Introduction to Grid Storage

Grid-scale storage can help integrate electricity generation from intermittent renewable energy technologies, particularly solar and wind, to help meet the increasing global electricity demand while simultaneously reducing CO_2 emissions. A scenario where renewable resources comprise 50% of energy generation is likely to require the integration of large-scale energy storage to support, balance, and stabilize the power system.

Energy storage options apply to different niches in the power system and are often categorized by their power ratings (kW to GW) and discharge rates (seconds to hours). They can be based in different fundamental processes including mechanical, electrical and electromagnetic, and electrochemical. Existing technologies, however, suffer from a number of drawbacks that inhibit widespread adoption and deployment such as low cycle life, cost, performance, durability, and scalability.

GCEP currently funds five programs to address grid-scale storage, four them started in in 2012 as a result of a targeted solicitation on grid-scale storage. The most recent program with Professor Honjie Dai started in the last quarter of 2013. It is entitled “Photoelectrochemically Rechareable Zn-Air Batteries” and attempts to develop novel nanocarbon-inorganic hybrid materials for the oxygen reduction reaction and oxygen evolution reaction. The objective is to create electrocatalysts and photoanodes for photoelectrochemical recharging of Zn-Air batteries.

Professor Scott Barnett at Northwestern University is collaborating with Professor Robert Kee at the Colorado School of Mines to develop “A Novel Solid Oxide Flow Battery (SOFB) Using H-C-O Chemistry”. The program performs fundamental studies of the materials, cells, stacks, and system designs to validate and improve upon the device. Progress over the past year involved testing cell-level models for reversible operation. System configuration studies also show promising round-trip efficiency for a pressurized, intermediate-temperature SOFB coupled with pressurized natural gas underground storage.

A team at the University of Texas, Austin led by Professor Allan Bard is conducting research on “Novel Electrolyte Energy Storage Systems”. This program is rooted firmly in re-examining the fundamentals of flow battery technology and engaging in an effort in which the active redox couples, the materials that separate the couples, and the flow characteristics that dictate the rate of delivery are optimized. This work allows system-level solutions with high efficiency and capital costs that are much lower than if each aspect of the system were optimized individually. To date, the group is completing the fundamental material and mechanistic studies and will begin to focus on designing and prototyping a Br_2/nitrobenzene flow battery where the challenge will be to find a compatible separator.

Professors Yi Cui and Robert Huggins from the Department of Materials Science and Engineering at Stanford University are leading a program to develop inexpensive, safe, high power lithium batteries using aqueous electrolytes. The team is exploring aqueous electrolytes to extend voltage ranges and new group of electrode materials based on Prussian Blue (PB), a common, earth-abundant material that has a zeolitic open framework type of crystal structure. Over the past year, the group has developed anodes that are well matched to open framework cathodes, demonstrating outstanding electrochemical properties and high cycle life. The remainder of the project will be to study the open framework materials in organic electrolytes and to perform electrochemical and crystallographic studies on the mechanisms of ionic conductivity.