Advanced 1-MW, 7-MWh, Peak-shaving, Sodium-sulfur Battery Energy Storage Project at Long Island Bus[1]

Yan Kishinevsky (New York Power Authority, New York, New York, USA); yan.kishinevsky@nypa.gov
Guy Sliker (New York Power Authority)

The New York Power Authority (NYPA), working together with the Metropolitan Transit Authority Long Island Bus (LIB) Company, the New York State Energy Research and Development Authority (NYSERDA), the Electric Power Research Institute (EPRI) and the U.S. Department of Energy, plans to install an advanced battery energy storage system (BESS) at the LIB facility located at 700 Commercial Avenue, Garden City, New York. The BESS will shift the electrical demand of the facility's natural-gas bus refueling compressor station from peak periods to off-peak periods. The project will be one of the first of its kind in the U.S. and is expected to realize significant cost savings for the LIB facility and provide grid stabilization benefits to the local utility.

The LIB depot chosen as the site for this demonstration is a natural-gas refueling station for 220 buses. Three 600-horsepower compressors (shown in Figure 1) comprise the load that is served by a dedicated line from the Long Island Power Authority (LIPA). The load operates 24-hours a day, 7 days a week over three shifts and incurs high on-peak demand charges for four months of the year. The proposed demonstration would install a 1-MW, 7.0-MWh NGK Insulators, Ltd. (NGK) NAS™ BESS in parallel with the utility grid. The BESS will power the compressor station load during the day (when utility rates are relatively expensive) and automatically recharge (using utility power) at night when rates are lower. BESS operation will be load following to prevent battery power from being exported to the utility grid. In the event of an interruption of utility power, the BESS will also be capable of standalone operation to provide backup power to the compressor station. During normal, grid-parallel operation, the BESS will also be capable of providing voltage support to LIPA (simultaneous peak-shaving/power quality support is a capability unique to the Na/S technology). The goals of this project are threefold—

- Achieve cost savings by reducing peak demand charges and eliminating the third work shift,
- Increase backup power for the entire depot facility, and
- Reduce peak demand on the heavily loaded utility grid.

Figure 1. Natural-gas-fueled compressors at the LIB refueling station.

The ultimate goal of the project is to demonstrate that the technology provides efficient, long-term operation in a commercial environment. The project will document the technical and economic details of the BESS

[1] This project is part of the Joint Energy Storage Initiative between the New York State Energy Research and Development Authority (NYSERDA) and the Energy Storage Systems Program of the U.S. Department of Energy (DOE/ESS), and managed by Sandia National Laboratories (SNL).

application and report the results of the system design, installation, acceptance testing, long-term performance monitoring, and interface to the electric-distribution grid.

The BESS used for the demonstration includes an NGK NAS™ battery and related controls capable of providing a nominal 1 MW of power to the compressor station for 6 to 8 hours per day, 7 days per week. NGK has configured a 1-MW NAS™ battery specifically for this project. The system battery comprises 20 NGK G50 battery modules, each with a nominal power rating of 50 kWac, and an energy rating of 360 kWhac. The 20 modules are divided into two parallel strings of 10 modules each. The system battery configuration is shown in Figure 2. Each 10-module string is equipped with an inverter to regulate the DC power from the battery modules to grid-parallel ac power. Each inverter is rated at 600 kVA. Power from each inverter is combined in a single junction box before feeding a single step-up transformer to provide system power for interconnection to the facility load at 13.8 kV. The 50-kW modules have a rated efficiency of 90% and a cycle life of 4500 cycles at 90% depth of discharge (DOD) and 2500 cycles at 100% DOD. The system is expected to operate through a single DOD per day.

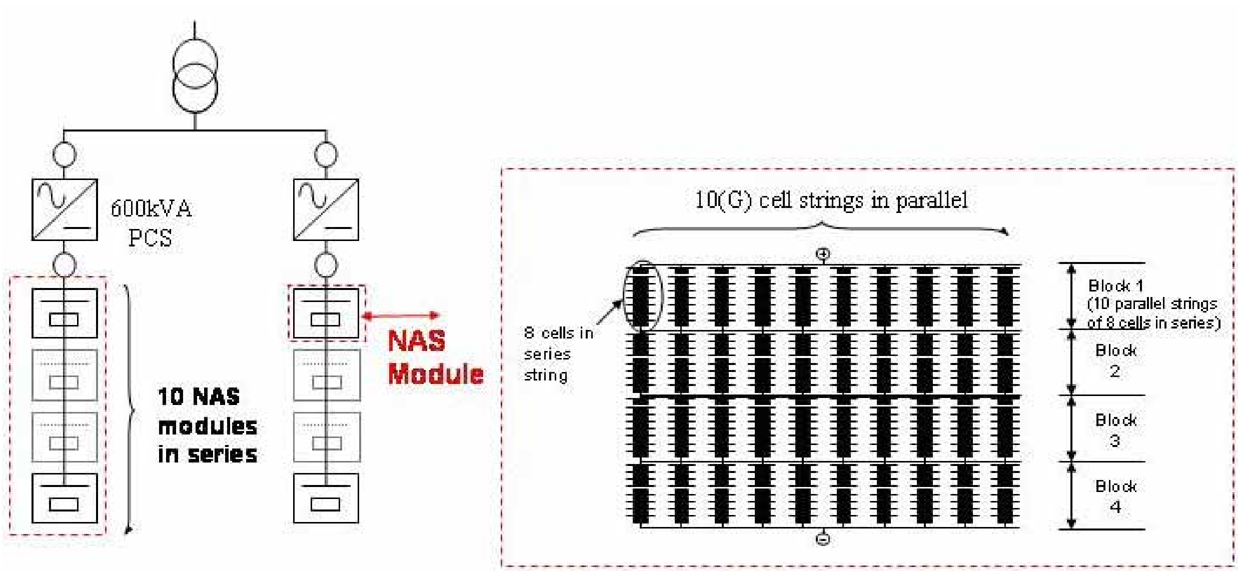

Figure 2. Na/S 50-kW module layout.

As shown in the right-hand portion of Figure 2, each 50-kW module consists of 4 blocks and each block contains 10 parallel strings of 8 cells connected in series (*i.e.,* 320 cells per 50-kW module). Each cell includes a center electrode made of liquid sodium. The sodium has an operating temperature of 300°C. The liquid sodium electrode is surrounded by concentric cylinders: a metal safety tube, a beta alumina solid electrolyte tube, and a positive sulfur electrode. In a charged state, liquid elemental sodium fills the central reservoir. As the cell is discharged, the liquid sodium is channeled up and down through the narrow annuli between the outer surface of the sodium chamber, the metal safety tube, and the beta alumina solid electrolyte tube. There, it disassociates an electron, which creates the current flow, and a sodium ion that conducts through the beta alumina and reacts with the sulfur to form sodium polysulfide. The reverse occurs upon recharging. Each cell is rated at 2 Vdc. Figure 3 shows the basic cell structure.

The 320 battery cells in each G50 module are closely spaced within the module enclosure. The space between the cells is filled with sand, which functions as both packing material and a heat sink. Thermal management of the module is provided by vacuum insulation between

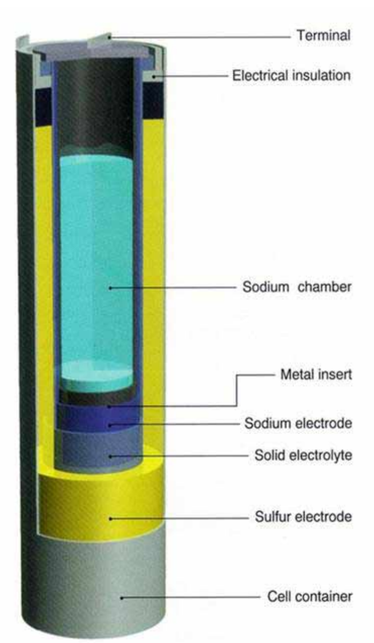

Figure 3. Na/S cell structure.

the inner and outer walls and integrated electric heaters to maintain a minimum operating temperature of 290°C. The heaters, rated at 3.4 kW per module, are not required during normal battery operation, but are required during extended periods of battery standby. A photo of a 50-kW battery module (with the cover removed) is shown in Figure 4.

Figure 4. NGK G50 50-kW battery module with cover removed.

The scope of work for the project includes BESS design, engineering, permitting, furnishing, delivery, installation, grid interconnection, start up, commissioning, acceptance testing, long-term performance monitoring, operations and maintenance training, and final disposition of the Na/S batteries. The preliminary layout for the system is shown in Figure 5 and the expected layout for the demonstration site is shown in Figure 6.

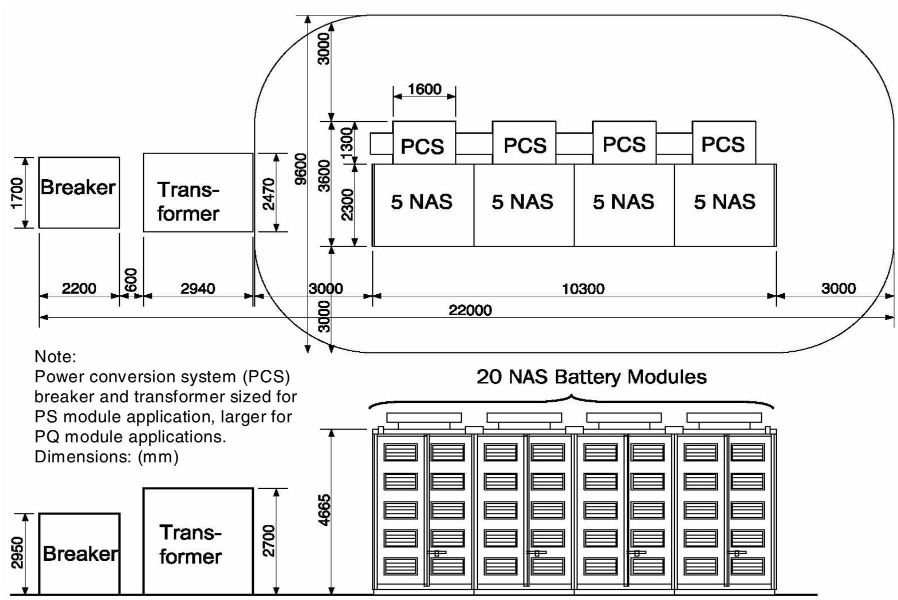

Figure 5. Preliminary system layout.

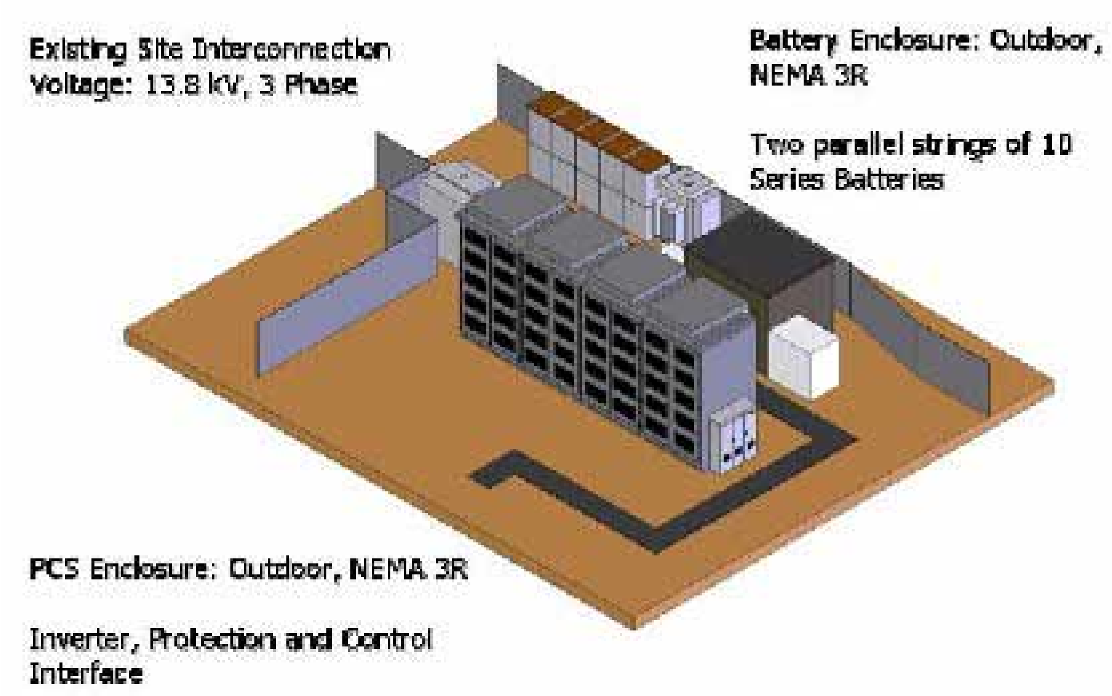

Figure 6. Demonstration site layout.

Long-term BESS performance monitoring and data collection will include the following system parameters:

- System operational modes (charge, discharge, standby, start-up, shutdown)
- System operating profile for the preceding 24-hour period
- System response times to changes in operating conditions
- Real and reactive power and energy into and out of the system at the utility interconnection point
- Three-phase active and reactive power to the load (customer compressors)
- System charge/discharge cycle count
- System failures/problems (alarm and trip signals)
- Battery temperature (module)
- Battery voltage (cell, module)
- Battery current (module)
- DC voltage and current (PCS, BESS)
- AC voltage and current (PCS, BESS)
- Battery system status (module)
- Battery detail alarm/trip signals (module)
- PCS temperature
- DC breaker status
- PCS status
- Real-time wave forms
- Battery state of charge (module, BESS)
- Internal battery temperature (module)
- Battery cycle data
- Enclosure information
- BESS auxiliary load power and energy

Data will be sampled at 1-second intervals, which is necessary to ensure that the acquisition rate is adequate to monitor individual cell performance. Data acquisition will be programmable and capable of providing 10- to 15-minute average values for the various parameters. Analog values (energy, power) will be accurate within ±1%. Secure storage and access to the collected data at the demonstration site will be provided. The ability to perform daily uploads of the data to a remote site via the internet will also be provided.

In general, the NAS™ BESS is expected to provide an effective and economical means of powering the LIB refueling station. The Na/S technology has the following advantages over diesel generation and other battery technologies:

- It has no moving parts and a long service life, which reduces operations and maintenance;
- It is quiet and has no emissions, so there is minimal environmental impact;

- It is versatile—it is the only battery technology capable of supporting peak-shaving/load-leveling applications and power quality applications simultaneously; and
- It has a small footprint (relative to other battery technologies) and, consequently, provides high efficiency, and high energy and power density.

Prototype commercialization of the Na/S battery has been achieved in Japan through the development efforts of (NGK) and their participation in demonstrations by the Tokyo Electric Power Company (TEPCO) Recently, American Electric Power (AEP) conducted the first U.S. testing on a 100-kW NGK NAS™ BESS in Ohio. A comparison between the AEP project and the proposed LIB project is provided in Table 1.

Table 1. AEP and LIB Project Comparison

Attribute	AEP Project	LIB Project
Purpose	Technology demonstration and testing using simulated load and power quality profiles.	Real-world operation to avoid peak demand charges for natural gas bus refueling station compressor load.
Specs	100 kW, 700 kWh	1,000 kW, 7,000 kWh
Operation	UPS and peak shave	Daily peak shave and grid backup
Configuration	Grid parallel, static-switch disconnect	Grid parallel, Emergency backup
Pulse Factor	5 × (500 kW for 30 seconds)	None
Commercial basis	R&D, commercial prototype	Commercial operation, extended warranty and service contract

To date, market development efforts for Na/S battery technology in the U.S. have lacked a genuine commercial demonstration at an economically viable scale and with appropriate system warranties. The LIB project supports both the first-time commercial and continuing technical demonstration aspects of the Na/S application efforts in the U.S.