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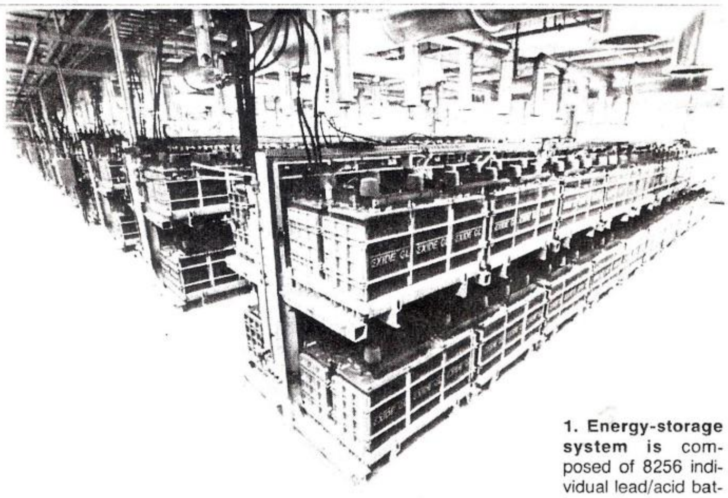
Edison recharges load management with batteries

World's largest battery system, charged with low-cost base-load power, delivers 10 MW during peak periods. Energy storage options like this one are key to load-leveling functions critical to utility operations



1. Energy-storage system is composed of 8256 individual lead/acid battery cells

Southern California Edison Co (SCE) set out to enhance operating flexibility by developing energy storage options for load management. It wound up with the world's largest battery (Fig 1). Located east of Los Angeles at SCE's Chino substation, the 10-MW facility is progressing through a two-year test period. Installation was completed in July 1988. Operating and maintenance (O&M) costs and system reliability associated with managing loads on a daily basis are the focus of the evaluation.

Joining SCE in this venture are the Electric Power Research Institute (EPRI) and the International Lead Zinc Research Organization (Ilzro). EPRI supplied the power conditioning system; Ilzro provided 2000 tons of lead for the batteries.

The objective of load-leveling is to store off-peak, low-cost power available from other utility systems or SCE's baseload plants and subsequently use it during periods of peak demand. This operating mode is economical when the costs for building and operating an energy-storage system are less than the energy-cost difference between periods of peak and minimum demand.

Lead/acid battery technology proved to be the choice for two reasons: (1) Legislation had been passed preventing the use of lead additives in paint and automobile gasoline, reducing the price of lead by half, and (2) advanced battery design and development—primarily sodium/sulfur and zinc/halide—have evolved more slowly than anticipated.

Battery systems have some unique attributes as storage facilities, compared to alternatives such as pumped hydro and compressed-air energy storage. They are more environmentally acceptable and can be located near loads and in existing suburban substations. Transmission losses are reduced and sites are readily more available. No environmental impact statement was required for the Chino facility—only hydrogen will be released, and that in trace quantities. Filters capture all other gases. The curbed building design eliminated the need for underground tanks and minimized the civil work to that required for sewers and storm drains. The one-story buildings are lower than the existing substation. Emissions and perceptible noise are not expected to occur at the site boundary.

Battery systems are very responsive to changes in demand. The Chino facility can swing from a 10-MW discharge to a 10-MW charge in approximately 16 milliseconds. An 8.5-MW battery energy-storage plant operated by the West German utility Berliner Kraft und Licht AG—previously the largest in the world—has been helping to achieve a frequency regulation tolerance of ±0.1 Hz for that utility since November 1986. One major objective of the Chino facility will be an investigation of operating modes that exploit the battery's fast response.

Storage can improve the use and efficiency of the electrical supply system by reducing the effect of independent power producers and integrating their generation with the customers' demands. SCE purchases a substantial amount of cogenerated and independent power, so this attribute is particularly important.

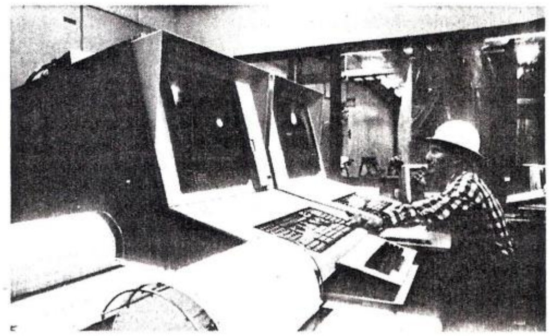
For its efforts to demonstrate an important new energy-storage technology, SCE is the recipient of POWER's 1989 Energy Conservation Award.

Project objectives

Although the primary objective of the facility is to demonstrate load leveling, the following goals are also of great interest:

- Demonstrate operating benefits—such as voltage and frequency regulation, spinning reserve, and improvement in the operation of base- and intermediate-load plants.

- Validate design, procurement, and installation/construction costs.
- Introduce the utility market to a new modular, environmentally acceptable storage alternative.
- Develop and test instrumentation and devices suitable for monitoring large battery systems.
- Identify design and construction methods that reduce overall cost of battery storage facilities up to 100 MW.



2. Control consoles are interconnected with remote locations to facilitate data gathering

System description

The energy storage system, supplied by Exide Corp, Horsham, Pa, incorporates 8256 individual lead/acid battery cells specifically designed for deep discharge capability. Each 2-V cell has a nominal storage capacity of 5 kWh. System design capacity is 10 MW for four hours—enough to supply the needs of 5000 customers. The cells are warranted for 2000 charge/discharge cycles, or approximately eight years, before requiring replacement. However, accelerated tests of similar cells at the Argonne National Laboratories Argonne, Ill, indicate that the batteries could last up to 4000 cycles.

The basic battery unit is a module of six cells connected in series and installed in two-tier racks to form rows. When bolted on the cantilever rack, the rack braces and rigid trays assure a row assembly capable of meeting Zone 4 seismic shock and vibration requirements. Individual cells are supported horizontally and vertically in each module tray. There are 16 rows per building, two buildings at the facility. Four rows form one 2000-V (dc) string.

Deep-discharge lead/acid batteries are similar conceptually to automobile batteries and require the regular addition of water to maintain the electrolyte level. Each cell has a 5-hr capacity of 6.2 kWh and a rated capacity of about 5 kWh at a 4-hr discharge rate. When the cells are new, efficiency of a charge/discharge cycle is 78%.

As a safety precaution, the two battery buildings have an 18-in. high curb that provides a containment volume of 233,000 gal of water. The worst-case scenario of a sustained short-circuit has an estimated spill volume of 100,000 gal of fire-protection water and the acid content of 400 cells—or 5000 gal. In event of a large spill, a licensed hazardous-waste contractor would neutralize the acid in place and pump the mixture into a truck for disposal.

The battery buildings circulate outside air to change the building volume 12 times an hour, thereby controlling the accumulation of hydrogen to less than Occupational Safety and Health Administration (OSHA) limits. Battery cooling is mainly by natural convection of the cells.

Auxiliary systems. The battery system requires two auxiliary systems for efficient operation: an air agitation system and a water supply system to maintain the electrolyte level. The air agitation system consists of a packaged air compressor supplying manifolds arranged along the racks. Tubes, connecting the manifolds to each cell, convey air to a vertical sparger in a corner of the cell, allowing air to bubble down the tube. This action stirs the acid electrolyte and prevents stratification, thus increasing the cell's operating efficiency and life.

A similar supply system provides water from a central tank to each cell. Manually operated valves provide water to sections of the racks in turn. A water valve located in the cell top cuts off the water supply when a predetermined level is reached.

Venting is a third auxiliary function. In addition to hydrogen, other gases—metallic hydrides formed from the lead-alloying constituents—are vented from the cell during the final stages of the recharge operation. These gases are captured by an activated-charcoal filter canister mounted within the flame arrester on each cell.

Ac/dc converter

The power conditioning system (PCS) is the primary interface between the battery facility and the SCE grid. It converts the dc power of the batteries to ac power and vice-versa. Manufactured under an EPRI contract, the PCS and its associated control systems monitor and control all functions of the battery system, including ramp-up rates, charging voltage, and power level.

Because of its unique design, the converter subsystem of the PCS can function independently as a synchronous generator to maintain unity power factor. It is also designed to produce power while maintaining a 97% one-way efficiency at full load. The system's overall efficiency is in the neighborhood of 75%.

General Electric Co's Drive Systems Div, Salem, Va, was selected to supply the PCS, comprised of a self-commutated voltage source and an 18-pulse stepped-wave converter that has the capability to continue operating through line voltage swings.

During the battery discharge mode, the PCS inverts the stored dc power to ac to return power to the grid. An integrated microprocessor controls the flow of power, protects the PCS from fault currents, charges the batteries automatically, and diagnoses the operating conditions of the PCS. The PCS is a new design but based on similar equipment used in variable-speed drives and uninterruptible power systems.

Facility monitoring and control system (FMCS). The microprocessor-based control system provides complete facility supervisory control and data acquisition (Scada). The system is interconnected with the PCS control system via a single communications cable and one hardwired contact to enable the facility to be operated from either the PCS or the FMCS console (Fig 2).

The FMCS is preprogrammed with a typical load curve for automatic control of the battery discharge rate but can be modified readily from the engineers' console to allow for different discharge patterns. Reactive power output can also be programmed into the FMCS.

Plant performance

Tests of the PCS conducted to date have demonstrated encouraging performance with respect to voltage and frequency regulation and balance, harmonic distortion, and PCS response time.

Operating at 75% overall efficiency, the plant is demonstrating that battery energy storage is an effective option for increasing the efficiency of existing electric systems while deferring the need for new peaking capacity and substation transmission/distribution equipment. ■