# VRLA ENERGY MANAGEMENT SYSTEM ANALYSIS

DOE  Peer Review
Energy Storage Program
Crystal City, VA Nov. 2001

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# Battery Energy Storage Systems: Perception

- It’s Old News
- Systems Don’t Meet Expectations
- VRLA Technology in Question

# Battery Energy Storage Systems: Reality

- VRLA Technology Is Being Demonstrated
- 7+ Years of Operational History
- Demanding Utility and Industrial Applications
- Ongoing Improvements in VRLA Process & Product Design (DOE Sponsorship)
- Improved Equipment and Controls
- DOE Top 100 Award

# Presentation Overview

- Objectives / Background
- Battery Operation and Life
- Operational Economic Analysis
- Future Activities

# Objectives

- Demonstrate Performance and Benefits of GNB ABSOLYTE IIP VRLA Battery Cells for Utility & Industrial Applications.
  - 1995 Vernon (5-MVA)
  - 1996 MP&L (1.2-MVA)

- Identify Economic Benefits Using Battery Energy Storage.

# Vernon BESS Background

- Lead Smelter: Battery Recycling
- Near Los Angeles, CA
- California Air Resources Board

# Vernon BESS Project

- Primary: Critical Load Backup
  - Environmental Restrictions
  - Load Shedding System
- Secondary: Energy Management
  - Demand Cost Reduction
  - Deferred Energy Costs

# Vernon Battery

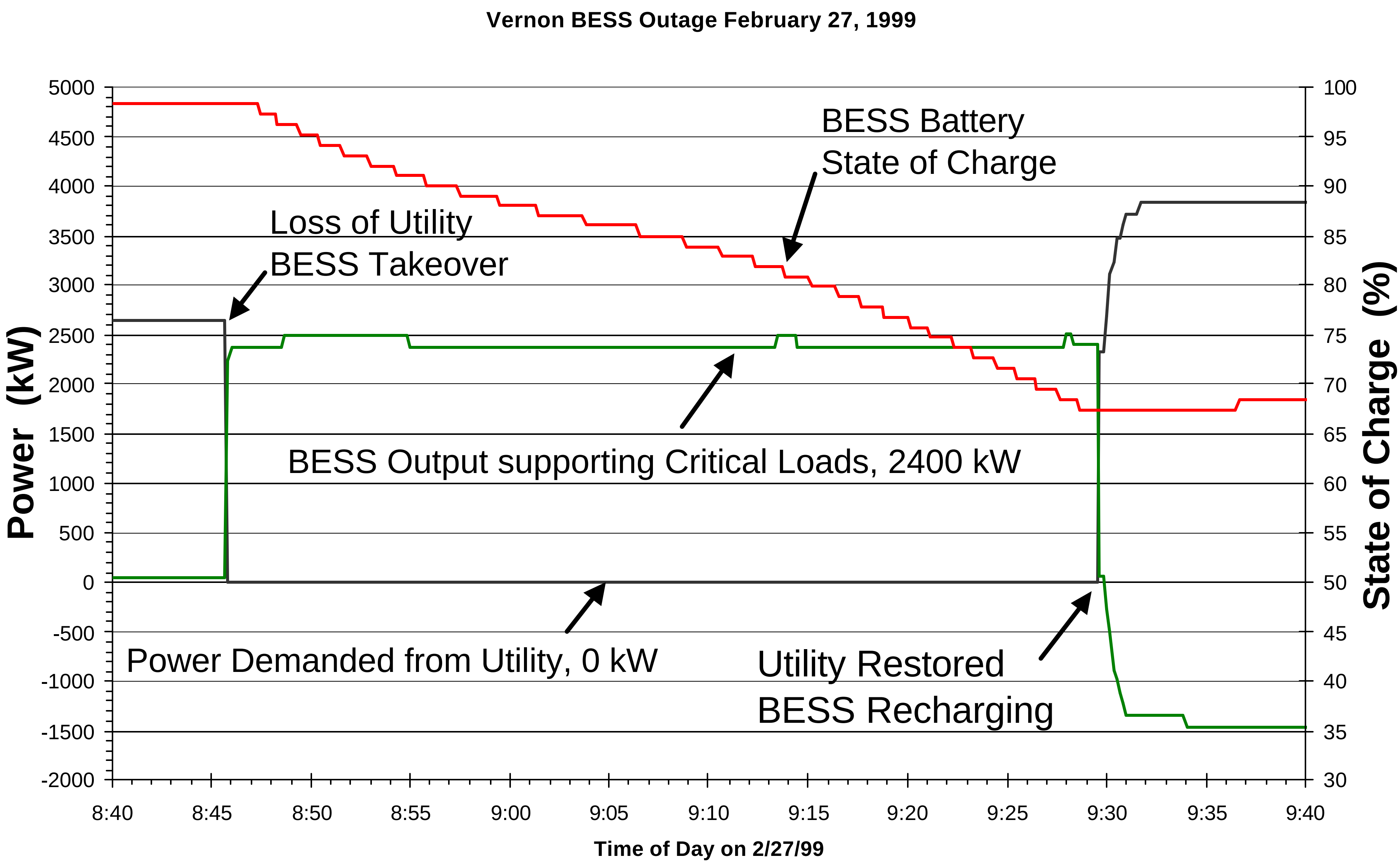
- First Large, High Voltage VRLA System
- Absolyte IIP Battery Cell Design
  - Valve Regulated Lead Acid (VRLA)
  - Absorbent Glass Mat (AGM)
- System Capacity
  - 5 Megawatt Peak Power
  - 3.5 Megawatt Hours
  - Operating Range 600 - 900 VDC

# Absolyte IIP VRLA Battery

- Layout
  - 2 Parallel Strings
  - 378 Modules per String
  - 3 100A33 Cells in Parallel per Module
  - Horizontal Stacks of 8 modules, Seismic Zone 4
- Cells Built in 1995

# Vernon Battery Operation

- Primary Function:
  Critical Load Backup
  Carried Load through 6 Outages

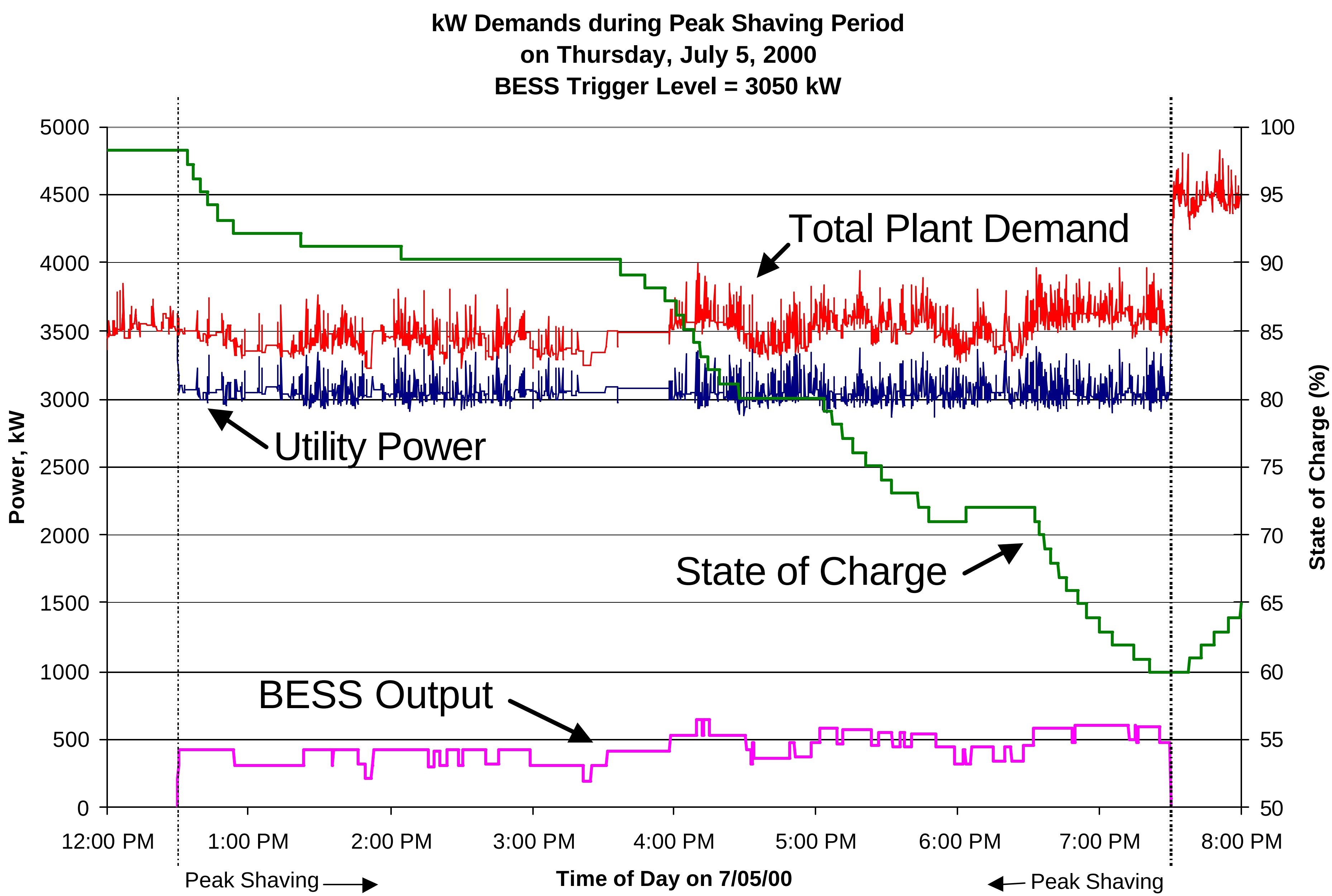


Vernon BESS Outage February 27, 1999
Power (kW)
State of Charge (%)
Time of Day on 2/27/99
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
8:40
8:45
8:50
8:55
9:00
9:05
9:10
9:15
9:20
9:25
9:30
9:35
9:40
BESS Battery State of Charge
Loss of Utility BESS Takeover
BESS Output supporting Critical Loads, 2400 kW
Power Demanded from Utility, 0 kW
Utility Restored BESS Recharging

# Vernon Battery Operation

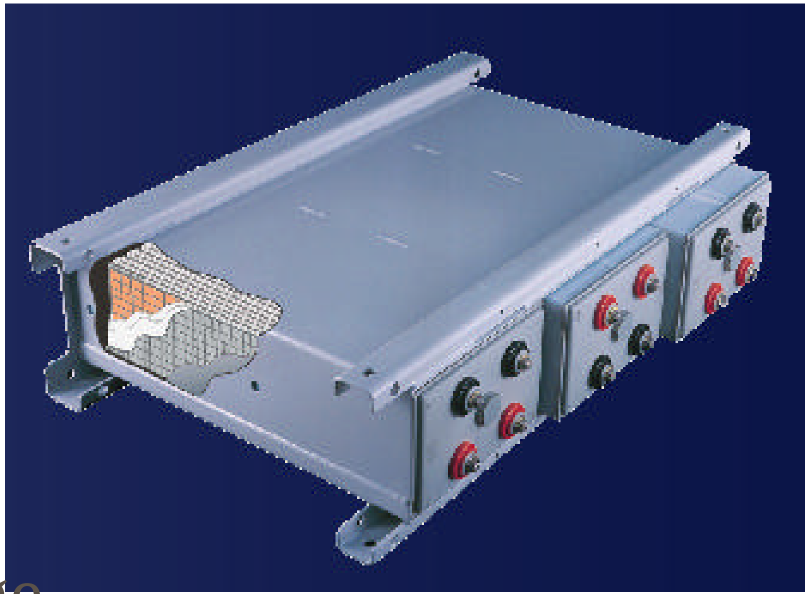
- Primary Function:
  Critical Load Backup

- Secondary Function:
  Energy Management



kW Demands during Peak Shaving Period
on Thursday, July 5, 2000
BESS Trigger Level = 3050 kW
Total Plant Demand
Utility Power
State of Charge
BESS Output
Power, kW
State of Charge (%)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
100
95
90
85
80
75
70
65
60
55
50
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
Time of Day on 7/05/00
Peak Shaving
Peak Shaving

# 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

# Float Life Calculation based on a 20-year Life

- Hours of Design Life (175,320 hrs)
  * Normal Float Current (2.16 A)
  = 378,691 Design Ah of Overcharge
- Actual Overcharge (136,520 Ah)
  ÷ Design Life (378,691 Ah)
  = 36% of Total Life Consumed
- Actual Years of Operation (6 years)
  ÷ % of Total Life Consumed (36%)
  = 16.6 Years of Total Projected Life

# Cycle Life Calculation based on 1200 cycles at 80% Depth of Discharge

- Cycles (1200) * Depth of Disch (0.80)
  * C/6 Capacity (4500 Ah)
  = Design Ah Throughput (4.32 MAh)
- Actual Throughput (769,823 Ah)
  ÷ Design Throughput (4.32 MAh)
  = 18% of Total Life Consumed
- Actual Years of Operation (6 years)
  ÷ % of Total Life Consumed (18%)
  = 33.7 Years Total Projected Life

# Vernon vs. Metlakatla Power & Light

| Operating Parameters | Vernon | MP&L |
| --- | --- | --- |
| SOC | 100% | 80% |
| Ah Overcharge | 136,000 | 0 |
| Equiv. 100% DOD Cycles/Mo | 2.4 | 5.8 |
| Governing Failure Mode | Overcharge | Throughput |

# Battery Life Projections

- Ah Overcharge
  - Vernon ~16 years
  - MP&L (Partial SOC, No Overcharge)
- Ah Throughput
  - Vernon ~34 years (Overcharge Will Limit)
  - MP&L ~14 years

# Battery Life Projection Verification

- Need to Verify Life Projections
- Postmortems for Data Correlation
  - Vernon 0 points, MP&L 1 point
- Need to Develop End of Life Predictor

# Economic Analysis

- Energy Management
  - Demand Reduction Aspect

# Vernon Smelter Electricity Costs

- Annual Expenditure
  $1.2 -> $1.4 Million
- 30% of Cost from Peak kW Demand
- Opportunity for Cost Reduction

# Economic Analysis

Net Cost Avoidance =

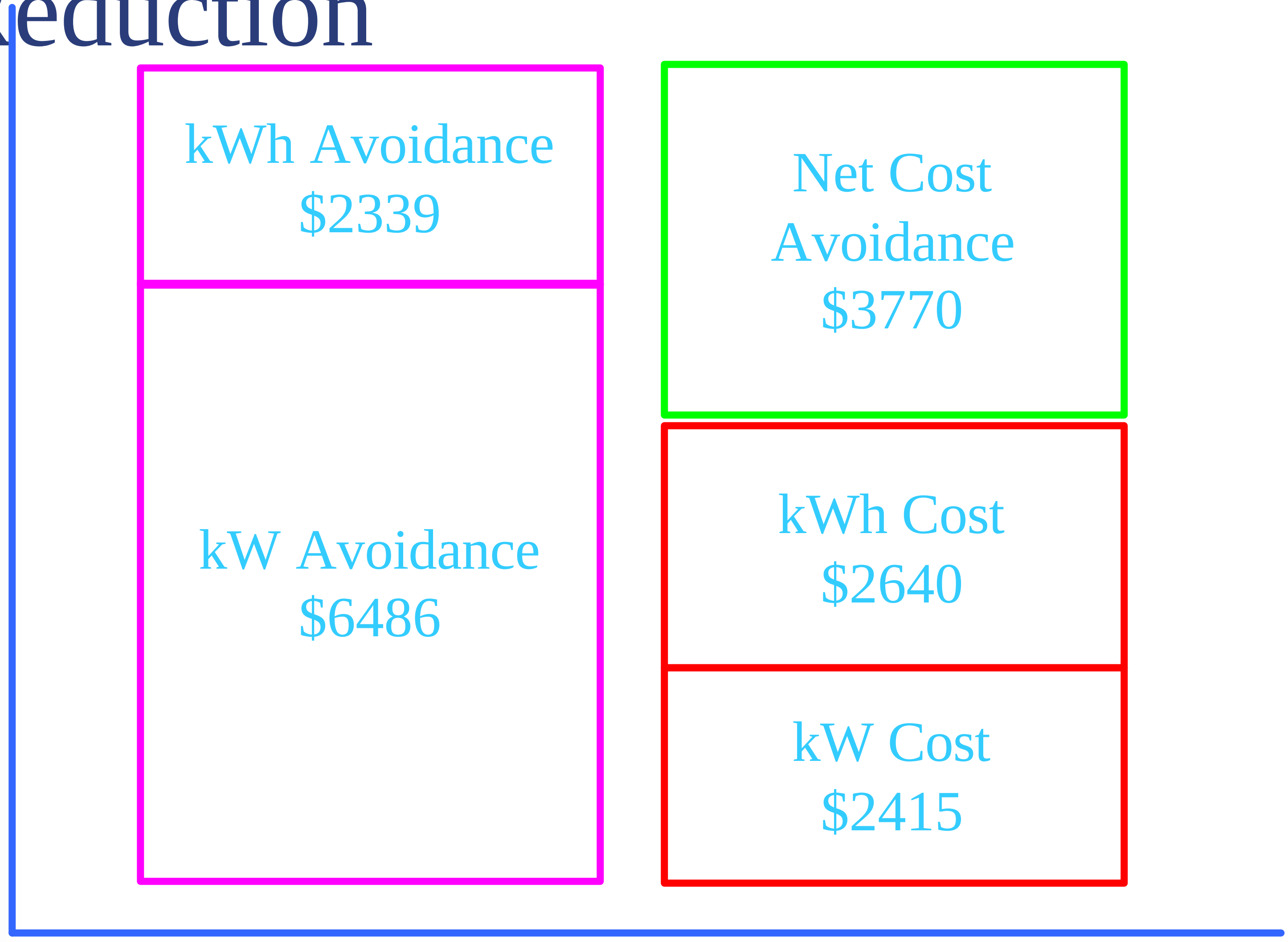
Avoided On Peak kW Demand Cost

\+ Avoided On Peak kWh Cost

\- Additional Mid Peak kW Recharge Cost

\- Additional Mid/Off Peak kWh Cost

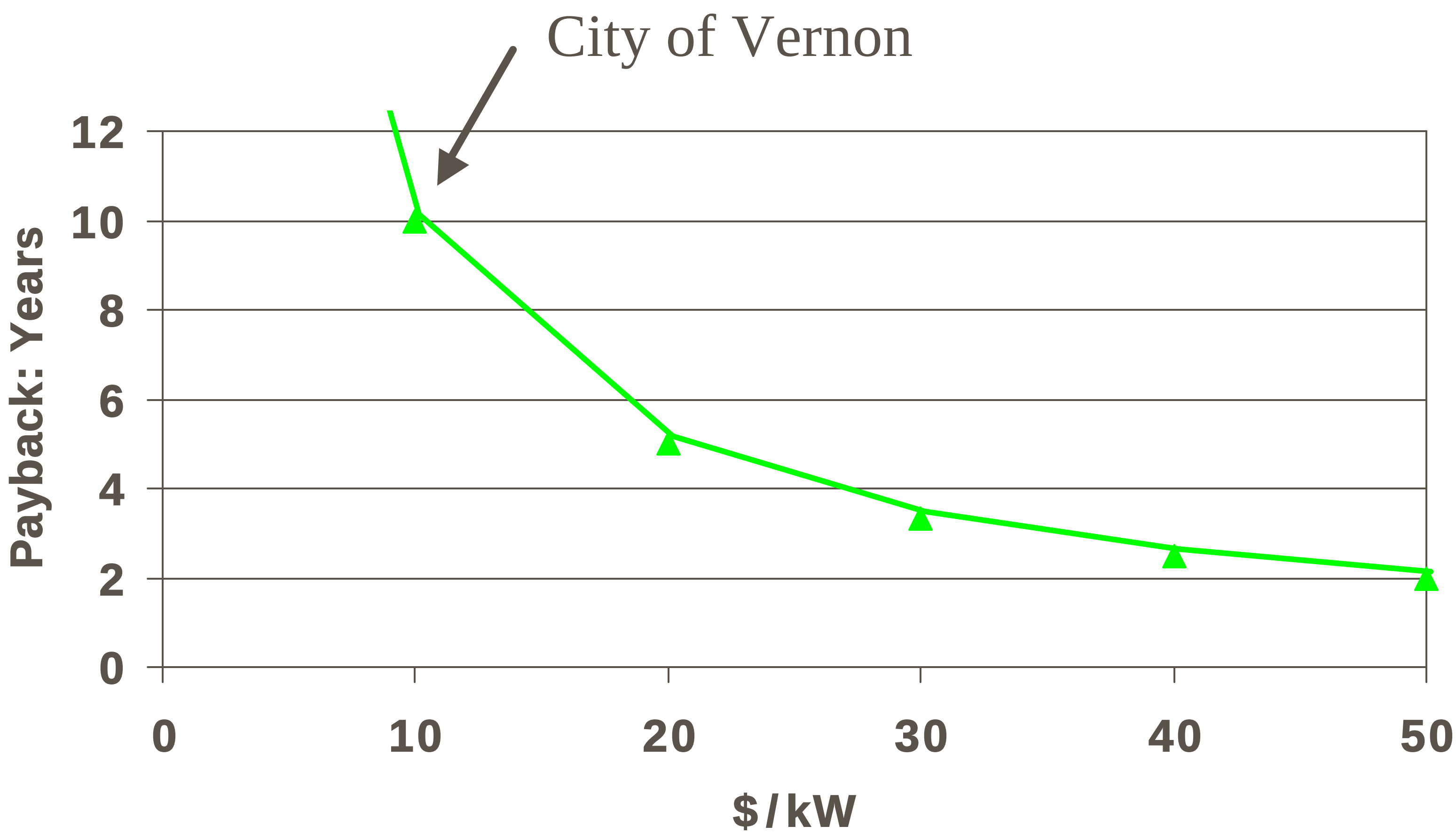
# Example Economics : Summer-High Demand Monthly Cost Reduction



# Results of Economic Analysis 3.5 Megawatt Hour System

- Primary Function = Critical System Backup Achieved
- Measured Individual Month
  $4,000 - $7,000 Cost Avoidance
- FY2000 $31,000 Cost Avoidance
- 10 year Payback for Energy Management Capability (1 Battery String) given Current Rate Structure (Low Cost Vernon)
- One Lost Day Can Reduce Cost Avoidance

# Effect of Rate Structure on Payback Period



# Conclusions

- Critical Loads Protected
- Demand Reduction Provides Cost Avoidance
- Absolyte IIP VRLA Chemistry Works in Energy Management Systems
- Demonstrated in Utility and Industrial Applications
- Battery Life Meeting Expectations

# Future Activities

- Continue Battery Field Data Collection
- Battery Inspections, Testing, and Postmortems: Additional Data Points
- R&D to Improve Performance and Life
- Optimize Software Control to Reduce Battery Recharge Costs

# Future Activities

- Utilize Intelligent Monitoring System to Develop Operational Database
- Refine System Data Analysis Tools
- Energy Storage Workshop to Heighten Understanding and Visibility
- Intelligent Energy Management Controls
- New Site for Next Generation BESS

# Acknowledgements

- DOE Sponsorship
- Sandia National Laboratories
  - Rudy Jungst Project Manager
- GNB Team
  - George Hunt
  - Joe Szymborski
  - Christopher John (cjohn@gnb.com)