Field Test Data and Examination of VRLA Battery Cells Sampled From The Metlakatla Alaska and Vernon, CA Battery Energy Storage Systems

U.S. Department of Energy

ESS Research Annual Peer Review

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GNB Industrial Power

Division of Exide Technologies

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Contracted for the U. S. Department of Energy by Sandia Corporation

- **Sandia National Laboratories PO 40767**
  - **GNB Industrial Power, Lombard IL**
  - **Performance period August 2002 - December 2003**
  - **Sandia Project Representative, Rudy Jungst**

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Presentation Outline

- Objectives of the project
- Brief description of the BESS sites
- Potential impacts of the project
- Main Tasks
- Timing

Project Objectives

- Studies to be conducted by GNB in cooperation with Metlakatla Power and Light and Exide Technologies
- Aging and Surveillance of VRLA battery systems operating in BESS having different duty cycles
- Identify any battery deterioration
- Assess estimates of battery lifetime
- Identify economic benefits for storage

Site Location # 1

- City of Vernon, California Industrial Plant
  - Lead recycling center
  - 5 MVA @ 4160 Vac (substation)
  - BESS operating on the demand side of meter
  - Battery cells manufactured 12/94 - 3/95
  - In service November 1995
  - Daily cycling with emergency reserve capacity
  - Battery life expectancy initially 8-years

Site # 1 Vernon

- Originally conceived as a UPS for orderly shutdown plant to prevent toxic emissions and prevent EPA fines.
- Also used for peak-shaving to reduce spikes and reduce draw from utility during times of highest electrical rates.

Vernon BESS

- Battery Layout
  - 2 Parallel strings
  - 378 Modules per string
  - 3 100A33 VRLA cells in parallel per module
  - Total 2,268 2-volt cells
  - Horizontal stacks 8 modules high
  - Seismic Zone 4
  - Nominal 756 Vdc
  - 3.38 MWh @ 1 hour rate

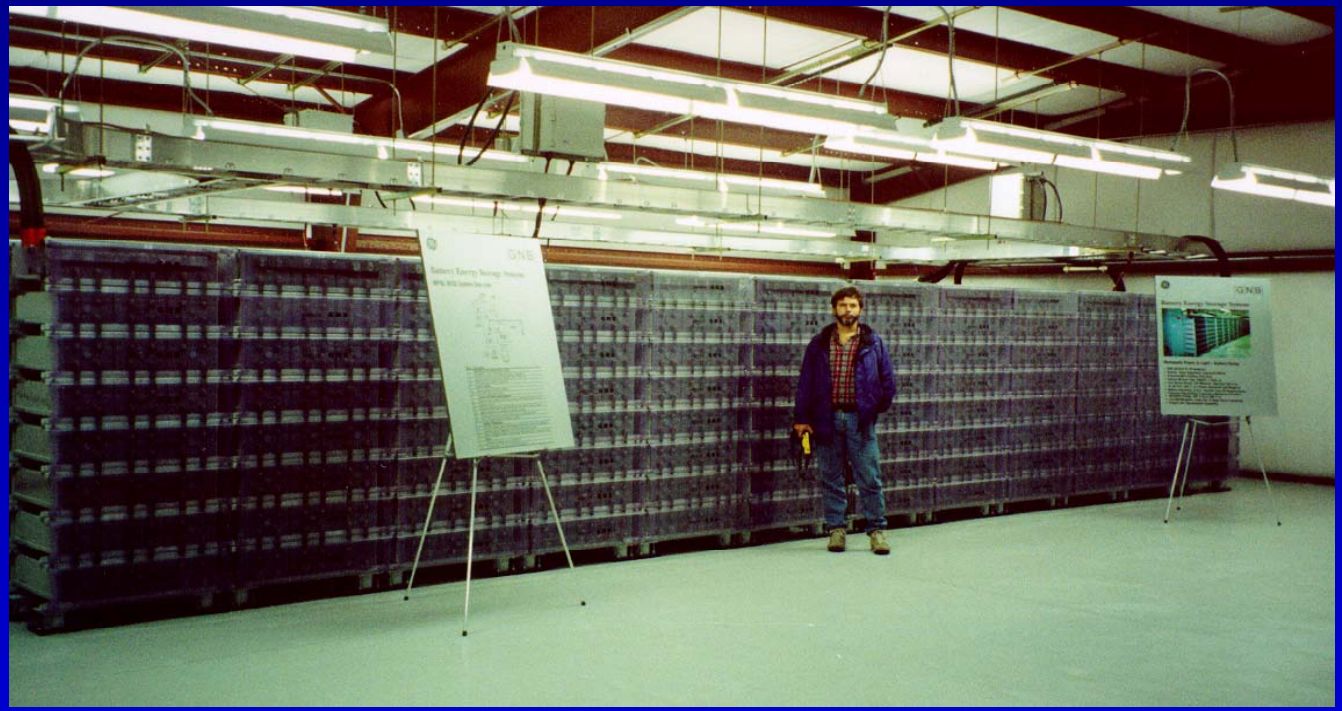
Site # 2 MP&L

- Island community at the southern tip of Alaska
- Serves 800 residents plus a commercial cold storage and cannery facility and a lumber mill
- Primary electrical sources are two rain-fed reservoirs feeding 4 hydro electric generators producing up to 4.0 MW of power
- System encountered brown-outs, overvoltage and frequency fluctuation

The Metlakatla "MESS"

- Installed in 1988 a 3.3-MW diesel generator
- Typically operated at 20% capacity to handle load swings.
- Diesel accounted for 55% of system load
- Overall poor efficiency
- Fuel usage 1989 -1996
  - 4.13 million gal cost $2.8 million
  - Additional $ 1 million in scheduled maintenance
- System problems persisted

MP&L BESS

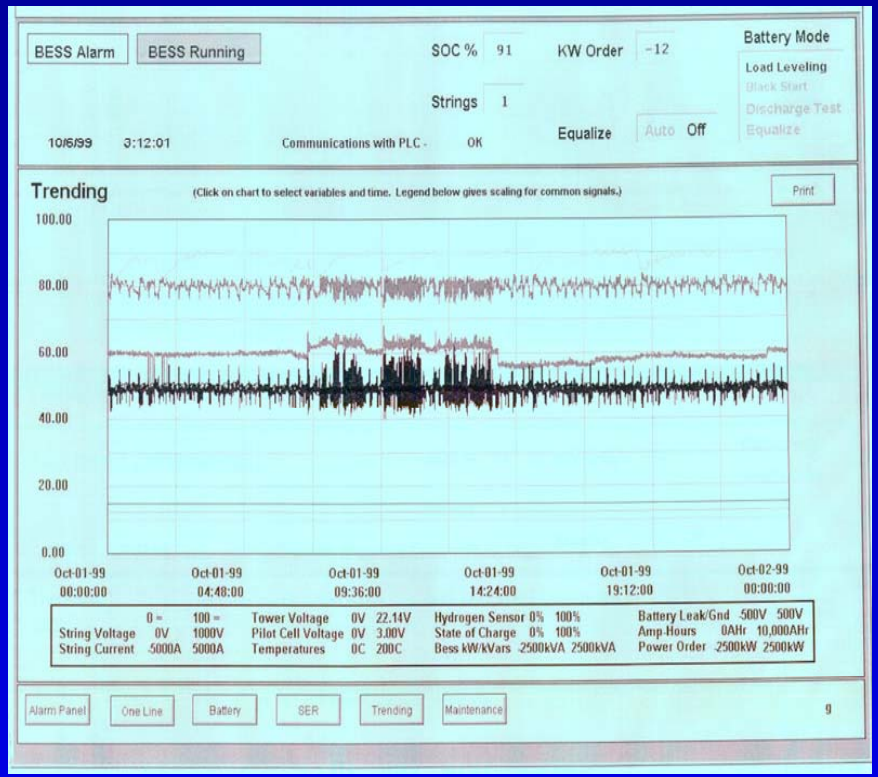


- **Battery Layout**
  - 1 string 378 100A75 modules (3-100A25 cells in parallel)
  - Total 1,134 2-volt cells
  - Nominal 756 Vdc, 1.27MWh at 1 hour rate

The Metlakatla BESS

- MP&L now uses only hydro supplemented by the BESS
- Generation control computer adjusts hydros to maintain battery at 80% state-of-charge
- Fuel savings alone results in 3-year payback
- Diesel is used only during BESS and hydro electric maintenance

The Metlakatla BESS



- BESS continuously supplies power for intermittent loads and accepts excess power to avoid overvoltage conditions
- Battery equalized only semi-annually
- Battery cells have been subjected to over 1 million hits, voltage swings

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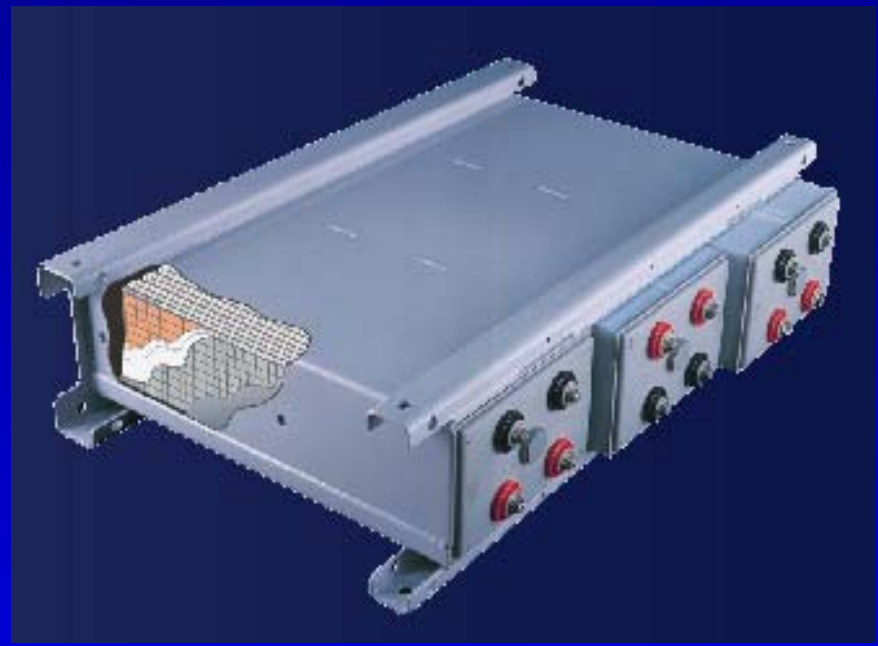
Battery Life Expectancy

- BESS Operations
  - Not pure float
  - Not pure cycle
  - Combination of Both
- Projected Life Basis
  - Float: Ah of Overcharge
  - Cycle: Ah of Throughput
- Will both Vernon and MP&L meet warranty projections?



Potential Impact of Project

- BESS can be a reasonable solution provided batteries achieve lifetimes used to justify costs
- Battery systems can solve other utility power quality issues
- Evaluation of *"unconventional"* approaches to battery operation.
- Viability of large, high-voltage VRLA systems use in other Battery Energy Storage Projects

Project Tasks

- Data monitoring and analysis
- Battery cell examination
- Additional battery cell electrical testing
- Cell component examination
- Economic benefits for storage

Battery Cells Examination

- Electrical Performance
  - 1st. time for Vernon
  - 2nd. Time for MP&L (Oct 1999 / 32 months)
  - As-sampled measurements
    - OCV, impedance, weight, external appearance
  - Discharge capacity tests
    - Charge Ah in, discharge Ah out, % rated @ C/8
    - Capacity increase
  - Other electrical tests
    - Rate characterization, float charge test, discharge throughput

Additional Electrical Testing

- Rate Characterization (Peukert)
  - Tested at C/1 to C/48 rates
  - Average compliance to specification: 105.6%
- Float Charge Test (Tafel)
  - 2.25 vpc at 25ºC: Float current = 55 mA/100Ah
  - Typical float current: 45 - 55 mA/100Ah
- Discharge Throughput (Cycle Life)
  - Total Discharge: 745,735 Ah
  - Equivalent Cycles: 259 at 80% of C/8 Capacity
  - % Lifetime Throughput: 21.6%

Cell Component Examination

- Vernon and MP&L VRLA cells
  - Negative plates
  - Positive plates
  - Positive grid
  - Separator and electrolyte
  - Internal lead hardware

Economic Benefits for Storage

- Vernon
  - peak demand reduction
  - savings
  - emergency power value (UPS)
  - battery replacement
- MP&L
  - savings in fuel and maintenance costs
  - efficiency improvements
  - environmental benefits
  - Battery replacement

Project Tasks and Timeline MP&L

1. Enable communication with DAS	Done
• modem, software	x
2. Replacement cells	x
3. Site visit	x
• pull test cells	x
• install replacements	x
• update communication link	x
4. Cell testing, analysis	12/02 - 03/03
• electrical testing and cycling	12/02 - 01/03
• tear downs	02/03
• chemical analysis	02/02 - 03/03

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Project Tasks and Timeline Vernon

5. Enable communication with DAS	Done
• modem, software	X
6. Vernon - order replacement cells	X
7. Vernon site visit	X
• pull test cells	01/03
• install replacements	01/03
• update communication link	X
8. Vernon cell testing, analysis	02/03 - 05/03
• electrical testing and cycling	02/03 - 03/03
• tear downs	- 04/03
• chemical analysis	04/03 - 05/03

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Project Tasks and Timeline

9. Data collection and analysis — on-going
10. Reporting
    - monthly — 09/02 - 12/03
    - final report — - 12/03