New York Clean Energy Future: BNL Role

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Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

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NYS Ambitious Clean Energy Goals Align with Federal Direction

Targets in NYS' Climate Leadership and Community Protection Act (CLCPA)

- 85% reduction in greenhouse gas emissions by 2050
- 100% zero-emission electricity by 2040
- 70% renewable energy by 2030
- 9,000 megawatts of offshore wind by 2035
- 3,000 megawatts of energy storage by 2030
- 6,000 megawatts of solar by 2025
- 22 million tons of carbon reduction through energy efficiency and electrification
- https://climate.ny.gov/

Decarbonizing the Energy System

Federal actions over the next 10 years to achieve net-zero by 2050

- Electrify energy services in transportation, building, and industry
- Improve energy efficiency and productivity
- Produce carbon-free electricity
- Expand the innovation toolkit

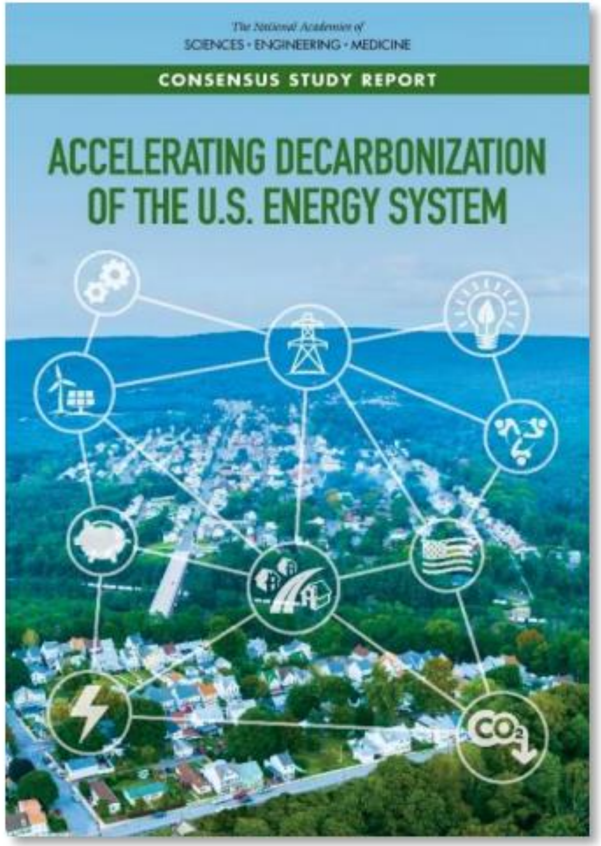
New York's ambitious clean energy goals align with Federal direction

Climate Leadership and Community Protection Act (CLCPA) Goals

Challenge and Risk

- Unprecedented magnitude and rate of decarbonization
- Introduction of massive scale storage, renewables, and electrified transportation, with many new unverified technologies
- Rapid transformation of electricity system introduces new levels of risk
- Protect the ratepayer and assure energy and environmental equity

Given the complexity of the challenges, stakeholders need to collaborate to understand the issues and identify a path forward

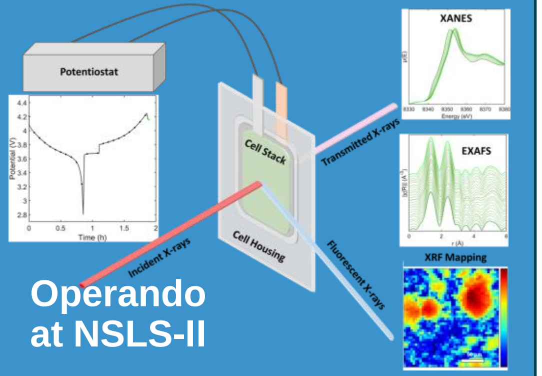


nap.edu/decarbonization

Clean Energy Overview

Vision: Integrated, team-oriented program for transformational discoveries in energy storage, clean energy generation and integration, catalysis, and physical biosciences

Energy Storage: build the scientific knowledge base to enable future creation of scalable electrochemical energy storage systems



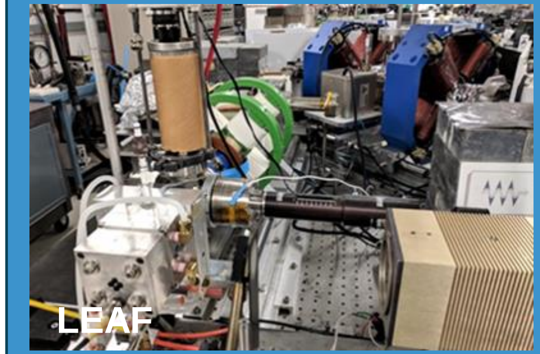
Gain mechanistic insight through operando studies at NSLS-II and CFN

Electric Grid: address northeast regional challenges including integration of massive offshore wind

Grid Modelling

Maintaining Reliability: how much storage is needed and where do you put it?

Chemical and biological energy conversions: advance fundamental science for sustainable energy conversions



Radiation chemistry of molten salts at the Laser Electron Accelerator Facility (LEAF)

NSLS-II and CFN: World-class capabilities and expertise for materials and chemical sciences are the foundation for this science

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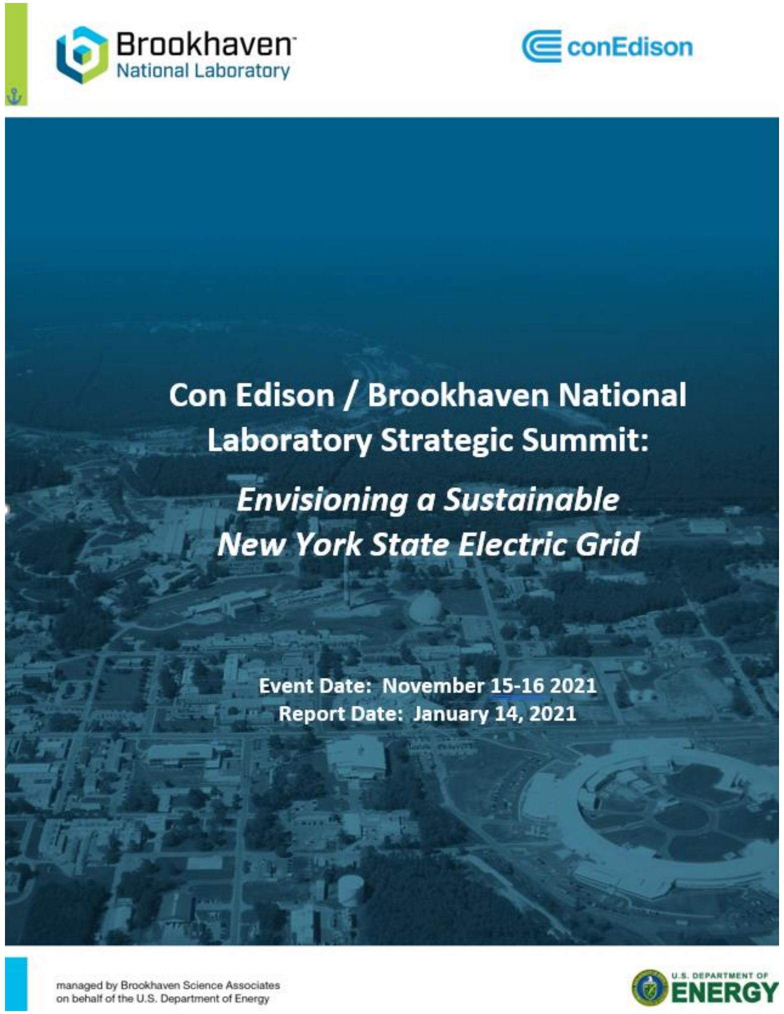
Mapping the Future:
BNL / ConEdison Workshop

- Strong engagement with regional stakeholders (utilities, state, academic)
- Identified and prioritized significant opportunities to advance clean energy
- Enhanced partnership with utilities, especially Con Edison
- Developing roadmap with regional utilities and stakeholders for a sustainable carbon-free electric grid



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Challenges and Opportunities

Electric Grid / Energy Storage

- How to integrate offshore wind?
- How much storage is needed and where do you put it?
- Can Green Hydrogen help New York?

Buildings

- How to make more efficient?
- How to decarbonize?

Transportation

- Can we charge our electric cars faster?
- What impact will rapid growth of electric vehicles have on the grid?

Electric Grid

BNL Clean Energy Initiatives

Grid Modernization

- Grid modeling and simulation
- Data analytics and machine learning applications
- Methods and tools for dynamic assessment and control design

Energy Efficiency/ Decarbonization

- Building efficiency
- Alternative fuels including biofuels and hydrogen
- Emissions measurement and analysis

Energy Storage/ Green Hydrogen

- EFRC – science of scalable batteries; Operando studies
- Batteries for electric vehicles – fast charge, higher capacity materials
- Battery systems suitable for large scale applications
- Green Hydrogen for Electricity, Buildings, Transportation

Environment (EBNN—Martin Schoonen)

- Urban microclimate studies
- Regional predictions

Brookhaven Lab Vision:
Northeast Center for Grid Innovation (NE-CGI)

Key Questions

- How to integrate offshore wind?
- What technology to use?
- How much storage is needed?
- Where do you put it?

Facility Vision

- Modeling center for grid
- Labs to demonstrate new technologies
- Industry/University/National lab partnership

Simulation to reduce risk

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NE-CGI Will Address Prioritized Use Cases

The design of the NE-CGI facility has been based on use cases identified by stakeholders as being important to meet their needs

1. Evaluation of New Grid Software Tools and Technologies to Reduce Risk
2. Development, Testing and Training on Cyber and Physical Security Technologies
3. Integration of Renewables
4. Enabling Grid Scale Energy Storage
5. Diverse Workforce Development

6. Emulation of Grid Operations
7. Integration of Micro & Macro Grids
8. Big Data Management
9. Equipment Configuration and Testing
10. Demonstrate Effectiveness of Demand Response Programs
11. Develop High Resolution DER Forecasting Tools
12. Probabilistic Risk Assessment
13. Testing Novel System Protection Schemes
14. Digital Substation and IEC 61850
15. Retail Market Emulation and Grid Interaction
16. Implementation of Transactive Energy
17. High-voltage equipment testing & training

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Use Case: Integration of Renewables

Challenge	Importance
▪ Many states have adopted aggressive goals to develop renewable energy resources as a means of mitigating climate change ▪ Large amounts of renewables can result in control and stability issues on the grid	▪ Reduction of grid inertia and variable nature of renewable resources can adversely impact grid stability ▪ New technologies are needed to enable high penetrations of renewable generation and achieve decarbonization
Technology Gap	**NE-CGI Facility Contribution**
▪ The level of renewable generation on the grid is relatively small, so there is only regional concern with little or no impact on overall grid performance ▪ As penetration levels rise control and stability issues will arise ▪ Present control and mitigation strategies are not well suited to handle these challenges	▪ Provide capabilities to develop and test new technologies for controlling and operating the grid with high penetrations of renewable generation ▪ Enables new technologies to be tested and validated using simulations of actual grid models

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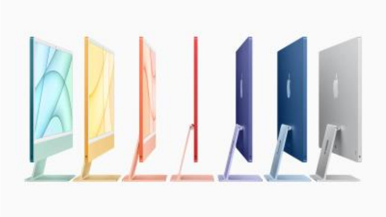
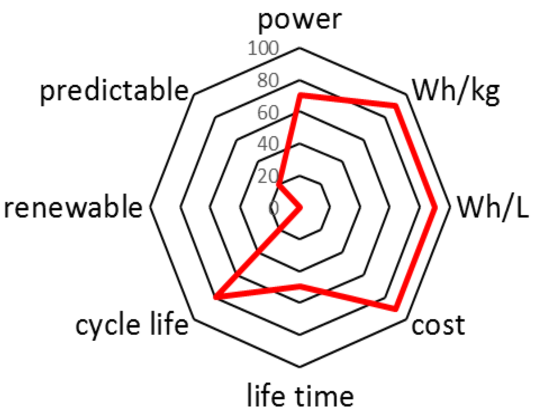
Energy Storage

Current and Future Energy Storage Technologies

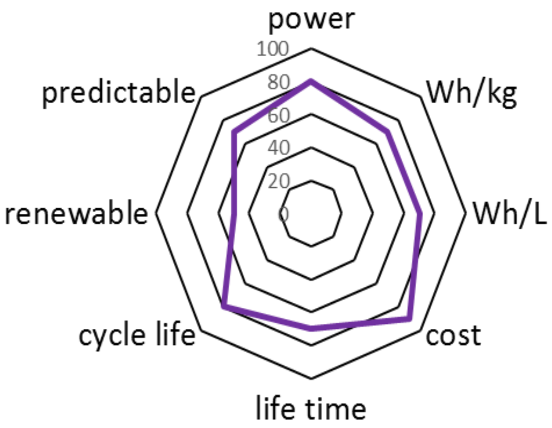
Current → **Future**

Consumer Electronics

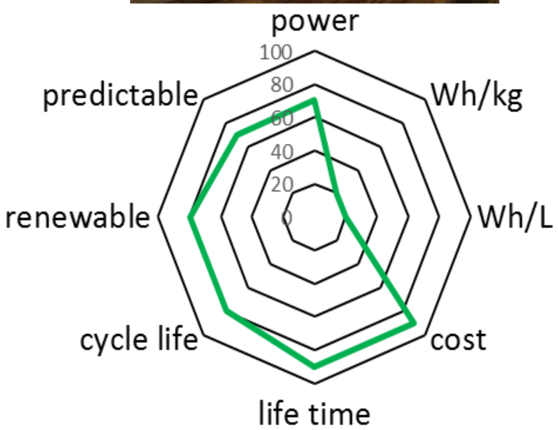




Electric Vehicles



Grid-Level Storage



Application specific development begins with understanding

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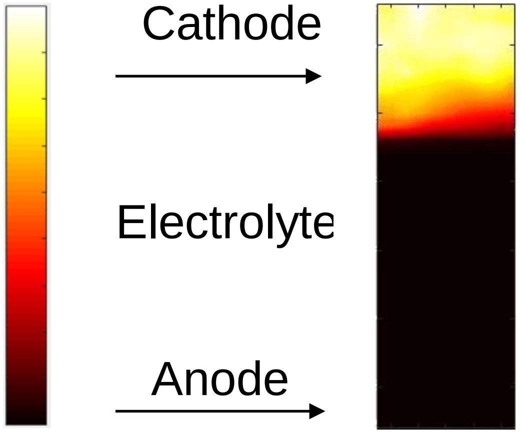
E. S. Takeuchi, Ashton Cary Lecture, "From Medical Applications to the Environment: The Important Role of Energy Storage", Georgia Institute of Technology, Atlanta GA, March 4,

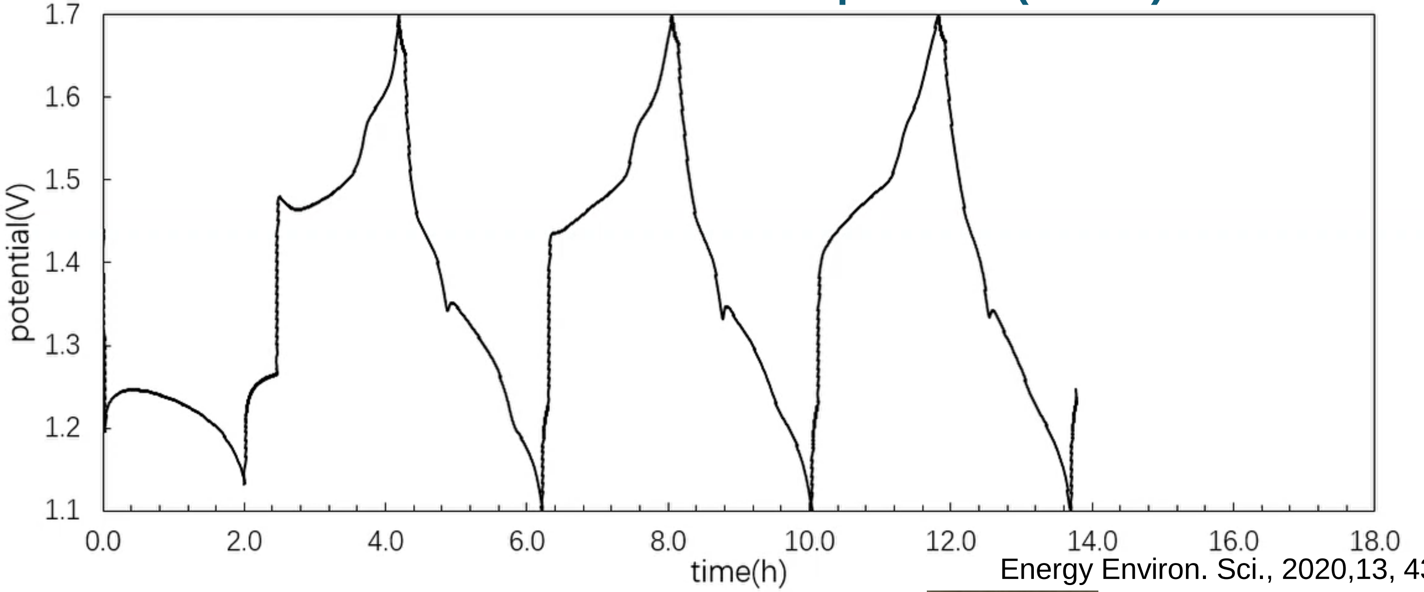
Operando Battery Studies at NSLS-II: Breakthrough Identifying Mechanism

Goal: Understand, predict, and control the mechanisms of electrochemically active materials and interfaces for scalable electrochemical energy storage

First Direct Demonstration of Reversible Mn Dissolution – Deposition (movie)



Zn/α-MnO_2 *operando* cell cycled under constant current



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molecular to mesoscale over time

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NSLS-II co-authors: R. Tappero, S.L. Nicholas, S. Ehrlich

Tough Challenges: Integration Across NY

New York Center for Grid Integration (NY-CGI)

Leveraging the Energy Resources and Expertise of Brookhaven Lab and Stony Brook University

Energy R&D
Workforce Development

NY Network:
- Columbia
- Cornell
- Clarkson

NYBEST
NYSERDA

NY-CGI

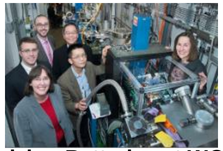
Battery Prototyping

Data Science at Scale

Northeast Solar Energy Research Center (NSERC)

Supplier Diversity Program
Engineer in Residence
Collaborative Grid projects

BNL microgrid testbed



Studying Batteries at WORK Operando Beamlines at NSLS-II

Vision for NYS Partnerships:

Statewide benefits to working together to solve electrical grid T&D challenges with potential application beyond NYS