NYSERDA Innovation and Technology Energy Storage Case Study

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Final Report

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Abstract

NYSERDA awarded funding to Urban Electric Power (UEP) and Ecolectro through its Renewables Optimization and Energy Storage Innovation Program. UEP is creating a less toxic battery that can enable peak-shaving and demand charge reduction. Ecolectro is creating electrolyzers and fuel cells without titanium or platinum, thereby making their systems much more cost-effective than existing technologies. NYSERDA assistance has helped these companies develop and bring their products closer to commercialization, which, in turn, has resulted in economic benefits to New York State and potential future energy and non-energy benefits.

Keywords

Renewables Optimization and Energy Storage Innovation, Energy Storage, Urban Electric Power, Ecolectro, Batteries, Electrolyzer, Fuel Cells

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Acronyms and Abbreviations

DPS	Department of Public Service
EIR	entrepreneur-in-residence
FDNY	Fire Department of New York
kWh	kilowatt-hour
M-Corps	manufacturing corps
MW	megawatt
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
PSC	Public Service Commission
R&D	research and development
UEP	Urban Electric Power
UL	Underwriter's Laboratories

1 Introduction

In June 2018, New York State Energy Research and Development Authority (NYSERDA) and the New York Department of Public Service (DPS) issued an Energy Storage Roadmap which charts a course to install 1,500 megawatts (MW) of energy storage in New York State by 2025. In December 2018, the New York Public Service Commission (PSC) issued an order which established a goal of 3,000 MW of energy storage in the State by 2030, along with mechanisms for achieving both the 2025 and 2030 goals. This document describes the many benefits of an expanded energy storage market including a more resilient and flexible electric system and thousands of new jobs as well as other benefits. Improved energy storage technologies will also benefit the growing New York State solar industry by expanding the range of installation locations, reducing operating costs, and making the availability of solar power less variable by balancing excess production and underproduction.

A key part of this strategy is NYSERDA's Renewable Optimization and Energy Storage Innovation Program. The program has, through $97 million in investments, helped develop 126 renewable energy and energy storage solutions, which has yielded $643 million in follow-on investments and 21 commercialized products.[1]

This case study takes a closer look at the support NYSERDA has provided and the impacts of that support for two energy storage companies: Urban Electric Power (UEP) and Ecolectro. Table 1 shows that NYSERDA has provided the companies with nearly $4 million in awards as well as other assistance over nearly a decade. The study describes how NYSERDA has supported the companies in each stage of development (research and development, product demonstration, and product commercialization), along with the benefits of that support.

Table 1. NYSERDA Support for Urban Electric Power and Ecolectro

Company	Urban Electric Power	Ecolectro
Location	Pearl River, NY	Ithaca, NY
First Year of NYSERDA Support	2012[a]	2017
NYSERDA Direct Awards	Number of NYSERDA awards: 6 Total NYSERDA funding amount: $2.9 million Additional cost sharing from company: $2.4 million	Number of NYSERDA awards: 3 Total NYSERDA funding amount: $0.7 million Additional cost sharing from company: $0.5 million
Other NYSERDA Assistance	Entrepreneur-in-Residence (EIR) program, Innovation Advisor program, Manufacturing Corps (M-Corps) program, technical support for developing testing protocols and strategies, and endorsement letters for non-NYSERDA award applications	

a NYSERDA provided support for battery research conducted at the City College of New York's (CCNY) Energy Institute, which was the birthplace of UEP, before 2012. However, this case study is focused on the impacts of the support since the foundation of UEP in 2012.

2 Research and Development

NYSERDA has provided extensive research and development (R&D) funding support to UEP and Ecolectro. This R&D funding is crucial because private investors are often reluctant to invest in technologies still in the development stage. "Generally speaking, venture [capital] firms don't want you to go through a long period of trial and error …. and that's really what's needed for a technology," said Gabe Cowles, Vice President of Finance and Business Development for UEP.

> "You need some bandwidth to take chances and vet different ideas. We wouldn't be able to do that strictly with private venture funding … and so [NYSERDA funding] is very necessary," said UEP's Gabe Cowles.

UEP's innovative zinc manganese dioxide (Zn-MnO_2) batteries have evolved with steady improvements in the materials used, the shape of the batteries, the capacity of the cells, their energy density, and the configuration of the battery management systems. Yet this process has not been simple or smooth. "Technology evolves very rapidly, so a lot of times there is a step function of improvements," explained UEP's Cowles. "We have a cell, and now we figured out how to manage it with the battery system. Now the cell evolves, so we have to evolve the battery management system with it … So maybe the exact system developed back in 2016 is not totally relevant now."[2] Table 2 summarizes the projects that NYSERDA has funded for UEP and their notable achievements along with some challenges encountered.

Table 2. NYSERDA Energy Storage Projects with UEP

NYSERDA Project (Award Amount, Time Period)	Notable Project Achievements and Challenges
Development and Testing of an Advanced Battery Management System ($0.25M, 2012–2016)	• Developed a battery management system customized for the new zinc-manganese dioxide technology. • Increased battery cell capacity by a factor of 3 (20 to 60 Ampere hours). • Created and revised procedures to shorten manufacturing times.[a] • Conducted third-party testing on the battery module for safety analysis. UEP discovered the costs of this third-party testing was much more expensive than originally expected partly due to testing protocols being designed for different battery technology. • UEP encountered some challenges with zinc anode corrosion, zinc anode shape change, and zinc dendrite formation. These problems can lead to internal short circuits, electrode deterioration and premature failure of the battery. UEP overcame these challenges through new separator selection and cathode formulation and changes in material selection.

Table 2 continued

NYSERDA Project (Award Amount, Time Period)	Notable Project Achievements and Challenges
Urban Electric Power Manufacturing Facility and Operations ($1.0M, 2013–2016)	• Demonstrated the manufacturability of a new battery technology. • Lessons learned from first manufacturing facility were used in new larger Pearl River, New York facility. • Conducted early field trials to test the technology outside the lab environment. • UEP secured over $10 million in Series A funding due to the success of the pilot manufacturing facility.
Smart Building Demand Response with Battery Storage and Curtailment ($0.16M, 2014–2019)	• Developed a control strategy to integrate batteries with building operations to minimize peak power demand in commercial buildings in urban areas. • Validated this control strategy in lab and field tests with systems as large as 30 kW. • Developed a battery lifecycle assessment system for New York City and other urban areas that integrates realistic battery models and time-of-day tariffs. This allows for estimation of the payback periods for the energy storage systems either with or without the assistance of the Building Automation System.
Scaling Zinc Manganese Dioxide Battery Capacity and Production ($0.25M, 2016–2019)	• Developed a new cylindrical battery configuration which is easier to manufacture. • Allowed UEP to reduce average battery production times to 20 minutes (from 200-minute average production times for first production).[b] • Tested new battery systems in customer sites for backup power applications.
Development and Demonstration of a 1MWh System for Peak-Shaving Charge Reduction ($1M, ongoing)	• Project is ongoing, but once completed, the installation at the City College of New York will be one of the largest indoor-sited energy storage systems in New York City. • Project has encountered some challenges getting approvals from the Fire Department of New York (FDNY) and other permitting entities to site the energy storage system inside a building resulting in a reduction of the system size to 800 kWh.
Zinc Battery-Based Demand Reduction Unit for Dairy Farmers ($0.25M, ongoing)	• Project is just starting with dairy farm site in Goshen, NY that was recently selected. • Once completed, the energy storage system will integrate with the solar PV system on the farm.

[a] These early increases in production efficiency contributed to the total reduction in production times from 200 to 20 minutes described below for the NYSERDA project: Scaling Zinc Manganese Dioxide Battery Capacity and Production.

[b] This reduction in production times from 200 to 20 minutes includes not only manufacturing efficiency gains from this project but also from the predecessor project Development and Testing of an Advanced Battery Management System listed earlier in the table.

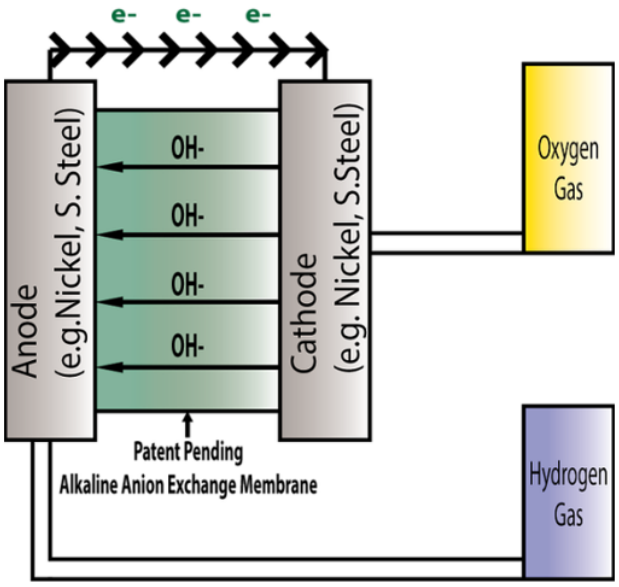
Improving electrolyzer and fuel cell technology is the goal of Ecolectro, an energy storage start-up based in Ithaca, NY. Ecolectro is much earlier in the product development stage than UEP but their technology holds much promise.

"Our polymers are really the enabling component of achieving lower than $2-a-kilogram hydrogen," said Gabriel Rodriguez-Calero, the CEO of Ecolectro.

The United States Department of Energy has determined that for fuel cells to be cost competitive in the transportation sector, hydrogen production costs need to be at or below $2 per kilogram. Figure 1 shows a diagram of the Ecolectro technology.

Figure 1. Ecolectro Alkaline Anion Exchange Membrane in a Fuel Cell

Source: "Ecolectro secures $1.7M ARPA-E award for development of alkaline exchange membranes and ionomers for fuel cells and electrolyzers," Green Car Congress, December 2, 2018.



In 2019, the company won a $1.7 million award from the U.S. Department of Energy's (DOE) Advanced Research Projects Agency-Energy (ARPA-E). The goal of the three-year ARPA-E project is for Ecolectro to develop a type of ink that can be coated on cathodes and anodes to make fuel cells and electrolyzers perform more efficiently with less corrosion. NYSERDA's Innovation Program recommended that Ecolectro apply for the ARPA-E award, sent ARPA-E an endorsement letter, and matched the award with $190,000 of its own funding. Table 3 summarizes the awards that NYSERDA has provided Ecolectro since the company was established as well as notable project achievements and challenges.

Table 3. NYSERDA Energy Storage Projects with Ecolectro

NYSERDA Project (Award Amount, Time Period)	Notable Project Achievement and Challenges
Low-Cost, Highly Conducting, and Chemically Stable Alkaline Fuel Cell Systems ($0.5 M, 2017–2020)	• Developed new polymers seeking to create a more stable alkaline exchange membrane (AEM) for electrolyzer and fuel cells. • Tested the new polymers for stability and other performance properties. Ecolectro discovered that some polymers were better than others at minimizing water intake (excessive water can reduce the electrochemical performance and durability of electrolyzers and fuel cells).
Accelerate Material Sales by Standardizing Product ($0.1 M, ongoing)	The goal of this project, which is in its beginning stages, is to standardize the chemistries used in Ecolectro's products and making sure these polymers can be produced at sufficient volumes to make them commercially feasible.
Modular Ultra-stable Alkaline Exchange Ionomers to Enable High-Performing Electrolyzers and Fuel Cells ($0.2 M, ongoing)	This was a cost share with the ARPA-E award described above.

3 Demonstrating the Technology

In its early phases of product commercialization, UEP is currently focused on demonstration projects that support their target markets. The company is working with City College of New York to install an 800-kilowatt-hour (kWh) energy storage system for peak shaving and demand charge reduction. Once completed, the system will be one of the largest indoor-sited energy storage systems in New York City.[3] Reducing annual system demand charges is one of the best ways for customers who invest in energy storage systems to recover their costs.

Yet putting a large energy storage system in a building has many challenges. For example, such systems cannot be installed in New York State buildings without the approval of the Fire Department of New York (FDNY). The FDNY requires energy storage systems to have five different Underwriter's Laboratories (UL) certifications. This certification testing can be very expensive for new battery technologies. UEP found that obtaining its first UL certification cost more than four times what it had originally budgeted. The company has obtained UL 1973 certification and is working on obtaining the other four required UL certifications. UEP credits NYSERDA's Innovation Program for helping the company develop new testing protocols and strategies.

Overcoming the challenges of putting an energy storage system inside a building could benefit the solar market—which accounted for over 10,000 New York State jobs in 2019[4]—and thereby support the State in its commitment to generating 70% of its electricity through renewables by 2030. Energy storage can also help the New York Independent System Operator (NYISO), which manages the State's electric grid, make intermittent renewable energy resources less variable by saving excess production or supplementing injections during underproduction.[5]

Getting energy storage systems inside buildings would also increase system performance and reduce costs by moderating the temperatures in which batteries are exposed. Battery charging capabilities diminish in temperatures below 40°F. The performance and durability of lithium-ion batteries also declines with higher temperatures, thereby often creating a need for costly refrigeration.[6]

Patrick Dias, President of Croton Energy Group, a New York City-based solar energy installer, is familiar with the UEP battery technology through a solar installation his company performed at UEP's production facility in Pearl River, NY. Dias noted that it is very difficult for his company to do solar installations in New York City because of FDNY restrictions on installing battery storage systems inside buildings.[7]

"One of the most intriguing things about the [UEP] batteries was we could install them in the City, where batteries are not allowed inside buildings," said Patrick Dias of the Croton Energy Group.

UEP is also testing their energy storage system with a solar installation on a dairy farm in Goshen, NY. The project is still in its early stages and UEP has credited NYSERDA with helping them with the system design. "We're getting advice from NYSERDA as to: 'Should we make a containerized system? What kind of value add would that provide?" said UEP's Cowles. "And they're giving us some degree of market intelligence, some degree of technical expertise to say, well, here are the pros and cons of the different potential scenarios for us to think about."

NYSERDA's support in helping develop UEP and its technologies is paying dividends in India which has a $5.5 billion market for batteries. UEP has a joint venture in India with Godrej and Boyce, a company that produces home appliances among other products. Suraj Singh, a marketing and sales lead for the joint venture, describes the relationship between them and UEP as more than a joint venture and more like a "strategic partnership."

Singh said his company is doing pre-commercial testing of the UEP batteries in various applications. One application is for backup power supplies for home use. Due to frequent power cuts, most homes in India have a small backup power supply to keep the lights and fans going during power outages. The company is also testing the UEP battery technology in forklifts (which the company manufactures), in street lighting applications, and in electric rickshaws.

Raghuveer Vadari, an R&D lead at the joint venture, said his company has done enough testing of the UEP technology that it is now providing regular feedback to UEP on the batteries' performance under different use cases. "We are working here in India to see how close or how far we are from the actual applications in terms of structure and chemistry," he said. "We are working together [with UEP] to bridge the gap if there is a gap in a particular application between what we have now and what it should be."

Vadari said UEP's battery technology has several advantages over competing batteries technologies such as lead acid and lithium ion. The zinc component of the UEP batteries is one advantage since India is one of the world's major zinc producers. "This technology will definitely make the country self-dependent,"

said Vadari. He also observed that materials in competing battery technologies, such as cobalt and nickel, are scarcer and have created political problems in the areas where they are mined. These advantages in component sourcing would also benefit the U.S. since it is the fourth largest zinc producer in the world.

Vadari also appreciated that the UEP batteries are made from less toxic materials than other battery technologies since India has serious contamination issues from lead acid battery disposal.[8] Finally, Vadari noted that UEP battery production costs are lower than those for lithium ion batteries and comparable to lead acid batteries. In India these lower costs are key for future market penetration.

The testing program at Godrej has found ways to increase the durability of the UEP batteries. "So, now we are trying to improve [the cycle life]…and we have done some modifications and improvements in the design part and we are already seeing cycles life that are close to or even better than lead acid batteries," said Vadari.

The Indian research is also producing economic benefits in New York State. "The [Indian] partnership has expanded our production line in New York and increased the number of jobs in the State," said UEP's Gabe Cowles.

Cowles noted that Godrej and Boyce have purchased most of the batteries manufactured by UEP. Due to this increased demand, UEP was able to expand from its small manufacturing facility in Harlem that employed 10 people to its facility in Pearl River which currently has 35 employees, employing as many as 60 during full battery production runs. The direct economic impact of this increase in employment is over $4 million.[9]

In addition to increasing jobs in New York State, the joint venture has also produced knowledge transfer benefits. "The partnership with Godrej has yielded a number of lessons learned that can be applied in the U.S. and beyond," said Cowles. "It has enabled us to build both large and small energy storage systems and learn how our batteries best work in these systems. Forklift …testing being performed in India can certainly be leveraged here once the product has been refined."

Green Jobs

- Since the start of NYSERDA's support in 2012, UEP has more than tripled its workforce resulting in over $4 million in direct economic benefits.
- Since NYSERDA started supporting Ecolectro in 2017, the company's staff has doubled producing over $1 million in direct economic impacts.

4 Getting the Products to Market

While UEP and Ecolectro are mostly in the product development and demonstration stages, they are both working toward commercializing their products. This is another area where NYSERDA has provided support. Both UEP and Ecolectro have taken advantage of NYSERDA's Entrepreneurship-in-Residence (EIR) Innovation Advisors programs.

"We have folks that are experienced entrepreneurs that have been down the tech start-up path, have been successful, and can help them with the business side of things, and help them with a pitch book, and all those kinds of things that help them prepare to talk to investors and potential investors," said NYSERDA Scott Larsen.

"They [NYSERDA] have been really supportive in the "soft services," service in providing intros, providing support, providing guidance, and all of that," said Ecolectro's Rodriguez-Calero. UEP's Ann-Marie Scuderi credited NYSERDA with "introducing us to potential equipment manufacturing companies."

> "If you need sales help or if you need product development help or marketing or financing, they [NYSERDA] provide very specific experts in those relevant areas," said Ecolectro's Gabriel Rodriguez-Calero.

In addition to expanding networks for investors and manufacturers, another key component of commercialization is reducing the cost of production. Since expanding to its Pearl River facility, UEP has been able to reduce the average time of producing a battery to 20 minutes from 200 minutes when they first started production in their Harlem facility. In 2018 the facility was able to produce about 50,000 batteries.

Ecolectro is also trying to reduce the product costs of its materials under a NYSERDA project that began in 2019. "The next step is making sure we can make any amount of these materials in a way that's commercially feasible," said Ecolectro's Rodriguez-Calero. "The goal of this project is to standardize the product manufacturing process to the point where we can start qualifying the materials in the hands of customers." [10] Rodriguez-Calero explained that the company is trying to get customers

to validate its technology by testing Ecolectro's products in their systems. The company has already seen some gains in productive efficiency. "In the beginning we could make tenths of grams [of certain polymers] and now we can make up to kilograms," said Rodriguez-Calero.

To help achieve these objectives, Ecolectro increased the size of its staff from four employees in 2017 to eight in 2020. The direct benefit of this increase in employees to the New York State economy is over $1 million.[11]

While it will take time for Ecolectro to produce a commercially viable product, the potential benefits could be significant. "NYSERDA sees [Ecolectro] as a potential rising star," said NYSERDA's Scott Larsen. "And the benefit [to their technology] is that you don't need titanium. You don't need the platinum. Their much lower cost of materials can bring down the entire cost of the fuel cell system or the electrolyzer system, and therefore, make generating the hydrogen or the electricity much more cost-effective."

Endnotes

[1] "Removing Barriers and Creating Opportunity For Renewables and Energy Storage Improving Resiliency and Reducing GHG Emissions Through A Renewables Rich Grid, NYSERDA, (https://www.nyserda.ny.gov/Partners-and-Investors/Clean-Energy-Startups/Research-and-Development-Innovation)

[2] The evolution of the cell referred to is UEP's switch from a prismatic to a cylindrical battery configuration which was funded under the NYSERDA project "Scaling Zinc Manganese Dioxide Battery Capacity and Production" which is summarized in Table 2.

[3] In early March 2020 UEP estimated the installation would be completed by the end of 2020. However, that estimate was made before the full impacts of the COVID-19 pandemic.

[4] https://www.thesolarfoundation.org/national/ - Solar Jobs by State

[5] "*The State of Storage, Energy Storage Resources in New York's Wholesale Electricity Markets*; the NY ISO. https://www.nyiso.com/documents/20142/2225293/2017-State-Of-Storage-Report.pdf/c80da6ff-b239-3464-3b6d-f191bf62c597

[6] K. Smith et al., NREL; "Predictive Models of Li-Ion Battery Lifetime," IEEE Conference on Reliability Science for Advanced Materials and Devices;" Colorado School of Mines; Golden, Colorado; September 7-9, 2014.

[7] NYSERDA's *New York State Battery Energy Storage System Guidebook* (https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Siting/Battery-Energy-Storage-Guidebook) contains all the New York building and fire code rules pertaining to the use of batteries in buildings.

[8] In 2019 UEP won a Green Chemistry Challenge Academic Award from the U.S. Environmental Protection Agency.

[9] Based on a DNV GL analysis using 2018 data on mean New York wages for electrical, electronic, and electromechanical assemblers and production managers from the U.S. Bureau of Labor Statistics (BLS). Due to the nature of startup companies, actual wages might deviate from the BLS mean wages.

[10] The project is called Accelerate Material Sales by Standardizing Product and is described in Table 3

[11] Based on a DNV GL analysis using 2018 data on mean New York wages for material scientists from the U.S. BLS and job counts and descriptions from Ecolectro. As noted, due to the nature of startup companies, actual wages might deviate from the BLS mean wages.

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