Abstract #479, 223rd ECS Meeting, © 2013 The Electrochemical Society

Redox Flow Battery Development for Stationary Energy Storage Applications

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Abstract:
Concerns over the longevity and environmental consequences from continued use of fossil fuels resources, along with the growing world demands in energy, have led to increasing the penetration of renewable energy resources such as solar and wind. However, the intermittent and varied nature of these resources makes integration and dispatch of the renewable power challenging. Electrical energy storage (EES) is widely considered as an effective approach to address this problem by improving the grid reliability, power quality, and economy of the renewable energy. The DOE Office of Electricity's – Energy Storage program at Pacific Northwest National Laboratory (PNNL) has been focused on the development of cost effective energy storage technologies to meet these future energy needs. Among the most promising EES technologies are redox flow batteries (RFBs). RFB is an electrochemical device that is capable of storing up to multi-megawatt-hours (MWhs) of electrical energy via a reversible electrochemical energy conversion. Unlike traditional batteries in which the electrodes serve as the sinks of ionic charge and store electricity, RFB's stores electricity in liquid electrolytes that flow on either side of membrane. As such, the power and energy of a RFB can be separately designed, offering greater flexibility for a greater selection of stationary applications.

One of the predominant RFB chemistries is an all-vanadium system that enlists the same element, vanadium, in both the catholyte and anolyte. Researchers at PNNL revisited the standard vanadium sulfate electrolyte chemistry used in this system and developed an electrolyte comprised of sulfate and chloride electrolytes which can stabilize all four vanadium cations at concentrations ≥ 2.5M within a temperature range of -5~50^{o}C. PNNL recently demonstrated a 1.0 kW/1.0kWh prototype battery using this electrolyte system. The prototype system delivered a continuous power of 1.1 kW in the operation range of 15 to 85 % state of charge (SOC) at 80 mA/cm^2 with an energy efficiency of 83 % and energy content of 1.4kWh. The kW scale VRFB with the mixed acid electrolyte successfully demonstrated stable, reliable and efficient operation without any precipitation even at elevated electrolyte temperatures of > 45 °C. The proposed talk will focus on various aspects of PNNL's VRFB battery system, including energy efficiency as a function of current density and capacity fade during cycling.