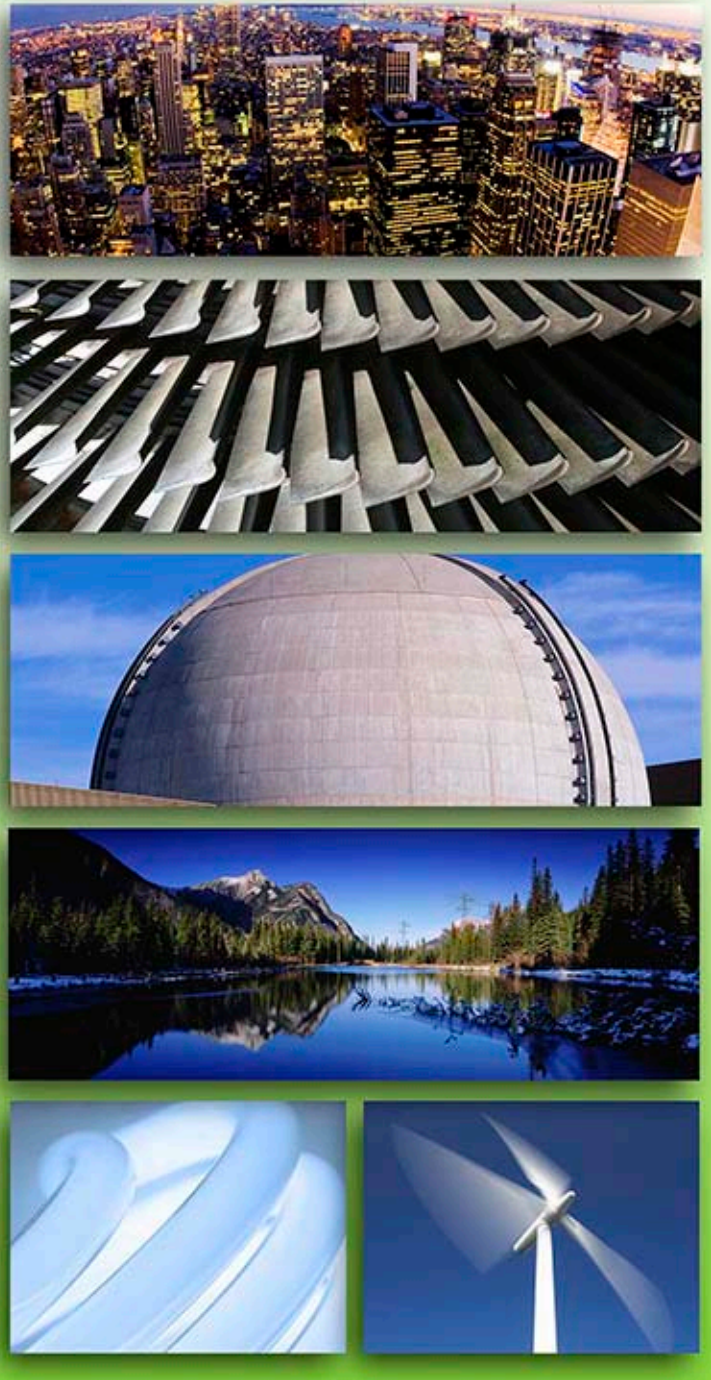

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Long Island Bus NaS Battery Energy Storage Project

U.S. DOE Peer Review

Seattle, WA

October 8, 2009

Steve Eckroad

Electric Power Research Institute

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Acknowledgements

- US DOE and NYSERDA
  - Imre Gyuk and Joe Sayer
- New York Power Authority
  - Chuck Herman and Guy Sliker
- NGK
  - Hiroyuke Abe
- EPRI funders
  (Con Edison, CPS Energy, HECO, Hydro One, NYISO, SDG&E, and TVA)

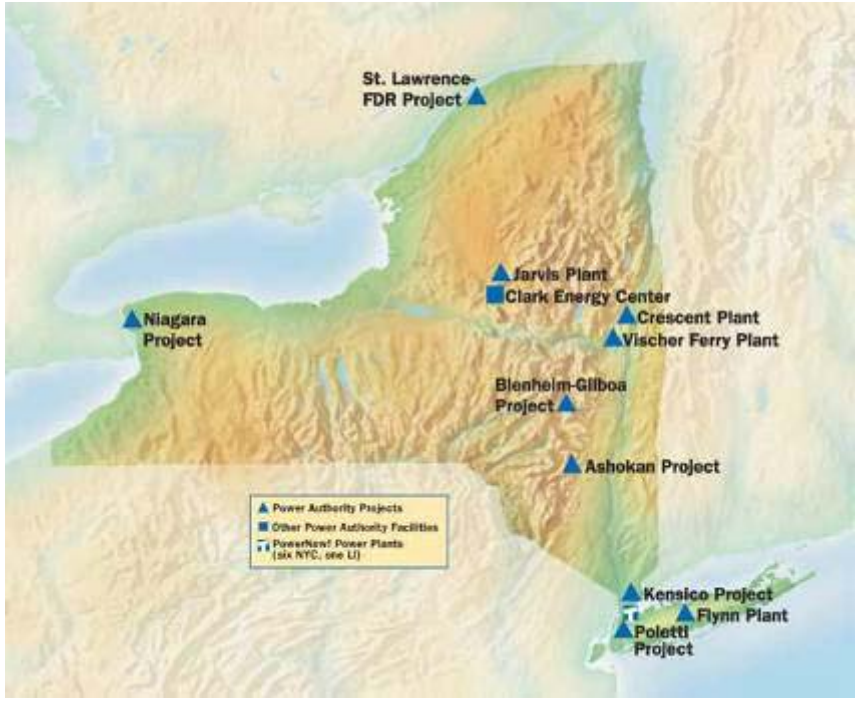
This project is part of the joint energy storage initiative between the New York State Energy Research and Development Agency (NYSERDA) and the Energy Storage Systems Program of the U.S. Department of Energy (DOE/ESS) and managed by Sandia National Laboratories (SNL). Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC84-94AL85000.

Project Team

- NYPA – Overall project implementation
- MTA/Long Island Bus – Host site, end user
- LIPA – Grid Integration, technical assistance
- NGK Insulators, Inc. – NaS battery manufacturer
- ABB – PCS, controls, design and installation
- DOE/NYSERDA – Project funding, guidance
- EPRI – Project funding, technical assistance, technology transfer
- Enernex – Performance monitoring

New York Power Authority

- A public benefit energy corporation founded 1931
- Largest non-federal public electric utility in United States
- NYPA owns and operates 17 power plants and 1,400 circuit-miles of transmission lines, and supplies one-fifth of New York State's electricity.



LI Bus Is an Electric Customer of NYPA and Distribution Customer of LIPA

Garden City Maintenance Yard – Electric Load

- Natural gas refueling station for 220 buses
- 3 x 600 HP electric compressor load
- Dedicated LIPA feeder
- 3-shift operation avoids high electric costs but increases administrative cost

New York Power Authority

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Research Objective

- Deploy an energy technology that can reduce electric bills and lower operating costs for customer
- Demonstrate long term, commercial operation of a high-efficiency peak shift energy storage system
- Reduce peak demand on the heavily loaded utility grid
- Increase back up power for the bus fueling to meet regional emergency response plan

Energy Storage Solution

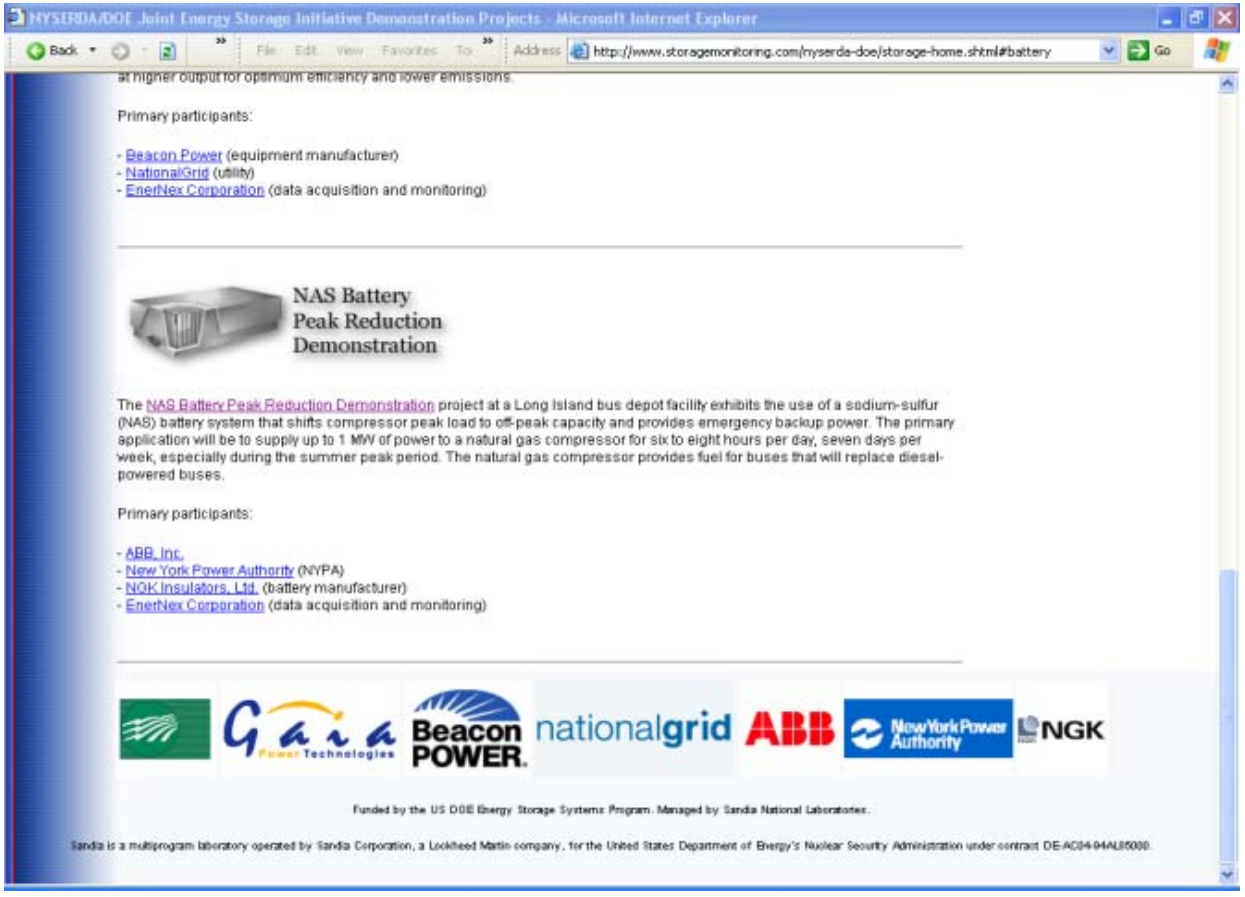
- 1.0 MW, 6.5 MW-hrs NGK NaS battery
- Grid parallel configuration
- Automated load shift
- 75% system efficiency
- Low maintenance
- Low noise
- Zero emissions

Project Scope of Work

- Battery modules and enclosure
- Power Conditioning System (PCS)
- Balance of Plant equipment and enclosures
- System integration with the grid and the load
- Installation, startup, training and commissioning
- Documentation and O&M manuals
- O&M and performance warranty during 18 month demonstration period
- Build for 15+ year life
- System performance monitoring (by DOE-provided DAS)

Public Information Website

www.storagemonitoring.com



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Project Delays During Construction & Start Up

- Interconnection issues with LIPA
- Weather-related delays
- Battery failure resulting from delayed startup
- PCS operational problems and component failures
- Black start capability not possible

Project Timeline
(Red Items Occurring Since Last Peer Review)

- Initial design and project bids – Summer 2005
- All contractual agreements in place – January 2006
- Battery and PCS factory tests – Summer 2006
- Bulk of system installed – Sept. 2006
- Interconnection problems – Oct. 2006 to Nov. 2007
- Battery failure – Dec. 2007
- Installation of (new) battery modules – Mar. to Apr. 2008
- Facility commissioning – Oct. to Nov. 2008
- Continued nuisance trips and DAS problems – Oct. to Dec. 2008
- Customer acceptance and commercial operation – January, 2009

Operational and Customer Issues Since Customer Acceptance

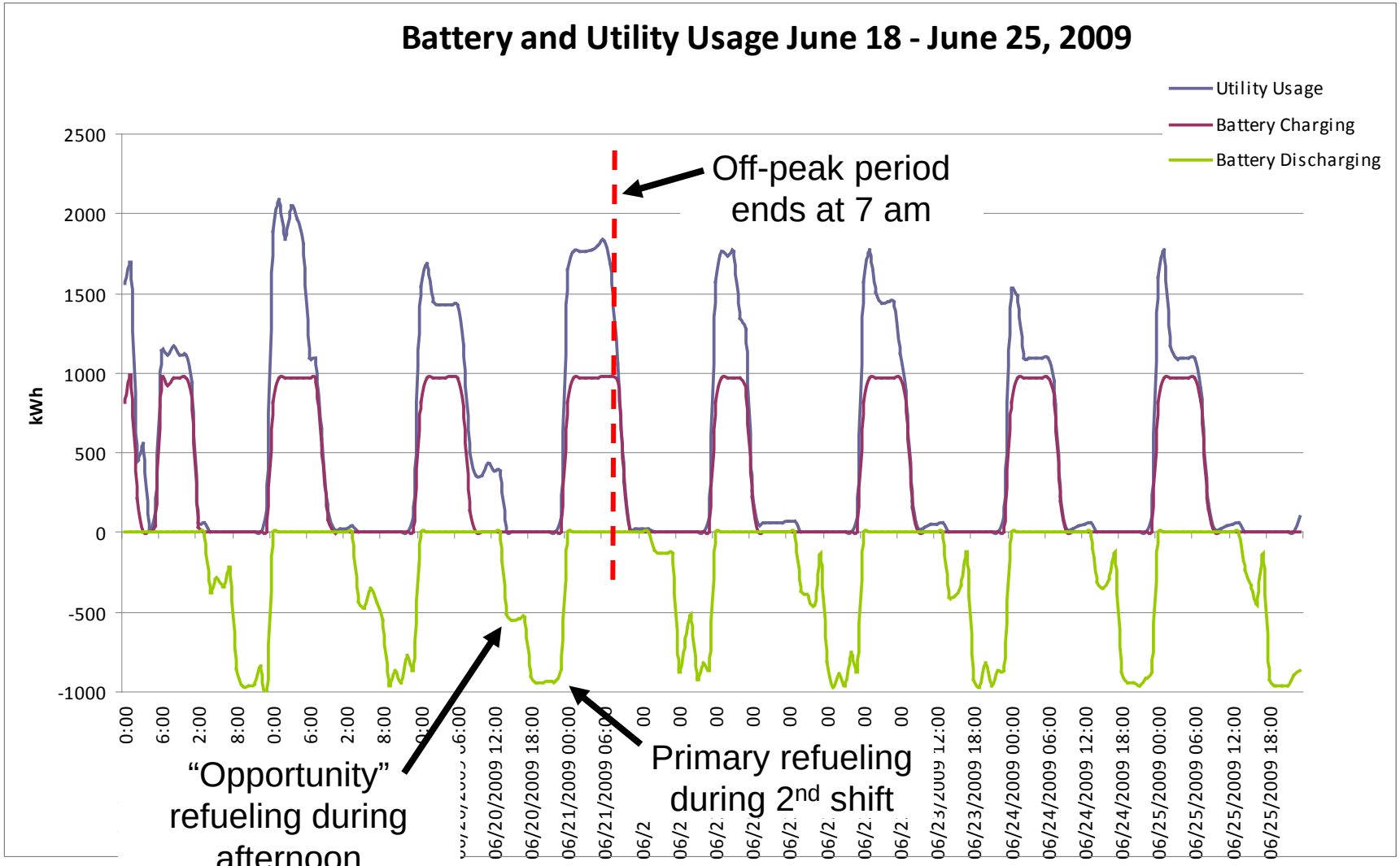
- Data acquisition system and communications link
- Management change in refueling operations
- Mechanical problems with compressors
- Increase in energy costs for 2008 over 2007
- New tariff structure starting July 5, 2009

Revised Bus Refueling Period Leading to Increased Costs and Abusive Discharges

- In 2009, management changes led to primary refueling operations during 2nd shift (6pm – 2am)
- This use delays start of charge such that charge finishes during intermediate peak, attracting increased costs
  - Charge from Midnight to 9:00 am
  - Intermediate peak period starts at 7:00 am

LIPA Tariff	Time	Energy ($/kWh)	Demand ($/kW/month)
I, off peak	Mid-7am	$ 0.0440	$ -
	June - Sep Mon – Sat		
II, peak	10am -10pm	$ 0.0762	$ 34.350
III, intermediate	All other	$ 0.0737	$ 3.420

Current Battery Charge-Discharge Profile



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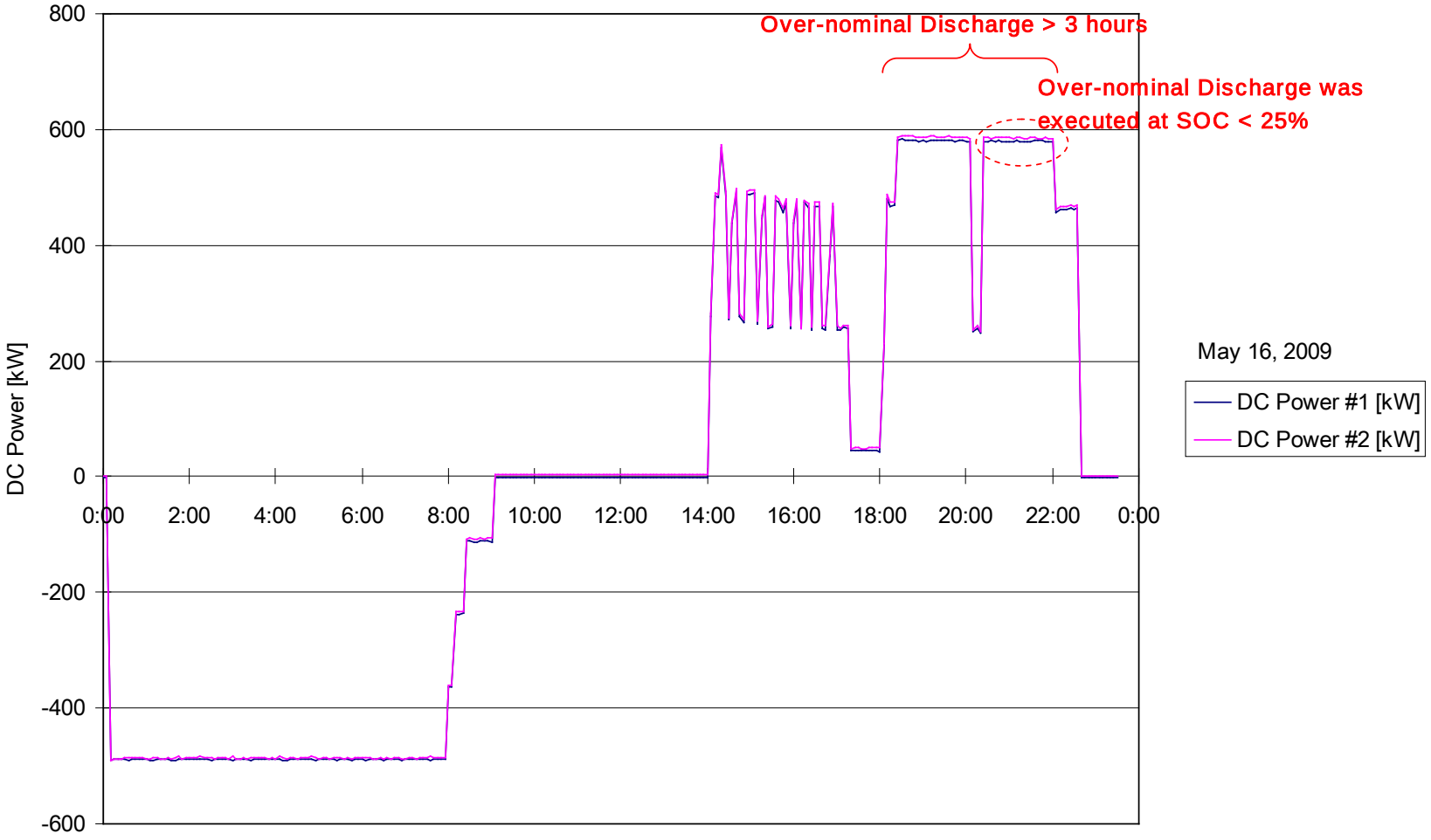
Abusive Over-nominal Discharge



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Compressor Problems Impacting Discharging and Charging Periods

- There are 3 electric compressors and one natural gas powered compressor
  - Initial plan to use 2 of 3 electrics plus the NG unit
  - NG unit has had major periods of outage
- Refueling crews are using 3 electric compressors
  - Battery can feed all 3 at up to 1.25 of nominal power
  - But, 1.25 rating not permitted more than 3 hours
  - Temperatures and SOC exceeding NGK specifications at the end of discharge
- Crews have not responded to management directions
- NGK warning NYPA of cell damage and warranty issues

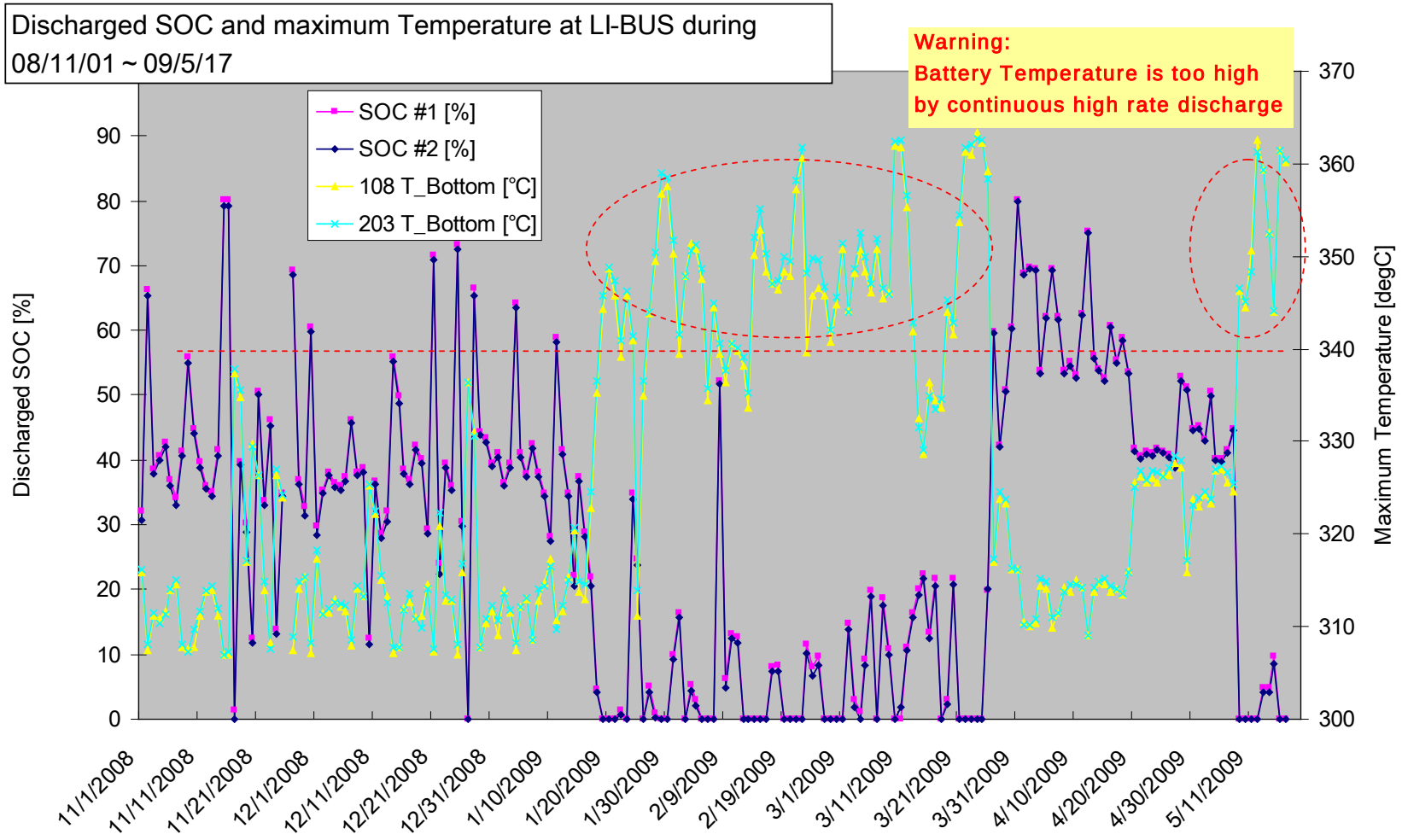
NGK Operations Manual – Excerpt

2.2 *DC Input-and-Output Specifications*

Table 2-2 -- DC Input/Output Specifications

1	Rated Power	DC 1.05MW (nominal) DC 1.26MW for 3 hours (up to 75% DOD)
2	Charge	DC 1.14MW
3	Supplementary Charge:	4 step constant power charge method (4/4P – 3/4P – 2/4P –1/4P)
4	Nominal DC Voltage:	(1) 640V
5	Stored Electric Energy(1)	DC 7.6 MWh
6	DC Voltage Range(1)	Discharge: 465 V Charge: 780 V
7	DC Current Range(1)	-900 to +1400 Amps /Battery Train ("-" Charge, "+" Discharge)
8	Mean Temperature at Start of Operation:	300°C
9	DC Current Ripple	<10%p-p / DC 1.05MW (PCS requirement)
Notes: (1) Including time-related changes over battery life		

Discharged SOC and Maximum Temperature Exceeding NGK-Specified Limits



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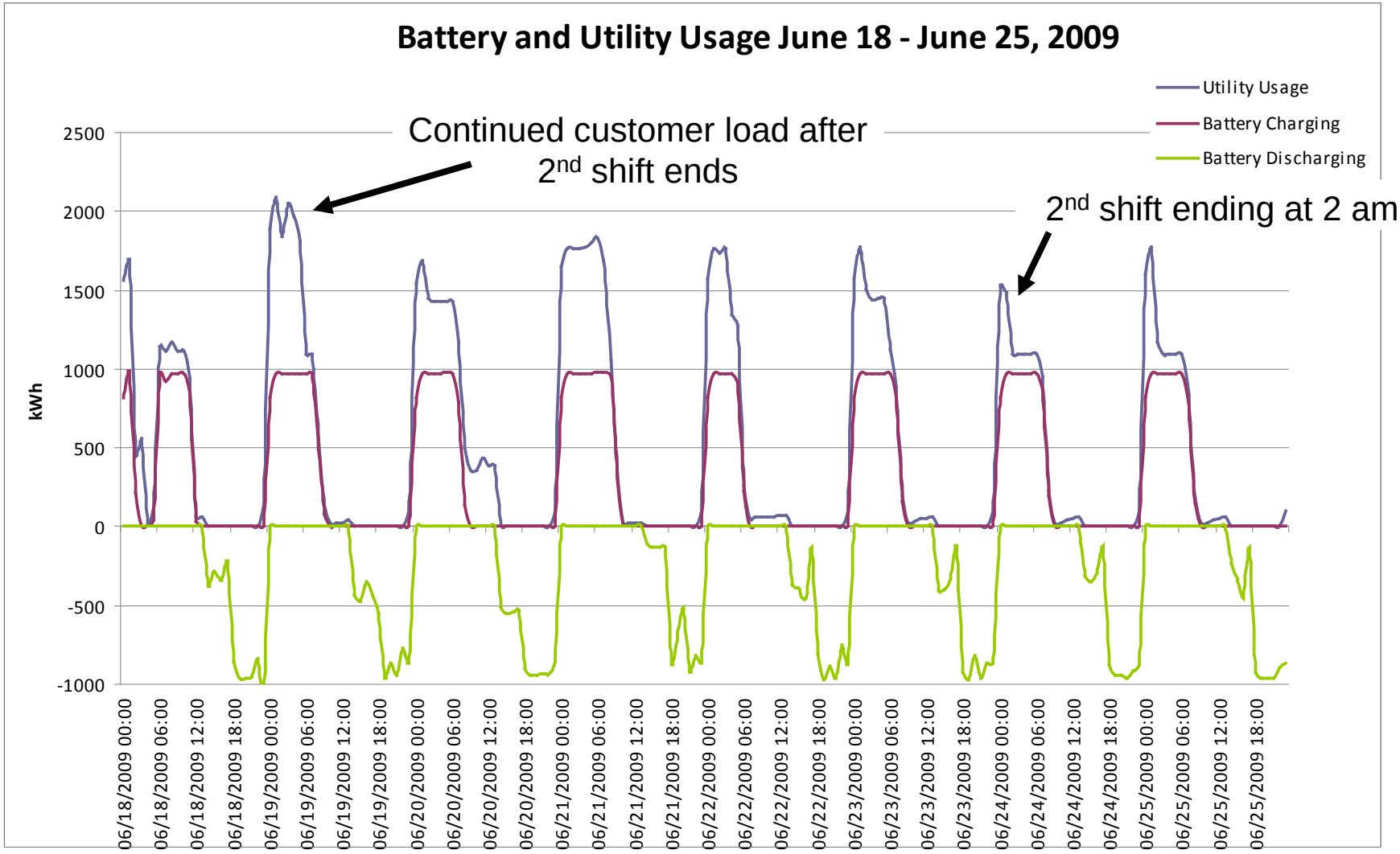
Energy Consumption Issue

- MTA reports 42% increase in energy use and cost between 2007 and 2008
  - NYPA analyzing battery usage to understand why
  - Finding to date: increase only partly due to battery
- Battery operations that contribute to increased cost
  - Operators are charging the battery as much as 20% during the Intermediate peak period
  - Battery system efficiency not as originally expected
- LI Bus operators are continuing to carry out operations during off-peak period
  - NYPA still trying to understand this aspect (not related to the battery)

Use Profile Shows Unexplained Load Beyond Battery Charge Load



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Battery System Efficiency Issue

- Expected efficiency of system = 75%
  - NaS battery DC-DC efficiency = 85% (EPRI Handbook)
  - PCS efficiency = 95%, one-way (ABB)
- Actual measured DC-DC to date ranges 82 – 90%
- Surprise! NYPA told by NGK that heaters run all the time, adding to losses (NGK email 6/23/09)
- Maximum heater power is 60 kW
  - 60 kW x 24 hours = 1440 kWh per day
  - This comes to additional 22%!
  - Probably not the case, but could explain part of increased energy use seen by MTA

NYPA Preliminary Conclusions for Increased Energy Consumption

- Measured battery system cycle efficiency meets or exceeds performance expectations (only DC-DC is measured)
  - Heater use not included in efficiency measurements
- Site energy usage is much higher than expected
  - Compressors left in recirculation mode after end of shift could be a very large factor
  - Increased number of buses being refueled
  - Extended natural gas compressor outage
- Battery cycling schedule to be changed to reflect new tariff rate periods

Changes to Tariff Structure in July May Change Costs

- New tariff in July 2009 may lead to even higher costs under current refueling period operations
- However, new tariff would allow earlier charge start with resulting decrease in intermediate peak charging

LIPA Tariff	Time	Energy ($/kWh)	Demand ($/kW/month)
I, off peak	~~Mid~~ 11pm – 7am	~~$ 0.0440~~ $ 0.0063	$ -
II, on peak	June - Sep Mon – Fri ~~Sat~~ ~~10am - 10pm~~ 12N – 8pm	~~$ 0.0762~~ $ 0.0441	~~$ 34.35~~ $ 38.10
III, intermediate	All other	~~$ 0.0737~~ $ 0.0408	~~$ 3.42~~ $ 3.81

Current Status

- System commissioned and operational
  - Daytime discharge does provide benefits in fueling operation (third shift eliminated)
  - Customer difficulties in understanding and complying with battery discharge limitations
- Data acquisition system seems to be working but communications still subject to outages
- Batteries have completed approximately 351 cycles as of 9/23/2009.
- ABB selected to provide black start capability
  - Will require new PCS to act as variable speed drive
  - Expected to be installed by summer of 2010

Lessons Learned (To Date)

- Need adequate specification of functional requirements
- Need thorough understanding of all stakeholder needs
- Normal project delays can “cascade” to major issues
- NaS technology suitable to application, but modules need initial burn in
- PCS units presented interconnection and operational problems
- Grid parallel operation requirements proved complex and costly at this site
- Remote data acquisition has been major problem
- Customers may desire greater control over discharge and charge regimes