Demand Response and Load Management Strategies for Electric Forklifts and Non-Road EV Fleets

Richard Cromie
Program Manager
Southern California Edison Co.
2244 Walnut Grove Ave.
Rosemead, CA 91770
Ph: (626) 302-1616
Fax: 302-1328
richard.cromie@sce.com

Abstract

Non-road electric vehicles (NREVs) such as forklifts and golf carts utilize grid power to charge batteries, and today much of this power is utilized on-peak. Estimates are as high as 100 MW in SCE service territory alone. Since batteries are by nature an energy storage technology, many customers find that charging can be easily shifted away from system peak hours, saving them money and enhancing the utility's system reliability. For many years various demand response (DR), energy efficiency (EE) and load management (LM) programs have relied on customers to interrupt or curtail their various electrical loads and processes during emergency events or high cost time intervals. Electric utility tariffs further encourage customers to actively manage their on-peak demand, which often involve voluntary interruptions for economic gain.

SCE has helped customers identify non-road EV load shifting opportunities from 2001 - 2006 at over 200 business customer locations, advising on how to actively manage battery charging loads (and other loads) either manually or automatically for economic benefit.

However, NREV battery charging is better suited to load shifting than demand response. Battery manufacturing, on the other hand, is very compatible with both. Yet most business customers still do not actively manage their battery charging despite the benefits. Some of the areas I will address are listed below:

- Background of NREV demand-side management
- Goals and target markets
- Utility control opportunities and customer load management strategies
- Barriers to action
- Real world examples
- Looking ahead

Keywords: "Load Management," "Demand Response," "Forklift," "Golf Cart," "Golf Course,"

1. Background – energy meltdown of 2000 – 2001 required action

The summer of 2000 and winter of 2000/01 saw record numbers of power interruptions in California and unprecedented spikes in spot market energy prices. In response, the California legislature authorized funds for a number of new and innovative programs to reduce peak system demands. The California Energy Commission (CEC) in the spring of 2001 requested proposals under the Innovative Peak Load Reduction Program banner.

Southern California Edison responded to the CEC and proposed to coordinate and administer a program to reduce on-peak demand from industrial and non-road electric vehicle battery charging. Edison's service territory has a population of around 70,000 existing electric forklifts, golf carts and other non-road electric vehicles. Many of them are connected to their charging circuits during the power-short summer afternoons and early evenings, contributing as much as 100 MW to system peak demand, with individual chargers ranging in size from 0.5 -15 kW.

In the fall of 2001 SCE signed a contract with the CEC to fully implement the program, officially naming it the Peak Load Reduction Program for Non-Road Electric Vehicles (referred to as PLRP), and it was designed to provide incentives to commercial and industrial users to purchase and install electronic controls that would delay their vehicle charger start times until after system peak. The program was designed to offer customers minimum inconvenience, providing a fully charged vehicle by the beginning of the next business day.

Eligible customers received one-time incentives to install load shifting technology in exchange for not charging on-peak June 1 – September 30, 2002 and 2003. Charging curtailment was required from 2PM – 6 PM during non-holiday weekdays between those dates. Compliance was remotely monitored 100% during the curtailment seasons.

Some customers were single shift operators who habitually plugged in their battery chargers when the shift ended in mid to late afternoon. Many of the newer large distribution centers (DCs) are two or three shift operations with multiple batteries per forklift, and they usually switch batteries when the 80% depletion indicator dictates. Although many chargers have microprocessors with some programmability for start and stop times, we found that most customers simply do not bother to use that functionality even if their chargers are so equipped. The reality is that many businesses simply have an assortment of vintage chargers and batteries with no common controls or operating strategies.

Customers often view their forklift and electric vehicle charging as a minor load, and most have not addressed the energy and demand implications of choosing to charge off-peak. SCE hoped to demonstrate that customer bills can be reduced substantially by moving the charging function off-peak, with annual savings from $300 - $500 per forklift (5 kW charger used daily). In view of 2000 - 2001 energy crisis headlines and heightened customer awareness of the necessity to lower demand and trim energy use, SCE targeted a 4% market penetration which was projected to yield approximately 8 MW of permanent demand relief. In the final analysis, 9.1 MW was achieved.

When surveyed, many subscribing customers hoped to curtail all charging until 11 PM when summer off-peak rates were at their lowest. In most cases demand relief could easily be delivered 365 days a year, not just the minimum four summer months required for program compliance. Customer inconvenience would be minimal, so the potential motivation for override or disablement was practically zero.

The proposed program represented a unique and untapped opportunity meeting the CEC definition of "Innovative" and addressing the spirit of what was hoped could be achieved. The proposed program was implemented quickly with available technology and proven delivery channels.

SCE management also emphasized that the program represented an especially high value solution, since it was designed to produce a permanent demand shift year round, not just for the summer months. It was also projected to shift demand in some cases to 11 PM or later, rather than just the minimum requirements of 6 PM, as system peaks can persist until 8 PM or later from time to time. Customers were enthusiastic, since they saw little or no inconvenience, and took comfort in simple override capability for emergencies.

Another benefit to both conservation and peak shifting goals was immediately identified, since the installed control system can serve as a platform for customers to expand their energy conservation and control strategies to other in-house loads. Such systems can further assist customers meet their conservation goals, lower their on-peak demand or shift load to a lower cost TOU block, yielding substantial ongoing savings.

Although battery manufacturers were at first skeptical, and some even warned customers not to interrupt their charging rituals, one unexpected benefit accrued. Batteries are at their maximum internal temperatures at the end of eight hours of hard use, and the additional cooling provided by an afternoon charge delay or interruption allowed them to cool down before being charged. Long term, a cool-down between discharge and charge cycles leads to reduced maintenance and increased cell life.

It was also discovered that the application of external controls or EMS technology could save energy by reducing or eliminating charger idle losses, which in some cases were unexpectedly high. This was especially effective at single shift businesses where chargers remained unused, but were still draining power up to 125 hours a week.

The direct customer incentives were set at $150 per kW for the subscribed curtailable load, and capped at the individual control system installed cost. The following table highlights the types of customers who participated and the delivered demand reductions.

Summary of Results: Vital Statistics NREV Peak Load Reduction Program 2001 - 2002

- 43 individual customers subscribed to the program comprising 74 sites

22 Refrigerated warehouses	4000 kW
13 Commercial-industrial	2000 kW
39 Golf courses	3100 kW
Total reported load reduction	**9100 kW**

- 5357 Electric Vehicle battery chargers were placed under control
  - 1780 forklifts and industrial vehicles
  - 3577 golf carts

- 8 qualified contractors participated offering 7 different energy management system platforms. The most active contractor supplied slightly more than half of the total installations, and the three least active contractors supplied just one system each, representing legacy EMS expansions.

2. Goals: 2008 and forward

2.1 Target market - equipment end-uses and emerging opportunities

The target market of the 2001-2002 PLRP program was strictly forklift users and golf courses, and still represents the largest of the opportunity segments. However as time has progressed and the issues of air quality, global warming, petroleum cost increases and the wide acceptance of hybrid vehicles have taken on more importance, other opportunities have emerged.

2.1.1 Non-road electric vehicles

There are approximately 70,000 electric non-road and industrial vehicles in the SCE service territory, which is still the largest target segment and source of future opportunity. Their breakdown is as follows:

Table 1: SCE service territory electric non-road vehicles (estimates)

Vehicle	**Numbers in Use**	**Percent Electric**	**Avg kW (diversified on-peak)**	**Total Peak MW (estimated)**
Class 2 & 3 Lift Trucks				
Narrow Aisle Electric Units	6291	100%	3.0 kW	22
Hand Truck Units	13,171	100%	1.1 kW	17
Class 1, 4 & 5 Lift Trucks	7,606	27%	4 kW	35
Tow Tractor Units	2633	55%	2 kW	5
Rider Scrubber/Sweepers	3963	32%	2 kW	6
Personnel/Material Carriers	15,042	70%	1.0 kW	4
Airport Ground Support Units	118	2%	6 kW	2
Golf Carts	22,145	98%	0.75kW	9
Totals	**70,000**			**100 MW**

2.1.2 Battery manufacturing

Another opportunity that has emerged over the past two years has been that of battery manufacturers in the SCE service territory. Lead acid batteries consume large amounts of electricity during their formation (initial charge) process, which can last up to 72 hours and represents a large untapped source of demand response and energy efficiency potential. Nearly every battery manufacturer in SCE territory has embarked upon a DR and energy efficiency strategy dependant on implementing new computer controlled precision formation processes.

2.1.3 Plug-in hybrid vehicles

The wide acceptance of hybrid vehicles has resulted in demand for a plug-in option (PHEV) which is being developed, tested and evaluated currently by several OEMs, and may be commercially available in the 2009-2110 timeframe. Control of the recharge time will be vital to electric utilities, most of whom have vast power resources available during off-peak hours and much smaller reserves on-peak.

2.1.4 Stationary power sources

Batteries are also becoming popular as stationary power sources to compliment the steady growth of photovoltaic (PV) systems for both commercial and residential customers. They will allow smaller and cheaper PV arrays as customers charge deep cycle batteries at less expensive off-peak rates to augment PV output on-peak. The advent of smart meters, widespread time-of-use (TOU) and real-time pricing tariffs will encourage adoption of these technologies.

2.2 Primary target markets and business segments

- Business customers generally 200 kW and above
- Customers with electronic interval meters
- Customers currently on time-differentiated rates, both demand and energy
- Includes Government, Manufacturing, Commercial and Golf industry
- Emphasis on refrigerated warehouses, food processing and distribution centers
- Segment uses 37 Billion kWhs annually at over $4 Billion, contributing 25% of system peak

2.3 Secondary target market

- Lead acid battery manufacturers – a multi billion dollar business nationally

2.4 Emerging target markets

- Plug-in hybrid EVs (PHEV) residential and small commercial users
- Stationary batteries used in tandem with PV systems

3. Utility control and customer load management strategies

3.1 Baselines – the key to understanding battery charging costs

Non-road electric vehicle (NREV) charging patterns are not widely understood. They are not akin to lighting, HVAC, compressed air or some other process loads that are easily estimated or generally recognizable as either on or off. Batteries are often connected to dozens, even hundreds of chargers, and without instrumentation there is no easy way to tell the total demand at any given time.

Batteries are often brought in for recharge at random times, and each may have been depleted to a different discharge level, so the exact charge profiles individually and collectively are difficult to project. A specific customer will tend to have consistent and predictable charging patterns, although they often vary by season. For instance, consumer product distribution centers often see large increases in activity from August to November, ramping up for the holiday retail season. Among different customers, even those in the same business segment, there are almost no charge profile consistencies beyond the basic models of single shift vs. multiple shift charging operations.

3.2 Measured baselines and findings

In 2004 SCE conducted a research project entitled the Electric Forklift Charging Load Profile Study that was commissioned to explore impacts on the grid from battery charging, in view of the huge influx of large new distribution centers driven by the growth of Asian trade and port expansions of recent years.

Beginning with a random sample of over 500 large business customers, we studied 128 electric forklift users and actually measured charging load profiles for two weeks on 31 sites, providing useful data and recommendations for cost reduction measures which were presented to each customer. Our findings validated the wide variability in load profiles, and also confirmed that normal charging diversity meant that, measuring a large numbers of chargers, the actual contribution to peak demand (or any other time interval of demand for that matter) of each charger was much smaller than nameplate ratings would suggest.

Often the diversified contribution to peak demand would only be 25% (maybe even less) of the total theoretical nameplate kW, and rarely exceeded 50% unless a single shift operator connected virtually all his depleted batteries during a short time window.

3.3 Types of SCE customer programs and their benefits

3.3.1 Energy efficiency

Energy efficiency programs, incentives and rebates have been promoted by SCE for over thirty years. Since NREVs, batteries and chargers comprise complex systems of equipment, often provided by different vendors, there has been little opportunity for customers to invest in equipment with highly differentiated levels of efficiency. Some of the newer AC lift trucks are more productive than the older DC versions, but it has been very difficult to validate actual energy conversion efficiencies and benefits, even with a rigorous EPRI sponsored test regimen. Major improvements will need to wait until we see changes in lifting and motive technology that can regenerate batteries from wasted vertical and horizontal motion.

Lead acid batteries are chemical and vary by nature, so we do not see opportunities for vast improvement on the immediate horizon, especially given the inconsistent (and often poor) maintenance and handling practices found in the real world.

Battery chargers have more potential for efficiency improvements, and our own extensive EPRI sponsored test and evaluation program in 2005 – 2006 highlighted this potential (see section 4.4.2.) High frequency electronics, precise charge cycle control, idle cutoff relays and good power quality are all available today and can contribute to lower energy costs. The key is to have them all delivered in a single package.

Longer term, we are supporting and contributing to Energy Star certification for NREV chargers and charger-battery systems based on criteria that include charge efficiency, standby loss reduction, increased power factors, power quality improvements and total harmonic distortion (THD) reduction. We are also supporting developments that will help deploy smart battery-charger systems that carefully monitor and control amp hours into and out of the battery to eliminate the inefficiencies of overcharging which happens routinely now. It would not be a stretch to project a 15% to 25% improvement in charge efficiencies if all these technologies were adopted. We hope the Energy Star program can serve as the springboard.

3.3.2 Demand response

In California, event driven demand response programs have been the prime emphasis in regulatory planning and program mandates over the past five years or so. Interruptible programs have been supported by SCE since the seventies, beginning with A/C cycling in 1978 and large C&I interruptible programs soon after. The interruptible option was exercised from time to time in the early years due to heat storms and system emergencies, but from the late eighties and on up to about the year 2000, years went by between interruptible events. Nationally and regionally, many utilities dismantled and decommissioned their A/C cycling and commercial interruptible programs and infrastructure. Some SCE customers even forgot they were being paid capacity incentives and were obligated to interrupt when called upon. In 2000 and 2001 a rash of deregulation-inspired shortages rudely, and sometimes expensively, awakened subscribers, and since then there have been a few interruptible events every year.

Today's programs are divided between reliability (interruptible) and economic (voluntary demand bidding) strategies. For C&I customers the most viable recent options have been the various demand bidding programs that can deliver economic benefits to customers willing to schedule curtailments of their demand either the day of an event or the day before. NREV battery charging has not been a popular candidate for these sporadic curtailments due to the potential for operating disruptions from depleted batteries that may be needed as soon as the curtailment has ended. Lighting, process and HVAC have been better candidates, although some customers have dedicated all or part of their charging capacity to DR strategies because they happened to have the right mix of capacity, work schedule and raw willpower. In exchange for bidding and dropping load the customer is paid a generous incentive for each kWh reduced, measured against their past rolling average demand.

3.3.3 Load shifting

NREV battery charging is particularly well suited to permanent load shifting. Batteries store energy, and with some planning and the right control equipment in place, customers can achieve substantial month to month cost savings, especially in summer when time-of-use rates are high during weekday afternoons. Customers are typically more comfortable establishing a charging schedule and sticking to it year round, rather that participate in a few disruptive demand response events. In 2001 and 2002 the PLRP incentive program proved that many large two and three shift operators could accommodate permanent load shifting with minimal inconvenience. The economic advantage of load shifting vs. demand response is in the range of 10:1, plus customers find that once these habits are formed, they are easy to maintain.

Our own studies and audits found that in some large refrigerated warehouses and distribution centers the forklift battery charging alone sometimes contributed as much as a third of the overall facility peak demand, far more than most customers ever imagined. Savings accrue from both the energy and demand cost reductions, as typical large C&I customers pay for summer on-peak energy that may be double the off-peak rates and 30% higher than typical mid-peak rates. Demand charges on-peak can be three to five times mid-peak demand costs, and typically the off-peak has no demand charges whatsoever. And by the nature of demand billing, the highest 15 minute interval during the month establishes the monthly charge.

The contributions and importance of permanent load shifting has recently bounced back on to the regulatory radar after a five year snooze, and we have recently responded to directives telling us to look into new and innovative programs to be in place for the summers of 2008 – 2011. Cost effective NREV charging programs have been proposed by third parties, but the Public Utilities Commission has focused on higher cost thermal storage cooling programs targeting broader markets. Proposals are being evaluated.

4. Barriers to action

4.1 Costs of charging are either unknown or underestimated

As mentioned before, battery charge load profiles are highly variable, unpredictable and even harder to measure cost-wise. Measuring the charging process is required for several weeks with portable instruments in order to determine what the customer is doing now, and what changes they have to make to save money. Monitoring is difficult and costly to do, and most customers either do not know how or are unwilling to spend the money, which can be up to $2500 using an outside electrical or M&V contractor.

SCE's Electric Transportation Department offers this service at no charge to any business customer with at least 15 forklifts or 50 golf carts or other NREVs. The customer is given his load profile charts and a detailed analysis of the results along with recommendations based on the most compatible cost reduction charging strategy options.

4.2 Failure to identify and engage the appropriate decision maker

Often customer account managers, sales professionals or program managers approach the wrong individual in the customer hierarchy. The warehouse manager, engineering manager or maintenance manager may be the most knowledgeable on forklift operations, but often are the least interested in making operational changes that they fear could slow down their work or reduce productivity. Usually the plant manager or chief financial officer is the key decision maker when it comes to paying the bills and reviewing potential cost reductions and capital investments to benefit the bottom line.

In the larger multinational corporations, we have seen some occasional paralysis as local management spars with headquarters over the pros and cons of recommendations and capital funds priorities. The easiest option for the bureaucracy is sometimes, unfortunately, simply doing nothing.

If recommendations are adopted and investments are made, it is important to make sure there is proper communication among the various departments and stakeholders within the customer organization. We have seen an occasional example of elegant solutions with expensive controls get installed but remain unused or underused from lack of direction from the top management or poor communication.

There are other employee issues that impact the effectiveness of any technological solution including human intervention, employee turnover and lack of training.

4.3 Cost of controls

An electronic control system capable of directing the activities of dozens, or even hundreds, of NREV battery chargers is not cheap. The installation often requires from two to five years for cost recovery, so these projects may reside on the corporate "wish list" awaiting an enabling incentive from the local utility. It is important the customer fully understand every possible benefit of such a system so that capital justification can be managed successfully. In addition to energy cost savings, there are often battery management benefits such as longer battery life, lower maintenance, longer run times and greater productivity from both the battery room and the factory floor.

There are less costly options as well. Time clocks can be nearly as effective as electronic controls or energy management systems (EMS) at a fraction of the cost. If the customer is considering replacing all his battery chargers, he should look into equipment with advanced control options that may allow networking and control using the chargers' internal microprocessors at a modest added cost. Sometimes existing chargers are sophisticated enough to facilitate cost saving strategies with a little creative programming at nearly zero investment.

4.4 Equipment suppliers

We have found that equipment suppliers who are driving the sale are usually the vehicle dealers, typically forklift or golf cart sales organizations. Sometimes everything is sold or leased as a package, but often the customer buys the batteries and chargers separately. In either case, most customers pay more attention to the vehicle than either the battery or the charger, and often buy based on the lowest price, not the lowest operating cost, because sales emphasis may not highlight the total life cycle cost of ownership.

4.4.1 Battery warranty issues

Warranty claims can be a large and unwelcome drain on the profits of battery manufacturers. Failures are often blamed on poor maintenance or improper operation by users. Charge cycle interruptions from demand response or permanent load shifting strategies have historically drawn criticism from battery OEMs who were concerned that battery life would be impacted, and customers were reluctant to give OEMs even more reasons to deny claims. However, in recent years widespread load management practices have gradually become accepted by battery suppliers, and our customers have had few problems related to battery failures blamed on load management activities.

4.4.2 Charger limitations

Customers have a wide array of industrial battery chargers to choose from. There are different choices for basic power conversion technologies as well as many permutations of control capabilities and optional features. Some chargers can be networked as part of battery management systems, and the newer “smart” chargers are beginning to incorporate capabilities and communications protocols allowing the charger to talk to the battery and deliver just the right charge cycle algorithm to ensure peak energy efficiency and longest cell life. The newer golf cart and personnel carrier designs have some of the charger intelligence and circuitry actually built into the vehicle itself.

In 2006 SCE and EPRI partnered on a project to measure the charge cycle interruption tolerance of all major brands of forklift battery chargers under a program titled Industrial Lift Truck Battery Charger Demand Response Study, which is due to be published by EPRI in the next several months. The study attempted to simulate conditions of charge interruptions from demand response and load shifting strategies, compressing years of activity into rapid charge-discharge duty cycling controlled by an automated test setup. All the chargers were purchased on the open market, and the manufacturers were consulted about test parameters and invited to assist, advise and comment. All welcomed the chance to partner with SCE and EPRI on this study, and most appear willing to consider updating their operating instructions and warrantee language to include load management given the successful outcome of the study.

Each charger was given a series of baseline characterization tests, and then put through its paces under high and low power interruptions, battery recognition tests and life cycle testing with 7200 on-off power interrupt cycles. This represented 66 years of DR events or 20 years of daily load shifting. No charger or battery damage was observed, and the only anomalies we found were several examples of chargers not recognizing where the charge cycle had been interrupted and failing to return to the correct point on the curve upon power resumption.

Our conclusions allowed SCE (including the risk-averse attorneys) to formulate a statement that endorsed customer participation in programs involving charge cycle interruptions inherent in the various demand response, load management and energy efficiency programs offered by the company.

The study was so successful, it was decided to commission a similar, although more limited, study this year on the new generations of 120 volt golf cart and personnel carrier chargers.

5. Real world examples and conclusions

Many of our customers have implemented energy focused procedures and controls on their industrial battery charging operations and enjoyed substantial savings. In some cases improved battery life and higher employee productivity was also reported. The following photos and examples will illustrate:

5.1 Charger and installation Photos

Figure 1: Industrial chargers

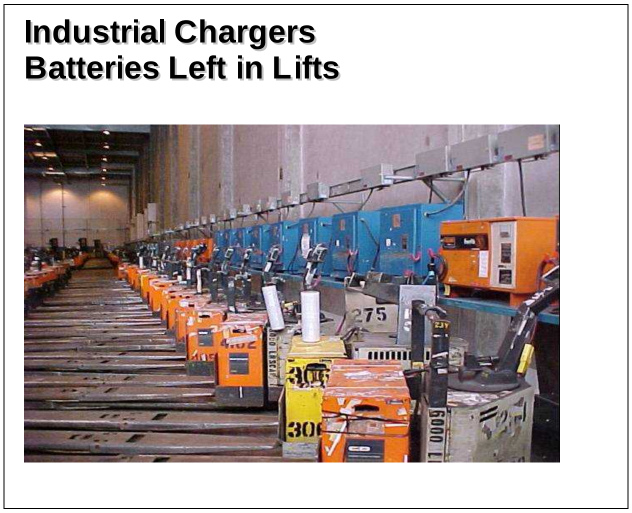


Figure 2: Industrial chargers

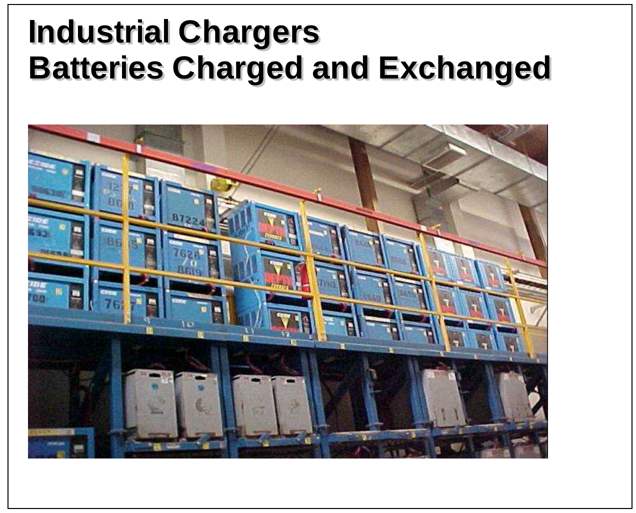


Figure 3: Small warehouse chargers

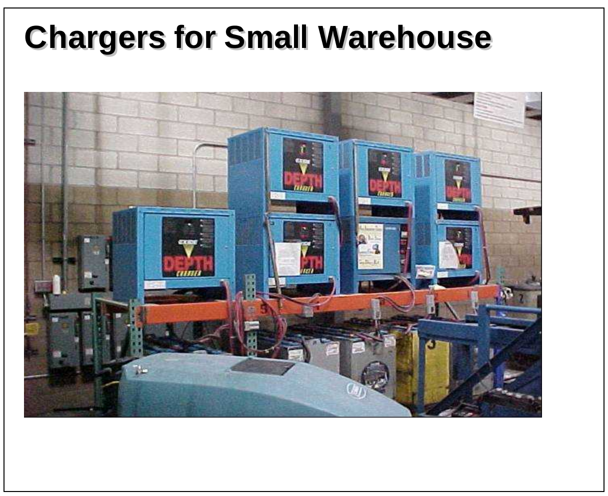


Figure 4: Golf cart chargers

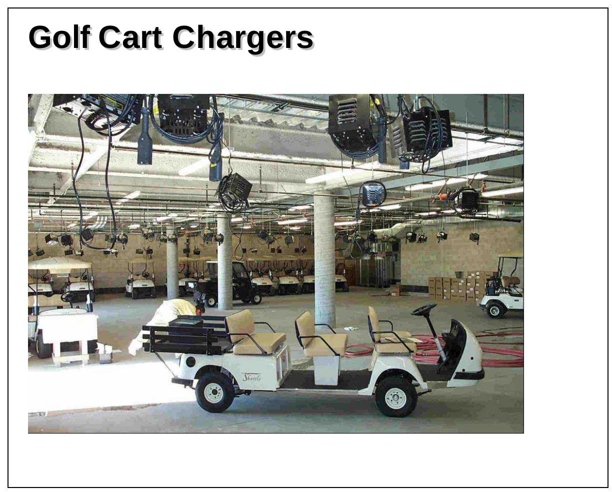
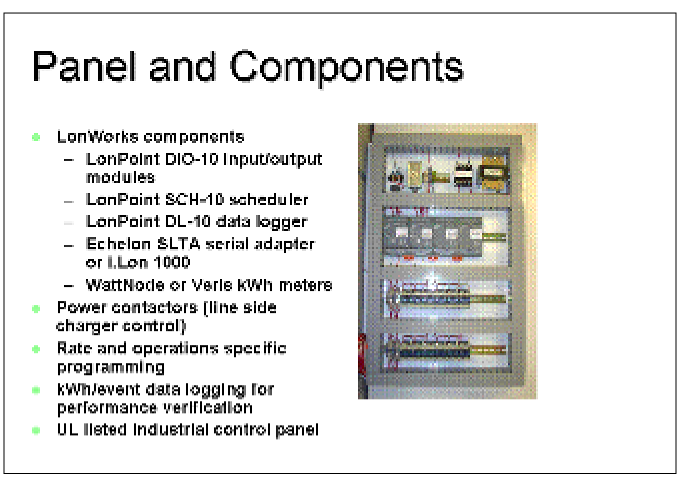


Figure 5: Energy management system (EMS) panel and components



5.2 Example: Typical large customer forklift controls installation

A large retail food distribution center was the largest single customer utilizing incentives under PLRP to install a forklift charger control system in 2002. Monitoring was done just before and just after installation to gather accurate predictive data, shown below:

- Projected reduction = 365 kW
- Measured 4 hour average reduction = 358 kW
- Measured peak one-hour reduction = 416 kW
- Average kW to peak kW ratio = 85%
- Savings over 4 summer months = $26,000 demand charges and $16,000 energy charges

Figure 7: Graph of charging before system activation

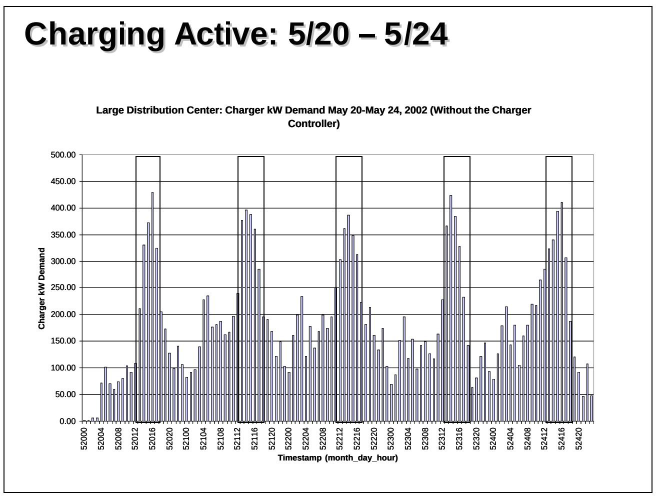


Figure 8: Graph showing curtailed charging after activation

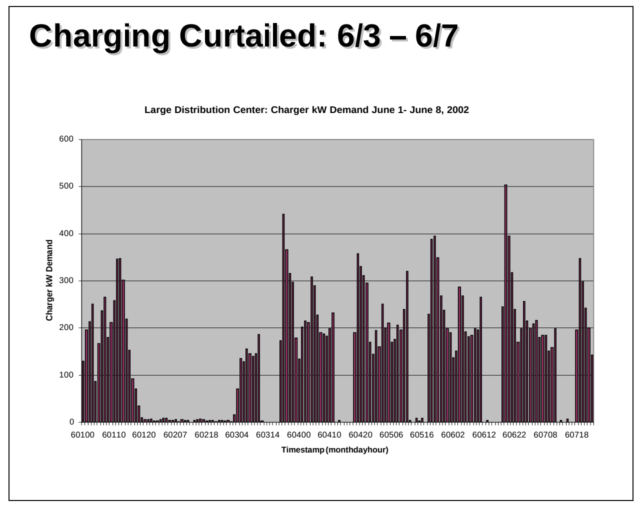
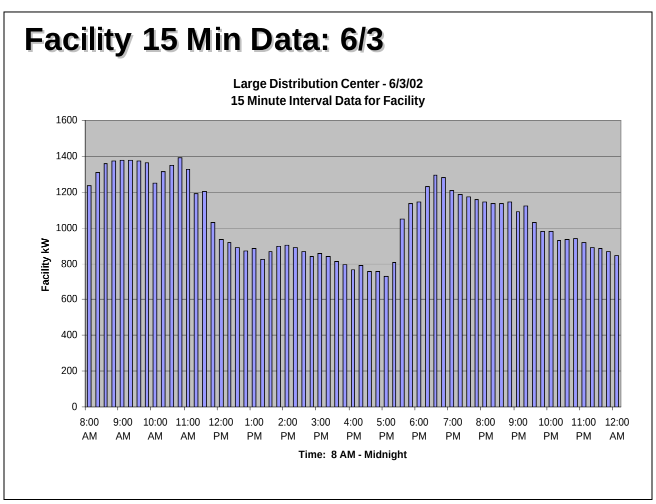


Figure 9: 15 Minute data for entire facility after activation



5.3 Large deep cycle battery manufacturer

One of the largest deep cycle battery manufacturers in the U.S. asked for our help measuring their battery formation load profiles. Formation is the final stage of production where the finished batteries are charged for up to 72 hours. The customer wanted to reduce their electricity costs per unit of production and also participate in SCE's demand response programs.

SCE's Electric Transportation load management team monitored the customer's high volume battery formation circuits and overall formation load profiles for extended intervals and provided a detailed report with recommendations for controls and cost saving measures, including participation in SCE's energy efficiency and demand response technology incentive programs.

After careful evaluation the customer made investments in plant process controls and battery formation computerization, enabling him to fine tune his formation profiles delivering a net savings of over three million kWhs per year. The new precision controls provided higher quality cells, reduced processing time and allowed participation in SCE's demand response program which provided generous participation payments with no adverse consequences for plant operations. Customer benefits can be summarized as follows:

- Over 3,000,000 kWhs per year saved ($330,000)
- Demand response load drop of 3.2 MW when called upon by SCE DR event ($4000/event)
- Technology incentive from SCE of $576,000 to automate battery formation and plant processes
- Improved quality and consistency of product

5.4 Lessons learned

5.4.1 Customer viewpoints – PLRP participants as a group

- Customers like controls – minimal inconvenience and supervisory empowerment
- They gained more control over their operations
- TOU customers saved up to $500 per forklift per year
- Golf courses under 200 kW (non-TOU) had more modest savings
- Customers surveyed showed 96% "satisfied" or "extremely satisfied"
- Second customer survey showed 88% remained on off-peak charge
- Standby and idle loss reductions were unexpected and sometimes substantial

5.4.2 Baseline measurements

- Baseline data is not available or unreliable
- Baseline charging patterns are far more variable than thought
- Baseline charging patterns have high peaks but lower than expected averages

5.4.3 Batteries

- Batteries and chargers are unique loads and posed some challenges
- Batteries remaining connected long term can be damaged by repeated cycling
- Equipment signage should be posted to warn against long-term connection
- Battery charging time and efficiency varies with age and condition

5.4.4 Battery chargers

- Charger kW is not on most nameplates, only kVA or volts and amps
- Charger power factors are highly variable (testing from 50% - 97%) and confuse projections
- Using kVA as a proxy for kW not advisable without power factor de-rating
- Many chargers overcharge batteries, shortening battery life and sacrificing efficiency
- Most newer chargers are programmable, but customers rarely use the functionality
- Manufacturers should be encouraged to offer charger value options:
  - Low voltage control input for interruption commands
  - Low voltage output relay to signal run status
  - Easy time-delay start programming interface – maybe remote
  - Smarter charge time and charge cycle optimization for efficiency
  - Automated responses to “interrupt,” “resume,” and “re-start”
  - Idle shut down relay for power supply when charger is in standby mode
  - Further development of “smart chargers” that communicate with the battery

5.4.5 Energy management & control systems

- Most of today’s EMS technology is adaptable to charger time control
- Baselines need to be established by sub-metering or kWh monitoring
- Remote monitoring and even third part supervision is recommended
- A need exists for integrating EMS and fleet battery management for larger users
- EMS software is generally easy to use
- Demand response subroutines should be an option
- Automated bypass logs to document customer overrides are recommended

6. Looking Ahead

With electric power supplies projected to tighten in the west and nationwide, government regulators and electric utilities are re-inventing and re-emphasizing the contributions of energy efficiency and demand-side management. We see the revivals of 30 year old air conditioning cycling programs and commercial-industrial demand response initiatives as valuable resources to help ease supply shortages in future years.

Rates and tariffs are evolving, with the aim of creating pricing structures that will encourage users to shift more and more load away from expensive system peaks, and by doing so, take advantage of lower prices and other incentives. The emergence of smart meters for smaller customers will begin to embed the habits of time-based scheduling into more of the general population, and eventually become the platform for off-peak plug-in-hybrid battery charging and even photovoltaic-stationary battery residential systems.

Lead acid battery manufacturing is a multi billion dollar industry, and is at the mercy of escalating material and labor costs, with savings opportunities limited mostly to automation benefits and productivity gains. While energy is not a huge cost component in battery manufacturing, it is indisputable that there is plenty of fat yet to be trimmed from the electric bills of most operations, and those savings migrate right to the bottom line. The technology is available, and some utilities are even willing to supplement the customers’ investment. Those who wait will lose their competitive edge quickly.

At the same time, environmental and clean air regulations are evolving into GHG and petroleum reduction initiatives that will continue to drive the acquisition and use of alternative fuel vehicles both on the road and off.

With greater numbers of non-road electric vehicles in use, the system impact of battery charging will continue to be of concern to power suppliers, and time-shift charging strategies will become more cost effective and eventually second nature to the majority of users large and small. I would expect to see the larger fleet suppliers begin to offer serious time-control and energy management options along with their forklift and golf cart fleet packages. With peak reduction strategies in place at large multi-shift customers, battery suppliers will learn how to make a good business case for additional batteries to compensate for fewer charge hours available in the day. Charger manufacturers must adapt their products to allow easy time-shift strategies, external EMS control options, idle loss reduction technology, better power quality and development of battery communication protocols if they want to stay in the ball game.

Overall energy efficiency of the entire vehicle drive system must be improved. Some chargers have power factor, power quality and efficiency variations that would be considered unacceptable in other products. Efficiency standards need to be developed that will allow customers to choose intelligently among alternatives with varying costs and efficiencies. An Energy Star testing and compliance initiative should be a top priority in the industry, and new equipment designs should aim to exceed these standards. And finally, all electric utilities should promote the benefits and cost savings of off-peak battery charging and energy efficiency options to their customers.