Pacific Northwest
NATIONAL LABORATORY

PNNL has developed new methods to advance the diagnosis of battery health, including state of charge, the presence of hydrogen bubbles, oxidation, and more.

IN-SITU HEALTH MONITORING OF FLOW BATTERIES

Portable, low-cost method to evaluate state of charge, safety, and more

HEALTHY BATTERIES, HEALTHY GRID

The redox flow battery is gaining traction as a promising technology for storing energy for the grid. With an extremely long lifecycle, these batteries provide premium back-up power; store energy from renewable sources, such as wind and solar power; and balance the load on the grid.

Keeping close tabs on the health of these batteries is critical to maximum efficiency and safety of battery operation. For example, monitoring the state of charge allows a grid operator to understand the amount of energy available in a battery at any given time. Additionally, keeping an eye on hydrogen levels generated during battery operation helps mitigate the risk of explosion.

However, current acoustic and spectroscopic methods for examining battery health are costly and non-portable, requiring placement of the battery in range of specialized equipment. Some methods require time-consuming sample preparation or temperature measurements.

Researchers at Pacific Northwest National Laboratory (PNNL) have developed a two-pronged approach that allows grid operators, utilities, and battery system integrators to perform *in-situ* monitoring of redox flow batteries that is portable, low cost, and provides fast determination of battery health—for which, until now, a viable solution did not exist.

TECHNOLOGY FEATURES

- Portable and non-invasive technologies that can be used where batteries are sited.
- Does not require large, specialized equipment for measurement.
- Lower cost than other health monitoring methods.
- Does not require time-consuming sample preparation.
- Monitors and diagnoses overall health of batteries, including oxidation, solid-phase formation, and more.
- Real-time observation of hydrogen bubbles, aiding in safety management and an increase in battery reliability.

Overview of the In-Situ Flow Battery Health Monitoring System.

ULTRASONIC- AND ACOUSTIC-BASED TECHNOLOGIES FOR FLOW BATTERY HEALTH

PNNL has developed two technologies that go hand-in-hand for evaluating battery health. The first technology, the *In-Situ* Monitoring System for Flow Batteries, is an ultrasound pulse-echo method that establishes a relationship between acoustic properties—such as sound speed and attenuation coefficient—and the state-of-charge status in flow batteries. Once the acoustic properties are measured, the current state of charge for the batteries can be determined.

The design uses an ultrasonic measurement cell, including a piezoelectric transducer, which converts the electrical signals produced by some forms of solid materials into sound vibration, and vice versa. The transducer is mounted on the wall of a specially designed ultrasonic probing cell, which bypasses the positive electrolyte reservoir.

A pump circulates the positive electrolyte solution at various stages of sound absorption to the positive electrolyte reservoir. The acoustic properties of the flow battery then can be directly measured by the transducer.

The second technology is called *In-Situ* Health Monitoring System for All-Vanadium Redox Flow Batteries: Detection of Hydrogen Bubbles.

This acoustic monitoring system detects hydrogen bubbles in the analyte solution of all-vanadium redox flow batteries. The system has a specially designed ultrasonic probing cell made of borosilicate glass that can be integrated on the analyte side. The analyte solution first flows through the negative electrode, where the chemical reaction occurs and hydrogen bubbles are typically generated.

The solution then flows into the ultrasonic probing cell. An ultrasonic transducer transmits signals into the probing cell and collects echoes that propagate through the electrolyte solution in the probing cell. The echoes are collected by an ultrasonic receiver and sent to a computer for analysis. Bubbles that flow through the acoustic path are reflected as abnormal in the measurements.

This method does not only detect bubbles in the negative electrolyte solution, but it also estimates bubble flow speed. The technology can continuously monitor bubble amounts without disrupting battery operation and provides real-time, non-invasive surveillance of battery health.

INDUSTRY APPLICATIONS

Grid operators, utilities, and battery system integrators that deploy redox flow batteries for energy storage purposes would greatly benefit from these technologies. Redox flow batteries provide these entities with critical services, such as enhanced grid reliability, premium back-up power, and load balancing. These low-cost, portable technologies will help assure that batteries are operating at maximum efficiency and safely.

AVAILABLE FOR LICENSING

These technologies are available together or separately for licensing. You can view all of PNNL's market-changing intellectual property at pnnl.gov/available-technologies.

LET'S CONNECT

If you have questions, regarding this technology, please send inquiries to commercialization@pnnl.gov. You can view all PNNL technologies available for licensing at www.pnnl.gov/available-technologies.