the CAISO work load.
- Demand response programs must not degrade the CAISO's ability to forecast load. The response itself must be simple and certain.
- For a response program to be accepted, the benefits for the individual and the power system must be clear to customers, system operators, and regulators.

The results from the initial brainstorming meeting were grouped into the following four **issues**:

1. Program ease of use
2. Using load to mitigate market fluctuations (level 1—demand elasticity) as well as for contingency response (level 2—reliability services)
3. Location and time issues with demand response
4. Pricing mechanisms and market

A “talking points” paper was sent to CAISO staff explaining these results (Appendix A), and telephone interviews were arranged to further define the needs and to discuss the problems as seen by the individual staff members. The interviews (summarized in Appendix B) were extremely useful in understanding the CAISO's perspective

Finally, in the plan, we look to the future. We consider what the landscape may look like down the road, and we use a perspective from the 40,000-ft level. There may be some research components that are controversial to special groups. However, we have attempted to consider the CAISO's needs objectively; to understand the common themes; and to prepare an outline for research aimed at revealing separate needs, understanding the problems, and planning research aimed at solving the problems.

DEFINITIONS and ACRONYMS

Aggregation: A group of organized loads that can be controlled together with one control signal.

Automation: A programmed process or series of actions taken by a computer or other circuitry in response to a set of inputs. The actions are well defined and understood; no operator intervention is needed.

Autonomic: A decision made independently.

Bid: A dollar value set by the customer at which it is willing to have its load interrupted. The customer can bid a value for either level 1 (bid) or level 2 response. In a level 1 (bid) response, the load is turned off automatically when the price reaches the customer's bid. In a level 2 response, the load is turned off by the CAISO when the CAISO needs reliability services.

Demand Elasticity: Electric load that is responsive to price—when price increases, demand decreases.

Demand Response: Electric load that is switched off in response to a signal. The signal may be a control command or a price signal.

Direct Control: Control to turn off a load where there is no permission required or other condition. The operator “pushes the button,” and the load is dropped.

Dispatch: A form of direct control where the CAISO can order a load to be turned off or a generator to be turned on.

Market Power: The ability of a group of generators or other commercial entities to influence price.

Price: The calculated value of electricity considering the demand and the available generation and transmission capacity.

Price-Responsive Load: Load that is sensitive to the price of electricity. As price increases, the load will voluntarily curtail. Price-responsive load is a synonym for demand elasticity.

Real Time: For purposes of setting a price for electricity, real time will be considered to be an interval of about one to three minutes, rather than instantaneous.

Reliability Services, also called ancillary services: Capacity held in reserve, such as spinning reserve and supplementary reserve. These reserves are used to deal with

contingencies and ensure that an adequate supply of generation is available. Load under the direct control of the CAISO could also provide a reliability service.

SCADA (supervisory control and data acquisition system): a system of remote control and telemetry used to monitor and control the electric system

Tariff: The algorithm used to assess or determine the net price charged to the customer for electric power. The equation may include such considerations as time of day, time of year, location, and price.

CAISO	California Independent System Operator
CPA	California Power Authority
CDWR	California Department of Water Resources
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
IOU	investor-owned utility
LMP	locational marginal price
NERC	North American Electric Reliability Council
PLP	participating load program
PTO	participating transmission owner
RTP	real-time pricing
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
TOU	time-of-use electrical rate
WECC	Western Electricity Coordinating Council

SECTION 1. INTRODUCTION

The goal of this research plan is to accurately relate the needs and concerns of the California Independent System Operator (CAISO) staff regarding demand response to increase power system reliability. This research plan does not attempt to build or amplify on needs as they were expressed by the CAISO staff; rather, it is intended to accurately reflect the needs and concerns as they were presented to us and to look to the future.

CAISO personnel expressed four basic **issues** repeatedly in the initial meeting and subsequent interviews.

Issue 1. Program Ease of Use

- The CAISO staff operates with an extremely heavy workload now. Any new programs must be automatic in nature, or they must mimic existing programs so that no new workload is created.
- Demand response could be divided into two parts, one level of market-responsive load that provides an inherent response (the CAISO would not be directly involved) and one level of dispatched load for reliability services.
- Dispatched load should be just like adding generation: simple, certain, observable, and controllable, like adding the next 100 MW in generation from the bid stack.

Issue 2. Using Load to Mitigate Market Fluctuations (Level 1—Demand Elasticity) as well as for Contingency Response (Level 2—Reliability Services)

- The CAISO staff is still sometimes challenged by load in excess of the forecast in certain areas.
- A program is needed to automatically provide demand elasticity. It must be simple and workable but still provide the needed level of response.
- The CAISO staff must have confidence in the level of demand response.
- The customer needs and response must be so well modeled that there are no surprises.
- When contingencies do occur, if the CAISO had 1000 MW of load it could dispatch with certainty, it would provide a huge advantage.

Issue 3. Location and Time Issues with Demand Response

- Being able to drop loads in a particular location during times of stress would give the CAISO a powerful level of diversity.
- A workable time- and location-based response would have a net effect on energy costs for the entire state.
- The benefits must be made clear for the regulators and customers.
- Modeling and control are easier with large, specific loads.
- In some locations, such as San Francisco, dropping a load can have an immediate and significant effect on line flows into the area.

- Location and time have an impact on the value of the response, but rates are averaged now over large parts of the state.
- There must be a vehicle or method that clearly conveys and explains the value of time and location to regulatory bodies and customers.
- There are large institutional barriers. There presently exists \$35 million worth of existing interval metering that is not being used.¹
- If there is a demand response system based on locational marginal price (LMP), it must be self-funded; the CAISO has no funds to pay for the services.

Issue 4. Pricing Mechanisms and Market

- Demand response programs do not fare well in general. Response is now minimal. The load aggregation program with 5-minute market price data has accomplished nothing. A standard, fixed, limited set of programs is needed that customers understand and trust. The information customers see must be something they will respond to.
- To ensure adequate participation, a minimum set of programs is required to address the needs, i.e., reliability services from load **and** load that simply responds to market price.
- An LMP system, modified to include load, may provide enough elasticity to address market power.
- The CAISO has to have confidence in the model and in the response.

These four issues were used as talking points in our interviews with CAISO staff.

In Section 2, “Fundamental Research Needs and Focus Areas,” we look to the future in developing a set of research requirements for elastic and dispatched loads. This section describes the findings from the interviews and expresses the needs from a high-level perspective. The needs are mapped back to the CAISO departments that brought them up.

Section 3, “Summary/Conclusions and Basic Research Questions by Priority,” provides a set of ten basic research questions. These ten statements are prioritized by weightings of required time frame, need for the information, whether the information addresses CAISO issues, whether the information is persuasive, and whether the task is useful for program development. Each of the ten statements is then discussed in terms of barriers and desired outcomes.

Section 4, “Suggestions for Near-Term Research Needs,” is a set of suggestions provided by the authors that are offered to complement the basic research questions developed in the report.

¹ Some of these meters are actually being used in Critical Peak Pricing and Demand Bidding tariff pilot programs now.

Appendix A is a set of “talking points” that were used as a guideline for CAISO staff interviews. These interview guidelines were developed after the initial staff brainstorming meeting.

Appendix B, “Discussion from CAISO Interviews,” is a compilation of the comments received during the staff interviews. The interview comments are broken down into three categories: Summary, Underlying Concerns, and Perceived Needs and Questions. In Appendix C, “Research Needs and Focus Areas Mapped from Staff Issues,” the results from the discussions are grouped into nine research areas or common themes. Specific concerns, needs, and focus areas presented by the CAISO staff and the points from the discussions are mapped back to the CAISO departments that brought them up.

Appendix D, “CAISO Staff Interviews,” is a set of notes of each of the telephone interviews. Staff members were interviewed from the following departments: Operations Engineering, Compliance Audits, Training, and Special Projects Engineering.

SECTION 2. FUNDAMENTAL RESEARCH NEEDS AND FOCUS AREAS

The CAISO interviews did not directly generate a preferred CAISO research agenda. Instead, they highlighted concerns and requirements. Taken together, their responses identify research requirements for two types of demand response in five broad **Research Areas**, summarized in Table 1. Each research requirement is discussed below and mapped back to the **issue** numbers in Appendix B. For example, [1.3.3] means Issue 1 (Program Ease of Use), Heading 3 (Perceived Needs and Questions), Item 3 (What automation features ...). After the issue number, the interviewees' departments are provided in italics. For example, *Billings and Settlements* means that the interviewee was from the Billings and Settlements department.

Table 1. Research requirements for elastic and dispatched loads

Research Areas	Elastic load (Level 1)			Dispatched load (Level 2)		
	Barriers	Research to understand	Research to solve	Barriers	Research to understand	Research to solve
Resource benefit, potential, and cost						
Residential	✓	✓	✓		✓	
Commercial		✓			✓	
Industrial		✓		✓	✓	✓
Value of time and location	✓	✓	✓	✓	✓	✓
Ease of use						
For the CAISO		✓	✓		✓	✓
For the load (customer)		✓	✓		✓	✓
Observability		✓		✓	✓	✓
Forecasting		✓	✓		✓	✓

2.1 TWO DEMAND RESPONSE TYPES: ELASTIC AND DISPATCHED

Discussions with the CAISO identified a common paradigm that there are two basic categories of demand response: elastic load and dispatched load. Elastic load responds continuously to the price of electricity through market mechanisms. It provides an inherent level of market response. If the price signals presented to the load reflect the locational and temporal constraints on the bulk power system, then elastic load can increase system reliability and decrease system costs. Potentially, this can be accomplished transparently for the system operator, requiring no direct involvement by the CAISO other than to provide the time-dependent locational prices. [1.3.3] *Billings and Settlements* [2.1.3] *Compliance Audits*

Dispatched load needs to be capable of responding to system operator commands, similar to the way generators respond to system operator commands. It could be useful for responding to contingencies such as the sudden loss of a major generator. Although the

interactions between dispatched load and the system operator cannot be as minimal as with elastic load, it is critical that the system operators' work load not be increased but that the response be certain, observable, and controllable. [2.3.1] *Compliance Audits* [2.3.5] *Operations Engineering*

Given these two types of demand response, five broad **Research Areas** were further identified:

- resource benefit, potential, and cost
- value of time and location
- ease of use
- observability
- forecasting

Within each of these five broad **Research Areas**, and for both types of responsive load, the CAISO discussions revealed separate needs for research aimed at understanding the problem and research aimed at solving the problem. In some cases, specific barriers were identified. Some **Research Areas** were clearly viewed by the CAISO as having higher priority than others. Table 1 provides an overview of the research structure that emerged from the CAISO discussions.

2.2 RESOURCE BENEFIT, POTENTIAL, AND COST

All of the CAISO staff that participated in this project agreed that responsive load is useful, needed, and underutilized. They felt that the benefits of increased system reliability and reduced costs were substantial but not clearly understood. They pointed out that providing a method to clearly demonstrate the benefit of demand response, and especially time- and location-differentiated demand response, should be the highest priority goal of any research project.

The CAISO stated that having 1000 MW of load that could be dispatched simply, with observability, would be a huge advantage. [2.1.1.] *Special Projects Engineering, Training* These potential benefits need to be quantified, however, if programs to encourage increased demand response are to be successfully designed and implemented. **This research is required primarily to understand the resource, as opposed to research required to solve a specific problem.**

2.2.1 Benefit

A number of questions need to be answered concerning the potential benefits responsive load can offer. How much capacity of each type is needed? [2.3.5] *Compliance Audits, Operations Engineering* [1.3.1] *Compliance Audits* What is the economic benefit of each type of responsive load? How much load would need to participate to provide a meaningful impact, and how much is needed of each type—elastic and dispatched? What level of response could help eliminate generator market power? Is response required throughout the state, or are requirements isolated to a few locations? [4.1.2, 4.1.5, 4.2.3]

Training [4.3.9] *Billings and Settlements, Training*, [4.2.2] *Special Projects Engineering, Training* Can responsive load help reduce transmission congestion? [3.3.1, 4.1.2] *Training* How can the value of demand response to address transmission congestion be determined? [3.3.3] *Special Project Engineering, Operations Engineering*

Presumably the incremental benefits of additional responsive load will begin to drop at some point. Quantifying the benefit of responsive load as a function of the amount of responsive load will help in determining what types of programs are needed and what costs can be justified. Benefits will include reduced need for new generation, decreased operating costs for existing generation, and reduced need for new transmission. Benefits will accrue to all customers.

The characteristics of demand response need to be determined as well, in order to determine the expected benefits. Loads may, for example, respond at significantly higher prices than generators. Overall market response may be dominated by generator activity during most hours. Still, demand response to price spikes could have substantial value. [4.3.4] *Special Projects Engineering*

2.2.2 Potential

What is the potential size of the responsive load resource? How much load can be elastic? How much can be dispatched? [4.2.1] [4.3.5] *Compliance Audits* What is the program potential for residential, large commercial, industrial, and municipal programs? [4.1.1] *Compliance Audits* What are the characteristics that make each type of load suitable for each type of response? This effort would characterize and quantify specific loads (e.g., space conditioning, water heating, pumping, refrigeration, lighting) within each category (residential, commercial, industrial, and municipal). It would also provide an estimate of how much response of each type might be available. For example, each of the market segments should be characterized, perhaps as suggested in Table 2. [4.3.5] *Compliance Audits*

2.2.3 Cost

Tightly coupled to the analysis of the potential size of the demand response is an analysis of the cost of obtaining that response. Some costs are tied to the communication, monitoring, and automated control functions. Infrastructure costs can be significant. \$35 million of existing interval metering is not being fully utilized. [3.2.4] *Special Projects Engineering* [3.3.9, 4.3.12] *Compliance Audits* Other costs are tied to impacts on the load's operations. Costs are likely to be a function of both response speed and response duration. Quantifying response costs, and cost drivers, will help determine how much demand response is economically justified. [3.1.3] *Operations Engineering, Special Projects Engineering*

Table 2. Suggested classification of potential response from various types of loads within each customer class

Customer class	Elastic load	Dispatched load
Residential Air-conditioning Pool heating Appliances Water heating ...		
Commercial Space conditioning Lighting Refrigeration ...		
Industrial Water pumping Air liquification Gas compression Process curtailment Rock crushing ...		

CAISO staff are also concerned about the cost to the CAISO of implementing any new demand response programs. The CAISO has no funds for any new programs or for the services; therefore, demand response programs should be self-funded. There must be a market mechanism that creates a pool of funding to reimburse providers (loads) for the services. [3.2.7] *Billings and Settlements, Compliance Audits*

2.3 VALUE OF TIME AND LOCATION

The CAISO staff identified the lack of time- and location-dependent retail prices as a critical problem for responsive load. They strongly feel that response will be limited and ineffectual unless loads are exposed to prices that reflect the cost of providing power at specific locations and specific times. The CAISO also believes that regulators are unwilling to expose customers to time- and/or location-dependent prices and that clear, credible research is required both to understand the problem and to find acceptable solutions that meet the requirements of both the regulators and the CAISO.

2.3.1 Quantifying the Cost/Benefit

Although CAISO personnel strongly believe that locational and time-varying prices will enable loads to respond in ways that increase system reliability and reduce costs for all customers, research is required to quantify the potential benefit. This research will help regulators determine if these benefits outweigh the costs associated with exposing loads to price volatility.

Responsive load may be more or less valuable than generation on a megawatt-to-megawatt comparison. It is, obviously, closer to the load, so it may not suffer from

transmission constraints and is likely more valuable for voltage response. Demand response is less well understood than generation response, however. This is important in determining how responsive load should interact with existing generation markets. The CAISO is developing a locational pricing system with 3900 nodes. Is this system appropriate (technically and administratively) for demand response? Can load participation be automated? Will load aggregators that span multiple price points be able to cope? Will price point clustering make demand response easier or harder? Will demand response (both in aggregate and individually) be *observable* at each location? Research is required to quantify and monetize the value of responsive load. [1.3.4, 3.3.6, 3.3.8] *Billings and Settlements* [1.3.6, 3.2.5, 3.3.2, 3.3.6, 3.3.7, 3.3.8, 4.3.2] *Compliance Audits* [3.2.3, 3.2.5, 3.3.6] *Special Projects Engineering* [3.2.3, 3.3.8] *Operations Engineering*

Demand response programs are being implemented in other regions. Case studies of the problems and successes of others would be useful. [4.3.8] *Special Projects Engineering*

2.3.2 Finding Solutions

The CAISO recognizes that decisions concerning the price signals that loads are exposed to are not strictly technical. These decisions must be made in a wide, more public forum. Response in locations such as San Francisco, for example, can have immediate and significant impact on line flows into the area. The often complex technical concerns must be articulated in a clear, understandable, credible method to establish the value of time- and location-differentiated demand response. [3.1.1 and 3.1.4] *Billings and Settlements*, *Operations Engineering*, *Special Projects Engineering*, *Training*

CAISO staff believe that regulators oppose exposing loads to prices that vary by location or in real time. If this belief is correct, the reasons must be understood in order to find solutions that address the legitimate concerns of both the regulators and the system operators. Work is required to help each organization understand the concerns of the other. Impacts must be clearly quantified and monetized to allow reasonable tradeoffs to be made. [3.1.2] *Billings and Settlements* [3.3.11] *Special Projects Engineering* [3.3.10] *Operations Engineering* [3.3.2] *Compliance Audits*

Research is also required to find solutions that satisfy both the CAISO and regulators. It is likely that carefully designed pricing schemes can be devised that meet the needs of both organizations. For example, selling energy at flat rates while buying back response at time- and location-dependent prices may have merit. Problems with verifying response and eliminating gaming opportunities would need to be worked out. A retail program must be developed and agreed upon to reflect the value of time and location and to pay for demand response. [3.2.1] *Special Projects Engineering*

2.4 EASE OF USE

CAISO personnel made it clear that any new program cannot add to the CAISO workload. The CAISO cannot take on the obligation of operating a new, labor-intensive program. It does not have the resources available to deal with thousands of individual loads as it now deals with hundreds of generators. One solution may be to insist that responsive loads be aggregated into larger entities that are required to behave as generators currently do. Automation also may help alleviate the CAISO workload associated with demand response. There may be other solutions as well. But there is a clear requirement *not* to increase the CAISO work load. [1.1.1, 1.2.1, 1.2.3] *Training, Compliance Audits, Operations Engineering* [3.2.6] *Compliance Audits* [1.2.3] *Billings and Settlements*

Similarly, CAISO personnel think a major reason that there has not been greater demand response is that the loads also need simple systems that are easy to use. Loads, which are not primarily in the energy business, can devote only limited effort to participating in various electricity markets and response programs. Customer response to existing programs is minimal. The proliferation of a large number of differing programs would likely cause additional confusion without eliciting greater response. A standard, fixed, limited, minimum set of programs that customers understand and trust is needed. [4.1.4] *Compliance Audits, Operations* [4.1.1] [2.1.4] *Compliance Audits*

2.4.1 Clarifying the Requirements

Research is required to clarify the CAISO requirements for ease of use. Establishing a requirement that a new resource behave exactly like an old resource does ease the difficulties associated with integrating the new resource into the existing system, but potentially at significant cost. Unique beneficial characteristics of the new resource may be lost. Significant added expenses may be incurred (monitoring, control, and communication, for example). These added barriers may be great enough to stifle innovation. Research is required to fully understand the CAISO workload associated with using demand response and to find ways to exploit the unique benefits of responsive load without burdening the ISO. This will include technical as well as institutional efforts.

There is a need to establish a reasonable set of standards for demand response. The requirements need to be simple but still provide reliability. We need to establish the minimum set of programs that are required to address the needs—price-responsive load and load dispatched to provide reliability services. [4.2.1] *Compliance Audits* [4.3.5] *Compliance Audits*. Specific algorithms, methods, and programs need to be designed, tested, and implemented. [2.1.4] *Compliance Audit* [2.1.2] *Operations Engineering* The program should also be self-funded. [3.2.7] *Billings and Settlements, Compliance Audits*

Loads need to be exposed to real-time locational prices in order to respond usefully, but the information transfer process needs to be automated. An automated process might accommodate large and small customers posting prices at which they would be willing to curtail consumption. [3.3.5] *Operations Engineering*, [4.2.5] *Special Projects*,

Compliance Audit The automated system could then aggregate the posted responses of all customers to present the CAISO with the total available and actual response by time and location. [3.3.10] *Operations Engineering*

2.5 OBSERVABILITY

Research is required to clarify responsive load observability requirements. These requirements will likely differ for elastic load and dispatched load. [1.3.5] *Special Projects Engineering, Training, Compliance Audits, Operations Engineering* Generators must be monitored every few seconds through the SCADA system because unexpected action by a single large generator can threaten system reliability. Although SCADA monitoring is expensive, the cost is both justified for reliability and reasonable on a per-megawatt or per-megawatt-hour basis. Loads, on the other hand, are typically individually much smaller, are not a threat to reliability, and are not individually monitored on SCADA.² Instead, aggregations of loads are monitored through substation, transmission line, and interconnection metering.

Monitoring requirements for loads providing response to the power system have not been fully determined. Clearly, mechanisms must be in place to ensure that the CAISO can reliably operate the power system. Equally clearly, mechanisms are required that tie payment for response to performance. The basic reliability impacts and underlying observability requirements related to demand response need to be determined. Appropriate monitoring requirements can then be developed. Monitoring requirements for elastic load and dispatched load are likely to be different.

Statistical modeling may prove adequate for elastic load. The CAISO must have confidence in the model and the response. [2.3.2] *Special Projects Engineering*, [4.2.4] *Billings and Settlements* Confidence metrics will be required if statistical modeling proves to be adequate. [2.3.2] *Special Projects Engineering*

Observability requirements will likely be stricter for dispatched load. Reliability of the response *and* reliability of the monitoring issues/requirements need to be addressed. Still, a range of monitoring options exists. Options include

- Real-time SCADA monitoring of each responding load
- Individual monitoring at reduced frequency
- Prior and periodic certification and testing of response capability (similar to generator certification) of individuals and/or the aggregation
- Random compliance monitoring
- Response certification similar to generator certification
- Subset monitoring

² Some loads, such as the California Department of Water Resources pumping loads, are individually large enough to warrant SCADA monitoring.

- Real-time response recording at the site and after-the-fact auditing (similar to energy consumption billing)
- Certification of an aggregation

[1.2.2] *Billings and Settlements, Operations Engineering* [1.3.2] *Training, Operations Engineering* [2.3.3] *Special Projects Engineering* [2.2.2& 2.2.3] *Compliance Audits, Billing and Settlements, Operations Engineering* [1.2.4] *Special Projects Engineering* [1.2.5] *Compliance Audits*

Observability requirements may differ for control-area-wide response versus location-specific response. Statistical modeling may be easier with a larger, more diverse population. [3.2.5] *Special Projects Engineering, Compliance Audits*

The reliability of at least three separate functions must be addressed: command communication, available demand response, and response monitoring. Since a single command is likely to go to many responding loads, command communication is a point for potential common-mode failure. Command communication must be very robust. Demand response is equally critical, as this is the reliability function that is to be performed, but *individual* response of single small loads within a statistical aggregation may not be as critical. Observability requirements will be tied to the reliability requirements. [2.3.4] *Billings and Settlements* [4.3.6] *Special Projects Engineering, Billings and Settlements*

This research area is critical. At present, the CAISO does not have confidence in the level of demand response it is getting or can get. It is far from accepting the concept that load can or will respond either elastically or through dispatch. [2.2.1] *Special Projects Engineering, Billings and Settlements, Operations Engineering, Training*

2.6 FORECASTING

Utilities have been forecasting aggregate load for decades, and they do it with remarkable accuracy. In 2002, for example, the average hour-ahead forecast error for the CAISO was 78 MW on a total load that averaged 27,000 MW. The average absolute error was only 368 MW or 1.4%. Errors of this size, though relatively small, continue to present a problem for system operators because this error represents a residual amount of capacity that the system operator must obtain quickly to make up for any shortfall in generation. But this level of accuracy would be excellent if it could be applied to the size of a responsive load resource. The potential for forecasting to increase the usefulness of responsive load exists. Serious questions remain concerning the ability to realize this potential.

Exposing loads to real-time locational pricing, even if this is only an option for loads, will, it is hoped, modify their behavior. That in itself will degrade the accuracy of current load forecast models. Even though the demand response will be beneficial, the reduced forecast accuracy will not. Research is required to determine if locational response to

real-time prices can be accurately predicted. [3.3.12] *Special Projects Engineering*
Research is also required to understand how to incorporate customer motivation (price) into forecast models. Can this be modeled statistically? What confidence levels can be achieved? [4.3.1] *Compliance Audits, Training*

Research is also required to determine if local weather forecasts can be incorporated into locational responsive load forecasts to provide greater detail and accuracy in densely loaded, congested areas. [3.2.2] *Special Projects Engineering, Compliance Audits*

SECTION 3. SUMMARY/CONCLUSIONS AND BASIC RESEARCH QUESTIONS BY PRIORITY

3.1 PRIORITIZATION CRITERIA

This study has resulted in the identification of several areas of concern and needed research, as listed in Appendixes B and C and discussed in Section 2. These research areas include elastic and dispatched load, resource potential, time- and location-based prices, ease of use, observability, and forecasting. To accommodate planning for a reasonable research agenda, these concerns and needs must be prioritized. We suggest a set of five prioritization criteria:

- Time frame: Can a research task be accomplished in a relatively short time frame, perhaps 6 to 10 months, and still provide a needed payback in understanding demand response?
- Needed information: Can a task provide information needed for ongoing work?
- Addresses the CAISO issues: Can a task address issues we heard repeatedly in the interviews?
- Persuasiveness to regulators: Can a task provide information that would be persuasive to state regulators?
- Developing programs: Can a task be useful in enabling actual program development?

We then summarized the areas of concern into ten statements of needed research. The prioritization criteria were then applied to each of the ten areas. A score of 4 is the highest priority weighting, and 1 is the lowest.

The areas of research need, listed in order of average priority, are as follows. The CAISO staff rated these research needs in a meeting to review and discuss the draft report; the areas fell into three groupings, which we have listed as CAISO first, second, and third priorities.

CAISO First Priority

- | | |
|----------------------------------------------------------------------------------|-----|
| 1. Location and Time Calculation Method for Level 1 (Demand Elasticity) Response | 4.0 |
| 2. Demand Response Procedure and Process | 3.8 |
| 3. Confidence in Level 2 (Reliability Services) Response | 3.6 |

CAISO Second Priority

4. Detailed Market Model for Demand Response	3.2
5. Understanding Resource Potential Benefit	2.8
6. Understanding Customer Perspective	2.8
7. Communication for Level 1 Responsive Load	2.6

CAISO Third Priority

8. Forecasting Level 1 (Demand Elasticity) Response	2.2
9. Case Studies	2.0
10. Understanding the Cost of Obtaining Demand Response	1.8

3.2 BASIC RESEARCH QUESTIONS

The following are the basic research questions.

CAISO First Priority

1. Location and Time Calculation Method for Level 1 Response Value

CAISO staff are keenly aware of the time and location value of demand response. Dropping loads in certain areas at certain times can provide a significant level of stress relief to the transmission system. Indeed, demand response may sometimes have a much greater value per MW than increasing generation because reducing load in a load pocket on a stressed system can do much more to relieve system stress than increasing distant generation. The value of responsive load could be calculated based on time and location. The calculation method must quantify the value of the demand response clearly and fairly. The value of demand response must be quantified so precisely that it can be used to create a revenue source to the load, just as generation provides a revenue source to the generation owner. [2.1.4, 3.1.4, 3.2.3, 3.3.1, 3.3.6, 4.2.1]

Time frame: 4

Needed information: 4

Address the CAISO issues: 4

Persuasive to regulators: 4
Developing programs: 4

Average: 4.0

Basic Research Question: How can the actual value of demand response be determined on both a time and location basis?

- How can the time value of demand response be quantified?
 - Barrier: It is obvious that the value of demand response does vary with time (it is worth more in mid afternoon on a hot day,) but should it just track the market price for energy, or are there unique characteristics that must be considered such as the amount of reserves available, the cost of reserves, and the type of reserve the load may be displacing?
 - A Desired Outcome: After research into various methods for quantifying the time based value of demand response, determine the exact method that is fair and equitable for the California market.
- How can the locational value of demand response be quantified?
 - Barrier: It is clear that the value of demand response does vary with location, but what are the many variables such as transmission congestion, transmission and distribution losses, line loading, voltage regulation, etc., how should they be quantified and weighted in an objective way?
 - A Desired Outcome: After research into the factors for quantifying the locational based value of demand response, determine the exact method that is fair and equitable for the California market.
- What is a fair calculation method to determine the value of demand response?
 - Barrier: A calculation for determining the value of demand response must fairly determine the effect of both the time and location, and it must be an exact, demonstrable, and credible method.
 - A Desired Outcome: A calculation tool that determines the value of demand response based on both time and location, and is accepted by the ratepayers as being fair and reasonable.

2. Demand Response Procedures and Process

A method and operational procedure for CAISO use for level 1 and 2 response must be developed. [1.3.1, 2.1.3, 2.3.1] The method must provide a way for the CAISO to obtain funding for the payments for demand response as well as for the operation and maintenance of the market itself. [3.1.3, 3.2.1, 3.2.4, 3.2.7, 3.3.9]

- The level 1 elastic response may take two forms. It may be a simple program where the load is automatically curtailed when price reaches a point that is established by a tariff, or it may be an automated system that allows the customer to bid a curtailment price trigger. The simple program may be a basic retail tariff, and it will be called the **level 1 (tariff)** elastic response. The automated form in which the customer can bid its own price trigger may be transacted over the

- Internet or some other low-cost communication system; it will be called a **level 1 (bid)** elastic response. Either level will provide demand elasticity because the customer has elected to respond to price. The method and process for these responses must require no CAISO workload, but the CAISO will still be able to predict its net load accurately with these responses included. [2.3.5, 4.1.1, 4.3.7]
- Level 2 is a dispatched load that the CAISO can call on for reliability services. The level 2 demand response will be called upon by the CAISO as needed for reliability services, just as generation is called upon to provide these services. [1.2.2, 1.2.3, 3.3.7] [2.1.4] [2.1.2] [3.2.7]
 - There is a need to establish a reasonable set of standards, methods and algorithms for demand response. [4.2.1, 4.3.5, 2.1.4, 2.1.2]
 - The program must also be self funded. [3.2.7]

Time frame: 4

Needed information: 4

Addresses the CAISO issues: 4

Persuasive to regulators: 3

Developing programs: 4

Average: 3.8

Basic Research Question: What would the demand response procedures look like from the CAISO viewpoint?

- What technical and institutional changes are needed?
 - Barrier: Both programs have to be simple and achievable yet impact a large number of loads.
 - A desired outcome: Program plans and procedures are developed that are simple and doable and that generate adequate funding to be self sufficient.
- How could the programs be implemented?
 - Barrier: Specific algorithms must be designed, tested, and implemented.
 - A desired outcome: Smooth-running programs that are put into service with no surprises.

3. Confidence in Level 2 (Reliability Services) Demand Response

The level 2 response is controlled directly by the CAISO to provide reliability services such as contingency reserves. The CAISO presently controls contingency reserves supplied by generators. The CAISO wants the level 2 response to be directly controllable and observable, just as generators are. Large individual loads may have to be equipped with SCADA to verify their response. Aggregators may also have a role in providing the level 2 response, because groups of smaller loads may be controlled as well as large, individual loads. SCADA will probably be too costly for individual smaller loads in aggregations. Instead, the aggregator may provide a verification that the load drop signal has been issued. A high-confidence-level statistical value of the demand response could be used in place of direct response measurement. It is essential that the CAISO have

adequate confidence in the demand response for reliability services. [1.2.4, 1.2.5, 1.3.2, 1.3.5, 2.2.1, 2.2.2, 2.2.3, 2.3.2, 2.2.3, 2.3.4, 3.2.2, 3.3.8, 3.3.10, 4.2.4]

Time frame: 3

Needed information: 4

Addresses the CAISO issues: 4

Persuasive to regulators: 3

Developing programs: 4

Average: 3.6

Basic Research Question: A 100% level of certainty is needed for the level 2 response. What additional load must be dispatched beyond the needed amount to provide this certainty?

- Can the needed 100% certainty in demand response be provided through a simple dispatch signal?
 - Barrier: It may be prohibitively expensive for each smaller load to provide a real-time confirmation it has dropped a certain number of megawatts.
 - A desired outcome: An accepted level of “excess” dispatch is developed that is cost-effective and meets the needs of the CAISO, yet allows loads to be dispatched with only a “one way” real-time communication signal.
- What is the impact on the confidence level for an aggregation of loads covering some large geographic area?
 - Barrier: How can the CAISO operator dispatch an aggregation of load and have confidence in the impact on the power system?
 - A desired outcome: A method for defining useful aggregation limits and control methods that ensures they can be controlled to provide a functional reliability service.

CAISO Second Priority

4. Detailed Market Model for Demand response

A method must be developed for clearly determining and conveying the market operation and market value of both level 1 and level 2 demand response. This method will include a detailed demand response model. The model may be statistically based, but it must provide an extremely high confidence level. The method or vehicle for explaining and proving the demand response concepts must be credible, be understandable, based on accepted analysis techniques, and use verifiable data. [3.1.1, 3.1.2, 3.3.3, 3.3.4, 3.3.11, 4.1.2, 4.1.5]

Time frame: 2

Needed information: 3

Addresses the CAISO issues: 3

Persuasive to regulators: 4
Developing programs: 4

Total: 3.2

Basic Research Question: How can demand response in a market be modeled?

- Exactly what impact would demand elasticity have on energy prices?
 - Barrier: A mathematical model is needed that determines the impact of demand elasticity on the overall price of energy.
 - A desired outcome: A model that is highly credible and based on accepted market theory.
- How can the model truly reflect the California electricity market?
 - Barrier: The model must not just be a generic market model but must contain all the unique features of the California electricity market, such as the locations of the load, transmission congestion, generation locations, generation historical bids, and instances of market power.
 - A desired outcome: A model that genuinely reflects the characteristics of the California electricity market and that produces results that are trustworthy.
- What impact would the market have on the cost of electricity for all consumers?
 - Barrier: The net cost effect of market changes must be clearly determined for all consumers over at least an annualized basis.
 - A desired outcome: Possible market configurations must be exhaustively analyzed and their impact quantified in a rigorous, dependable, and conclusive manner. The analysis will include such contingencies as transmission line failures, natural gas shortages, and abnormally hot weather.

5. Understanding Resource Potential Benefit

The CAISO views demand response as being of only two basic types: elastic response (level 1) and dispatched load to provide reliability services (level 2.) How much capacity of each load type is available? What is the economic benefit of each type of responsive load? What level of response could help eliminate generator market power? Is the response required throughout the state, or are requirements isolated to a few locations? Can responsive load help reduce transmission congestion? Presumably, the incremental benefits of additional responsive load will begin to drop at some point. Quantifying the benefit of responsive load as a function of the amount of responsive load will help in determining what types of programs are needed and what costs can be justified. Loads may, for example, respond at significantly higher prices than generators. Would 20% of the load being responsive mean that 20% of the generation becomes obsolete? Research would be performed to address these questions. [4.3.4, 3.3.3, 2.3.5, 1.3.1, 4.1.2, 4.1.5, 4.2.3, 4.3.9, 4.2.2, 3.3.1, 4.1.2]

Time frame: 3
Needed information: 4
Addresses the CAISO issues: 3

Persuasive to regulators: 2
Developing programs: 2

Total: 2.8

Basic Research Question: How much of each load type is needed?

- What percentage of total load must be available as elastic demand, level 1?
 - Barrier: Demand elasticity is a key factor in healthy market systems, but how much is enough? How much is needed to eliminate generator market power? Would 5% of the connected load be adequate, or is 20% needed? Could the responsive load have an impact on transmission congestion? Are there areas where the response would be of very little value and other areas where the response would be extremely valuable? Would this have an effect of accelerating the retirement of older generating stations because the prices are no longer adequate?
 - A desired outcome: We will have a reasonable estimate of what we can expect and what its impact will be, but this is not the development of a model. We will know the resource adequacy and can address California Public Utility Commission orders, but the exact quantification of price will be established by the market. The elasticity will be implemented smoothly without dramatic price fluctuations.

- What percentage of the total load could be available as dispatchable, level 2?
 - Barrier: The North American Electric Reliability Council (NERC), the Western Electricity Coordinating Council (WECC), and the Federal Energy Regulatory Commission (FERC) provide guidance as to the various levels of supplementary reserves for generation, but are these directly applicable to dispatchable load? When dispatchable load is used together with generation to provide reliability services, how much will be available?
 - A desired outcome: We will have a clear understanding of the effect of load dispatch, as opposed to generation dispatch, for the provision of reliability services. We will know how much load would be available and what the reliability benefit would be. The load's statistical response characteristic is clearly known for a variety of load types.

6. Understanding Customer Perspective

Customer response to load control programs is now at a minimum, and the CAISO perception is that customers are skeptical of demand response programs because of the number that have been introduced and then discontinued. The new demand response concepts must be developed into tariffs and programs that are understandable, trustworthy, and viewed as worthwhile by the customer. Research is needed into the customer's perception of demand response and into the customer's needs and wants, as well as its dislikes and options it finds unacceptable. After the customer's perspective for elastic and responsive loads is known, there is a need to quantify and understand the

potential response for various incentive levels and types of involvement. [2.1.1, 2.1.2, 4.1.4, 4.3.1, 4.3.7]

Time frame: 3

Needed information: 3

Addresses the CAISO issues: 2

Persuasive to regulators: 3

Developing programs: 3

Average: 2.8

Basic Research Question: What demand response program characteristics are attractive to the customer, and what characteristics are unacceptable?

- What are the customer's wishes in a demand response program?
 - Barrier: If a program contains elements that a large majority of customers consider unacceptable, the program will never be implemented to the needed degree.
 - A desired outcome: A clear understanding of the customer's needs and dislikes in demand response for a range of customer types: residential, commercial, and industrial. Determine any program aspects that customers find to be intolerable.
- What are the needed incentive levels to get the customers to participate?
 - Barrier: What is the price signal needed to obtain the demand response? There must be a high confidence level that the needed levels are available at an appropriate cost.
 - A desired outcome: A clear statement of the response available from different load types. This response would be based on the specific demand response program elements and on a range of prices to be paid for the demand response.
- What up-front costs are acceptable to customers?
 - Barrier: Some customers may not be willing to invest heavily in demand response equipment.
 - A desired outcome: A clear understanding of what initial costs are acceptable to various types of customers, and why. Also desired is a curve of customer population vs. initial cost for various customer types.
- What sales approach would be most useful to encourage customer participation?
 - Barrier: Some customers may be reluctant to take the time to understand rate structures, equations, average demand profiles, etc.
 - A desired outcome: A program description and explanation that would be appealing to the largest number of customers. It must be simple and effective.

7. Communication for Level 1 (Bid) and Level 2 Responsive Load

Both level 1 (bid) and level 2 response programs will require at least an hour-ahead communication that allows the system operator to post prices and elicit response. This

will allow the loads to decide if they wish to respond. This communication of price must be fully automated (perhaps through the Internet or through pagers). Neither the customer nor the ISO can spend time making phone calls or being involved in transactions. Communication *may* be required back from each individual load indicating if the load will be participating in the upcoming response. An additional fast communication path is required for contingency reserve (level 2) deployment commands. This communication path, and the loads' response to curtail when the price trigger is met, must also be automatic. Research is needed for methods to perform this communication and response. [1.1.1, 1.2.1, 1.3.3, 3.2.6, 3.3.5, 4.1.3, 4.2.5, 4.3.10]

Time frame: 3

Needed information: 2

Addresses the CAISO issues: 3

Persuasive to regulators: 2

Developing programs: 3

Average: 2.6

Basic Research Question: How can the communication for responsive load be done?

- How can the load participate in the market with essentially no expense in time and little in infrastructure?
 - Barrier: Owners of small loads, such as appliances or air conditioners, will participate only if the system is simple and quick to use.
 - A desired outcome: An Internet or pager-based system where the load owner places a trigger price at which the load will be automatically curtailed, and does so as quickly as checking his email. The customer can adjust the price, for example, when he/she goes on vacation and would like to be save more money, or when he/she hosts a party and does not want to be curtailed at all.

CAISO Third Priority

8. Case Studies

Demand response is less well understood than generation response. There are market-based demand response programs in other areas, real-time pricing, for example. The actual operation and function of these programs are sometimes quite different from a quick review of the program highlights would lead one to believe. The CAISO suggested that case studies would be helpful to establish how responsive load actually interacts in markets with established programs. Case studies of the problems and successes of these established programs would be useful. [4.3.8]

Time frame: 3

Needed information: 3

Addresses the CAISO issues: 2

Persuasive to regulators: 2

Developing programs: 1

Average: 2.2

Basic Research Question: What have been the experiences of responsive load programs in other parts of the country?

- Is there experience with demand response programs in other reliability councils that would be valuable?
 - Barrier: Demand response as part of the electricity market is still relatively new and unproven, and there are many options on how to implement it.
 - A desired outcome: Review the demand response experiences and programs in other areas and discover pitfalls and useful program features.

9. Forecasting Level 1 Response

The CAISO stressed that an important aspect of a level 1 response (demand elasticity) must be the ability to accurately forecast the net load so that the CAISO can plan resources to meet the expected load. An accurate forecast is especially critical in densely loaded areas because small changes can translate into large impacts on system operation. Research is needed on forecasting methods, geographic information systems, and statistical analysis to estimate the accuracy of the elastic load forecast. [1.3.1, 3.2.2, 3.2.5, 3.3.12]

Time frame: 2

Needed information: 2

Addresses the CAISO issues: 3

Persuasive to regulators: 2

Developing programs: 1

Average: 2

Basic Research Question: Can the load level be accurately forecast if the load is elastic?

- Are there market analysis tools that could be added to existing load forecast methods so that they could include elastic demand?
 - Barrier: Adding varying price and diverse demand response increases the complexity of the load forecast.
 - A desired outcome: A highly accurate load forecast that includes variable prices and elastic demand response.

10. Understanding the Cost of Obtaining the Demand Response

Some of the costs of obtaining responsive load are for the communications, monitoring, and automated control functions. Other costs are tied to the impact on the load's operation; these costs are likely to be a function of both response speed and response

duration. Understanding these costs is critical for designing successful demand response programs. Performing research to quantify response costs and cost drivers will help determine how much demand response is economically justified. [3.2.4] [3.3.9, 4.3.12] [3.2.7] [3.1.3]

Time frame: 1

Needed information: 2

Addresses the CAISO issues: 2

Persuasive to regulators: 2

Developing programs: 2

Average: 1.8

Basic Research Question: What is the cost of implementing the program?

- What is the cost of the communication, monitoring, and control systems?
 - Barrier: We do not know what systems are needed, how fast they need to be, and how many loads or aggregations will be included.
 - A desired outcome: A well-defined analysis of estimated costs as a function of system requirements and response.
- What are the direct and opportunity costs to the load for providing the service?
 - Barrier: The load's cost will depend on the specific application. If the load owners feel the price is worth it, they will participate.
 - A desired outcome: A determination of the probable average cost for a range of potential responsive loads.
- What are the CAISO costs of developing and implementing a program?
 - Barrier: The program must be planned in sufficient detail that staffing needs can be estimated.
 - A desired outcome: An accurate picture of the program implementation costs including needed staff, infrastructure, and other factors.
- What is the total cost per megawatt of level 1 and level 2 response?
 - Barrier: The problem is somewhat circular, with response depending on cost and cost depending on response.
 - A desired outcome: A parametric analysis that integrates the above results to estimate the cost of demand response for elastic and responsive load.

SECTION 4. SUGGESTIONS FOR NEAR-TERM RESEARCH NEEDS

Based upon the totality of the CAISO responses and likely areas where significant progress could be made, we offer the following eight additional suggestions for near-term research. These suggestions are not based on the CAISO staff interviews, per se, but are reflective of projects in which the authors are presently involved or have had recent experience. These research suggestions are to complement the basic research questions provided in Section 3. These suggestions are listed in order of perceived priority. The CAISO staff **issue** that the research suggestion addresses is also referenced.

1. Determine if (and how) it would be beneficial for aggregations of small responsive loads to provide ancillary services as regulated transmission or distribution resources.

First, determine if it is beneficial for regulated transmission and distribution (T&D) companies to include the costs associated with aggregations of responsive loads that provide ancillary services in the rate base. There are potentially two primary benefits to this approach. First, this approach may greatly reduce the risks associated with introducing new ancillary service technologies. Technical issues can be addressed, and new technologies can prove their capability and value without the necessity of redesigning the ancillary service markets to accommodate them before the technologies are fully understood. It will be easier for the ISO and regulators to adjust the technical requirements rules to extract the full technical benefits if these are separated from market profit issues. Reducing risk, for both the ISO and the technology supplier, will accelerate the development of new technologies and speed their deployment and benefits.

Second, provision of ancillary services from aggregations of loads may inherently be more of a regulated T&D function than a competitive market function. For example, capacitors are T&D assets whose cost is recovered through the rate base after regulators determine that they are needed. Capacitor costs are unlikely to be recovered through market participation even if generators are paid market costs (or lost opportunity costs) for reactive power. Aggregations of responsive loads may be similar. It may be preferable to treat aggregations of responsive loads as regulated resources whose costs are recovered through tariffs and whose ancillary service response is offered to the ISO at no cost. All customers benefit through lower ancillary service costs. All customers pay through the regulated T&D tariff. Costs are greatly reduced because individual responsive load market interactions do not need to be accounted for and compensated.

This suggestion pertains directly to Pricing Mechanisms and Market Item 4.1.1: What minimum set of demand response programs are needed to address the needs.

Recommended Projects

- Develop a methodology for provision of ancillary services from regulated resources. Establish the relative benefits and costs. Produce a report documenting the results.
- Demonstrate the provision of spinning reserve from SCE's Carrier Comfort Choice® thermostats as regulated resources providing spinning reserve at no cost to the ISO. Determine the benefits, from lower spinning reserve costs, to all customers. This proposal can be linked with proposal 2 for actual testing.

2. Assessment of dynamic reactive power

Dynamic reactive power is needed to reduce distribution losses and to assist in prevention of cascading voltage collapse. An economic evaluation of dynamic reactive power is needed. This assessment would be useful for Issue 3, Location and Time Issues with Demand Response, specifically Item 3.2.1: Reactive power and supply has a pronounced dependency on location and time. "Lumpiness" of reactive power is presently causing transmission congestion.

- What is the present payment being provided by various ISOs and foreign utilities for reactive power?
- What is the operation and maintenance (O&M) cost to utilities of capacitor banks and switches, synchronous condensers, reactive power from generation?
- What is the anticipated O&M cost of new technologies: SuperVar, StatCom, Switching converters?
- How could we quantify the economic advantage of supplying reactive power locally, from distributed electrical resources (DER) and what is an estimate of the value of this local supply? (Some authors have suggested that local supply of reactive power is worth ten times more than when supplied at generating stations.)
- What are the resultant cost goals for mass-produced power electronic converters for DER?
- How much dynamic reactive power is needed from local sources? Could we develop rules of thumb for estimating the needed level based on feeder parameters?

Recommended projects

- Perform a survey of payment methods used by various ISOs and international agencies (e.g., the UK, Australia) to procure reactive power. Also, survey the utility O&M cost for providing reactive power, including conventional methods (capacitors, synchronous condensers, and generation) and new technologies (SuperVar, StatCom.) Develop an understanding of the total cost of reactive power supply and of its cost as a function of location and voltage level. Perform a survey of various authors who have developed methods for valuing reactive power based on location in the system and provide a synopsis of each author's methods and findings. From these determinations of present payment methods,

costs for provision, and potential valuation of reactive power based on location, determine a reasonable set of cost goals for technologies to supply dynamic reactive power locally.

- Perform a study and analysis of “typical” distribution feeders to determine how much dynamic reactive power is required. SCE may be able to provide sample data. The object would be to determine how many DER units would be required for a typical feeder.
- Perform a trial demonstration of dynamic reactive power supplied locally. Select a feeder with known power factor and voltage regulation problems. Evaluate the impact of the local dynamic reactive power control.

3. Aggregations

How should aggregations be formed? Should different aggregations be used for level 1 (bid) and level 2 (reliability services)? These projects would apply directly to Item 3.2.3: How can load aggregations deal with locations.

- Should aggregations be formed in certain geographic areas that would be key to resolving congestion problems? Or should they simply be formed wherever it is most convenient to enroll load in a program?
- Should aggregations be formed basically by customer type—i.e., residential, small commercial, industrial—so that the response characteristic is uniquely defined, or would it be better to have aggregations that contain a range of load types so that the response is diverse?

Testing of various methods and applications will be essential to provide the WECC and CAISO with needed background information.

Recommended projects

- Perform a survey of existing aggregations and
 - Determine what load types they contain and what geographic areas they cover.
 - Determine if there are certain “natural” configurations (location and response type) for different types of aggregations?
- Perform an analysis of the impact of aggregations when supplying response to determine
 - What is the impact of an aggregation spanning an area that covers several feeders and perhaps several substations?
 - Are there reliability advantages from having load diversity in aggregations?
 - Are some aggregation types better suited for supplying level 1 and some for supplying level 2?
 - Recommend tests of existing aggregations to assess response under various conditions, response time, duration, etc.

4. Responsive load demonstration projects

The WECC Minimum Operability Requirements Committee (MORC) indicated that it is conceptually interested in allowing aggregations of responsive loads for level 2 - reliability services, specifically spinning reserve. Because it is responsible for power system reliability, WECC is understandably conservative and slow to make changes to reliability rules. WECC stated that it would be useful to perform tests to verify characteristics and responses. Fortunately, SCE has a significant number of Carrier ComfortChoice® thermostats that it is willing to test for supplying reliability services. Other technologies and possibly aggregators would also be receptive to performing tests. The MORC working group indicated that the rule(s) and tariff(s) for spin from load would have to be well thought out and thorough before “the door is opened.”

These projects would be useful for Issue 4, Price Mechanisms and Market. Item 4.3.6, communications, monitoring, and control, would be directly addressed by performing these projects.

Recommended projects

- Develop a test protocol for responsive load to supply spinning reserve. Heavily involve WECC, MORC, and the CAISO in the test design to ensure that the test covers all technical issues of concern.
 - Tests may include multiple deployments at the CAISO command.
 - Tests may be conducted during times of relative system calm so that full response can be observed on interconnection metering as well as substation metering.
- Test SCE’s Carrier ComfortChoice® thermostats supplying spinning reserve during the summer of 2004.
 - The existence of a large number of already installed responsive thermostats will greatly reduce the project cost. Additional costs will be limited to any additional instrumentation that is required for test verification and analysis costs.

5. Examine the provision of the regulation ancillary service from storage devices that are treated as regulated T&D assets, placed in the regulated rate base, and paid for through the T&D tariff.

This proposal is similar to proposal number six, except that it involves the T&D company’s purchasing equipment to provide ancillary services. Regulation is inherently a zero-energy service. We obtain regulation from generators because they are the only technology currently available. New storage technologies are becoming available that could provide minute-to-minute real-power regulation of superior quality. Since they would not be involved in the energy market (unlike generation), they could potentially be regulated resources. Treating them as regulated resources has the benefits described in proposal 7 of reducing the risks associated with new technologies and of separating the ancillary service market issues from the technical issues.

This suggestion is related to Item 2.3.1 regarding a service that has the same look and feel as generation. This project would provide useful information on an alternate method to provide reliability services.

6. A 100% response certainty

Research methods of developing a 100% probability of level 2 response from a large number of small loads.

- What percentage of excess must be called upon? What notification confirmation would be needed?
- What communication time frame is needed? What technologies are available, and what is their reliability?
- What data need to be collected to improve demand response forecasts?
- What monitoring methods for aggregations of large numbers of small responsive loads are required to ensure the same power system reliability currently provided by generators?
- What response forecasting tools are needed? Are existing forecasting methods sufficient? What additional data need to be collected to develop improved forecasting methods?
- What NERC, WECC, and CAISO rule changes are required? What are new appropriate rules for large aggregations of responsive loads?

Recommended projects

- Establish a framework for quantifying and predicting demand response reliability. Include considerations such as required feedback, communication time, monitoring methods and monitoring level (feeder, lateral, service transformer.)
- Determine equivalent reliability criteria for large aggregations of small resources vs. larger individual resources. Consider deployment communications as well as various types of potential readiness and response monitoring.
- Collect data from large collections of existing responsive resources, such as SCE's Carrier ComfortChoice® thermostats, for resource readiness and for actual response.
- Recommend specific demonstration projects that will build WECC and CAISO confidence in statistical response.

7. Research methods for time- and location-based pricing

This suggestion is a direct match with Issue 3, Location and Time Issues with Demand Response.

- What methods and pricing algorithms are in use in different ISOs and foreign countries? What characteristics are considered: available reserves, location of reserves, congestion, losses, etc?

- Assemble information to develop an understanding of California’s specific needs, such as lumpy reserves and distant generation. Investigate possible algorithms. Obtain data for different scenarios and assess results with various algorithms.

Recommended projects

- Perform a survey of time-and location-based pricing methods and algorithms. Data may be available from several ISOs and possibly other nations; obtain specific algorithms and variables. Develop a set of price calculation methods that could be used for responsive load.
- Obtain a set of data that reflects the specific needs of California, such as market power, remote reserves, and generation. Develop a set of California system stresses such as high temperature, natural gas shortage, low water levels, etc.
- Perform a matrix of analyses using the set of calculation methods and the set of stresses. Use the matrix to identify weaknesses and strengths in the various demand response pricing methods.

8. Characterize the level 2 and ancillary service potential of various types of responsive load.

Determine the limitations, costs, aggregate availability, and benefits of various types of responsive load (residential and small commercial space-conditioning equipment, commercial freezers, rock crushers, etc.) Compare potential reliability service response with peak reduction and energy saving response. This suggestion will provide needed input for Item 2.3.2: How can customers and their loads be better modeled? What statistical algorithms and methods must be developed? How do monitoring methods differ for the level 1 and level 2 response?

Recommended projects

Perform a study that quantifies the potential resource size, costs, and benefits.

- Specify exactly what response is required for each ancillary service.
- Enumerate the types of loads available in California, including
 - The peak load size
 - The typical individual load size
 - How loads vary with time of day, season, weather, location, etc.
- Estimate how much of each ancillary service could be available from each type of load.
- Determine the costs associated with each type of load providing each ancillary service. Direct as well as opportunity costs will be important.

Recommended project

- Conduct a demonstration project for storage to provide the regulation ancillary service. Have one or more of the transmission owners conduct the demonstration

project and treat the storage equipment as a T&D asset. Provide the regulation to the ISO at no cost. Evaluate the storage technology's technical ability to supply regulation and adjust the regulation supply rules appropriately.

Appendix A. TALKING POINTS ON DEMAND RESPONSE FOR RELIABILITY

Note: This appendix is the set of “talking points” that were provided to CAISO staff prior to the interviews to suggest topics and issues for their input.

Do you have specific suggestions for research activities that you would like to see addressed in a research plan? We want your unabridged, long-term vision and short-term priorities. We want to hear about both the problems and the opportunities, such as specifics as applicable on the issues: examples, technologies, challenges, wishes. Is there anything we forgot?

Program Ease of Use (Workload) Issues

- The demand response must be invisible (automatic)—no more employees, no more work load.
- The demand response should be just like another generator coming on line.
- The new system must be automated; it’s okay to modify software, but do not add more workload.
- How is demand response accommodated currently in existing “systems”? What is cumbersome currently about incorporating load into them?

Using Load to Mitigate Market Fluctuations (Level 1—Demand Elasticity) as well as for Contingency Response (Level 2—Reliability Services)

- Could short-term load forecasting be improved?
- What can be the confidence level the ISO has in the load? That is, the uninstructed deviation penalty.
- How is load currently treated in short-term load forecasting? What might be an approach or method for better incorporating demand response into these forecasts?
- How would the ISO document/measure increased confidence in demand response?

Location and Time Issues

- The ISO is more prone to use large, specific responsive loads rather than distributed loads. Modeling and control are easier with fewer, larger loads.

- How can locational issues be fed into demand response? In downtown San Francisco, dropping any load would make things better. The San Francisco price is averaged with the Northern part of the state; is there any research on developing locational prices?
- Should we explore methods for better conveying information on the locational/temporal value of demand response to investor-owned utilities (IOUs)? What might be some examples we could explore?
- Is there a way the ISO could provide a dollar benefit for demand response considering the time of day? For example, the Fresno pumping problems sometimes occur in the middle of the night.
- Locational pricing or other mechanisms may provide more of a dollar benefit and may encourage load to bid in

Pricing Mechanisms and Market

- Could we be more relaxed on the standards and still provide the reliability? Why is it difficult to sell the programs?
- Demand response could be important for dealing with market power. What makes load different from generators to help this transformation of perspective?
- The information (or mechanism) the customer is seeing must be something that they will respond to.
- What is working and not working in the participating load program (PLP)?

Appendix B. DISCUSSION FROM CAISO INTERVIEWS

This appendix constitutes a compilation of the comments received during the phone interviews with CAISO staff and during the brainstorming meeting. The staff comments are not interpreted or refined at this point because we did not want to lose any subtleties of meaning. Many of the comments are in the form of concerns or questions regarding demand response. The comments have been grouped and categorized by four primary issues:

1. Program ease of use
2. Using load to mitigate market fluctuations (level 1—demand elasticity) as well as for contingency response (level 2—reliability services)
3. Location and time issues with demand response
4. Pricing mechanisms and market

The CAISO staff comments for each of these four primary issues have been categorized into these three groups:

1. Summary
2. Underlying concerns
3. Perceived needs and questions

Issue 1. Program Ease of Use (ISO Workload)

1.1. Summary

1. What automation features must the demand response program contain so that it essentially requires no new CAISO workload and is simple to use, but the demand response is still certain, observable and controllable?

1.2. Underlying Concerns

1. The CAISO operations staff is heavily loaded at this time and cannot add more programs that increase the work burden.
2. Can demand response be integrated into the existing system and made to look like generation, like adding the next 100 MW in generation from the bid stack?
3. Can the level 2 response be fully automated, like a push-button, like conventional generator control?
4. Could loads, and or aggregations, be certified like generation?
5. What functions should the aggregator perform to ensure the response is observable and controllable?

1.3. Perceived Needs and Questions

1. If demand response were divided into two parts, level 1 being market-responsive load that provides an inherent, autonomic response (the CAISO would not be directly involved), and level 2 being dispatched load for reliability services, how much do we need, or could we get, of each?
2. How can demand response be made certain, observable and controllable? How much feedback is needed?
3. What automation features are needed so that a demand response program requires no new workload? An evolution is needed in the response program process.
4. What are the engineering differences in response characteristics between load and generation? That is, does one kW of demand response add the same value as one kW of generation?
5. What level of observability is needed in demand response—would a statistical response level be adequate? If so, what confidence level is needed?
6. Can load be integrated into the existing market system? Would it have the same value as generation?

Issue 2. Using Load to Mitigate Market Fluctuations (Level 1—Demand Elasticity) as well as for Contingency Response (Level 2—Reliability Services)

2.1. Summary

1. The CAISO does not get enough demand response now; there is very little real time control of load. During the previous crisis periods, when load was called on too many times, demand response dropped off. If they had 1000 MW of load they could dispatch with certainty, it would be a huge advantage.
2. What is a reasonable set of standards for demand response that would provide the needed demand elasticity and why? Can the standards and programs be simple and still provide the needed level of reliability?
3. Will there be two levels to demand response?
 - a. Level 1 to provide an autonomic, elastic load demand based on the market.
 - b. Level 2 to provide a reliability service that the CAISO can call on with direct control when needed.
4. What specific programs, algorithms and methods must be developed?

2.2. Underlying Concerns

1. At present, the CAISO does not have much confidence in the level of demand response and does not even know if it gets a response. It is far away from either the concept of elastic demand or load as a reliability resource.
2. What level of SCADA is needed to monitor and control load? Could this be less stringent than generation? Could the CAISO just send out a curtailment signal with only a verification that the signal was issued?
3. Is reliability tied to SCADA and program standards for load?

2.3. Perceived Needs and Questions

1. Two levels of demand response may be appropriate. In level 1, load is incorporated directly into the energy market to provide a reliable, forecastable, response. The forecast would be accurate because of statistical modeling of demand response. When the price for electricity rises, some users will curtail. Level 2 is the use of dispatchable load by CAISO operators to provide reliability services. This level should have the same look and feel as generation. Different types of loads would likely be better at supplying each type of response.
2. How can customers and their loads be better monitored and modeled? What statistical algorithms and methods must be developed to minimize surprises? How do monitoring requirements differ for the level 1 and level 2 response?
3. How costly would it be to formally contract and test loads just like generators? Is there a lesser level that would be satisfactory?
4. Is a telemetered response always needed, or can sufficient confidence be provided with just a confirmation that the shutoff signal was issued? Do requirements differ for level 1 and level 2 resources?
5. How much load is needed for level 1 and level 2? How could load be incorporated into the energy market to provide a reliable, forecastable level 1 response? What changes would be needed in the energy market?

Issue 3. Location and Time Issues with Demand Response

3.1. Summary

1. There must be a vehicle or method that clearly conveys and explains the value of time and location to regulatory bodies and customers. Regulatory approval would be required for time- and location-based demand response.

2. The customers in San Francisco are accustomed to having their rates averaged with Northern California. In a location- and time-based program, some customers would be impacted with higher prices, others with lower prices. What would be the net cost effect? Can we demonstrate how the energy costs for the entire state would respond?
3. A retail tariff program would have to be developed to reflect value for time- and location-based demand response.
4. What would be the cost of a real-time automatic system to calculate the time and locational cost and a communication system to provide the cost to the customer?
5. Modeling and control are easier with large, specific loads.
6. In some locations, such as San Francisco, dropping a load can have an immediate and significant effect on line flows into the area.

3.2. Underlying Concerns

1. If load does have a different value from generation based on location and time, how could automated mechanisms be developed to pay for demand response? How will they differ for large and small responsive loads?
2. Could short-term zonal load forecasting be improved to reduce surprises? For example, the peak load in San Francisco depends on how far inland the fog comes. Could this be predicted more accurately?
3. How can load aggregations deal with locations? What would be the problems with load aggregations that cover multiple zones?
4. Could demand response programs be done within the existing market system or the proposed LMP system?
5. Could the LMP system provide visibility as to what loads were actually responding in a location, or could this be modeled accurately?
6. If there is a demand response system based on LMP, it must be transparent to the ISO; the CAISO cannot be involved in the daily operation of the system—it must be totally automated.
7. Also, if there is an LMP-based demand response system, it must be self-funded, i.e., the CAISO has no funds to pay for the services.

3.3. Perceived Needs and Questions

1. Could a program be developed to value locational demand response to address impending congestion?
2. Could large, specific loads replace generation one-for-one in a zonal market system, or is demand response actually more valuable?
3. How can the location and time value be quantified, both in a set of algorithms, and also in a method or vehicle that conveys the value clearly to regulators? Being able to drop loads in a particular location during times of stress or congestion would give the CAISO a powerful level of diversity. If this powerful tool could be fairly valued, the pricing would encourage load to bid in.
4. What sort of research program is needed to clarify the issues for regulators, customers, and the CAISO?
5. Could there be an automatic, Internet-based program that would make it easy for customers, small and large, to post a price at which some of their loads would be curtailed?
6. The CAISO is developing an LMP system, and the goal is to have 3900 nodes. There are no plans, however, to use these nodal prices in a demand response system.
7. Could a program be developed, similar to generation, in which to mitigate congestion or address other problems, the operator selects the loads in the needed area in order of price—a level 2 system?
8. The CAISO plan is to use the LMP system to cluster prices in areas of common price. There are a number of questions regarding the use of these prices for a demand response program: Will the cluster areas change, or will they be fixed so that fixed aggregations of load could be used? Is the LMP cost appropriate to use for demand response, or does it need to be modified (i.e., does demand response have greater value)? Does the CAISO need to have a monitor to see which loads are responding to LMPs, or could this be part of the level 1 system discussed earlier (i.e., normal demand elasticity, and something that could be forecasted accurately)?
9. How would the needed infrastructure be paid for?
10. If load is contracted with an Internet-based system, could the system provide a signal to the CAISO as to the size and location of the available and actual response?

11. The CAISO perception is that the regulators will not allow loads to be exposed to LMPs. Is this perception correct? What is needed to assess the “costs” (direct, indirect, and political) and benefits so that regulators can assess the wisdom of allowing loads to be exposed to LMPs for response? How can the regulators be convinced that a new LMP-based demand response system is going to significantly reduce prices overall? What method, vehicle, or demonstration could be used to explain the value of the program to public regulatory bodies and to customers?
12. If the LMP program were optional for the customer, that is, customers could elect to use a fixed rate or to use the LMP system, could we predict reliably how many customers would participate and what the effect would be?

Issue. 4. Pricing Mechanisms and Market

4.1. Summary

1. To ensure adequate participation, what minimum set of demand response programs are needed to address the needs, i.e., load that simply responds to market price (level 1) **and** reliability services from load (level 2)?
2. Would the proposed LMP system, modified to include load, be sufficient to address market power?
3. How difficult and costly would communicating the real-time price to the customer actually be?
4. There have been many demand response programs in the state, many that have been dropped. The programs do not fare well in general. Response is now minimal. The load aggregation program with 5-minute market price data has done nothing. We need a standard, fixed, limited set of programs that the customers understand and trust.
5. If it were dependable, demand response could be important for dealing with market power. If load could be involved in a meaningful way, the generators could see that the CAISO has a way of dealing with problems other than using generation.

4.2. Underlying Concerns

1. What is the demand response program potential size for residential, large commercial, industrial, and municipal programs?
2. How much demand response is needed to eliminate market power?

3. Is this demand response to deal with market power needed in specific locations, or spread across the state?
4. The CAISO has to have confidence in the model and response.
5. The load needs to see the price in real time to be responsive, but not necessarily in person—the process could be automated.

4.3. Perceived Needs and Questions

1. The price information the customers are seeing must be something they can and will respond to. (This process can be automated; the customer does not have to react in real time.)
2. Can this fit into the existing market mechanism?
3. How much value can the simple solutions, such as time-of-use pricing, have?
4. Is it true that the generators will become interested at much lower prices than loads? Does it matter? Is there sufficient benefit from mitigating price spikes if load typically responds at higher prices than generation?
5. What demand response is potentially available? Characterize it by load type and response type.
6. What communications, monitoring, control, and certification, are required for each type of load and each type of response?
7. What motivates a customer to sign up and actively participate? Should we focus on specific customers that have major loads such as water pumping, sewage treatment, waste disposal, etc.?
8. How are the ERCOT and other area LMP systems working? Case studies would be helpful.
9. How much load would need to participate to have a meaningful level of demand elasticity? How much is needed to eliminate market power? Is it needed only in specific locations, or spread across the state?
10. How costly would communicating the LMP to the customer in an automated, Internet-based system actually be? Do these costs differ for large and small loads? Do they differ for level 1 and level 2 response?
11. What types of responses can be supported by the \$35 million interval metering already installed?

Appendix C. RESEARCH NEEDS AND FOCUS AREAS MAPPED FROM STAFF ISSUES

In this appendix, we take the discussion from the CAISO interviews and divide it into nine groups of research needs. These groups are based upon common, re-occurring themes that came up repeatedly during the interviews and during the brainstorming meeting. This appendix provides a detailed tabulation of the interview responses.

The nine groups of research needs are as follows:

1. Two demand response types: elastic load and dispatched load.
2. A demand response program for providing demand elasticity.
3. Observability of the demand response.
4. Is demand response more valuable than generation in the market?
5. How to convey the value of time and location for demand response.
6. Load forecasting.
7. Institutional challenges regarding locational marginal pricing.
8. Customer issues.
9. Program ease of use.

Under each group, we first provide a brief synopsis of the issue; then we list the specific concerns, needs, and focus areas that were presented by the CAISO staff. The source for each research need and focus area is referenced by its issue number in Appendix A, “Discussion from CAISO Interviews.” After the issue number, the CAISO department that provided the comment is listed in italics.

1. Two Demand Response Types: Elastic Load (Inherent) and Dispatched Load (Reliability Services)

Could demand response be divided into only two types as follows:

- Type one—a level of autonomic market responsive load that provides an inherent demand response with no CAISO direct involvement (demand elasticity.) [1.3.3] *Billings and Settlements* [2.1.3] *Compliance Audits*
- Type two—dispatched (direct control) load the CAISO can call on for reliability services? [2.3.1] *Compliance Audits*

Specific concerns, needs and focus areas presented by the CAISO staff

1.1. How much capacity do we need of each type? [2.3.5] *Compliance Audits, Operations Engineering* [1.3.1] *Compliance Audits* The CAISO mentioned that if it had 1000 MW of load that could be dispatched simply, with observability, it would be a huge advantage. [2.1.1.] *Special Projects Engineering, Training*

1.2. What is the demand response program potential for residential, large commercial, industrial and municipal programs? How much capacity can we get of each type? [4.2.1] *Compliance Audits* [4.3.5] *Compliance Audits*

1.3. To ensure adequate participation, what minimum set of demand response programs are required to address the needs, i.e. reliability services from dispatchable load and load that simply responds to market price. [2.1.4] *Compliance Audits* [4.1.1] *Compliance Audits*

2. A Demand Response Program for Providing Demand Elasticity

What form should a demand response program for providing demand elasticity take (a level 1 program)? What are the constraints?

Specific concerns, needs and focus areas presented by the CAISO staff

2.1. How simple could a price-responsive program be made and still be effective, that is, no new CAISO workload, but the demand response is still certain, observable and controllable? [2.3.5.] *Operations Engineering*

2.2 What is a reasonable set of standards for demand response that would provide the needed demand elasticity and why? Can the standards and programs be simple and still provide the needed level of reliability? What specific algorithms, methods and programs must be developed? [2.1.4.] *Compliance Audits* [2.1.2] *Operations Engineering*

2.3 The program would have to be totally self-funded. [3.2.7.] *Billings and Settlements, Compliance Audits*

2.4. The load needs to see the price in real time to be responsive, but not necessarily in person; the process could be automated. Could they have an automated program where small and large customers could post prices at which some of their loads would be curtailed? [3.3.5.] *Operations Engineering* [4.2.5] *Special Projects Engineering, Compliance Audits*

2.5. If price-responsive load is contracted with an Internet-based system, could the system provide a signal to the CAISO as to the size and location of the available and actual response? [3.3.10.] *Operations Engineering*

2.6. How much load would need to participate to have a meaningful level of demand elasticity? How much demand response is needed to eliminate market power? Is it needed only in specific locations, or spread across the state? [4.3.9.] *Billings and Settlements, Training* [4.2.2.] *Special Projects Engineering, Training*

3. Observability of Demand Response

What level of operator observability is needed for each of the above two types of demand response? [1.3.5.] *Special Projects Engineering, Training, Compliance Audits, Operations Engineering*

Specific concerns, needs and focus areas presented by the CAISO staff

3.1 For the level 1 response, that is, a user-initiated, inherent, price-based response, is only a statistical, modeled understanding of response adequate? The CAISO has to have confidence in the model and the response. [2.3.2] *Special Projects Engineering* [4.2.4] *Billings and Settlements*

3.2 If a statistical response is adequate, what confidence level is needed? Surprises must be avoided. [2.3.2] *Special Projects Engineering*

3.3 For level 2, operator-dispatched demand response, does the response need to be directly observable, certain and controllable, like adding the next 100 MW in generation from the bid stack by pushing a button? [1.2.2.] *Billings and Settlements, Operations Engineering* The CAISO wants a certain, observable and controllable response. [1.3.2] *Training, Operations Engineering*

3.4 Does the type two response need to be certified in a way similar to the ways that generators are certified? How costly would it be to formally contract and test loads just like generators? Is there a lesser level that would be satisfactory? [2.3.3] *Special Projects Engineering*

3.5 What level of feedback is needed for the level 2 response, what level of telemetry? [2.2.2.] *Compliance Audits, Billings and Settlements, Operations Engineering*

3.6 Is the reliability of the response tied to the telemetry and program standards? [2.2.3] *Compliance Audits, Billings and Settlements, Operations Engineering*

3.7 Could the CAISO just send out a curtailment signal with only a verification that the signal was issued? [2.3.4] *Billings and Settlements*

3.8 If an aggregation is used to provide the level 2 response, does the aggregation need to be certified? Does each individual load in the aggregation need to be certified? What is the role of the aggregator to ensure that the response is observable and controllable? [1.2.4] *Special Projects Engineering* [1.2.5.] *Compliance Audits*

3.9 What communications, monitoring, control, and certification are required for each type of load and each type of response? [4.3.6] *Special Projects Engineering, Billings and Settlements*

3.10. At present, the CAISO does not have much confidence in the level of demand response and does not even know if they get a response. They are far away from either the concept of elastic demand or load as a reliability resource. [2.2.1] *Billings and Settlements, Operations Engineering, Special Projects Engineering, Training*

4. Is Demand Response More Valuable than Generation?

What are the differences between demand response and generation response considering their value to the distribution and transmission system?

Specific concerns, needs, and focus areas presented by the CAISO staff

4.1 Does one MW of demand response add the same value as one MW of generation response? [1.3.4] *Billings and Settlements* [3.3.3] *Special Projects Engineering, Operations Engineering*

4.2 Should load have the same dollar value as generation, or is demand response more valuable? [1.3.4] *Billings and Settlements* [3.3.2] *Compliance Audits*

4.3 Could load be integrated directly into the existing market system for generation? [1.3.6.] *Compliance Audits*

4.4 How much demand response is needed to eliminate market power? [4.1.5.] *Training* [4.3.9] *Billings and Settlements, Training*

5. How to Convey the Value of Time and Location for Demand Response

What is a clear, understandable, credible method for determining and establishing the value of demand response capacity based on time and location? [3.1.1] *Billings and Settlements, Operations Engineering, Special Projects Engineering* Modeling and control are easier with large, specific loads. In some locations, like San Francisco, dropping a load can have an immediate and significant effect on line flows into the area. [3.1.4] *Operations Engineering, Special Projects Engineering, Training*

Specific concerns, needs and focus areas presented by the CAISO staff

- 5.1. The CAISO perception is that state regulators will not allow loads to be exposed to locational marginal prices (LMPs). Is this perception correct? What is needed to assess the “costs” (direct, indirect, and political) and benefits so that regulators can assess the wisdom of allowing loads to be exposed to LMPs for response? How can the regulators be convinced that a new LMP-based demand response system is going to significantly reduce prices overall? What method, vehicle, or demonstration could be used to explain the value of the program to public regulatory bodies and to customers? Can we conclusively and clearly demonstrate how the electricity costs for the entire state would respond with a time- and location-based program? [3.1.2] *Billings and Settlements* [3.3.11] *Special Projects Engineering*
- 5.2. How could a retail tariff program be developed to reflect the value of time and location and pay for demand response? Would they differ for large and small responsive loads? [3.2.1] *Special Projects Engineering*
- 5.3. What is the demand response program potential for residential, large commercial, industrial, and municipal programs? [4.1.1] *Compliance Audits*
- 5.4. What would be the cost of developing a real-time automatic system to calculate the time and locational cost, and developing a communication system to provide the cost to the customer? [3.1.3], *Operations Engineering, Special Projects Engineering*
- 5.5. Could a program be developed to value locational demand response to address impending congestion? [3.3.1] *Training*
- 5.6. How can load aggregations deal with locational pricing? What problems would occur with aggregations that cover multiple zones? [3.3.2] *Compliance Audits*
- 5.7. Can this fit into the existing market mechanism? The CAISO is developing an LMP system, and the goal is to have 3900 nodes. Is the proposed LMP for energy appropriate to use for demand response, or should a separate pricing system be developed? [3.3.6] *Billings and Settlements, Special Projects Engineering, Compliance Audits* [3.2.3] *Operations Engineering, Special Projects Engineering* [4.3.2] *Compliance Audits*
- 5.8. Could the LMP system provide visibility as to what loads were actually responding in a location, or could this be modeled accurately? [3.2.5] *Special Projects Engineering, Compliance Audits*
- 5.9. Could a program be developed in which demand response is automatically valued, and to mitigate congestion, the operator dispatches the loads in the needed area in order of price—a level 2 system? [3.3.7] *Compliance Audits*
- 5.10. The CAISO plan is to use the LMP system to cluster prices in areas of common price. There are a number of questions regarding the use of these prices for a demand

response program: Will the cluster areas change, or will they be fixed so that fixed aggregations of load could be used? Is the LMP cost appropriate to use for demand response, or does load have a greater value? Does the CAISO need to have a monitor to see which loads are responding to LMPs, or could this be part of the level 1 response system, or demand elasticity, and something that could be forecasted accurately? [3.3.8] *Billings and Settlements, Operations Engineering, Compliance Audits*

5.11. If it were dependable, demand response could be important for dealing with market power. If load could be involved in a meaningful way, the generators could see that the CAISO has a way of dealing with problems other than using generation. [4.1.5] *Training*

5.12. How much LMP demand response is needed to eliminate market power? [4.1.2] *Training*

5.13. Is the demand response that is needed to deal with market power required only in specific locations, or is it spread across the state? [4.2.3] *Training*

6. Load Forecasting

Can load be modeled accurately?

6.1. If the LMP program were optional for the customer, that is, the customer could elect to use a fixed rate or to use the LMP system, could we predict reliably how many customers would participate and what the effect would be? [3.3.12] *Special Projects Engineering*

6.2. Is it true that the generators will become interested at much lower prices than loads? Does it matter? Is there sufficient benefit from mitigating price spikes if load typically responds at higher prices than generation? [4.3.4] *Special Projects Engineering*

6.3. What demand response is potentially available? Characterize it by load type and response type. [4.3.5] *Compliance Audits*

6.4 Can weather forecasts be integrated into load forecasts in smaller locations, i.e. in urban centers, to provide a more detailed and accurate forecast in densely loaded areas? [3.2.2.] *Special Projects Engineering, Training, Compliance Audits*

7. Institutional Challenges Regarding Locational Marginal Price

There are a number of demand response programs that have come and gone. The institutional climate is presently not hospitable to new programs.

7.1. The CAISO perception is that the regulators will not allow loads to be exposed to LMPs. Is this perception correct? What is needed to assess the costs and benefits so that

regulators can assess the wisdom of allowing loads to be exposed to LMPs for response. How can regulators be convinced that a new LMP-based demand response system is going to significantly reduce prices overall? What method or vehicle could be used to demonstrate the value of the program to public regulatory bodies and to customers?

[3.3.10] *Operations Engineering* What sort of research program is needed to clarify the issues for regulators, customers, and the CAISO? [3.3.2] *Compliance Audits*

7.2. If there is an automatic demand response system based on the LMP, it must be transparent to the CAISO; the CAISO cannot be involved in the daily operation of the system—it must be totally automated. [3.2.6] *Compliance Audits*

7.3. How would the needed infrastructure development be paid for? There is presently \$35 million of existing interval metering that is not being used. How could this resource be used better? What types of possible Type One and Two response could it support? Where would that response be located? What types of loads is it connected to? [3.2.4] *Special Projects Engineering* [3.3.9] *Compliance Audits* [4.3.12] *Compliance Audits*

7.4. Would an LMP system for demand response be sufficient to solve the problem of market power during times of stress? [4.1.2] *Training*

7.5. How are other load LMP programs working, such as ERCOTs? Case studies would be helpful. [4.3.8.] *Special Projects Engineering*

7.6. Any LMP-based demand response system must be self-funded; the CAISO has no funds to pay for these services. [3.2.7] *Billings and Settlements, Compliance Audits*

7.7. How can the location and time value be quantified, both in a set of algorithms and as a method or vehicle that conveys the value clearly to regulators? Being able to drop loads in a particular location during times of stress or congestion would give the CAISO a powerful level of diversity. If this powerful tool could be fairly valued, the pricing would encourage load to participate. [3.3.3] *Special Projects Engineering, Operations Engineering*

7.8. Would the proposed LMP system, modified to include load, be sufficient to address market power? [4.1.2] *Training*

8. Customer Issues

The price, information, and program must be something the customer will respond to.

8.1. Customer response is now minimal. The load aggregation program with 5-minute market-price data has done nothing. We need a standard, fixed, limited set of programs that the customers understand and trust. [4.1.4] *Compliance Audits, Operations Engineering*

8.2. What will motivate the customer? Can this be modeled statistically with an adequate level of confidence? [4.3.1] *Compliance Audits, Training*

8.3. What motivates a customer to sign up and actively participate? Should we focus on specific customers that have major loads, such as water pumping, sewage treatment, waste disposal, etc. [4.3.7] *Special Projects Engineering, Training*

9. Program Ease of Use

The CAISO has neither the resources or the staff to implement new programs. [1.1.1] *Training, Compliance Audits, Operations Engineering*

9.1 The CAISO operations staff is heavily loaded at this time and cannot add more programs that increase the work burden. [1.2.1] *Training, Compliance Audits, Operations Engineering*

9.2 Any new program must not create new workload; it must be fully automated. What automation features are needed so that no new workload is created? [1.1.1, 1.2.1] *Training, Compliance Audits, Operations Engineering* [1.2.3] *Operations Engineering, Billings and Settlements*

9.3 If there is a demand response system based on LMP, it must be transparent to the ISO; the CAISO cannot be involved in the daily operation of the system—it must be totally automated. [3.2.6] *Compliance Audits*

Appendix D. CAISO STAFF INTERVIEWS

The Operations Engineering Perspective

Program Ease of Use (Workload) Issues

- The demand response must be invisible (automatic) no more employees, no more work load. **Absolutely, they cannot spare more resources to manage another program.**
- The demand response should be just like another generator coming on line. **Yes, the demand response should be just like adding the next 100 MW in generation from the bid stack. It must be simple, certain, observable, and controllable.**
- The new system must be automated, it's okay to modify software, but do not add more workload. **It is okay to have it automated, but the load drop must be visible. They must be able to observe it, just like a generator. They have an MW meter on all the generators, and they can see the MW ramp up when they are dispatched. If an aggregator has 1000 air-conditioning units controlled by radio, a signal from the aggregator saying that the 1000 air-conditioning units had been telemetered to turn off would be okay. But they must have some sort of feedback that the response has been made.**
- How is demand response accommodated currently in existing "systems"? What is cumbersome currently about incorporating load into them? **Today, interruptible load is handled by the participating transmission owner (PGE, SDGE, etc.) The systems have always been vague, and a mixture of market-based systems, systems for reliability services, and voluntary load shedding in emergencies (state office buildings.)**

Avoiding Emergency Situations Rather than an Emergency Response Tool

- Could short-term load forecasting be improved? **Yes, they still get surprised. Some loads want a one-day notice before they are asked to interrupt. The ISO can't always do this because the day-ahead forecast was not good enough, or there was a storm, or a unit down.**
- What can be the confidence level the ISO has in the load? That is, the uninstructed deviation penalty. **The confidence level is not tight enough. There is little real time control. Also, if they have planned an interrupt in the day-ahead market, they can't stop it in real time if they don't need it. They have to go ahead and take it and pay for it.**

- How is load currently treated in short-term load forecasting? What might be an approach or method for better incorporating demand response into these forecasts? **The ISO markets group is developing a new tool for load forecasts. Some issues are with the real-time data—they are often spurious. If they lose telemetry to a generator, this messes up the short term forecast. They really need more redundancy, fiber optic backups, in communication. The new communication systems are not as reliable, and when you lose a line, you lose a lot of information.**
- How would the ISO document/measure increased confidence in demand response? **Now, when they contract for generators to supply supplemental energy, non spin, etc., they are documented. They do exercises to show that they work. The demand response programs are not always dependable. In the summer of 2000, when they were called on the first time, most of them responded. When they were called on the 30th time, a lot of them felt they were losing too much money and did not respond.**

Location and Time Issues

- The ISO is more prone to use large, specific responsive loads rather than distributed loads. Modeling and control are easier with fewer, larger loads. **Distributed demand response does work, but where is it? Dropping load in Fresno does not help the San Francisco peninsula.**
- How can locational issues be fed into demand response? In downtown San Francisco, dropping any load would make things better. The San Francisco price is averaged with the Northern part of the state; is there any research on developing locational prices? **The California Power Authority was trying to implement a locational load program. They were trying to find loads in a specific area. There was a data telemetry problem, and there is load price sensitivity. If 1000 customers respond, then the LMP drops. If customers could be sensitive to time also, it could help.**
- Should we explore methods for better conveying information on the locational/temporal value of demand response to IOUs? What might be some examples we could explore? **Yes, but the IOUs can't do anything with the locational or temporal value of demand response unless they have approval from the regulators. They are subject to the regulatory process. The regulators must also be convinced that this is the way to go.**
- Is there a way the ISO could provide a dollar benefit for demand response considering the time of day? For example, the Fresno pumping problems sometimes occur in the middle of the night. **Yes, but again, with a concept such as this, there is a regulatory problem.**

- Locational pricing or other mechanisms may provide more of a dollar benefit and may encourage load to bid in. **Load could provide a substantial benefit, and substantial payments could encourage participation, but this is the original political problem. The people in San Francisco are accustomed to having their rates “peanut buttered” with the rest of Northern California, and a very extensive education program would be needed to convince the regulators that this should change.**

Pricing Mechanism and Market

- Could we be more relaxed on the standards and still provide the reliability? Why is it difficult to sell the programs? **We need a fixed, standardized, limited set of programs that people understand and trust. The ISO had the demand relief program. Then the California Public Utility Commission said that the utilities should do it, and there is a lot of confusion. People won't buy in when they are confused.**
- Demand response could be important for dealing with market power. What makes load different than generators to help this transformation of perspective? **Demand response must look like generator response. Load needs to see the price to be responsive. We must send the correct signal.**
- The information (or mechanism) the customer is seeing must be something that they will respond to. **It must be simple and consistent, and the dollar value must be there.**
- What is working and not working in the PLP program? **The only loads are individual large loads like the large California Department of Water Resources and Pacific Gas and Electric pumps. Aggregations of air-conditioning have not happened. This apparently costs too much. If the customers could get a free DSL line with their power, and could have a consistent program, maybe this would change. With MD-02, LMP will happen. Will loads have access to the LMP in the zones? This is a regulatory question. The regulators have to be educated before the customers will start getting LMP signals.**

The Compliance Audits Perspective

Program Ease of Use (Workload) Issues

- The demand response must be invisible (automatic) no more employees, no more work load. **Agree; they can't support additional program management.**
- The demand response should be just like another generator coming on line. **There should be two levels. One level that is totally transparent to the ISO—it**

would be done in the markets, the load decreases in response to market signals, the ISO is not directly involved. Second level—the same look and feel as generation.

- The new system must be automated, it's okay to modify software, but do not add more workload. **Yes**
- How is demand response accommodated currently in existing “systems”? What is cumbersome currently about incorporating load into them? **The large loads do participate. It's seamless to control operations of participating large loads; it is easy to schedule and dispatch them. Aggregations of load do bring in complications and the locational issue. Where is the aggregation? They hope to keep aggregations in demand zones. In the long term, with LMP, how will they aggregate the price from multiple nodes if they are in one aggregation?**

Avoiding Emergency Situations Rather than an Emergency Response Tool

- Could short-term load forecasting be improved? **Yes**
- What can be the confidence level the ISO has in the load? That is the uninstructed deviation penalty. **The large loads that are dispatched have done well. When new ones are added, they don't know yet how they will do, but they do have to go through the ancillary services (A/S) testing.**
- How is load currently treated in short-term load forecasting? What might be an approach or method for better incorporating demand response into these forecasts? **We need to separate two issues. The A/S, market service issue from the emergency response issue. The response for market services has been predictable. Emergency response has performed well, but getting a large number of loads has been difficult. During 2000 and 2001, with utilities not paying the settlement fee, loads did not want to curtail. They were not getting paid. No one wants to provide a service they are not getting paid for.**
- How would the ISO document/measure increased confidence in demand response? **Increased response in the A/S program might be available if the telemetry requirement were relaxed.**

Location and Time Issues

- The ISO is more prone to use large, specific responsive loads rather than distributed loads. Modeling and control are easier with fewer, larger loads. **The large loads are the ones that are available right now. They are working with the CPA on their program to increase aggregated loads. The real issue in a market program is the funding. The customer must be paid appropriately for his response. The payment funds must be available. The ISO does not have them.**

- How can locational issues be fed into demand response? In downtown San Francisco, dropping any load would make things better. The San Francisco price is averaged with the Northern part of the state, is there any research on developing locational prices? **LMP will be a part of market redesign. Also, the retail tariff must be changed to reflect the LMP to the customer.**
- Should we explore methods for better conveying information on the locational/temporal value of demand response to IOUs? What might be some examples we could explore? **This is really an IOU issue. You could include it in a tariff. The CPA has a demand bidding program. Loads can offer curtailment in advance. To the ISO, it must be transparent.**
- Is there a way the ISO could provide a dollar benefit for demand response considering the time of day? For example, the Fresno pumping problems sometimes occur in the middle of the night. **This is the same issue, really. The IOU or the load-serving entity or the energy management company could provide a payment for the demand response. It should be transparent to the ISO.**
- Locational pricing or other mechanisms may provide more of a dollar benefit and may encourage load to bid in. **Locational pricing may well provide an additional dollar benefit, but this has to be an automated market/reliability system. The ISO should not be involved.**

Pricing Mechanism and Market

- Could we be more relaxed on the standards and still provide the reliability? Why is it difficult to sell the programs? **It depends on the market. In the day-ahead market, there is no need to change anything at the ISO. In the emergency market, there is no telemetry, they validate performance after the fact with meter data. This has been easy for the customer.**
- The information (or mechanism) the customer is seeing must be something that they will respond to. **The revenue has to be worthwhile to the customer.**
- What is working and not working in the PLP program? **The participating load program is working well now. The problem is that they don't have enough load participating. Smaller loads just are not involved much.**

Additional Issues

- The key issue to increase load participation is to focus on industries that could provide the greatest impact. Use the 80/20 rule. For example, municipalities and cities have sewage treatment and pumping systems and water pumping systems, recycling plants, etc. This could be load that is flexible in operation. Some city activities—refuse separation for example—could be done at night.

- Telemetry is an issue for load aggregations. Could telemetry requirements be relaxed? How much could they relax them? Could they be less stringent than generation? This may be a viable thing to do.

The Training Perspective

Program Ease of Use (Workload) Issues

- The demand response must be invisible (automatic) no more employees, no more work load. **The load must be like a generation bid in the merit order stack. If the operator needs a load reduction, he just goes to the next bid.**
- The demand response should be just like another generator coming on line. **Yes.**
- The new system must be automated, it's okay to modify software, but do not add more workload. **Yes, it is okay to add a lot more automation. Retraining should not be much of a problem if it looks and acts like generation.**
- How is demand response accommodated currently in existing "systems"? What is cumbersome currently about incorporating load into them? **There was a demand response program a couple years ago; it was about 75 MW. This was a blip on the screen of a 40-GW system. Now, they don't have any demand response to speak of. They do it manually to mitigate a reserve inadequacy or transmission congestion.**

Avoiding Emergency Situations Rather than an Emergency Response Tool

- Could short-term load forecasting be improved? **It is fairly rare to have a mistake in the short-term, day-ahead forecast. They do have bad days though, because of contingencies or just because it is so hot. If you had 1000 MW of responsive load at some price, on bad day, it would be a huge advantage.**
- What can be the confidence level the ISO has in the load? That is, the uninstructed deviation penalty. **Right now, they don't even know if they get a response. You probably could not see 75 MW being dropped if it were distributed around the state.**
- How is load currently treated in short-term load forecasting? What might be an approach or method for better incorporating demand response into these forecasts? **Now, demand response is not even considered in forecasting. It is sometimes if they are actively campaigning for load conservation. It is considered in large pumping loads. These are highly reliable.**

- How would the ISO document/measure increased confidence in demand response? **If they had demand response, and dispatched it, you would be able to see that it did respond in the monthly settlements.**

Location and Time Issues

- The ISO is more prone to use large, specific responsive loads rather than distributed loads. Modeling and control are easier with fewer, larger loads. **Unless you are mitigating transmission congestion, you are just going to go down the merit order stack.**
- How can locational issues be fed into demand response? In downtown San Francisco, dropping any load would make things better. The San Francisco price is averaged with the Northern part of the state, is there any research on developing locational prices? **You can see the impact on the line flows into San Francisco; when they drop load there, it is a critical situation. They are developing an LMP system.**
- Should we explore methods for better conveying information on the locational/temporal value of demand response to IOUs? What might be some examples we could explore? **Yes, there is a definite location and time value for demand response that could motivate customers. This would give the ISO more diversity. Maybe people would curtail air-conditioning for a price if it were easy.**
- Is there a way the ISO could provide a dollar benefit for demand response considering the time of day? For example, the Fresno pumping problems sometimes occur in the middle of the night. **At the Helms pumping hydro plant, which is a 900-MW plant, they pump up the reservoir at night. Sometimes the base load at night is so high that they can't turn on the third pump to pump up the reservoir, and they are going to need a full reservoir the next day to help with the peak. If there were a way they could send a price signal to decrease the off-peak load when this situation was occurring, it would allow them to start the pump.**
- Locational pricing or other mechanisms may provide more of a dollar benefit and may encourage load to bid in. **Load needs something simple and no more work load for them, either. If there were an Internet method where they could just put in a price that would do it for them, that would be the way to go.**

Pricing Mechanism and Market

- Could we be more relaxed on the standards and still provide the reliability? Why is it difficult to sell the programs? **All he needs is the difference in load before and after the dispatch. He wants to see the response, but he does not care about standards.**
- Demand response could be important for dealing with market power. What makes load different than generators to help this transformation of perspective? **They are looking at times and areas where people are using market power. MD02 is addressing these. If load could get in the game in a meaningful way, the generators would see that the ISO has another way of dealing with problems, and the generators would not be as likely to take a risk in trying to create problems.**
- The information (or mechanism) the customer is seeing must be something that they will respond to. **The customer wants to get a dollar amount that is worth it to him. He needs to see a price in real time. He might want to go the Internet in the morning and plug in a price that would do it for him that day depending on what he is doing that day. We should have had that five years ago.**
- What is working and not working in the PLP program? **Not much participation, they did not actually dispatch loads very much. There was not enough load. You have to use it to see how it actually works. They wanted to get 300 MW; they did not get anywhere near that.**

Other Issues to Bring Up?

The California State Assembly has passed a bill saying that California is to have 20% of its generation capacity from renewables in 15 years. Hydro is not a renewable. It is going to have to be solar and wind. It will be difficult to get 20%. Demand response may be something that would help. It may not qualify as a renewable, but it might be something that could be applied toward the goal.

The Billings and Settlements Perspective (some questions were skipped because of lack of time)

Program Ease of Use (Workload) Issues

- The demand response must be invisible (automatic) no more employees, no more work load. **Our preference is that programs do treat load just like generation, and that we don't have to create a separate set of methods to deal with load.**
- The demand response should be just like another generator coming on line. **This is a key issue. Load and generation are not created equally. The challenge is**

to get load to look more like generation. We can relax the telemetry to get them in, but they should look just like generation in the market system.

- The new system must be automated; it's okay to modify software, but do not add more workload. **Correct, like extra notifications and so forth.**
- How is demand response accommodated currently in existing "systems"? What is cumbersome currently about incorporating load into them? **They used to have subsidized programs; they are moving away from that now. They are going in the opposite direction as the programs in New England.**

Avoiding Emergency Situations Rather than an Emergency Response Tool

- Could short-term load forecasting be improved? **The biggest swings they ever saw in demand response were from either calls for conservation or the economy tanking. As far as the load forecast goes, it is generally pretty good.**
- What can be the confidence level the ISO has in the load? That is, the uninstructed deviation penalty. **The interruptible programs were hard to predict—customers had signed up to get cheaper rates, and then got tired of all the interruptions. It got to the point where operations would just look at what happened last time to predict what the interruption response would be.**
- How is load currently treated in short-term load forecasting? What might be an approach or method for better incorporating demand response into these forecasts?
- How would the ISO document/measure increased confidence in demand response?

Location and Time Issues

- The ISO is more prone to use large, specific responsive loads rather than distributed loads. Modeling and control are easier with fewer, larger loads.
- How can locational issues be fed into demand response? In downtown San Francisco, dropping any load would make things better. The San Francisco price is averaged with the Northern part of the state; is there any research on developing locational prices? **This is a highly volatile and political topic. They will have locational prices for resources. They will have high level aggregations of load. There will be four load zones across the whole state. Some companies will get a negative impact from LMP and don't like it. In New England, on March 1, they instituted load zones by states, except that Massachusetts was divided into three regions. Boston is fighting this in the legislature because they say they are going to get hurt economically. The California state legislature has**

asked them to slow down and study the situation. This is a difficult thing to do politically.

- Should we explore methods for better conveying information on the locational/temporal value of demand response to IOUs? What might be some examples we could explore? **Information regarding LMP is important for IOUs and the Public Utility Commission to have as they look at ways to reduce rates as a whole. What does peanut buttering the San Francisco loads cost the rest of the state? Some people do not want the information visible because then they may have to pay it (in San Francisco).**
- Is there a way the ISO could provide a dollar benefit for demand response considering the time of day? For example, the Fresno pumping problems sometimes occur in the middle of the night. **The market has to provide the signal. It is going to be a better signal with a nodal system.**
- Locational pricing or other mechanisms may provide more of a dollar benefit and may encourage load to bid in

Pricing Mechanism and Market

- Could we be more relaxed on the standards and still provide the reliability? Why is it difficult to sell the programs? **Their operators must have confidence in the program. Their demand relief program provided payments, but customers paid a penalty for not responding. It was a discretionary program, but they would get responses back for the next day. The operators would know. Today, with generators, they get data every 4 seconds. Do they need the same from load? With an aggregation of 10,000 customers, where they have some statistical experience, 1 minute is probably okay. The feedback depends on the control. If you have air-conditioning control, you know, you shut it off. In an emergency mode, they need to know what is going on. If a market-based system is working, telemetry is a lesser issue.**
- Demand response could be important for dealing with market power. What makes load different than generators to help this transformation of perspective?
- The information (or mechanism) the customer is seeing must be something that they will respond to.
- What is working and not working in the PLP program?

Additional Thoughts

- Reliability
They really need more demand response. Also, as a particular program operated by a muni or IOU gets sizeable, when it gets to be 500 MW, they need to know if

it is going to cut tomorrow. The operators need to know so they can plan accordingly.

- Market Operation
Programs must operate **within** their market if they are going to be involved in settlements.

Miscellaneous

- Some regulators say real-time pricing (RTP) is a subsidy for big, sophisticated users. Others say it is great; the customer makes the decision.
- Do not forget a simpler approach for the average customer:
 - Time-of-day rates worked well. It was easy—between noon and 6 p.m., power was 4 times higher, turn off the pool pump and postpone the washer, dryer and dishes.
 - The 20/20 program was criticized, but people understood it, and many used it. If you could reduce your demand by 20%, you saved 20% plus the state chipped in an additional 20%.

Another big issue is: How do you make load look like a generator? How do you value demand response? The industry has not faced this question.

The Special Projects Engineering Perspective

Program Ease of Use (Workload) Issues

- The demand response must be invisible (automatic) no more employees, no more work load. **This is the ideal, but it may not be achievable. They have to do certification with each generator, they will have to do it with load also.**
- The demand response should be just like another generator coming on line. **There are differences that must be considered; load does not ramp—it is on-off. How do you get it back on line?**
- The new system must be automated, it's okay to modify software, but do not add more workload. **The issue is the visibility of what the load is doing? Also, certifying the aggregator.**
- How is demand response accommodated currently in existing “systems”? What is cumbersome currently about incorporating load into them? **Metering for real-time pricing—the metering was installed but is not being used. California Public Utility Commission did not agree that the customer needs to see the RTP. This is simply a policy issue.**

Avoiding Emergency Situations Rather than an Emergency Response Tool

- Could short-term load forecasting be improved? **Yes, there is room for improvement. When the fog bank comes in over San Francisco, the load goes up depending on how far the fog comes in. If it's sunny, you don't need the heat. The fog makes the peak load go up. They need better weather forecasting.**
- What can be the confidence level the ISO has in the load? That is the uninstructed deviation penalty. **The confidence level is not where they want it. The error rate is less than 2%, but it needs to be better. The weather data come in mostly from airports.**
- How is load currently treated in short-term load forecasting? What might be an approach or method for better incorporating demand response into these forecasts? **Typically, they do a similar day analysis, modified for special events such as holidays and temperature, etc. Demand response is so small that they are not concerned with it except for pumping system loads.**
- How would the ISO document/measure increased confidence in demand response?

Location and Time Issues

- The ISO is more prone to use large, specific responsive loads rather than distributed loads. Modeling and control are easier with fewer, larger loads. **With larger specific loads, such as pumps, you can schedule them.**
- How can locational issues be fed into demand response? In downtown San Francisco, dropping any load would make things better. The San Francisco price is averaged with the Northern part of the state; is there any research on developing locational prices? **They hope to have LMP in the distant future, maybe in a year. Their state estimator program is working well, and the goal is to create pricing for 3900 nodes. They will cluster the prices in areas of common price. The problem is that they don't have enough monitors to see what load is actually responding.**
- Should we explore methods for better conveying information on the locational/temporal value of demand response to IOUs? What might be some examples we could explore? **Southern California Edison (SCE) is claiming success with a satellite communication to a bunch of loads. They see a macro response. To get return on investment, loads must be a certain size. The substation could see a change in load on a feeder. They could see a change during a test of all state facility loads in response to a command.**

- Is there a way the ISO could provide a dollar benefit for demand response considering the time of day? For example, the Fresno pumping problems sometimes occur in the middle of the night. **They could use better methods for modeling and simulating the market. You could then see what the value is in demand response. The model is producing surprisingly good results.**
- Locational pricing or other mechanisms may provide more of a dollar benefit and may encourage load to bid in **Yes, particularly in areas where the price is quite high. Also, if it is not too late for the load to respond. This may not ever work for residential load.**

Pricing Mechanisms and Market

- Could we be more relaxed on the standards and still provide the reliability? Why is it difficult to sell the programs? **This has been debated. The aggregators must be certified. Show me a few times until we have trust in the model. If I see the response 14 times, then I will build up some confidence. In the market, the generators don't need a lot of price change to get interested. At a price of \$30 to \$40, the generators are interested, but load is not. At \$300 to \$400, load is interested, but these only happen a few times a year.**
- Demand response could be important for dealing with market power. What makes load different than generators to help this transformation of perspective? **A small amount of load can have a huge impact. A small amount of load can really shave the peak, and then you don't have to build the generation and transmission for the peak, but you still have to have excess capacity for maintenance periods.**
- The information (or mechanism) the customer is seeing must be something that they will respond to. **Yes, this is understandable, there must be value both ways.**
- What is working and not working in the PLP program?

The barriers are not technical. Loads above 100 kW had to have the RTP meter put in to be in the program, but the meters are not being used. It is a political issue. They need a major education program. The public is not dumb. The pricing at the customer level does not have to be that complex. Some credible models should be built—with and without demand response. ERCOT data on their systems may be coming out soon. These would be actual case studies and could be used to build credibility.

Link the RTP program with other causes: drilling for oil in the Arctic wildlife refuge, air quality, economic climate, etc.

People do respond. During the energy crisis, 7 GW of load was turned off on their 40-GW system. People will buy more efficient equipment, operate more efficiently, and turn things off.