

Development of rechargeable zinc manganese dioxide batteries from concept through product to market

Sanjoy Banerjee

CUNY Energy Institute and Urban Electric Power, Inc

A high performance, low environmental impact battery to enable widespread deployment of grid-scale energy storage was developed at the City University of New York (CUNY) Energy Institute. The Institute was founded in 2008 with the mission to develop sustainable energy technologies with low carbon footprints. One focus was energy storage to assure capacity from renewable but intermittent generation such as solar and wind power. To this end, zinc anode batteries were researched with federal, notably DOE Office of Electricity, ARPA-E, and New York State, support. The work resulted in a 'green' rechargeable battery concept with earth abundant manganese dioxide (MnO₂) and zinc (Zn) as the non-toxic, easily recyclable and inexpensive, active constituents. These materials are widely used in the ubiquitous and safe primary alkaline cells, but these cells cannot be repeatedly charged and discharged. The breakthrough made at the Energy Institute was to find dopants and processing methods for the manganese dioxide which enabled access to its full two electron producing capacity through thousands of charge-discharge cycles.

Both Zn and MnO₂ are non-toxic, and have lower CO₂ emissions when compared to other rechargeable batteries. Life cycle CO₂ emissions from Zn-MnO₂ batteries are seven times lower than lithium batteries and four times lower than

lead batteries. Additionally, lead recycling is energy intensive and has a significant environmental impact and lithium recycling has not fully matured. In contrast, Zn and MnO₂ can be recycled by low energy consuming chemical processes allowing the Zn-MnO₂ battery to further reduce its greenhouse gas footprint.

To commercialize the concept, Urban Electric Power Inc. (UEP) was spun-off from the CUNY Energy Institute to manufacture, market, and deploy rechargeable large-format Zn-MnO₂ batteries. When manufactured at GWh/year scale, battery packs will cost less than \$50/kWh leading to energy storage systems with a levelized cost of energy (LCOE) below \$0.05/kWh, widely identified as the target for widespread adoption of grid scale energy storage.

In this presentation, we will discuss the evolution of the Zn-MnO₂ rechargeable battery concept from its beginnings at the Energy Institute, through development of prototypes for grid energy storage, to manufacture of commercial products at UEP, and their deployment to provide power backup during grid outages, and to provide storage capacity that support solar and wind generation.



Sanjoy Banerjee is a Distinguished Professor of Chemical Engineering, City College of New York and Director of the City University of New York (CUNY) Energy Institute. Banerjee is also the Founder and Chairman of Urban Electric Power, spun out of the CUNY Energy Institute to develop 'beyond lithium' batteries. Banerjee was recruited from UC Santa Barbara, where he had been Department Chair and previously taught at Berkeley, McMaster University, and worked at Atomic Energy of Canada, as Director of the Applied Science Division. He has also served as Mitsubishi Professor at the University of Tokyo, the Burgers Professor at TU Delft, and at ETH Zurich. He has also served on several advisory boards: NASA Fluid Physics, the oil- industry Flow Assurance Consortium, and the Advisory Committee on Reactor Safeguards, congressionally mandated to advise on nuclear facilities.

Presenting author: Sanjoy Banerjee e-mail: banerjee@ccny.cuny.edu, sanjoy@urbanelectricpower.com