White Paper

# The Technology, Business and Market Cases for Load Control

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## Executive Summary

Load control as defined by utilities is the ability to remotely switch consumer loads to meet business objectives. Utilities have long used load control technology, at least to some extent, to shed load to ensure grid reliability and defer capital investment. More recently, utilities have exercised load-control to limit their wholesale power costs. The expanding implementation of distributed energy resources in all utility segments (IOU, municipal, cooperative) has created new challenges in balancing the grid that are uniquely addressed by load control and make the case for load control more compelling.

In this paper, we will examine:

- Load control market drivers, including aging infrastructure, demand volatility, wholesale price volatility, renewable portfolio standards, energy-efficiency resource standards, and generation and transmission markets.
- Available technology for load control, comprising communications networks and load-control hardware and software.
- The business case for load control, which involves calculations based on the estimated load shed per enrolled appliance, the number of each type of participating appliance, the market value of the load shed, and the duration of the load shed.
- The market value of load control, which can vary based on the utility's energy supplier and the programs the utility has in place.

Since there are many different applications of load control, it important to select the technologies that will best meet your utility's intended applications both now and into the future.

## Market Drivers for Load Control

There are many key market drivers for load control. These drivers cause, are a result of, or help manage local capacity constraints. (For example, if the electric grid cannot economically deliver the energy and capacity to where it is needed). Capacity constraints result in reliability issues and the possible loss of power, or in economic issues where the cost of delivering the power skyrockets. These factors include:

1. **Aging Infrastructure.** The US electric grid has served us well, but growth in energy demand has increased faster than many grid components can be upgraded. This can be at the generation, transmission, or distribution level and tends to be localized in nature.

2. **Demand Volatility**. US consumers take electricity for granted. They are used to switching on their appliances when desired without regard to the impact to the operation or capacity of the electric grid. When tied with extreme hot or cold weather, peak demand may locally be many times the base load and approach or exceed the capacity of the electric system.

3. **Wholesale Price Volatility.** Tied to aging infrastructure and demand volatility, wholesale energy and demand prices follow the cost of procuring generation and delivering the energy over the transmission system. System operators utilize economic dispatch to reduce generation costs by activating the least expensive resources to produce energy first. When electric demand rises and falls so does the wholesale price. It has been shown that a few very high-priced periods drive over 30% of the average annual energy bill.

4. **Renewable Portfolio Standards.** These standards require specific levels of renewable generation added to a utility's generation mix. Driven by state legislation/regulation, investor owned utilities are required to comply, and cooperatives and municipalities, while not required, comply because they face consumer/member pressures to do so. Renewables constitute variable generation often operated at maximum capacity, and therefore have no inherent regulation capability. This variability occurs rapidly as cloud cover or winds occur, resulting in challenges to locally balancing the grid.

5. **Energy Efficiency Resource Standards**. These establish specific, long-term targets for energy savings that utilities must meet through energy efficiency programs. Some states, like Delaware, include a peak reduction to their goals. Like renewable portfolio standards, this is driven by state legislation/regulation. Investor owned utilities are required to comply and cooperatives and municipal utilities, while not required, do comply, facing consumer/member pressures.

6. **Generation and Transmission Markets**. A variety of market mechanisms are available for utilities to procure and supply energy and capacity. These mechanisms vary regionally and range from individual bi-lateral agreements to organized markets (regional transmission organizations and independent system operators) that trade energy products much like the stock exchange. There are also joint purchasing groups that allow groups of smaller utilities to have the buying power of much larger utilities. These joint purchasing groups include generation and transmission cooperatives (G&Ts) and joint action agencies (JAAs.) Each entity has a variety of energy and capacity products that allow a utility to both purchase and sell energy and capacity resources. In some cases, there are also regulation and ancillary services and other products that are marketed as well. Each entity prices the products based on the local prevailing conditions of generation and transmission.

This has given rise to locational marginal pricing (LMP) in many areas. The California Independent System Operator defines LMP as, "the marginal cost of supplying, at least cost, the next increment of electric demand at a specific location (node) on the electric power network, taking into account both supply (generation/import) bids and demand (load/export) offers and the physical aspects of the transmission system including transmission and other operational constraints."

Load control is treated much like generation in these organized markets and is traded at the LMP. Many of the G&Ts, and JAAs trade energy products within these organized markets but simplify the products to the member utilities by providing rates that include levelized active energy, capacity, and reactive energy or power factors charges. The G&Ts and JAAs have been recently evolving their rates to include a time-of-use component to reflect the real-time wholesale markets or bilateral contracts they operate within.

## Available Technology for Load Control

By definition, load control is under the prescriptive control of the utility or its member organization (whether G&T or JAA). Therefore, the available technologies are designed to be owned by the utility or its member organization but placed at or near the consumer device/appliance that is remotely controlled. Appliances commonly under control include domestic water heaters, heating, ventilation, air conditioning units, pool pumps, spas, irrigation pumps, grain dryers, and other switchable agricultural and consumer loads.

The distributed nature of these appliances requires communication networks to interface between the remote control and load control devices that interface between the communications network and the appliances under control. Networks historically have included one-way paging, one-way automated meter reading (AMR), two-way advanced metering infrastructure (AMI), and public cellular networks. Managing field devices, enrolling consumers, and creating and executing control strategies is accomplished by software that is either located on premise or is subscribed to as a Software as a Service.

### Communication Networks

Networks for load control today require two-way communication and are rapidly replacing legacy one-way systems. Two-way communication is required to measure the amount of load control and to verify its operation. This is extremely important as consumers are often reimbursed for their participation.

Likewise, utilities, G&Ts and JAAs must verify the amount of load shed to be reimbursed for their actions. Since load control is managing consumer devices and affecting the reliability of the electric system, reliability, availability, and low known latency are critical to achieving the desired load shed in the required time to be effective. For this reason, proprietary AMI networks are chosen by utilities over public cellular networks.

When it comes to performance, one also must consider the architecture of the AMI system to be sure the system can manage both meter reading and control without restricting the system's critical load control events. Architecture must guarantee that latency is both low and known, ensuring load shed commands are executed in a known repeatable way. This capability is required to participate in the majority of energy products to not incur penalties from failure to deliver. Lastly, the network must be secure and, depending on the number of devices and the size of the load under control, may fall under NERC CIP (National Reliability Corporation Critical Infrastructure Protection) standards.

### Load Control Hardware

Load control hardware contains the UL-listed interface between the communications network and the consumer appliance in a weatherproof enclosure suitable for both indoors and outdoors installation. Advanced hardware can measure load shed, can have intelligence to locally provide load shed optimization, and can provide autonomous operations if communications is severed, or other advanced functionality.

As part of the interface function of the load-control device, there are one or more relays (electrically operated switches) of appropriate rating to interrupt the circuit to the appliance. For water heaters, pool pumps, and spas this is normally a 30-amp, 240-volt relay that interrupts the actual line current and voltage. For heating ventilation and air conditioning units (HVAC) and large motor loads, this is normally a 5-amp, 120-volt relay that interrupts the low-voltage control circuit. Some utilities like to use one load control device and bring all control wiring to a single location, while others prefer to have a load control device at each appliance and minimize additional wiring.

Local load-shed optimization functions should include ramped pickup, duty cycle, short cycle time, cold load pickup, and an event log. Advanced local optimization can consist of a locally stored load profile that optimizes the load shed to the individual consumer load while maintaining consumer comfort. Another advanced feature for fast emergency response to reliability conditions is autonomous under voltage/under frequency load shed.

### Load Control Software

Load control participation is complex. There are significant rewards for implementing load control, but there are also penalties in some markets for non-performance. It is critical to have software that simplifies the participation in the available energy markets or takes advantage of opportunities within bi-lateral agreements.

Key elements of the software necessary for successful load control are the abilities to forecast the available power resource, track the progress of load control events, measure and verify the results for correct compensation of the utility by the markets as well as participating consumers by the utility.

Software that treats load control resources as virtual power plants allows the specific consumer-based constraints to be converted to attributes that can be bid into the markets or leveraged within bi-lateral contracts. The software should manage attributes including ramp rates, costs curves, and operational constraints to balance consumer comfort with budgetary rewards. The software must have the ability to manage a multitude of resources from residential spas to agricultural irrigation pumps and optimize the least-cost dispatch along with emergency shed for reliability of all these appliances. Advanced software will also orchestrate the inclusion of distribution automation, such as capacitor banks and voltage regulators, as resources in the mix.

## The Business Case for Load Control

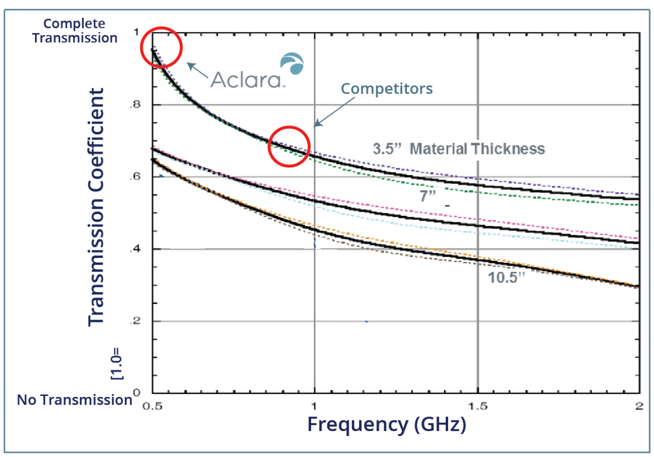
Load control has well-known, documented benefits. Two major areas of benefit should be evaluated in scoping a load control implementation. The two areas of benefit are reliability and economic savings. To estimate the value of the benefits is a straightforward calculation of the estimated load shed per enrolled appliance multiplied by the number of each type of participating appliance times the market value of the load shed. For energy, the duration of the load shed will also need to be factored in.

## Aclara Load Control

Aclara's AMI networks are purpose-built and designed to support both the present and future needs of electric utilities, including Load Control capabilities to support emergency load shed for reliability as well as economic dispatch and ancillary services. Our point-to-multipoint architecture and network design, with its low latency, redundancy, message prioritization and security, is ideal for applications that require reliable, near-real time grid visibility and control.

The characteristics of Aclara's licensed Synergize® RF solution that make it ideally suited for load control include:

### NISTIR 6055 Electromagnetic Signal Attenuation in Construction Materials




**RF Penetration**

- NIST report available about signal loss through building structures (NISTIR 6055)
- 450 MHz penetrates **foliage** and **standard construction materials** far more effectively than 900MHz
- Head-to-head comparison result in **measurable** performance **difference** in "hard-to-hear" locations.

**Low/deterministic latency:** Due to the point-to-point/multi-point communications structure, the Aclara network can provide fast, reliable, and predictable control for critical load control applications.

**Message priority:** Architecture is built to configure message priority by type of application – i.e. load control message can be set as a higher priority than a meter read AMI message.

**Licensed frequency:** Utility is granted the exclusive right to operate on a specific spectrum without any interference from competing devices, unlike unlicensed networks.

**Dedicated frequencies for load control applications:** Eliminates contention between applications and ensures that each parallel network (operating on the same infrastructure) is optimized for the application.

**Frequency:** 450-470 MHz operation provides further range, ability to bend around obstructions and to penetrate building materials.

For over 30 years, one large utility on the east coast of the U.S. has depended on Aclara load control to deliver fast, reliable load shed to maintain system reliability. The utility also uses the system for economic dispatch to ensure the most cost-effective procurement and delivery of electricity to its 4.9 million customers – an estimated 10 million people.

### Estimated Load Shed per Appliance

Each area of the country has a different mix of consumer appliances that can be selected for enrollment into a load control program. Both the load and run times of those appliances vary as well. As mentioned, typical appliances commonly under control include domestic water heaters, space HVAC units, pool pumps, spas, irrigation pumps, grain dryers, and other switchable agricultural and consumer loads.

As a starting point, an estimate should be made for the coincident peak shed for each class of appliance to be enrolled in your load shed programs. For residential air conditioning, 1.0 kW per premise and for domestic hot water heating 0.2 kW per premise are good starting points. Be sure to use the coincident peak value. For example, domestic hot water heaters with 3.5 kW elements provide 0.2 kW of coincident load shed due to the diversity of operation among a large population. Additional devices like pool pumps, spas, and electric space heating should also be estimated for your region. Be sure to include large motor loads such as agricultural irrigation pumps, which provide high value.

**Program Participation**

The value of the load shed varies by both location and the class of appliance to be controlled. Therefore, program participants should be highly targeted to provide the most value to both the utility and the participants. Areas with the most severe capacity constraints should be addressed first. Well-orchestrated load-control programs have participant enrollment of 25% or more of the total consumer population with one or more appliances under load control.

Driving participation on load-control programs requires a well-crafted marketing message and repeated delivery to the target audience to succeed. The message should clearly articulate both the societal and participant benefits. Consumer engagement software benefits utilities by helping to manage messaging to drive enrollment, to enroll participants, to keep them informed and engaged, and to provide an on-line portal for opt-in and opt-out transactions. Many utilities start load control efforts with a pilot program of 3-5% of their consumer population to tweak their marketing message, establish installation procedures, and adjust back-office processes.

## Market Value of Load Control

The market value of load control varies depending on the utility's energy supplier and the programs that are in place. The price of capacity and energy are the biggest factors, but other energy products such as regulation and ancillary services also come into play. For utilities with bilateral contracts or members of buying groups, this may be simplified to peak demand charges. The other big factor is capital deferment (putting off spending today to sometime in the future). Since peak periods only occur for a limited number of hours per year, load control can shave the peaks to allow those constrained assets to continue to be in service without costly upgrade. Typically, upgrading infrastructure is difficult to do as few communities welcome new substations or new wires in their backyards.

The long-term value of capacity ranges from $35 to $200 per kW per year or even more in some cases. The market mechanisms to monetize the capacity component of load shed differ based on how generation is obtained. For vertically integrated utilities, the market mechanism would be the avoided cost of generation, which can be part of the resource planning model. For open markets with capacity trading such as PJM Interconnection LLC, this value is published for current and future years on their websites. In energy-only markets such as the Electric Reliability Council of Texas (ERCOT), there are generally mechanisms to value emergency load reductions. For example, ERCOT has an emergency response service that pays for load reductions on 10- or 30-minute notice. For utilities with bi-lateral contracts or that are members of purchasing groups, capacity reduction would result in shaving the peak demand charges from the wholesale power bill.

Avoided energy charges are the wholesale kilowatt-hours not purchased during the load shed. These kilowatt-hours are generally the most expensive ones as they occur during critical peaks. As mentioned earlier, these high-priced peak periods often are responsible for over 30% of the wholesale energy bill. This value can range from $9 per kilowatt per year to more than $100 per kilowatt per year.

Regulation and ancillary services are set in each individual market or via bi-lateral contracts. Ancillary services are market offerings that assist the stability, reliability, and security of generation and transmission. These services include: reactive power-voltage regulations, system-protective services, loss-compensation services, system controls, load-dispatch services, and energy-imbalance services, and other localized products. The key attributes that set apart ancillary services from standard capacity and energy markets are reduction of notification time, increased response speed, and the accuracy of measurements. The value of these products ranges from less than $60 to more than $300 per kilowatt per year.

Deferred capital expense can be a sizable benefit of load control. Load control can be targeted to address localized capacity constraints on both the transmission and distribution levels. This in turn defers the need for capital projects to build or reinforce substations or circuits. The generally accepted value for deferred capital for transmission and distribution is $20 to $30 per kilowatt-hour per year, but can range to more than $75 per kilowatt-hour per year.

## Conclusion

Load control is a proven technology that can assist a utility to deliver reliable energy at the lowest cost. Though the business case varies depending on location, load control is a flexible resource that is proven to be economical across the U.S. as well as internationally. Since there are many different applications of load control, it is important to select the technologies that will meet your utility's intended applications both now and for years into the future.

## About Aclara

Aclara is a world-class supplier of smart infrastructure solutions (SIS) to more than 800 water, gas, and electric utilities globally. Aclara SIS offerings include smart meters and other field devices, advanced metering infrastructure and software and services that enable utilities to predict and respond to conditions, leverage their distribution networks effectively and engage with their customers. In 2016 Aclara won a Frost & Sullivan Global Smart Energy Networks Enabling Technology Leadership Award and was named a finalist in three categories of the Platts Global Energy Awards.

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