Progress On The 34MW NAS Battery System For The 51MW Rokkasho Wind Farm

Tomio Tamakoshi, NGK Insulators, Ltd, Japan) tamakosi@ngk.co.jp; Matsuo Bando (Japan Wind Development Company, Ltd.)

1. Introduction

Renewable energy installations are being accelerated by countries worldwide to mitigate global warming and become more energy independent. Japan has decided to increase its proportion of new energy derived from such sources as solar, wind, and biomass to 3% of primary energy by 2010. That achievement would double the amount of energy produced from renewable resources in 2003. Wind power will play an especially important role in new electricity generation in Japan. The target capacity of wind power in 2010 is 3000MW, triple the amount installed in 2003.

Japan must overcome a number of issues to integrate large amounts of wind generated electricity. These include insufficient transmission line capacity between areas ideal for wind generation and metropolitan load centers, as well as potential grid instability when injecting large amounts of fluctuating wind generated power. To solve these problems a study committee consisting of government, university and power company experts recommended developing hybrid wind-battery farms.

Based on this recommendation, the Japan Wind Development Company, Ltd. (JWD) will install a 51 MW hybrid wind-battery farm configured as a constant power producing power plant at Rokkasho Village in northern Japan. The wind farm is scheduled for operation in 2008. Upon successful completion of a one-year evaluation period, the regional utility company will accept the wind generated power on to the grid with no restrictions.

This paper describes the results from pre-construction tests of a small-scale wind-battery hybrid test system, as well as the status of design and construction of the full-scale hybrid wind farm at Rokkasho.

2. Results from Pre-Operational Tests of a Small Scale Hybrid Wind-NAS System

A small scale test facility was built to guide design of the full-scale wind farm at Rokkasho. The test facility integrates 2, 400 kW wind turbines with a 500 kW NAS battery for the purposes of training operators and evaluating design features to be deployed at Rokkasho. Specifically, the constant power control scheme and the technique for managing battery state-of-charge (SOC) being confirmed. In addition, a battery enclosure design for coastal salt-air environments is being assessed. .

The test facility is located at the Miura Wind Park, about 50km south of Tokyo, where it is connected to a 6.6kV distribution line (Fig. 1). To maintain the output of the integrated system at a constant power level during fast wind fluctuations, power signals at the point of interconnection (POI) and at wind turbine output are compared. The NAS system compensates for power mismatches by injecting or absorbing sufficient energy to mitigate the fluctuations. A diagram of constant power control logic is shown in Fig. 2.

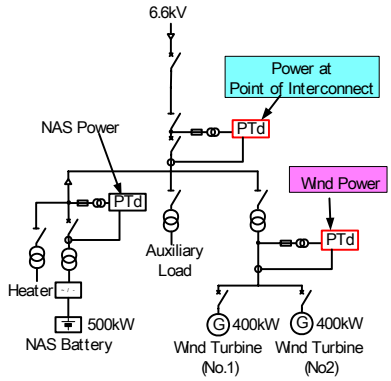

Figure 1. One-Line Diagram and Picture of Hybrid Wind-NAS Test Facility at Miura Wind Park

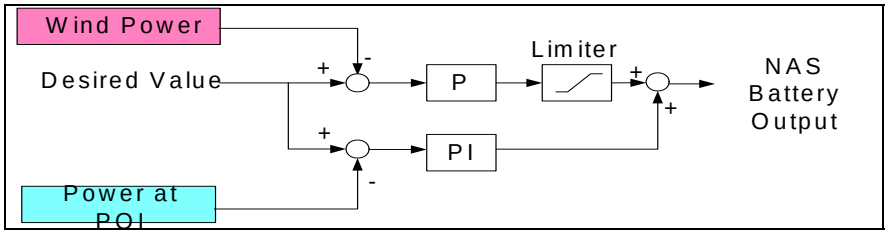

Figure 2. Block Diagram of NAS Constant Power Control

The results of constant power control are shown in Fig. 3. The desired value is adjusted in three steps: 400kW, 500kW to 600kW. In accordance with Tohoku Electric Power Company requirements, the 1-minute average power output is controlled within 2% of the desired value.

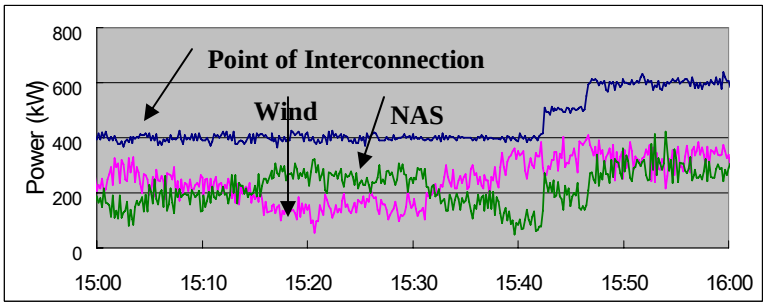

Figure 3. Results of Constant Power Control

The hybrid wind-NAS test facility at Miura is remotely controlled from the Rokkasho office of JWD, adjacent to the first large commercial hybrid wind-NAS farm now under construction. The staff in Rokkasho plan the day-ahead power delivery schedule on the basis of weather forecasts and the battery condition. The staff also monitors the continuous operation of the Miura system at intervals of several hours. Wind generation data, along with NAS battery SOC and temperature data, are automatically plotted for use in updating the power delivery schedule.

The battery SOC is one of the most important parameters for planning system operation. Since the SOC is calculated by integrating battery DC current, the SOC must be periodically re-calibrated to eliminate accumulated measurement errors. In load leveling or peak shaving applications, SOC calibration is easily accomplished each time the battery is fully charged. However, in wind power applications, the battery must be maintained in a partially discharged state in order to accept energy at any time. Since calibration in a fully charged state is not an option for wind applications, a method of calibration based on the “single chemical phase” characteristics of NAS battery electrodes in an open circuit voltage condition (Fig. 4) was developed and verified at the Miura Wind Park test facility. The NAS battery controller automatically calibrates SOC after the battery has been in a standby state for 30 minutes. The accuracy of the “single phase” method of calibration has been confirmed to be greater than 99%.

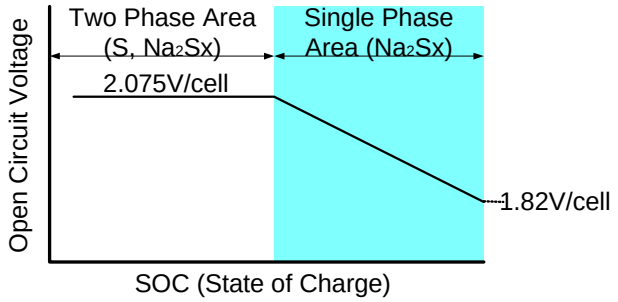

Figure 4. NAS SOC Calibration - Single Phase Method

Since wind farms are often located near the coast, countermeasures for corrosive salt-air environments are deemed necessary. The NAS battery enclosure for such applications is equipped with air filters that minimize exposing equipment to a corrosive atmosphere. This measure made it necessary to incorporate a forced air ventilation system. The performance of these features were confirmed at Miura and are being installed at Rokkasho.

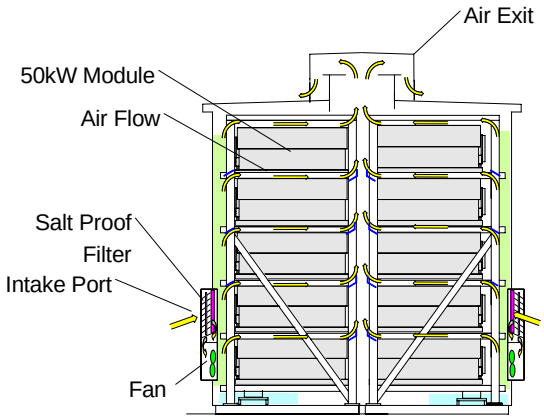

Figure 5. Cross Section of NAS Battery Enclosure for Corrosive (Salt-Air) Emvironments

3. Rokkasho Hybrid Wind-NAS Farm

3.1 System Outline

The hybrid wind-battery system consists of three major subsystems:

- 34 sets of 1.5MW wind turbines with a Wind Farm Management System (WFMS)
- 17 sets of 2MW NAS batteries
- A Wind Farm Control System that maintains the power delivery schedule

Fig. 6 shows an isometric view of the 34MW NAS battery system and a one-line diagram of the hybrid wind-battery farm. Seventeen sets of 2MW NAS battery enclosures are located outdoors, and 17 sets of accompanying Power Conversion System (PCS) are installed indoors to protect against the salt air coastal environment. The specifications for the 2MW NAS battery systems are shown in Table 1, and the specifications for the 1.5MW wind turbines are shown in Table 2. The wind turbine and NAS battery systems are connected to a 154 kV transmission line through a three winding transformer. In order to produce constant power output on a prescribed schedule, active power is controlled at 2 points: 1) Fast changes are compensated by controlling wind power output via fast response transducers and controls before the transformer as shown in Fig. 2, and 2) Scheduled power delivery to the grid is controlled at the point of interconnection, and is supplied at the power level and for the duration previously committed to the power company. In addition, the WFMS automatically suppresses generated power if the battery is unable to accept charge.

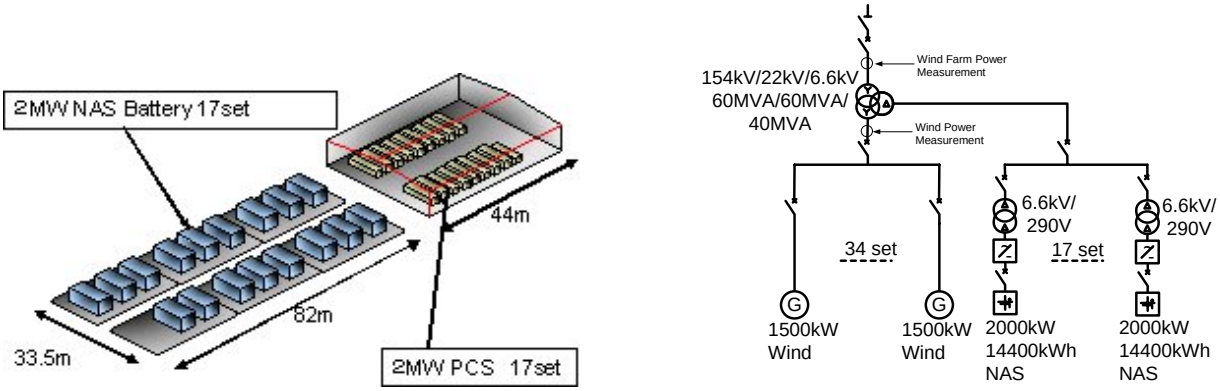

Figure 6. Isometric of 34 MW NAS (left) and One-Diagram of 51 MW Hybrid Wind-NAS Farm (right)

Table 1. 2MW NAS System Specification Specification

PCS(Power Conversion System)	
Phase	3
Voltage	6.6kV
Frequency	50Hz
Conversion Method	Self-commutated Voltage Sourced PWM Method
Device	IGBT
Nominal Power	2400kW
Conversion Efficiency	95%
NAS Battery	
Connection of 50kW Module	10series * 4pararell
Voltage range	DC470V to DC745V
Current Range	D: 0A to 1400A C: 0A to 900A
Nominal Power	DC2105kW
Max. Power	DC2526kW
Energy	DC15158kWh

Table 2. 1.5 MW Wind Turbine

Generator	
Phase	3
Voltage	690V
Frequency	50Hz
Generator Type	Wire Wound Induction Generator
Pole	4P
Rotational Frequency	1500rpm
Nominal Power	1500kW
Wind Turbine	
Number of Rotor Blades	3
Rotor Diameter	70.5m
Hub Height	64.7m
Rated Wind Speed	13m/s
Cut-in Wind Speed	4m/s
Cut-out Wind Speed	25m/s
Power Control Method	Active Blade Pitch Control

*Wind Turbines provided by GE.

3.2 Day Ahead Scheduled Power Delivery

A constant power producing hybrid wind-battery farm is planned to deliver power by way of the Day Ahead scheduling process illustrated in Fig. 7. Based on wind power forecasts, NAS battery energy and electricity price information, the schedule for power output from the hybrid wind-battery farm is planned one day in advance, and the schedule is sent to the power company. While the wind farm is operating through the schedule coordinated with the power company, the wind farm control system monitors real-time data and determines whether or not the system can maintain the scheduled power delivery. If the power delivery schedule has to be changed, an updated schedule is coordinated with the power company at least 30 minutes before delivery.

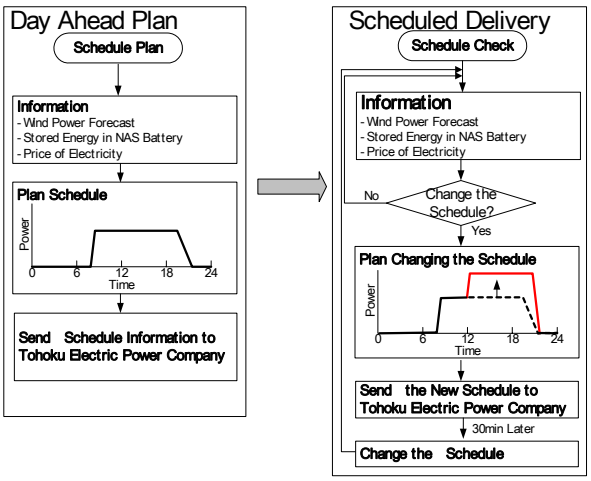

Figure 7. Day Ahead Scheduling Logic for Hybrid Wind-NAS Farm

3.3 Construction Schedule

The 34MW NAS battery installation will be completed by December 2007, and the Wind turbines will be installed by February. Also in February the NAS batteries will be energized. A test of the integrated wind turbines and NAS battery system is scheduled for March, and the hybrid wind-battery farm is scheduled to begin operation in April, 2008. The status of construction is shown in Fig. 8.
After one year of successful constant power operation of this first full-scale project, the Japan Wind Development Company will offer the hybrid wind- battery power system commercially in Japan.

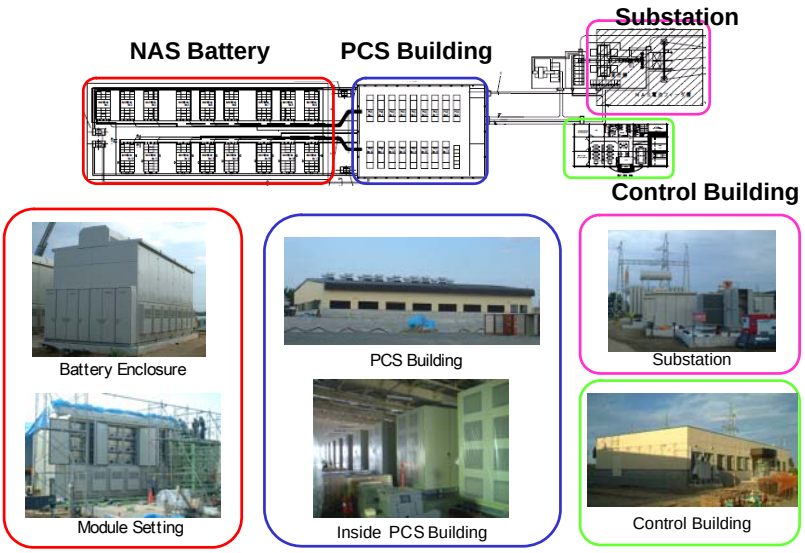

Figure 8. Construction Status of the 34MW NAS Battery System at Rokkasho (September 2007)