

Assessing Battery Performance with Distributed Energy Technology Simulators¹

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Commercial and industrial customers operating their own generation and storage technologies may not be so unusual in the future. They will be able to ride through periods of peak demand without incurring excessive costs. They will be able to avoid expensive production downtime by operating their own power quality systems. Or they will be able to cost-effectively generate a portion of their electricity needs everyday.

How will they make the decision to install these distributed generation and storage technologies? By simulating the technical and economic performance of distributed energy technologies with an assessment tool no more expensive than a traditional paper feasibility study. The virtual device can prove in real-time that operation of the distributed energy technology results in energy and expense savings sufficient to exceed the costs of installation and operation.

The simulator is designed to be a user-friendly product that utility personnel could learn to install, operate, and evaluate at customer sites. The tool monitors the facility load and evaluates up to five different onsite generation and storage technologies in real time:

- Peak-shaving battery
- Peak-shaving diesel generator
- Power quality battery
- Microturbine
- Phosphoric acid fuel cell

The feasibility assessment is generic in nature; customers will not be able to specify equipment solicitations on the basis of this assessment. Rather, they will gain a clear indication of which technology is the most competitive at their particular site. The simulation program also provides multiple choices for dispatch algorithms.

The National Rural Electric Cooperative Association and the US Department of Energy have sponsored the development, validation, and demonstration of the distributed energy technology simulators. The project goals by project phase are presented in Table 1.

Table 1. Simulator Goals by Project Phase

Develop	Validate	Demonstrate
<ul style="list-style-type: none">• Investigate each technology• Write computer code to monitor voltage, current, and frequency• Assemble the monitoring and simulator boxes	<ul style="list-style-type: none">• Install and operate simulators minimum two weeks• Compare performance of virtual and actual devices• Document findings	<ul style="list-style-type: none">• Install and operate unified simulators at two sites one month each• Evaluate performance of virtual device• Document findings

In April 1999, the simulator completed its peak-shaving validation period successfully mimicking the operation of a 500-kWh flooded lead-acid battery (see Figure 1). It matched the timing and duration of the peak-shaving battery system, responding to signals from the electric cooperative and the investor-owned utility providing the peak power (see Table 2). Comparing the operation of the virtual and actual devices revealed a close approximation in both discharge and recharge events, as measured in terms of current, voltage, and power. Figure 2 shows very close discharge current comparison on April 8, 1999. Note that power output from the actual device was 402 kWh, compared with a simulated output of 410 kWh. Figures 3-4 illustrate recharge current and voltage comparisons on April 9, 1999. The simulator was unable to match the full magnitude of the current charging into the battery, but over the almost three hours that the recharge lasts, the power input

¹ Sponsors: National Rural Electric Cooperative Association, U.S. Department of Energy, and Sandia National Laboratories

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received by the virtual device almost equaled that of the actual device - 438 versus 439 kWh. The simulator appears to match voltage closer than current on this particular recharge event.

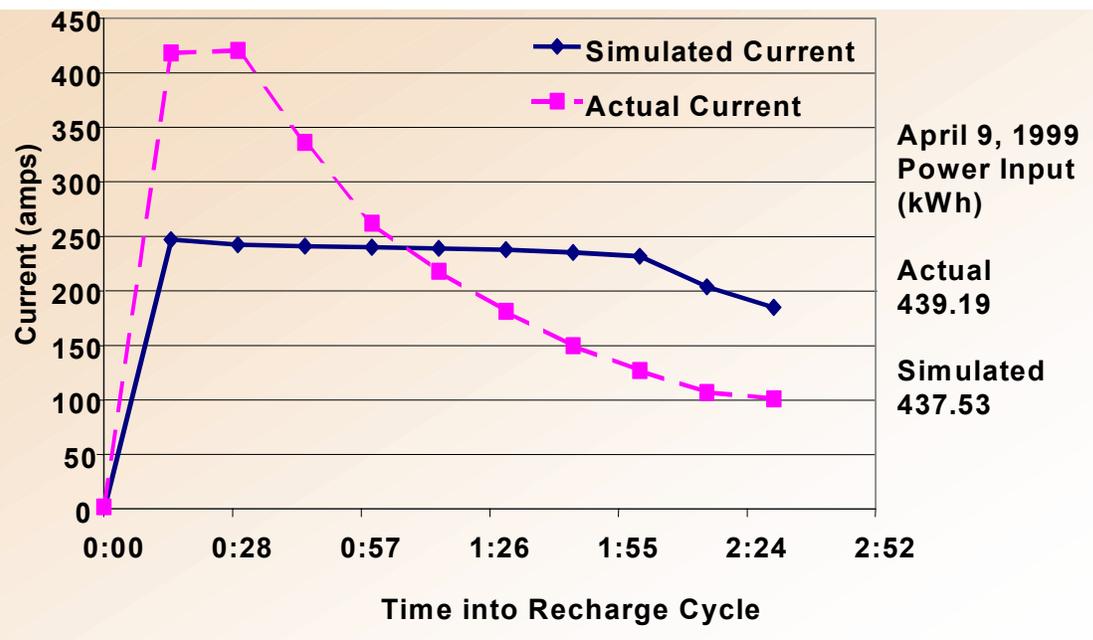
Figure 1. Peak-Shaving Battery Validation Site



Table 2. Peak-Shaving Battery Validation Results

<i>Date</i>	<i>Actual Peak Event Time</i>	<i>Simulated Peak Event Time</i>
2/22/99	6:50-8:30	7:15-8:45
2/23/99	6:50-8:10	7:15-8:15
3/2/99	6:50-8:25	7:00-8:15
3/3/99	not recorded	17:00-18:00
3/4/99	6:50-8:29	7:00-8:15
3/5/99	6:50-9:05	7:00-9:00
3/8/99	6:50-8:30	7:00-8:30
3/9/99	18:20-20:55	no event
3/11/99	6:50-8:00	7:00-8:00
4/8/99	15:29-17:20	15:30-17:15

Figure 2. Peak-Shaving Battery Discharge Current Comparison



From this validation, a peak-shaving battery module has been programmed that can be integrated with the peak-shaving diesel generator and other similarly-operating devices. This unified software is being debugged for use at two demonstration sites. The first demonstration is scheduled at a facility served by a rural electric cooperative in southern Virginia.

Figure 3. Peak-Shaving Battery Recharge Current Comparison

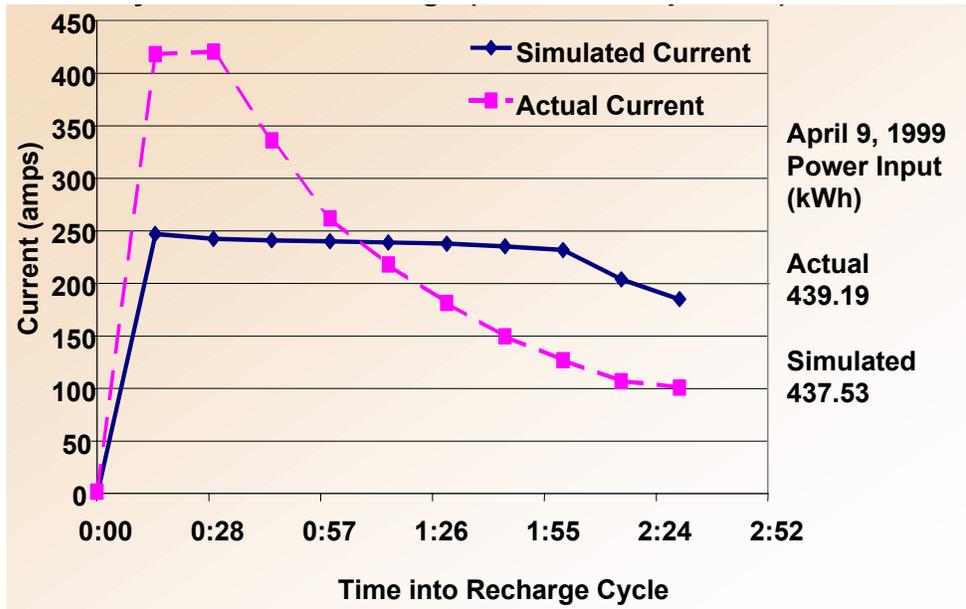
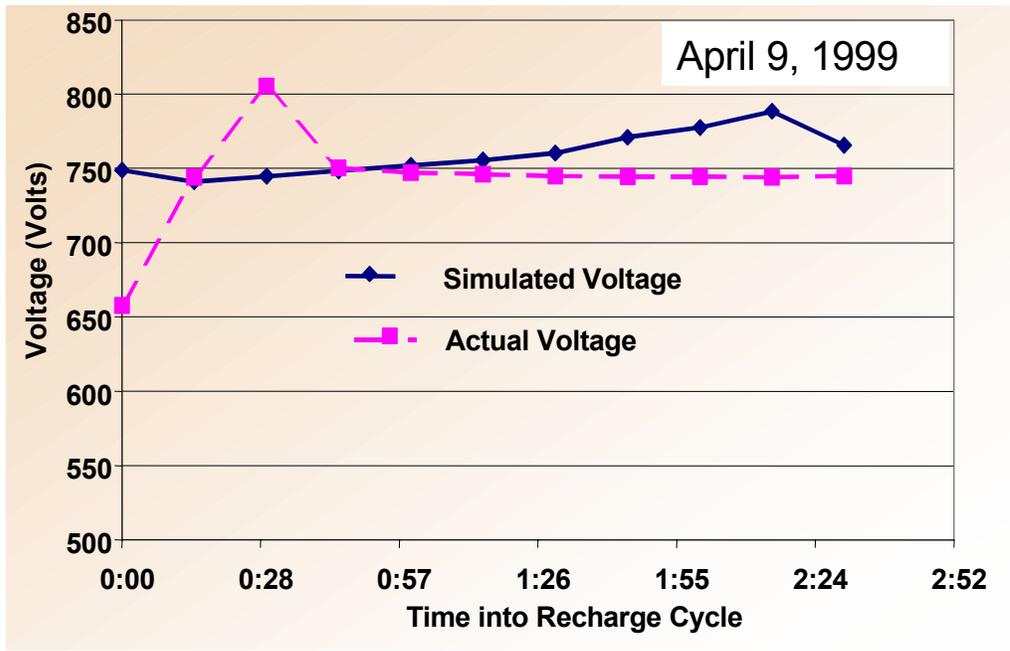


Figure 4. Peak-Shaving Battery Recharge Voltage Comparison



In August 2000, the power quality battery simulator completed its validation period at an industrial site, mimicking the operation of a 1-MW PQ2000 system (see Figure 5). It emulated nine power glitches that would have resulted in production shutdowns (see Table 3).

Figure 5. Power Quality Battery Validation Site



Table 3. Power Quality Battery Simulated Events

Date	Time	Duration (sec)
3/4/99	1:32:02 PM	2
6/20/99	1:06:33 PM	10
6/23/99	12:44:29 AM	2
10/22/99	12:11:02 PM	1
11/6/99	1:50:46 PM	5
1/24/00	7:45:05 AM	1
2/10/00	1:41:41 PM	1
2/15/00	11:40:58 AM	5
6/14/00	3:53:53 PM	1

Analysis of the actual and virtual power quality devices is not complete. A validation report will be issued to the clients and host site. The power quality battery cannot be incorporated into a unified simulator as the peak-shaving modules have been. Final decisions on treatment of the power quality battery simulator remain pending.