Innovative Developments in Load as a Reliability Resource

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Abstract-- **This paper reports on work the Consortium for Electric Reliability Technology Solutions (CERTS) has been pursuing to hasten the arrival of meaningful load participation in competitive electricity markets. The activities include: experimental economic analysis of the effect of price responsive load in reducing market prices and price volatility; assessments of emerging demand response programs and technologies for enabling customer participation in electricity markets, and demonstrations of load in providing ancillary services (notably, spinning reserve).**

***Index Terms*—Load Control, Deregulation, Ancillary Services.**

I. Introduction

There is growing recognition of the value of load control in increasing reliability, promoting market efficiency, and curbing market power. Securing these benefits, however, requires that customers have meaningful opportunities, incentives, and technologies in order to participate actively competitive electricity markets. Today, these characteristics of well-functioning markets are not widespread.

The Consortium for Electric Reliability Technology Solutions (CERTS) is engaged in a multi-year program of research to accelerate meaning customer participation in competitive electricity markets [1]. Currently, CERTS is pursuing research in the following three areas: a) better understanding of the effect of customer participation (or demand response) in improving the reliability and operation of markets; b) assessments of current programmatic efforts to elicit demand response toward improving their performance; and c) demonstrations of innovative load control applications (e.g., to provide ancillary services). This paper presents a summary of these activities.

II. The Effect of Demand Response on Competitive Market Performance

A key policy issue that must be addressed in promoting increased demand response in competitive markets is: *How much demand response is needed?* Toward this end, CERTS is using experimental economics techniques to test the performance of markets and to begin assessing the effects of demand response on market performance. Analysis to date has shown that price responsive load in a uniform price auction (in which all suppliers receive the same market clearing price) is an effective way to lower both the average price and volatility.

The analysis of the effect of demand response is part of larger inquiry in the performance of alternative market clearing price rules [2]. Specifically, we have demonstrated the poor performance of both a discriminative auction (suppliers are paid their actual offers for each unit of capacity sold) and a soft-cap auction (similar to the auction implemented in California by FERC). In a uniform price auction, most capacity is offered into the auction at relatively low prices, and high offers are submitted on a few marginal units (this results in a supply curve shaped like a hockey stick). Occasionally, a price spike is set by one of the marginal units due to the uncertainty of load. In a discriminative or soft-cap auction, suppliers soon learn to offer in all capacity at roughly the expected market price (why get paid $50/MWh if someone else is selling at $100/MWh?). The supply curve is almost flat (very price elastic), and all capacity is offered into the market at relatively high prices. This makes the average price in a discriminative auction or a soft-cap auction much more insensitive to reductions of load than a uniform price auction. These results were replicated in independent experiments conducted at the University of Illinois, and by staff of the New York Public Service Commission.

We have also modeled the actual behavior of suppliers in the PJM market to show that small reductions of load lead to large reductions of average price by reducing the number of price spikes [3]. (The model predicts the amount of capacity, and the associated prices, submitted into the next day's auction by each supplier using the current market price and a forecast of the next day's load.) The reason is that the aggregate offer curve submitted into a uniform price auction by suppliers has the familiar shape of a hockey stick. The supply curve is very price inelastic at high prices, and therefore, high prices are sensitive to load reductions.

We are currently conducting a new series of experiments to test the effectiveness of price responsive load in a soft-cap auction as well as a uniform price. Participants will be recruited from the electric utility industry for these new experiments. In addition, new research on forward markets has shown how customers can hedge against the financial consequences of high prices and still have an incentive to respond to market signals by reducing load when load and price are both high.

III. MarketAssessment/Evaluation of Demand Response Programs

The work described in this paper was coordinated by the Consortium for Electric Reliability Technology Solutions on behalf of the U.S. Department of Energy's Transmission Reliability program. The work was funded by the Assistant Secretary of Energy Efficiency and Renewable Energy, Office of Power Technologies of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

A second set of policy issues that must be addressed in promoting demand response in competitive markets is: *What has been the performance of markets in eliciting demand response? Is this response sufficient to improve the performance of markets? If not, what else is needed?* CERTS is addressing these issues through partnership with key stakeholders in the two states (e.g., grid operator, state energy agencies, and program administrators). Specifically, CERTS is conducting market assessments of selected DR programs and projects targeted to medium and large commercial/industrial customers. Our objective is to evaluate key enabling technologies; identify "best practices" among program administrators, contractors/aggregators, and end users; and analyze the technical, market and institutional barriers that affect how widespread participation by large customer loads is likely to be in key regional electricity markets.

Restructuring of U.S. electricity markets has created new opportunities for load serving entities (LSEs), either utilities or retail suppliers, to partner with retail customers in curtailing or altering their demand in response to either electric system reliability needs or high prices in bulk power markets. Although the benefits of allowing customers to manage their loads in response to system conditions or economic prices are potentially large, there are numerous challenges to creating workable and widespread price and demand responsive markets.

Utilities have operated load management programs in a completely regulated environment for many years [4]. With restructuring, load management (now called demand response or DR) programs are increasingly designed and administered by different entities (i.e., Independent System Operators), involve new market participants (e.g., retail suppliers, aggregators, or curtailment service providers), and are triggered by economic considerations as well as electric system conditions. Moreover, success in enabling customer participation in day-ahead markets for power hinges on both technical and market/institutional requirements.

Among the technical requirements are:
- Widespread deployment of interval meters with two-way communications capability;
- Multiple, user-friendly communication pathways to notify customers of load curtailment events;
- Energy information tools that enable near-real-time access to interval load data; development of demand reduction strategies optimized to meet differing high-price or generation emergency scenarios; and
- Building energy management control systems that facilitate automation of load curtailment strategies at the end use level.

Two states – New York and California – have been conspicuous leaders in the demonstration of demand response programs utilizing innovative enabling technologies and including an array of programs with both emergency and economic objectives. These diverse demand response programs offer a unique opportunity to study the effect of key technical and market/institutional variables, such as:
- Market segmentation and recruiting strategies;

Alternative pricing schemes and program designs on market response;
- The value of participant access to interval load data;
- Measurement, verification, and settlement approaches; and
- The role of back-up generation and aggregators.

California Energy Commission Demand Responsive Buildings Program (DRBP)

The California Energy Commission (CEC) is working with Nexant, Xenergy, and CERTS in an evaluation and market assessment effort addressing all aspects of the DRBP. The CERTS effort focuses on analyzing the relationship between the contractor's offer, which includes both price and non-price features such as enabling technologies, in inducing customer participation and effective demand reducing performance. CERTS is analyzing metered electricity consumption data in response to demand curtailment requests and will combine this information with market research data taken from in-depth phone interviews conducted with 70 facility operators and building occupants of selected CEC DRBP Contractors.

NYISO/NYSERDA "Enabling Technologies for Price-Sensitive Load Management" Grant Program

The New York ISO, in conjunction with the NY Public Service Commission, NYSERDA, and regulated and unregulated load serving entities and retail service providers, has implemented two large state-wide demand response programs – the Emergency Demand Reduction Program (EDRP) and the Day-Ahead Demand Reduction Program (DADRP). In partnership with these parties and an evaluation contractor (Neenan Associates), CERTS is conducting evaluations of how enabling technology affects customer demand reduction performance. CERTS is conducting interviews with ~30 facility operators that are participating in demonstration projects offered by several LSEs and CSPs (Curtailment Service Providers) with special funding from NYSERDA. Market research data will be analyzed in conjunction with facility load data, which includes four curtailment events in August 2001. CERTS is utilizing both qualititative and quantititive methods in an effort to identify relationships between customer's actual demand reductions in 2001, their estimated demand reduction technical potential, enabling technologies utilized by the customer, and customer's business/institutional issues, concerns, and attitudes.

CERTS will use the analysis and results from both the California and New York programs to prepare a technical report for state and federal policymakers and DR program administrators as well as DR market participants. The report will contribute to CERTS long-term research objectives by identifying major technical/market/institutional barriers that inhibit widespread participation by different types of commercial/industrial customers in emergency and economic demand response programs, identify additional R&D activities that could accelerate development of enabling technologies, and identify key issues that policymakers need to address in order to facilitate the long-run sustainability of providers of demand response services and technologies.

IV. DEMONSTRATION OF LOAD PROVIDING SPINNING RESERVE

A third set of policy issues that must be addressed promoting demand response in competitive electricity markets is: *What is the technical potential for load participation in competitive electricity markets? What are the institutional barriers to realization of this potential and how can they be overcome?* Toward this end, CERTS is working with industry partners to demonstrate the potential for provision of spinning reserve by reducing loads quickly instead of by supplying generation. Spinning reserve is a type of reserve generation that is held in reserve to ensure the reliability of the grid in the event of a contingency such as a loss of a transmission line or a generating station. Typically, lost generation is supplied quickly, in a few seconds, by other generation to make up for the loss.

Large municipal water pumping systems usually utilize tanks, reservoirs, lakes, etc. to store water as it is distributed along the system. These water storage devices also have a natural short-term energy storage capacity. To provide spinning reserve, the pumping rate only has to be slowed down for about two hours and even that is actually required fairly infrequently (perhaps two to three times per month). With the appropriate operations and controls changes that keep the reservoirs adequately filled, we believe that many water pumping systems could be used to provide spinning reserve. Some densely populated states, especially, have huge opportunities for this because of the tremendous size of some of the pumping stations. For example, individual pumping stations along the California aqueduct have pump loads sometimes exceeding 300,000 horsepower.

Spinning reserve has never been supplied by load before because a rule change is required. Present NERC and WSCC rules require spinning reserve to be supplied only from generation. CERTS is in discussions with NERC regarding this rule, and the time may be right for a rule revision. NERC has expressed interest in testing this concept, and has suggested to the authors that a waiver request be submitted. CERTS is presenting this concept and proposing the plan at several locations, including the California Department of Water Resources.

Greatly improved pumping system efficiency may be an important, additional benefit of controlling pumps to provide spinning reserve. That is, one method for implementing spinning reserve from load may be to install adjustable speed drives on the pumps. Centrifugal pumps typically have a discrete operating band where they perform at maximum efficiency. Outside of this band, efficiency falls dramatically. When pumps are throttled using a control valve, they operate inefficiently. When pump flow is reduced using an adjustable speed (variable frequency) drive, the pump operates at a slower speed and provides less flow, but operates efficiently.

Providing spinning reserve through load will provide several distinct benefits. First, the grid operator does not have to plan for the reserves to be supplied through a congested transmission line. Second, the impact on voltage regulation by reducing local load is much greater than by simply increasing power generation at a remote location. Third, there is a potential for a relatively large amount of reserve "generation." Fourth, pumping system efficiency and operational flexibility would be improved.

V. SUMMARY

CERTS is engaged in a multi-year program of research to accelerate meaning customer participation in competitive electricity markets. The program is focused initially on addressing the following key strategic issues: a) better understanding of the effect of customer participation (or demand response) in improving the reliability and operation of markets; b) assessments of current programmatic efforts to elicit demand response toward improving their performance; and c) demonstrations of innovative load control applications (e.g., to provide ancillary services).

VI. REFERENCES

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