Rechargeable $Zn\text{-}MnO_2$ Battery Systems for Energy Assurance Applications

Jinchao Huang [a, *], Gabriel Cowles [a], Valerio De Angelis [a], Gautam Yadav [a], Roman Yakobov [a], Meir Weiner [a], Aditya Upreti [a], Jungsang Cho [b], Sanjoy Banerjee [a, b]

** Email: jinchao@urbanelectricpower.com*

a. Urban Electric Power Inc., Pearl River, NY; b. City College of New York, New York, NY

Introduction

Power insecurity remains a consistent problem. UEP's $Zn\text{-}MnO_2$ battery is well-suited for power assurance applications in supporting electrical systems during power outages, due to its low cost, safety characteristics, and reliable performance. To further enhance this battery for such applications, UEP has developed a hydrogel electrolyte to replace the liquid electrolyte currently being used, which improves the battery's transportability as well as its durability. UEP also developed an in-situ polymerization technique for an easy scaleup, and fabricated production scale gel cells and a modular power assurance product which demonstrated satisfactory.

Technical Objectives:

Task 1. Develop a stable and ionically conductive hydrogel electrolyte that can be easily manufactured through a scalable process.

Task 2. Develop production scale gel cells that can be manufactured using UEP's existing plant equipment and is functional within UEP's energy storage system architecture.

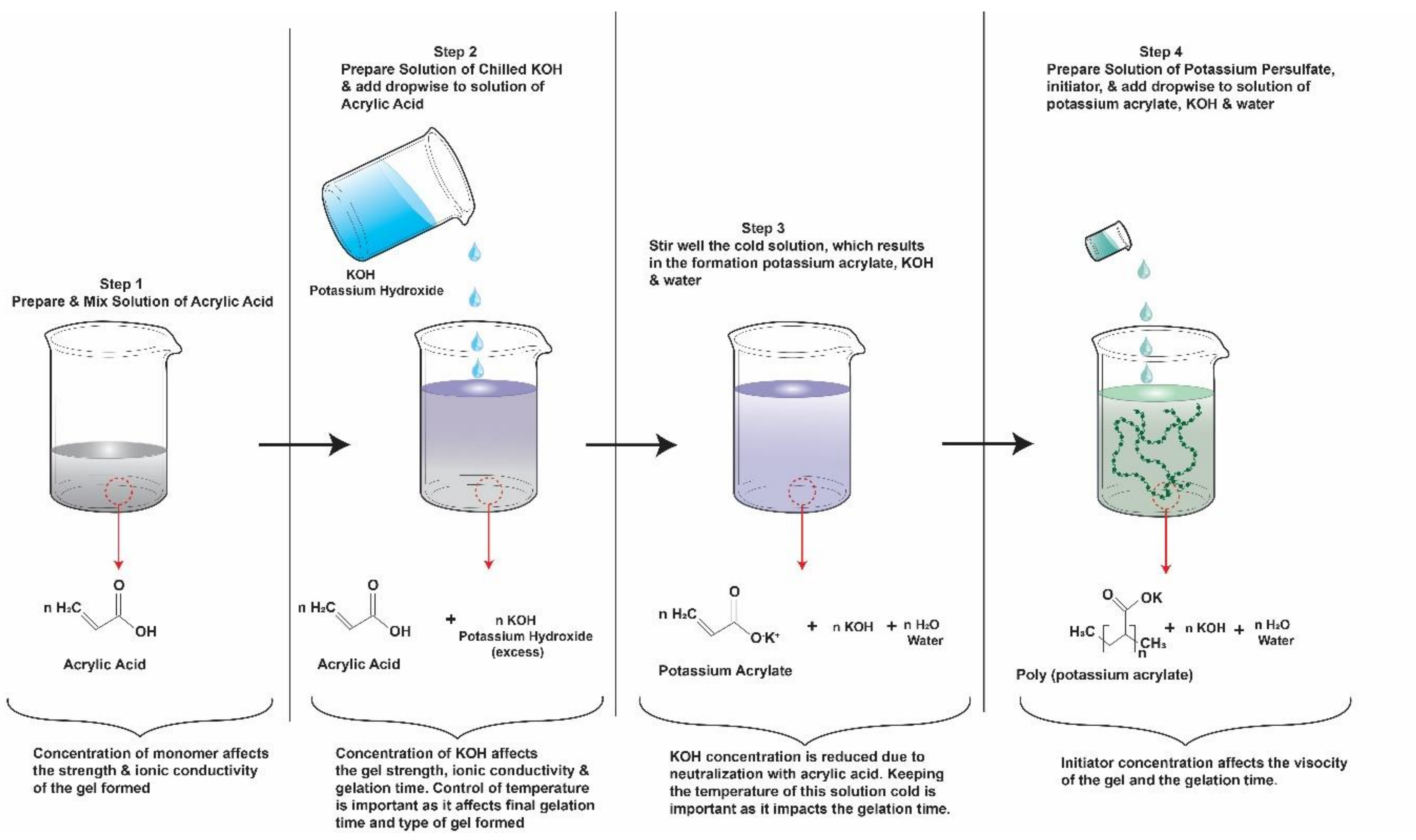
Task 3. Develop a portable energy storage system using cells with gel electrolyte.

Task 4. Demonstrate successful product installations.

Task 5. Apply for relevant product certifications to scale commercialization.

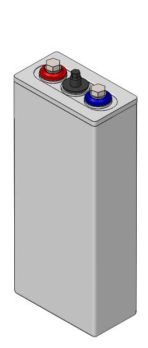
Task 1. Development of Gel Electrolyte

UEP developed a poly(acrylic acid)-potassium hydroxide (PAA-KOH) gel electrolyte for rechargeable $Zn\text{-}MnO_2$ batteries. The electrolyte was optimized to balance the ionic conductivity, chemical/mechanical stability, polymerization reaction kinetics and electrochemical properties.

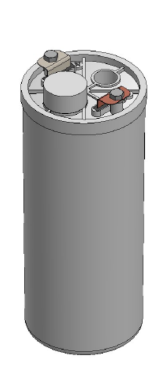


Task 2. Development of Production Scale Cells with Gel Electrolyte

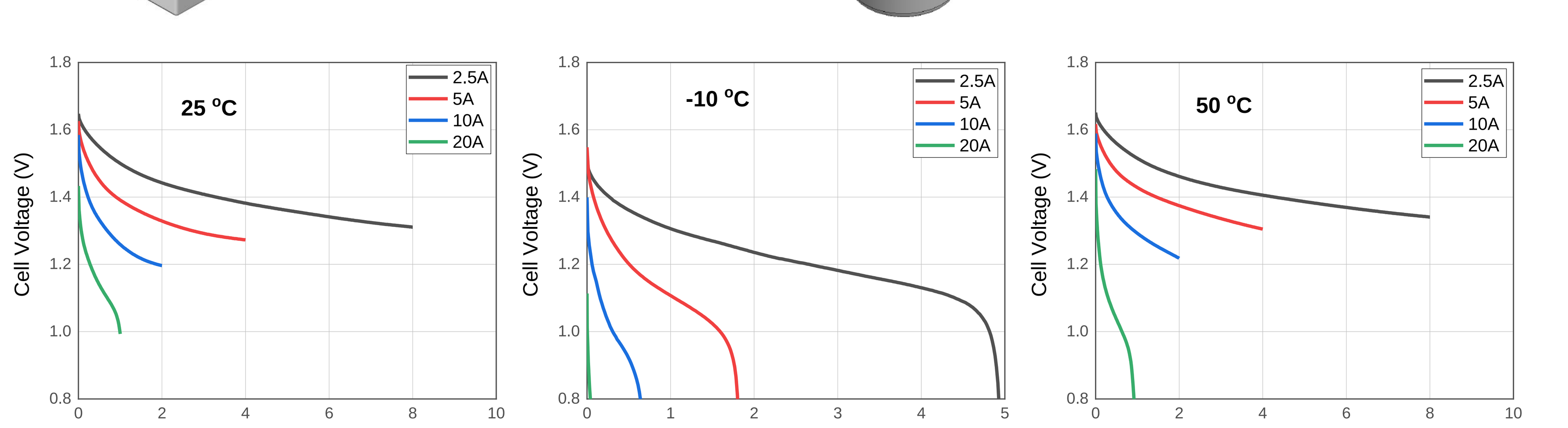
UEP developed an in-situ polymerization technique for an easy scaleup and demonstrated that it can be incorporated in UEP's commercial size cells. Both prismatic and cylindrical cells were successfully filled with gel electrolyte and tested.

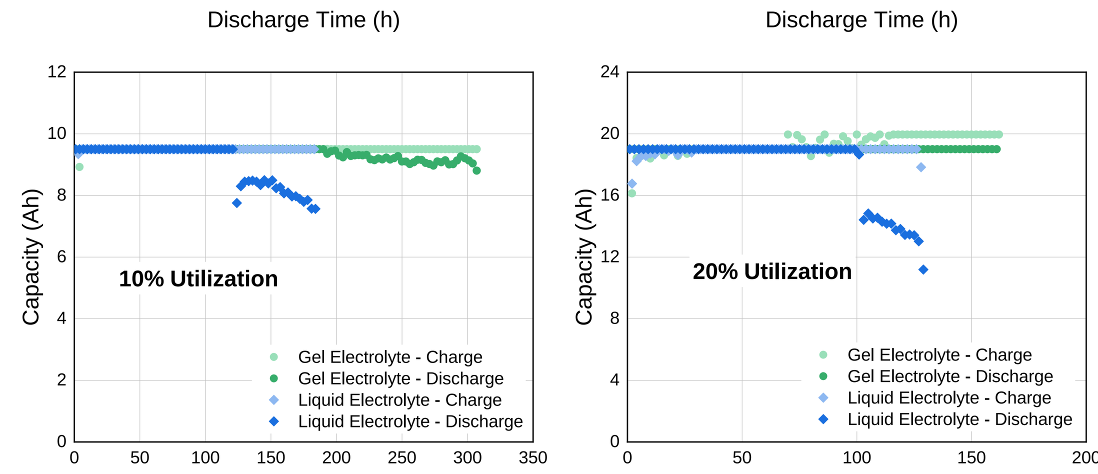


Capacity	80 Ah (rated at 160h discharge)
Voltage	1.3 V
Dimension	8.7x4.7x22.1 cm
Weight	1.54 kg



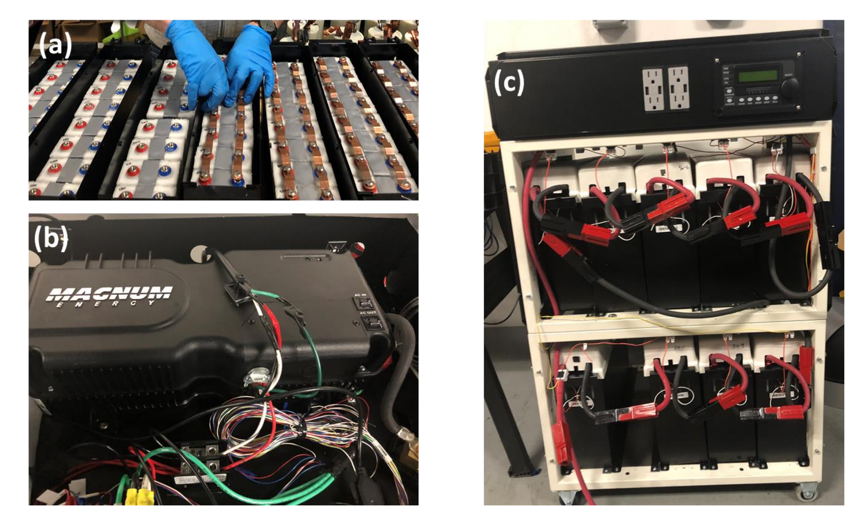
Capacity	120 Ah (rated at 160h discharge)
Voltage	1.3 V
Dimension	9.86x24.00 cm
Weight	2.64 kg

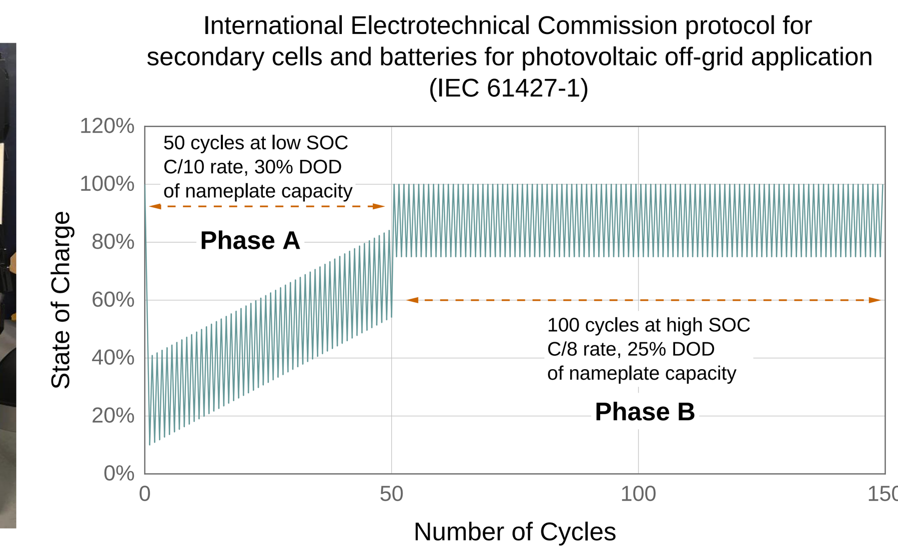




Cell with gel electrolyte showed satisfactory characteristics at various discharge rates and temperatures. It also showed more reliable cycling performance compared with liquid electrolyte cells.

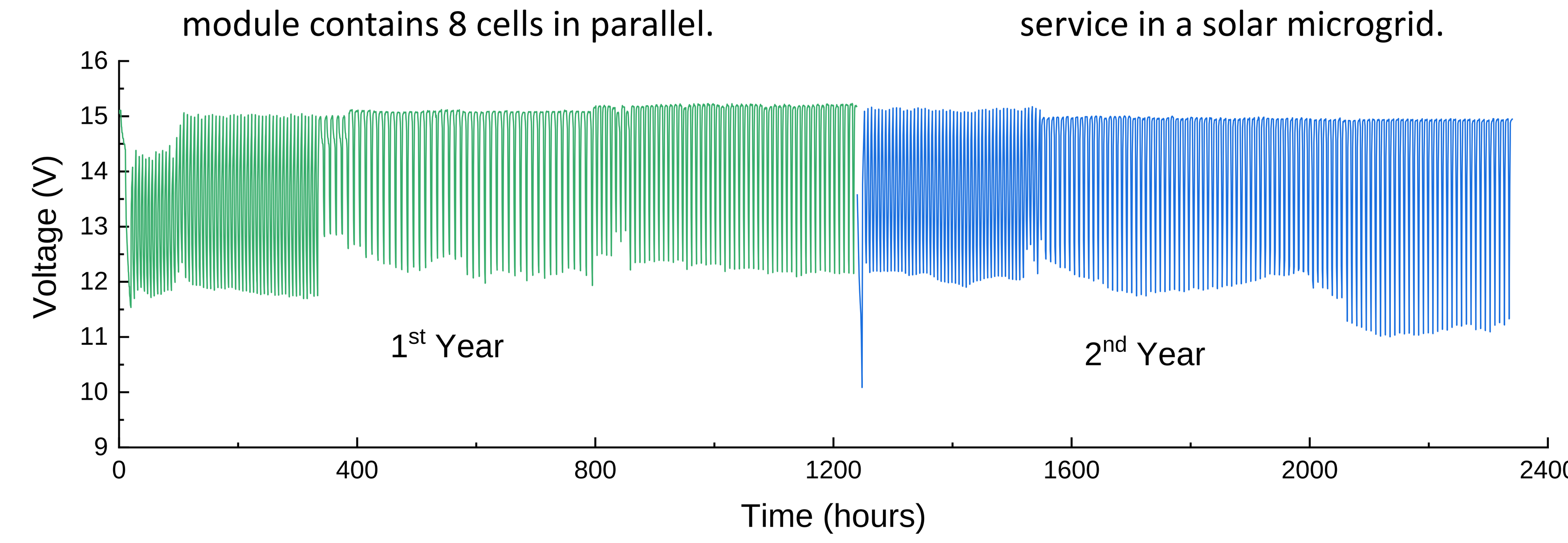
Task 3. Development of a Portable Energy Storage Unit with Gel Electrolyte Cells





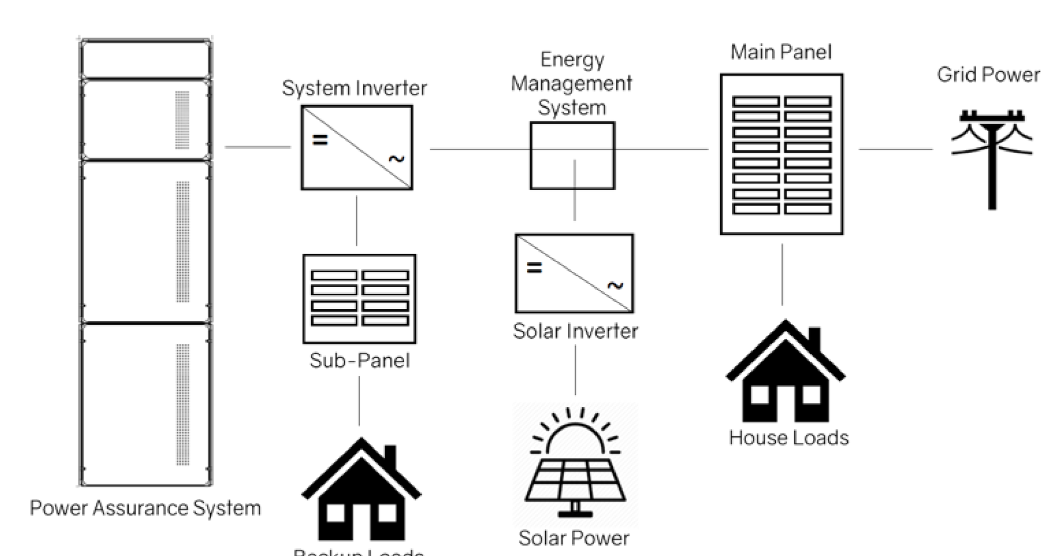
UEP has assembled a 12 V portable system with 2 kWh nameplate energy by using 72 prismatic gel electrolyte cells. The system has 9 modules connected in series and each module contains 8 cells in parallel.

The IEC 61427-1 protocol consists two phases to mimic seasonal cycles and periods with different levels of solar irradiation. Completion of these two phases is equivalent to 1-year service in a solar microgrid.



The system is currently being tested according to the IEC 61427-1 protocol. The system has completed 300 cycles which is equivalent to a 2-year service life.

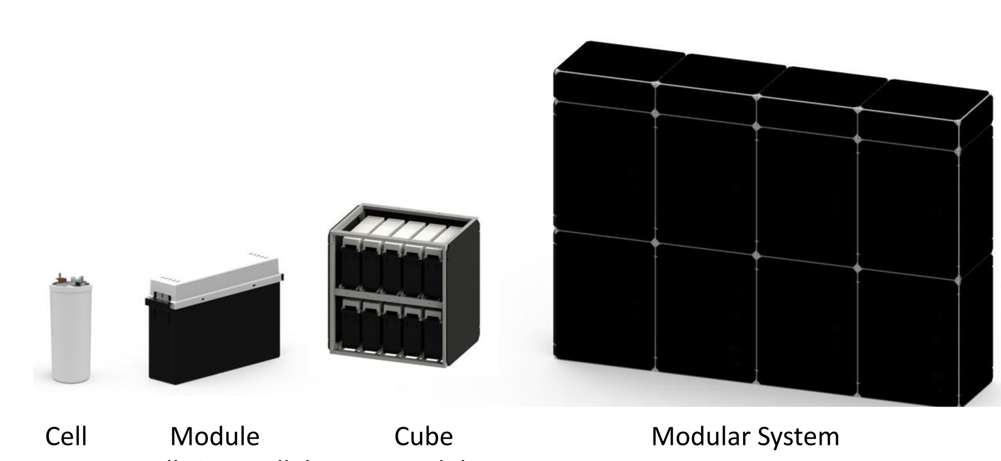
Task 4. System Development and Demonstration of Product Installations



UEP has developed a modular power assurance product which connects through the system inverter to the backup loads sub-panel to provide power during outages. Customers can also connect a grid-tied solar inverter to power the backup loads and charge the batteries in the power assurance system during outages.

System Installation:

1. UEP installed a 56-kWh backup system in the home of a client in Redding, CT.
2. UEP installed a 112-kWh backup system at a commercial office in Norwalk, CT.
3. UEP installed a 20-kWh backup system in UEP and paired it with solar to run off grid for days with a daily recharge from the sun.



UEP cells are housed in modules and scaled to meet the needs of households and small businesses.

Task 5. Apply for relevant product certifications

UEP received UL 1973 certification for the cylindrical cells after completing the UL tests to satisfaction. This certification is a base requirement for energy storage systems. UEP is in the process of adding addendum to the current certification to incorporate the gel electrolyte.

Conclusions:

UEP optimized a gel electrolyte and demonstrated that it can be incorporated in UEP's commercial size cells. UEP also demonstrated scalable manufacturing of the gel electrolyte which can be easily incorporated into UEP's current manufacturing line. Several systems were installed to serve as validation for both system and cell and provide valuable performance insight to guide future improvements. Finally, the testing and certification needed for scaled system deployment has been identified and initiated, which is a key step in bringing this product to market.

In summary, UEP has accomplished all primary objectives, and is in a strong position to scale and commercialize this technology.

A manuscript has been submitted to Energy & Environmental Science.

Acknowledgement:

This work was supported by the U.S. Department of Energy, Office of Electricity under the Small Business Innovation Research (SBIR) Program with Grant No. DE-SC0019913.

Dr. Imre Gyuk, Director of Energy Storage Research, Office of Electricity is thanked for his continued support and Dr. Stanley Atcitty, Distinguished Member of Technical Staff at Sandia National Laboratories, is thanked for his technical support.