US DOE PEER REVIEW

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Long Island Bus Sodium Sulfur Battery Storage Project

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LI Bus Issues

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

- Peak demand charge for four months of the year: $34.35/kW plus fuel surcharge
- Current 3–shift operation
- High electric bills and administrative charges

Project Goals and Objectives

- Achieve cost savings by eliminating third shift while avoiding peak demand charges
- Increase back up power for the entire facility
- Reduce peak demand on the heavily loaded utility grid
- Demonstrate long term, commercial environment, high efficiency energy storage operation

Battery Storage Solution

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

Why NaS ?

Advantages over DG and other Batteries:

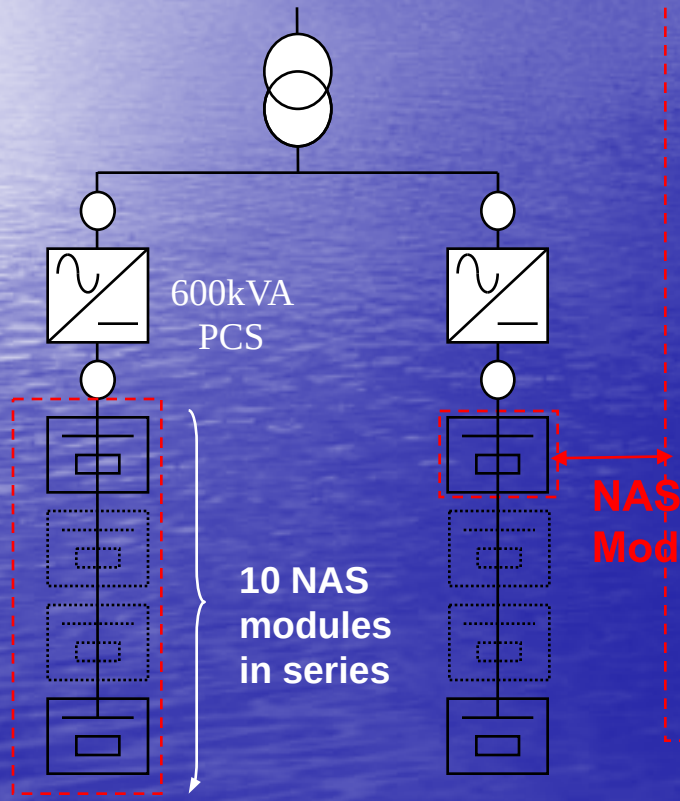
- Ease of Operation & Maintenance
  - No moving parts, long service life
- Minimal Environmental Impact
  - No emissions, silent
- Versatility
  - Peak-shaving, load-leveling, and PQ mitigation
- Relatively Small Foot print
  - High efficiency, energy and power density

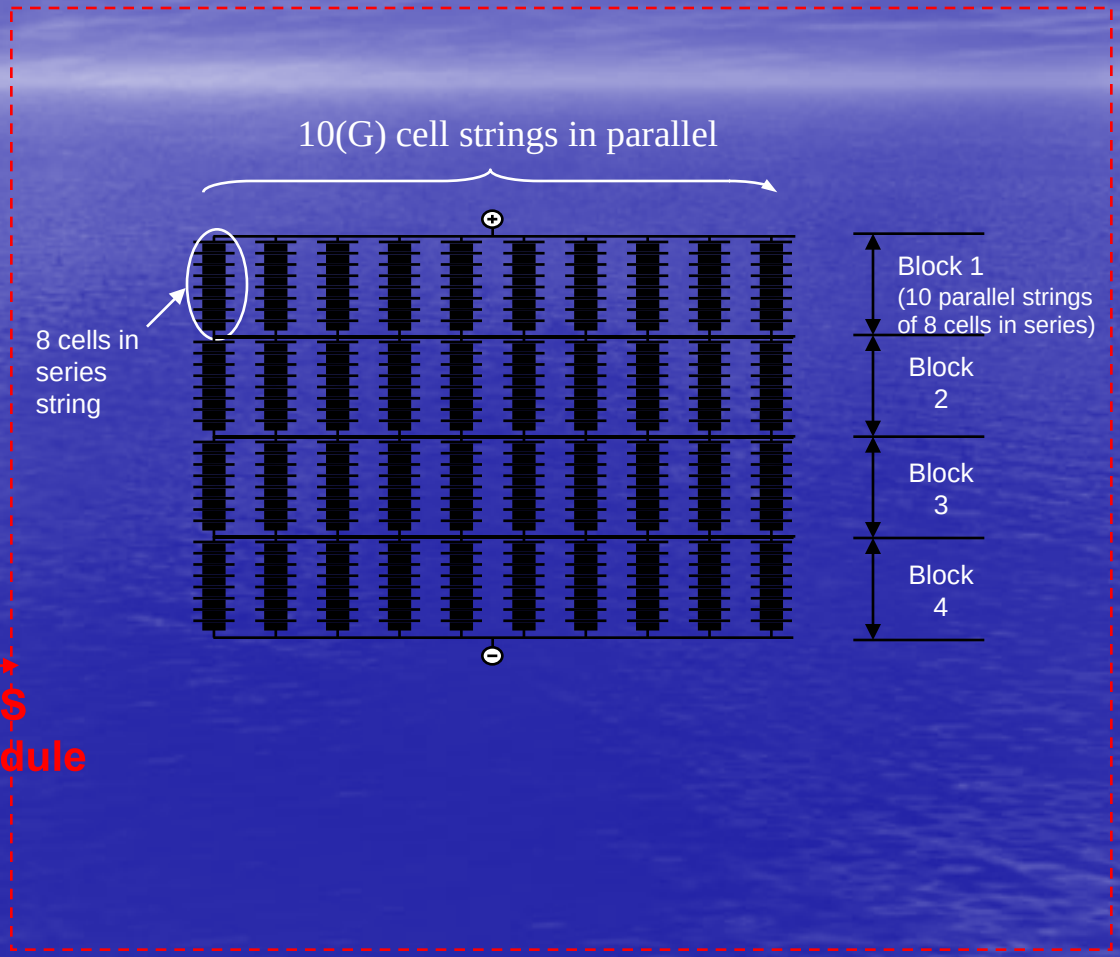
NAS Battery Characteristics

Characteristics	Individual NaS Cell	NaS G50 Battery Modules
Nominal Voltage (dc)	2	64 or 128
Operating Temperature	290 to 360^{0}C	
Cell Arrangement ("s" series; "p" parallel)	Single	(8s x 5p) x 8s or (8s x 10p) x 4s
Electrical Protection	NA	Internal fuse within each 8s string
Rated AC Capacity	628 Ah	360 kWh ac
Rated AC Power	NA	50 kW ac
Projected Calendar & Cycle Life	15 years: 4500 to 90%, 2500 to 100% DOD cycles	
Avg DC Efficiency, %	90	85
Standby Heat Loss, kW	NA	3.4
Dimensions, mm (in)	515L x 91Φ (20.3L x 3.6Φ)	2,270W x 1,740D x 720H (89.4W x 68.5D x 28.4H)
Weight, kg (lb)	5.5 (12.1)	3500 (7920)

1MW NAS Module Configuration

Each NAS module is rated at 50 kW and consists of 320 strings configured as shown



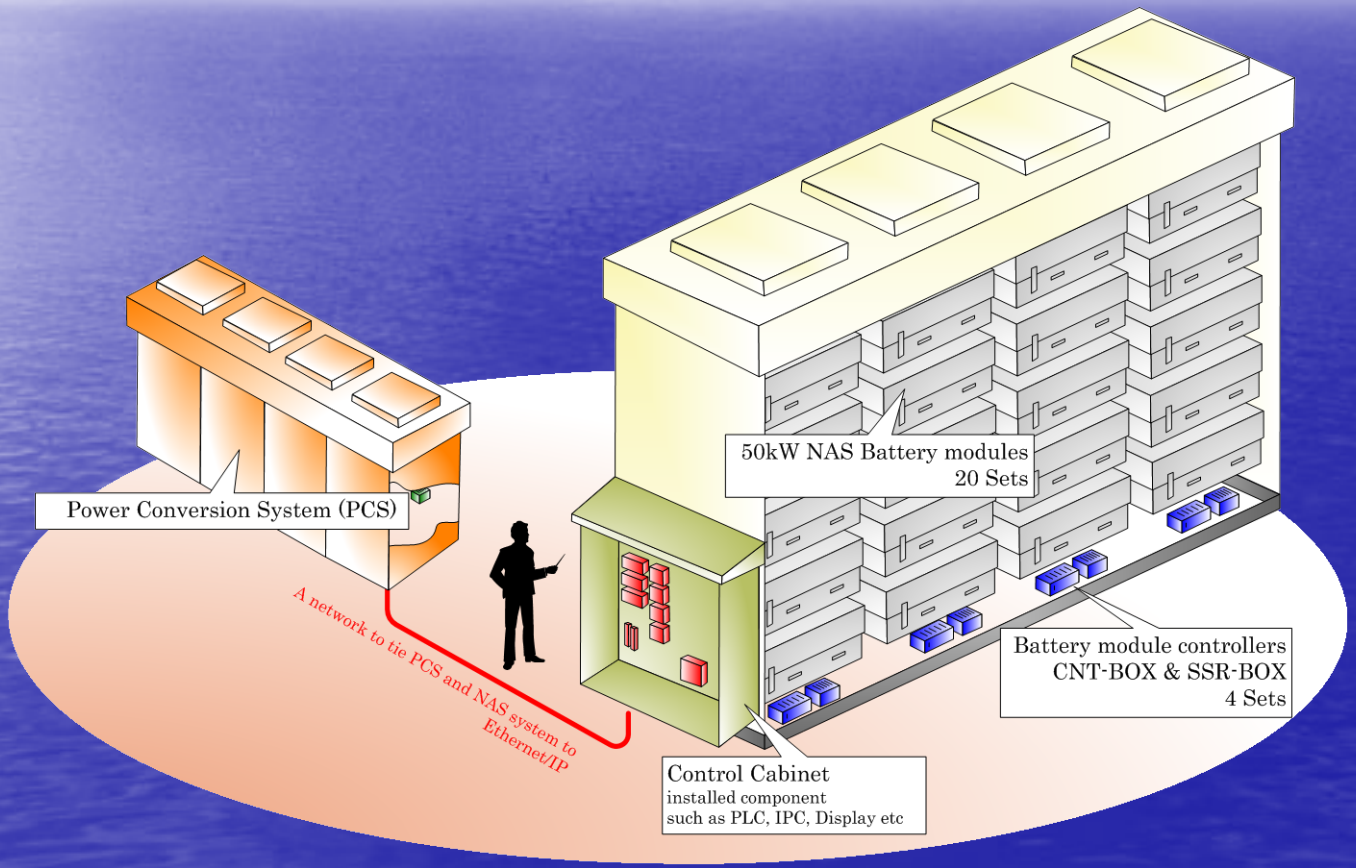


Site Description

- Natural gas refueling station for 220 buses
- 3 x 600 HP compressor load
- Dedicated LIPA feeder

LI Bus Gas Compressor Site

NAS Battery System Overview



Scope of Work

- Battery modules and enclosure
- Power Conditioning System (PCS)
- Integration of PCS with the battery system
- Balance of Plant (BOP) equipment and enclosures
- System interconnection and integration with the grid and load
- Installation, startup, training and commissioning
- Documentation and O&M manuals
- O&M and performance warranty during 18 month demonstration period

Project Team

- NYPA – Overall project implementation
- MTA/Long Island Bus – Host site, end user
- NGK Insulators, Inc. – NaS battery manufacturer
- ABB – PCS, Controls, Design and Installation
- DOE/NYSERDA – Performance monitoring
- EPRI – Technical assistance, technology transfer
- LIPA – Grid Integration, technical assistance

Budget & Cofunding

Total Project Cost:	$3,850,000
DOE/NYSERDA	$1,000,000
EPRI*	$585,000
CEATI/NRCAN	$52,000
LIPA	$200,000+
APPA	$75,000
	$1,912,000

* The following utilities are providing cofunding through EPRI: Con Ed, PSE&G, NYISO, FirstEnergy Corp., Hydro One, Hydro-Québec, SDG&E, Southern Company, TVA

Project Installation Snapshots

Battery Module

- Comprised of 320 individual battery cells
- Picture shows cover removed
- Variable series and parallel arrays to yield module DC voltages of 64 or 128 V
- Sand packing used between the cells for structure and heat sink
- Thermal management using electric heaters and vacuum insulation to maintain a minimum operating temperature of $290^{0}C$
- Standby loads about 3.4 kW when not in operation

PCS Units

System Performance Monitoring

(Data Management will be provided by DOE)

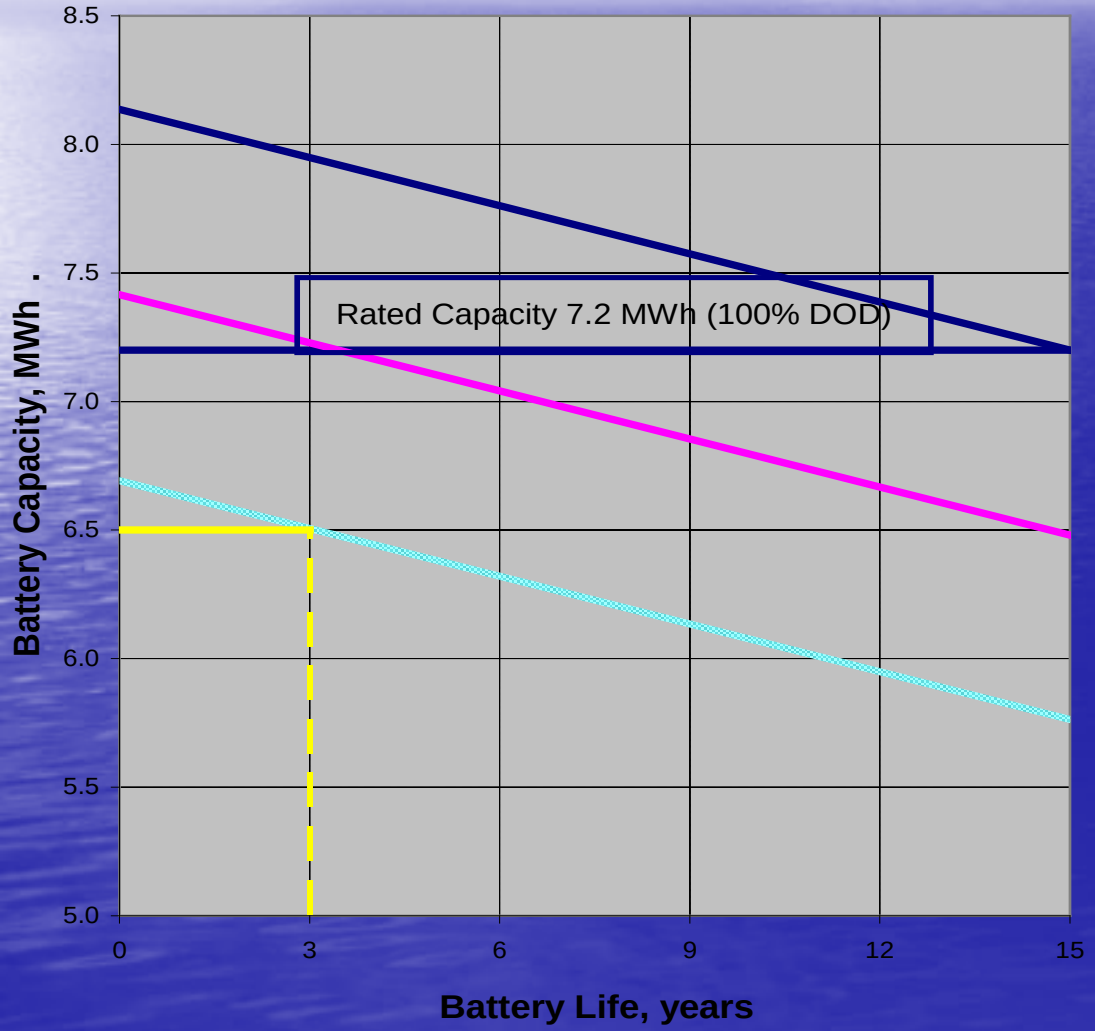
- System operating state durations
- AC voltage and current
- DC voltage, current, state of charge, and internal temperatures
- Ambient temperatures
- Auxiliary loads
- System response times to changes in operating conditions
- Energy and power into and out of the system for each AC phase in the system

System Performance Monitoring (continued)

- System loads
- System duty cycle count
- System failures and problems
- System conversion efficiencies during full and part-load operation
- Losses during periods of standby
- System response to abnormal events
- Data uploaded daily to central server
- All data time stamped to 1 second, with 15 minute averaging

Expected System Performance (light cycle)

Chart A: NAS Battery Expected Performance at 167 Cycles per Year



- Rated Capacity 7.2 MWh (100% DOD) (2500 cycles or 167 cy/yr)
- No Cell Failures (CF) (167 cy/yr)
- Up to 1 CF ea Blk (167 cy/yr) (Avail > 97% for MTTR = 3 yr)
- Up to 2 CF ea Blk (167 cy/yr) (Avail > 97% for MTTR = 15 yr)
- Warranted Capacity, Period

System Rating:

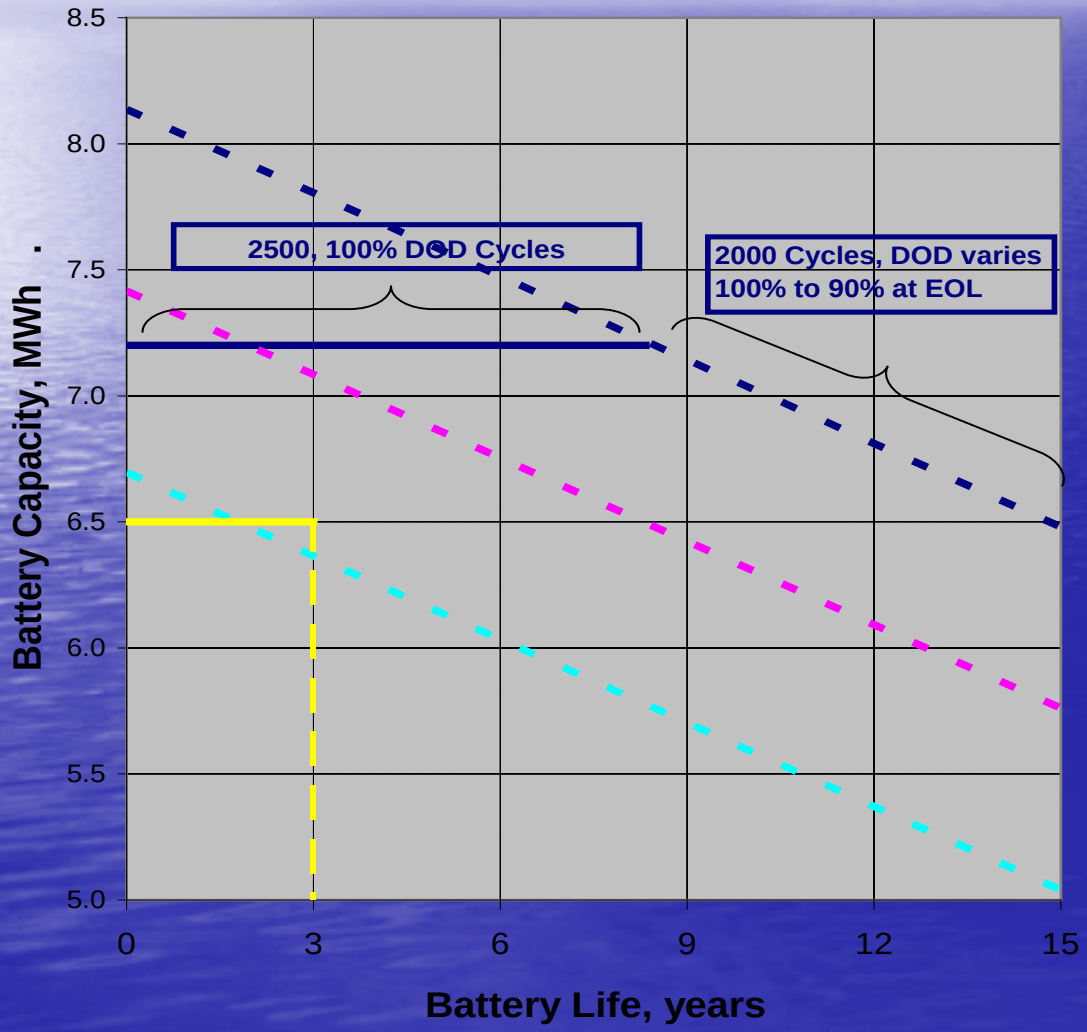
Rated Power: 1 MW
Rated Capacity: 7.2 MWh
Max Power: 1.2 MW (< 3 hr)

Assumed Duty Cycle:

2500, 100% DOD cycles over 15 yr
Equivalent to 167 cy/yr

Expected System Performance (heavy cycle)

Chart B: NAS Battery Expected Performance at 300 Cycles per Year



System Rating:

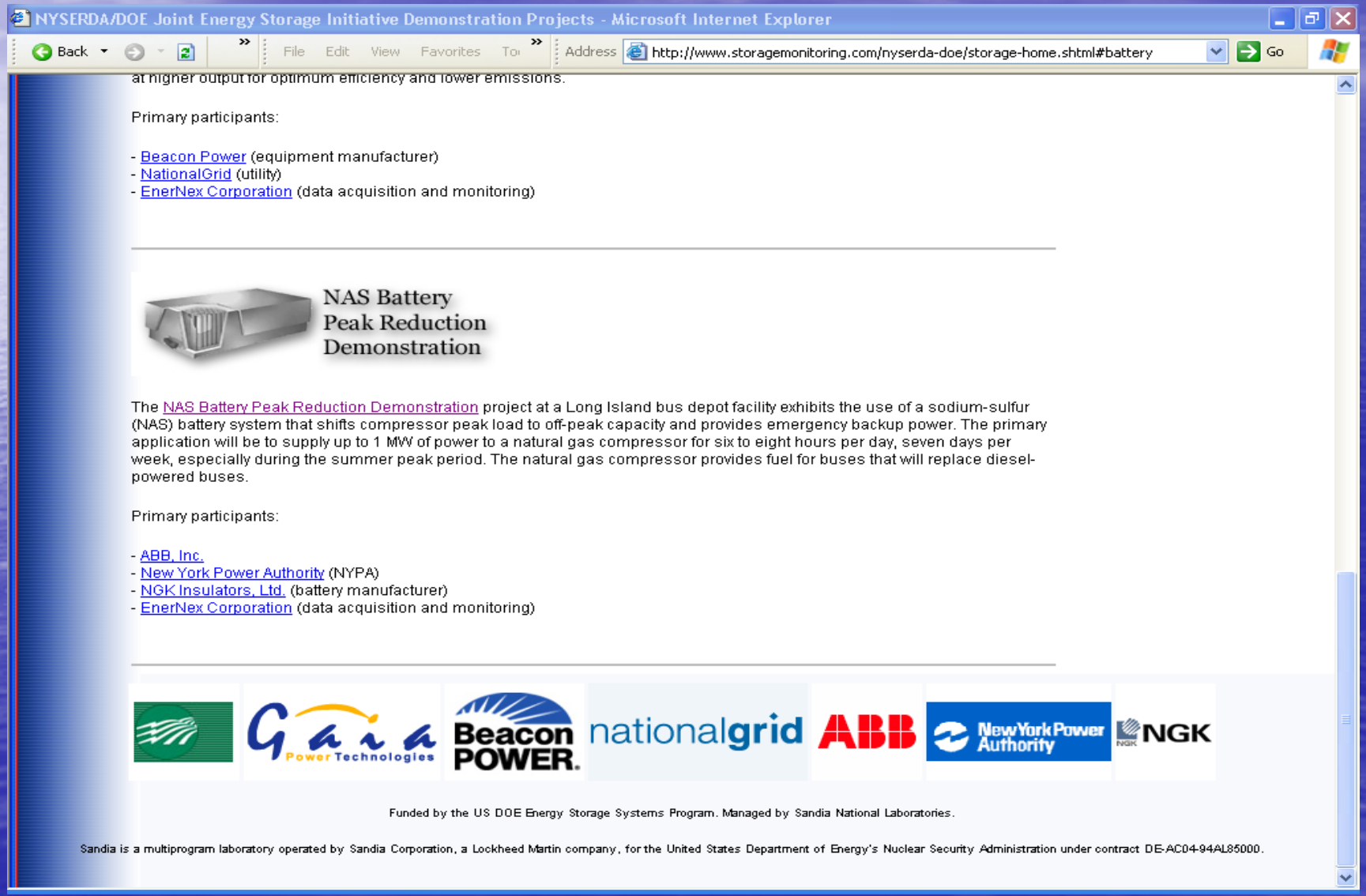
Rated Power: 1 MW
Rated Capacity: 7.2 MWh
Max Power: 1.2 MW (< 3 hr)

Assumed Duty Cycle:

2500, 100% DOD cycles over 8.3 yr +
2000, cycles avg 95% DOD over 6.7 yr
Equivalent to 300 cy/yr

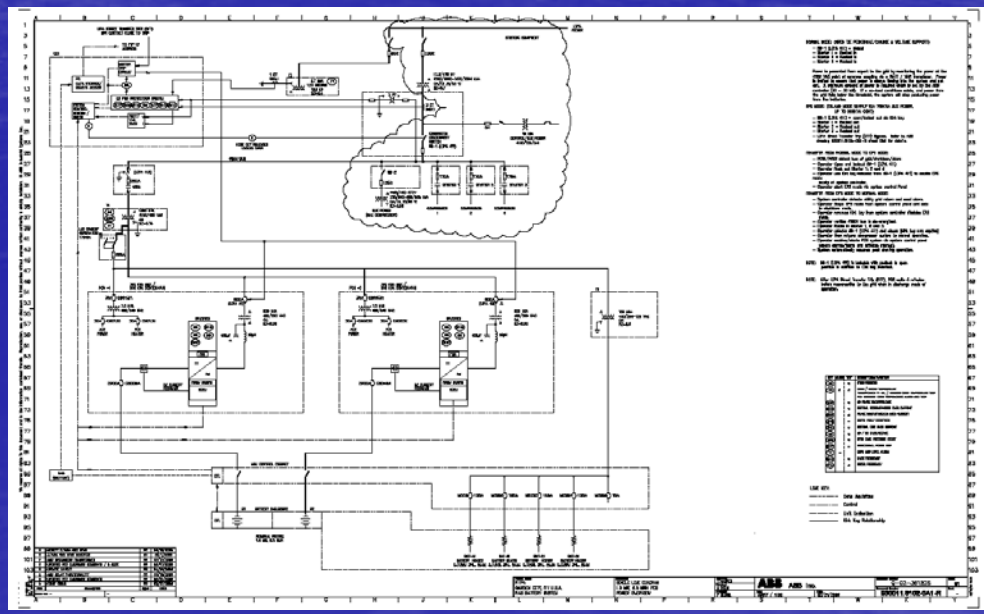
Public Information Website

www.storagemonitoring.com



Interconnection Issues

- Keyspan review
- Grounding transformer
- Redundant GE F60 relay
- Direct Transfer Trip



Emergency Power Supply and Backup Power Issues

- PCS units will not operate in parallel
- PCS units not configured to handle compressor motor surge current
- Compressor start and load test analysis underway to determine options
- Backup power for battery thermal management system

Current Project Status

- Batteries, PCS and BOP installed
- Grounding transformer specified, to be installed by December
- Direct Transfer Trip specified, to be installed by November
- Initiate system start up in December
- Initiate monitoring in January
- Monitoring period is 18 months

THANK YOU