Towards Cost-Effective Redox Flow Batteries for Grid-Scale Energy Storage

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Abstract

Vanadium redox flow batteries (VRFBs) are an emerging energy storage technology that offers unique advantages for grid-scale energy storage due to their flexible design and decoupled power-energy feature. Despite these advantages, the relatively higher capital cost of VRFBs limits their commercial viability. One possible approach to reduce the capital cost is to improve the lifetime of these systems. Currently, their lifetime is limited by the capacity fade due to unwanted active species transport across the membrane (i.e., species crossover). In the first part of this talk, a computationally-efficient lumped parameter model which accounts for all modes of vanadium crossover and enables the prediction of long-term performance and related lifetime of the system will be presented. Several mitigation strategies for improving the long-term performance will be discussed.

In line with this study, another approach to reduce the capital cost is to improve the performance of these systems for less material use. Among different sources of performance losses, mass transport limitations play a major role and can significantly hinder the electrochemical performance of VFRBs utilizing carbon paper electrodes. In order to better understand this issue, recently we designed an experimental study that investigates the effects of various flow field designs paired with raw and perforated carbon paper electrodes on the electrolyte flow and the performance of VRFBs. In the second part, a detailed comparison of the experimental performance results for each configuration and corresponding pressure drop measurements will be presented. The talk will conclude with the introduction of a cost-effective all-copper flow battery using flowable slurry electrodes. Details of the system operation along with the current technical challenges will also be discussed.

Biography

Dr. Ertan Agar is an Assistant Professor in the Department of Mechanical Engineering at the University of Massachusetts Lowell. He earned his Ph.D. degree in Mechanical Engineering from Drexel University in September 2014. His Ph.D. dissertation work was a combined experimental and modeling effort, which was aimed at understanding the species transport mechanisms governing capacity fade in vanadium redox flow batteries. Following his doctoral studies, Dr. Agar worked as a post-doctoral researcher in the Electrochemical Engineering and Energy Laboratory at Case Western Reserve University. In this role, he worked on performance diagnostics of flowable slurry electrodes for cost-effective flow batteries. His research interest includes modeling and experimental diagnostics of flow-assisted electrochemical energy systems (fuel cells, flow batteries), mass/charge transport phenomena, electrochemical reaction kinetics, and flowable slurry electrodes. He currently serves as Assistant Editor for the International Journal of Hydrogen Energy.