ENERGY STORAGE
--
VALUES AND APPLICATIONS

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE
On August 14, 2003 the Lights went out in much of the Midwest and Northeast
<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Affected</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 65</td>
<td>NY CT MA RI ONT</td>
<td>30 M</td>
<td>20,000 / 13 hrs</td>
</tr>
<tr>
<td>July 77</td>
<td>NY CITY</td>
<td>9 M</td>
<td>6,000 / 26 hrs</td>
</tr>
<tr>
<td>Dec. 82</td>
<td>West Coast</td>
<td>5 M</td>
<td>12,350</td>
</tr>
<tr>
<td>July 96</td>
<td>West Coast</td>
<td>2 M</td>
<td>11,850 / min-hrs</td>
</tr>
<tr>
<td>Aug. 96</td>
<td>West Coast</td>
<td>7.5 M</td>
<td>28,000 / min - 9 hrs</td>
</tr>
<tr>
<td>June 98</td>
<td>Upper Midwest</td>
<td>152,000</td>
<td>950 / 19 hrs</td>
</tr>
<tr>
<td>Aug. 03</td>
<td>MidW NE ONT</td>
<td>50 M</td>
<td>61,800 / 4 days</td>
</tr>
</tbody>
</table>
Any Stressed Un-buffered Non-linear System is Highly Susceptible to Collapse!
Stored vs. Delivered Energy:

- 2.5% U.S
- 10% Europe
- 15% Japan
Outage Costs for U.S. Industry estimated at $79 Billion Annually in a recent study by Joe Eto, LBL

Total Cost of Electricity $250 Billion Annually
Momentary Interruptions (<5min) are More Costly than Sustained Interruptions

U.S. Total: $79 Billion

- Sustained Interruptions: $26.3 Billion (33%)
- Momentary Interruptions: $52.3 Billion (67%)

Joe Eto
LBL
Distribution of Voltage Problems

- **Swell**: 3%
- **Overvoltage**: 0%
- **Voltage Sag**: 95%
- **Undervoltage**: 2%

**Magnitude**
- 110%
- 90%
- 10%

**Duration**
- 0.5 cycle
- 3 sec
- 15 sec
- 1 min

**Category**
- Transient
- Notch / transient
- Momentary
- Temporary
- Sustained Interruption

**Normal operating voltage**
Momentary Outages of only a few Cycles or Minutes can lead to Hours of Downtime
Only Energy Storage can provide Seamless Continuity of Power Supply
Energy Storage provides both 

Real (MW) Power and 

Reactive (MVVAR) Power 

locally
Storage Technologies for Potential Application in California
Energy Storage
protects the Consumer
and Stabilizes the Grid
<table>
<thead>
<tr>
<th><strong>POWER</strong></th>
<th><strong>ENERGY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Seconds</td>
<td>diurnal</td>
</tr>
<tr>
<td>PQ, Digital Reliability</td>
<td>Peak Shaving to Avoid Demand Charges</td>
</tr>
<tr>
<td>Voltage Support, Transients</td>
<td>Mitigation of Transm. Congest. Spinning Reserve</td>
</tr>
<tr>
<td>DER Support for Load Following</td>
<td>Dispatchability for Renewables, Micro Grids</td>
</tr>
</tbody>
</table>

**ENERGY STORAGE APPLICATIONS**
Power Quality for a Microchip Plant

10 MW / 15 sec  Lead - Acid System in Arizona
Voltage Regulation and VAR Support for Golden Valley, Alaska Utility

27 MW / 14 MWh NiCd Batteries – 10MVAR at Rest!
Integration of Energy Storage, Loads, Wind, Hydro, and Engine Generation for a Palmdale, CA Water Treatment Plan Microgrid

**GENERATION:**
- 950 kW Wind Turbine (Average!)
- 2 x 225 kW Energy Bridge Ultracaps
- 800 kW + 350kW Backup Diesel
- 250 kW Natural Gas Backup Generator
- 244 kW Hydroelectric Generator

**LOAD:**
- 320 kW Critical Load
- 930 kW Non-critical Load

A Project of the CEC / DOE Energy Storage Initiative
Peak Load Management for a Japanese Resort Town

6 MW / 8hrs  Sodium-Sulfur Batteries at Ohito
Spinning Reserve and Transient Management for the Puerto Rico Island Grid

20 MW / 14 MWh   New: 10MW Tubular L / A Batteries
STATE INITIATIVES:

CEC / DOE:

- ZnBr for Substation Congestion Management (PG&E)
- Flywheels for Frequency Regulation (CAISO, PG&E)
- Supercaps for Microgrid Wind Support (Palmdale Water Distr.)

NYSERDA / DOE:

- NaS for Large Consumer Load Shifting (LIPA)
- Flywheels for Frequency Regulation and Consumer PQ

Details in IEEE Power & Energy Magazine, March 2005
Storage Benefits, California

- T&D Congestion
- Ancillary Services
- T Access Charge Reduction
- T&D Support
- Renewables Firming
- Central Capacity
- Arbitrage
- Customer Reliability
- Demand Charge Reduction
- Transmission Upgrade Deferral
- Renewables Time-of-Production Payments
- D Deferral – median CA cost
- End-user PQ
- DUA Associates

U.S. = 8 x CA single benefit!
Storage Potential, California

U.S. = 8 x CA single benefit!
CONCLUSIONS:

• Energy Storage has an Essential Role in a Modernized, more Stable Grid

• Storage Technology is developing more Options and more potential Applications

• The Importance of Storage is becoming increasingly Accepted
Energy Storage Meetings:

• ESA Annual Meeting
  May 23-25, 2005   Toronto
  http://www.electricitystorage.org

• EESAT 2005 (Electric Energy Storage Applications and Technology)
  October 17 – 19, 2005   San Francisco
  http://www.sandia.gov/eesat
Contacts and Resources:

• Sandia National Laboratories (Boyes) Report Archives, News, Solicitations:
  http://www.sandia.gov/ess

• EPRI / DOE Handbook

• EPRI Storage Task Force (Schainker, Eckroad)