The 400 kWh ABESS for the Detroit Edison Company

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Abstract

ZBB Energy Corporation is presently manufacturing a 400 kWh Zinc/Bromine Advanced Battery Energy Storage System (ABESS) to be tested at a utility site. Two sites with differing power requirements have been selected by the host utility and trials will be conducted for 3 months at each site, commencing in October 2000. The status of this project will be discussed in this paper.

Introduction

ZBB Energy Corporation has been a successful candidate in securing funding from the Energy Storage Systems program, conducted by Sandia National Laboratories (SNL) and sponsored by the U.S. Department of Energy's Office of Power Technologies, for the ongoing development of its zinc/bromine battery system for utility applications. SNL contracts enabled the development of an initial 100 kWh system built and trialed by ZBB in 1996/97. As a result of the success with this 100 kWh system, SNL further committed to the ongoing development that has led to the emergence of suitably sized systems for utility applications.

In 1997, ZBB entered into the first contract of a four-stage development for the further refinement of the basic battery module. This stage was conducted to advance the "2 stack" 33 kWh module used in the earlier 100 kWh system to a 3 stack, 50 kWh module that becomes the building block for larger utility sized systems.

In September 1998 ZBB entered into the second stage of development, specifically to assist in the completion of the design package, the complete manufacturing cost study and for specific testing and qualifying of the module network system. This stage was successfully concluded in October 1999.

The third stage of development for this project commenced in January 2000 for the construction and delivery to site of a 400 kWh energy storage system. The Detroit Edison Company is the host utility for testing the battery system, and Inverpower Controls, Ltd. is providing the Power Conversion System (PCS). The complete system is due for site delivery during the fall of 2000.

The final stage for this project will be a testing program commencing in fall of 2000. Both fall and summer sites with differing power requirements have been selected and trials will be conducted for 3 months at each site.

Battery System Description

The zinc/bromine battery consists of battery stacks, electrolyte storage reservoirs, and an electrolyte circulation system. Reactants are continuously fed to the battery stacks, which insures uniform zinc plating and separates the reactive polybromide from the electroplated zinc in the battery stack. A heat exchanger in the anolyte tank provides good thermal management for the entire module. The heat exchanger cools the anolyte, which in turn cools the catholyte when the two electrolyte streams come in intimate contact inside the battery stacks.

The electrochemical reactions in the Zinc/Bromine battery occur on opposite sides of the same electrodes. This is considered a bipolar design, which allows the current to travel directly through the battery stack, increasing the specific energy of the battery. The electrolyte is an aqueous solution of zinc bromide salt. During charge, zinc is electroplated on the anode (negative electrode), and bromine is evolved at the cathode (positive electrode). A microporous separator isolates the two half-cells. A non-reactive component in the electrolyte forms a polybromide complex with the elemental bromine produced during charge. This complex significantly reduces the vapor pressure and reactivity of the elemental bromine, minimizing self-discharge and significantly improving the safety of the system. During charge, the complexed bromine is removed from the battery stacks via the flowing electrolyte and is stored in an external reservoir. On discharge, the complexed bromine is returned to the battery stacks by the

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operation of a valve or a third pump, allowing zinc to be oxidized to zinc ions on the anodes and bromine to be reduced to bromide ions on the cathodes.

A 50 kWh Zinc/Bromine battery, module has been developed by arranging three 2500 cm^2 battery stacks electrically in parallel with a common set of electrolyte tanks and plumbing for circulating the electrolyte as shown in Figure 1. Each battery module is completely self-contained in an epoxy coated steel container, and is equipped with a fully integrated electrical control system, which controls pump speeds and monitors battery parameters. The pumps and motors are commercially available products, and the electrolyte tanks are rotationally molded plastic. The modules have a 24 ft^2 footprint and weigh approximately 3,000 pounds. They can be utilized individually or connected in series/parallel with additional modules as part of a larger system.

Figure 1. 50 kWh Zinc/Bromine Battery Module

Under the DOE/SNL contract #4362, ZBB energy Corporation is manufacturing a 400 kWh Zinc/Bromine battery system. The system consists of eight battery module units configured in two separate electrical strings of four modules in series and enclosed in a standard sized shipping container shown in Figure 2. The container has a footprint of 160 ft^2 and will weigh approximately 40,000 pounds with the battery system fully assembled. The container has bi-fold doors on both sides, allowing full access to the battery modules. The battery modules are supported in the container by commercially available cantilever racks. Two chillers will maintain the temperatures of the two module strings, and heaters will be available in the container to prevent freezing of the electrolyte.

The control system for the 400 kWh ABESS utilizes a three-tier communication network. An overall system controller monitors system parameters and communicates with individual strings, modules and the PCS. The same controllers are used to monitor the two individual strings and the eight battery modules. The controllers are commercially available components that are programmed specifically for the ZBB battery system. The module and string controllers communicate to the main controller through serial and network ports. Also, RF connections are available for remote monitoring and control of the battery system.

A 200 kW/250 kVA PCS, supplied by Inverpower Controls, Ltd., is capable of operating the two individual strings simultaneously or independently. This allows the system to be charged and discharged as a single 400 kWh battery, or for one 200 kWh battery to be charged while the other 200 kWh battery is discharged. The PCS has been designed to interface with the DC power from the battery output to the utility power line in a Grid Connected Mode, or to a load in Stand Alone Mode as an option. The unit inverts the available DC power from the Zinc/Bromine battery to AC power to supply the line or the load. The inverter has been designed for three-phase output connection of 480Vac, 60Hz operation and output voltage of 400V at 50/60Hz.

The host utility, Detroit Edison, is providing a trailer, site preparation, and a 300 kVA pad-mounted, three-phase, dual voltage (4800V x 13200V) transformer for this project. The battery system, PCS and transformer will be mounted on a standard 40-foot flatbed with the connecting cables underneath the bed of the trailer. The ABESS uses a standard container that is approved for shipping cargo.

Figure 2.   400 kWh ABESS Container

Utility Test Sites

A site for testing the system during the fall of 2000 has been secured at a grain drying facility in Akron, Michigan (approximately 100 miles north of Detroit). This site, shown in Figure 3, supports the drying needs for all the local farms in the area. The battery system will be located just to the right of the poles in the picture.

The drying season typically runs from mid-September to early December. The facility uses three 75 horsepower motors, which cause power quality sag issues for the other customers in the area. Four to six disturbances are encountered per day, plus a number of small events from running the conveyer. The battery system will be located relatively close to the grain dryers, which will hopefully take care of the flicker observed by the rest of the circuit. This is primarily a power quality application for the battery system, but power for peak shaving will also provided at this test site.

Detroit Edison will also test the system in a summer site where the customers encounter low voltage problems during hot days. This location, shown in Figure 4, is very temperature dependent due to a high concentration of residential and commercial air conditioning load**.**   The customer will utilize the battery for peak shaving applications during the hot days during the summer of 2001.

Figure 3. Location of ABESS at Akron Grain Drying Facility

Figure 4. Location of ABESS at Lum Site

Target Markets

The ZBB Zinc/Bromine Battery can provide energy storage benefits to many potential customers including utilities, independent power producers (IPP), energy service companies and industry. Although the Zinc/Bromine system may be suitable for other markets, the most promising applications appear to be load management, power quality and renewable energy. A combination of these applications into multiple marketing channels presents the most valuable opportunities for this energy storage technology.

Load management benefits can be accomplished through Var compensation, facility and line upgrade deferrals in the transmission and distribution areas, and through peak demand reduction for the end customers. Energy service companies can utilize the battery system to provide demand side management and peak shaving opportunities.

The power quality benefits of the ZBB system include eliminating noise, over and undervoltages and voltage spikes, sags and swells. The zinc/Bromine system will enable utilities and energy service companies to provide guaranteed service to their customers, and allow customers to protect critical processes.

The ZBB ABESS will provide a critical benefit in the field of renewable energy. Energy generators, such as photovoltaic and wind turbines, need energy storage devices to store the generated energy for use during intervals of low energy output, and to address the power quality issues inherent with the fluctuating power generators. Batteries will be needed for both grid connected renewable energy sources and for remote area power suppliers.

Conclusions

The 400 kWh Zinc/Bromine ABESS is scheduled for delivery to site in October 2000. The testing program for the next phase of this program has been established and will extend through the end of the 2001 fiscal year.