Attachment #8.1
Return to Agenda

De-Carbonization / DER Report for NYSRC Executive Committee Meeting 7/14/2023

Contact: Matt Koenig (koenigm@coned.com)

The July 2023 edition of the De-Carbonization / Distributed Energy Resources (DER) Report includes the following items:

- NERC Publishes Introductory Guide to Inverter-Based Resources on the Bulk Power System
- NERC Announcement: Electro-Magnetic Transient Bootcamp Webinar Series
- Power and Energy Magazine – May/June Edition: System Disturbance and Blackout Analysis
- Webcasts from EPRI Program 221: Bulk Energy Storage
  - Webcast #1 by E2S Power: Converting Fossil Fuel Power Plants to Clean Energy Storage
  - Webcast #2 by RedoxBlox: Thermochemical Energy Storage Technology
- NYISO Press Release and Blog Articles
  - Shaving Peaks from the Sun
  - NYISO Board Selects Transmission Project to Deliver Offshore Wind Energy
- Snapshot of the NYISO Interconnection Queue: Storage / Solar / Wind / Co-located

NERC has announced a new publication entitled "Introductory Guide to Inverter-Based Resources on the Bulk Power System" (Newsroom Headline / Full announcement)

This 6-page publication covers the basics of the inverter's role in supporting renewable resources and energy storage, as well as the functionality, limitations, and concerns for their usage. Extracts from the document include the following:

Consistent energy production levels from inverter-based resources (mainly renewable and variable energy) are still relatively low; however, even today, instantaneous penetrations of inverter-based resources are reaching very high levels (70+%) across multiple areas in North America.

NERC continues to analyze large-scale grid disturbances involving common mode failures in inverter-based resources that, if not addressed, could lead to catastrophic events in the future. It is crucial that industry recognize that the aggregate impact of these resources must be considered when developing policies, regulations, and requirements. The historical approach of examining individual generators' impact on the BPS is increasingly obsolete under this rapid grid transformation toward inverter-based resources.

Differences between Inverter-Based Resources and Synchronous Generation

Inverter-Based Resources	Synchronous Generation
• Driven by power electronics and software	• Driven by physical machine properties
• No (or little) inertia	• Large rotating inertia
• Very low fault current	• High fault current
• Sensitive power electronic switches	• Rugged equipment tolerant to extremes
• Very fast and flexible ramping	• Slower ramping
• Very fast frequency control	• Inherent inertial response
• Minimal plant auxiliary equipment prone to tripping	• Sensitive auxiliary plant equipment
• Dispatchable based on available power	• Fully dispatchable
• Can provide essential reliability services	• Can provide essential reliability services

Other references to IBR material on the NERC site include:

- Link: Inverter-Based Resource Quick Reference Guide
- Link: Recommendations for Solar Energy Cybersecurity
  Collaboration with Sandia / SEIA (Solar Energy Industries Association) / NERC
  Includes observed weaknesses in IBR/DER equipment, along with recommendations for the IBR/DER Ecosystem

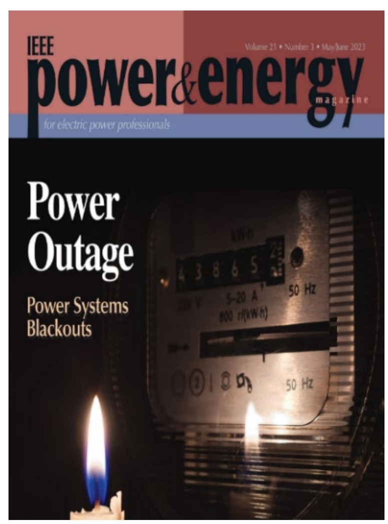
Announcement: Electro-Magnetic Transient Bootcamp Webinar Series Link
U.S. Department of Energy Interconnection Innovation e-Xchange (i2X) and NERC have facilitated the EMT Boot Camps to provide hands-on training on using EMT simulation tools and models to perform individual IBR plant performance assessment and system impact assessment as part of enhanced interconnection studies, both manually and through automation for a streamlined workflow.

Who Should Attend
Transmission Planners and Planning Coordinators are especially encouraged to participate. The Boot Camps are part of a concerted effort to prepare them for the widespread adoption of EMT modeling as NERC standard development effort is currently underway to include EMT modeling in relevant reliability standards.

About i2X Link
The U.S. Department of Energy Interconnection Innovation e-Xchange (i2X) is led by the Solar Energy Technologies Office and the Wind Energy Technologies Office and supported by Pacific Northwest National Laboratory, National Renewable Energy Laboratory (NREL), and Lawrence Berkeley National Laboratory (LBNL).

- Pre-Session: (7/27 from 1pm to 3pm) Register
  Establish baseline competence in EMT tool of choice. EMT software vendors will be invited to deliver basic software demonstrations and to answer questions. Participants are expected to have installed the software and worked through one tutorial example prior to this session to ensure software readiness.
- Session 1: Individual IBR Plant Performance Assessment (8/3 from 1pm to 5pm) Register
  EMT modeling fundamentals, model quality verification tests and disturbance ride-through performance assessment tests recommended in the Reliability Guideline, and IEEE 2800 performance assessment.
- Session 2: System Impact Assessment (9/14 from 1pm to 5pm) Register
  Modeling and validating bulk power system models and performing system impact assessments as part of enhanced interconnection studies. Walk-through of interconnection study on an EMT platform with the IBR plant model from the first Boot Camp interconnected to a sample system area model.

IEEE Power and Energy Magazine
The May/June edition of the Power and Energy Magazine (IEEE PES Membership Required) was devoted to Power Systems Blackouts, and contained multiple articles covering this theme, including:



- How To Keep the Lights On: Lessons from Major Blackouts Over the Last 35 Years (Editors' Voice)
- Blackouts: Root causes and lessons (Guest Editorial)
- Unexpected Consequences: Global Blackout Experiences and Preventive Solutions
- System Disturbance and Blackout Analysis: Identifying Trends in System Behavior (Reviewed in detail below)
- The Utility Operational Response to the August 14th 2003 Blackout: Analysis and Case Studies
- Real-Time Grid Management: Keeping the Lights on!
- Challenges in Operator Training: Avoiding Blackouts in the Evolving Power Grid
- From "Animal Crackers" to Winter Storm Uri: Reflecting on Blackouts in the United States
- Are We Prepared Against Blackouts during the Energy Transition? Probabilistic Risk-Based Decision-Making Encompassing Security and Resilience

IEEE Power and Energy Magazine -May / June Edition: System Disturbance and Blackout Analysis

This comprehensive article written by Robert Cummings provides historical information on the impacts, root causes and analytical methods associated with major system disturbances and blackouts over the last 20 years. The author starts with a list of recommendations regarding the general approach for the analysis of any given system disturbance event. For example, the following four basic types of events can occur during a disturbance:

- Initiating event: An event that kicks off a system disturbance such as a lightning strike, a line or generator tripping, or a failure of a transmission system element. The initiating event is not necessarily the root cause of the disturbance.
- Causal event: This event is often described as the "root cause" of a disturbance, but it may be well into the sequence of events and may require other contributory factors to set the stage for it to happen.
- Contributory event: This is any event that contribute to the severity of the disturbance or may be a precursor or prerequisite for the causal event to really create a problem.
- Coincidental event: This includes any event that occurred during the sequence of events of the disturbance but cannot be directly tied to a cause from the rest of the event. One needs to be careful about declaring an event as only coincidental; the relationship to another event in the sequence of events may be difficult to immediately identify.

The author then provides background information on each of the following events:

- 2003 Northeast Blackout — August, 2003
- Westwing Disturbance: Arizona — June 2004
- Western Interconnection Forced Oscillation Event: — September, 2005
- Eastern Interconnection Frequency Event: — August, 2007
- Upper Midwest System Separation: — September, 2007
- South Florida Disturbance: — February, 2008
- Arizona-Southern California Outage: — September, 2011
- Washington DC Disturbance: — April, 2015

There are several system disturbances in the recent past where significant amounts of IBRs and other resources were lost ("tripped" or went into momentary cessation) when the IBR performance was undesirable for common system events (faults and switching). These include, but are not limited to the following:

- Blue Cut Fire disturbance (2016)

  The Blue Cut Fire disturbance kicked off a rash of significant system disturbances caused by IBRs during what are considered as normal transmission system operating conditions. That disturbance occurred during a forest fire in California that caused multiple line faults. The Blue Cut Fire itself caused 13 500-kV line faults and two 287-kV line faults.

  Several distinct observations of this event are listed here:

  - A 500-kV line-to-line fault cleared normally in 2.5 cycles (41.7 ms).
  - The PV resources impacted amounted to 1,178 MW (per SCADA 4-s scan-rate data). This was later back-calculated to be a 2,500-MW momentary loss
  - There were 26 different solar impacts involved in an area with radius greater than 200 miles.
  - All IBR plants were connected at 500 kV or 230 kV (the sizable transmission lines in that area).
  - Plants consisted of equipment from 10 different inverter manufacturers. None of the protection relays or breakers operated at the 26 solar sites; all action was taken by onboard inverter controls.

Following this event, a detailed report was issued by NERC in June 2017, highlighting the use of "momentary cessation" by the inverters (cessation to energize). NERC also issued an industry recommendation on June 20th 2017 to remedy the use of momentary cessation on IBRs wherever possible and to limit instantaneous tripping for frequency perturbations.

- Canyon 2 Fire disturbance (2018)
  The California fires continued to wreak havoc with IBRs in the electric system. This event included:
  - A normally cleared 220-kV phase-to-phase fault occurred followed by a normally cleared 500-kV phase to phase fault.
  - SCADA recorded a 900-MW resource, later back-calculated to a 1,500-MW loss from interconnection inertia.
  - The disturbance reflected no frequency-related IBR tripping but showed a continued use of momentary cessation and signs of transient-overvoltage-related tripping of IBRs.

  Following this event, a detailed disturbance report was published by NERC in February 2018 with a second industry advisory issued in May 2018.
- Palmdale Roost disturbance (2019):
  This event involved a fault on a short 500-kV line—cleared in 3.6 cycles approximately 900 MW of BPS-connected PV involvement, again with load-embedded PV resource tripping.
- Angeles Forest disturbance (2019). This event involved the following:
  - A 500-kV "bolted" line-to-line fault occurred—cleared in 2.6 cycles.
  - There was ~1,100 MW in BPS-connected PV (SCADA recorded) during the evening PV ramp
  - There was evidence of a jump in the CAISO net load (see Figure 7) coincident with the disturbance—an indicator of distribution rooftop PV losses.
  - One natural gas turbine at a 2-on-1 combined-cycle power plant tripped offline because of the fault event on low gas pressure while loaded at 125 MW. That resulted in reduced output of the associated steam turbine from 150 MW to 75 MW over the course of 19 min.

Other events noted in the summary include:

- Palmdale Roost Disturbance (2019)
- San Fernando disturbance (2020)
- Odessa disturbances (2021)
- Odessa II Disturbance (2022)
  This was a NERC Category 3 event, with the loss of >2,000 MW of resources
- California 2021 disturbances (2021)
  - Victorville, June 24th, 2021
  - Tumbleweed, July 4th, 2021
  - Windhub, June 28th, 2021
  - Lytle Creek Fire, August 25th, 2021
- Texas Panhandle Wind Event (2022)

To continue to monitor and improve the reliability of a BPS with the growing IBR penetration, there are several recommendations that should also be pursued:

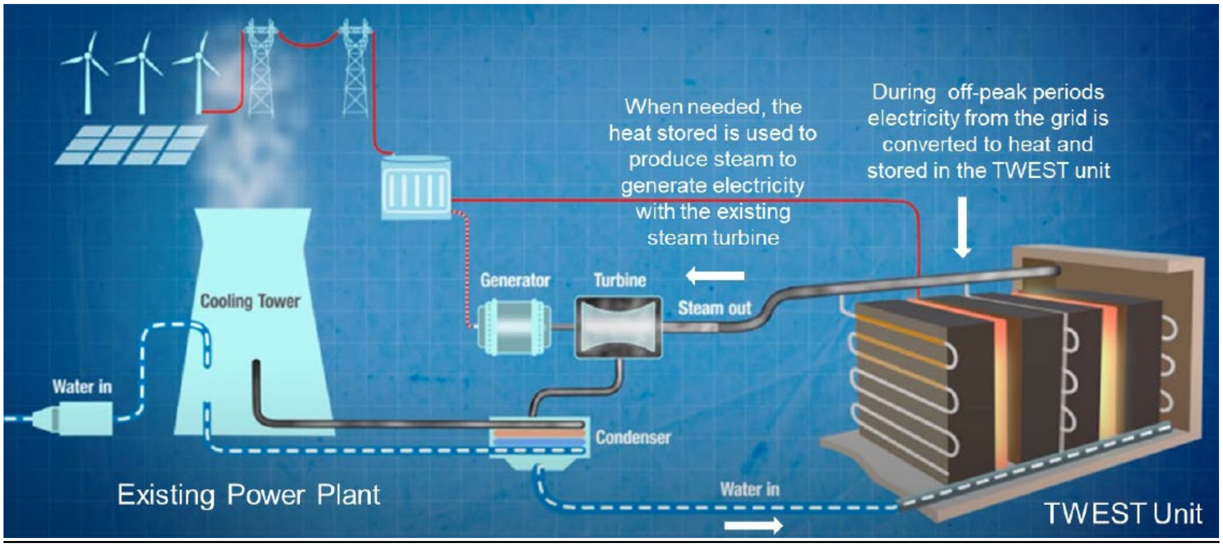
- The electric power industry should adopt IEEE Standard 2800-2022, "IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems."
- Better high-speed monitoring devices that can detect interarea oscillations across North American Interconnections are needed for the detection of forced oscillations and their sources.
- Many more point-on-wave high-speed data recorders are needed across North America, especially near larger (100+ MW) IBR plants.
- Much better IBR plant-level models are needed for the analysis of system events

Additional helpful links can be found here:
Major event analysis reports, North Amer. Elect. Rel. Corp., Atlanta, GA, USA.
Event analysis, reliability assessment, and performance analysis, North Amer. Elect. Rel. Corp., Atlanta, GA, USA.
WECC base case review: Inverter-based resources, North Amer. Elect. Rel. Corp., Atlanta, GA, USA

The EPRI Program 221 is dedicated to Bulk Energy Storage and is a part of EPRI's Generation Sector, which covers all aspects of conventional and advanced concepts in generation. This sector is a separate organization within EPRI that overlaps with the Power Delivery and Utilization Sector within certain areas such as renewables, storage, and decarbonization. The leaders of program 221 announced a series of 6 Webcasts to be given over the course of the year, each dedicated to a technical deep dive on a selected energy storage technology. The first 2 presentations were given recently and are summarized on the next few pages.

EPRI Program 221 Webcast #1 by E2S Power: Converting Fossil Fuel Power Plants to Clean Energy Storage

This Presentation (Free for Funding Members) describes a thermal energy storage "Plug in" solution for near term deployment into existing fossil fuel power stations. The concept is called "Travelling-Wave Energy Storage Technology"(TWEST) and uses power plant steam to transfer heat to graphite blocks for storage. During discharge, stored heat is used to produce steam to generate electricity from the existing steam turbine.



Graphite systems provide these advantages:

- High energy density for a low-weight and compact design
- High thermal conductivity for fast charging and compact steam generator design
- High thermal shock resistance and superior mechanical properties for a long cyclic lifetime at high temperatures
- Competitive cost for power applications (Graphite is a low cost, abundant material)
- Readily available in large volumes for fast project execution

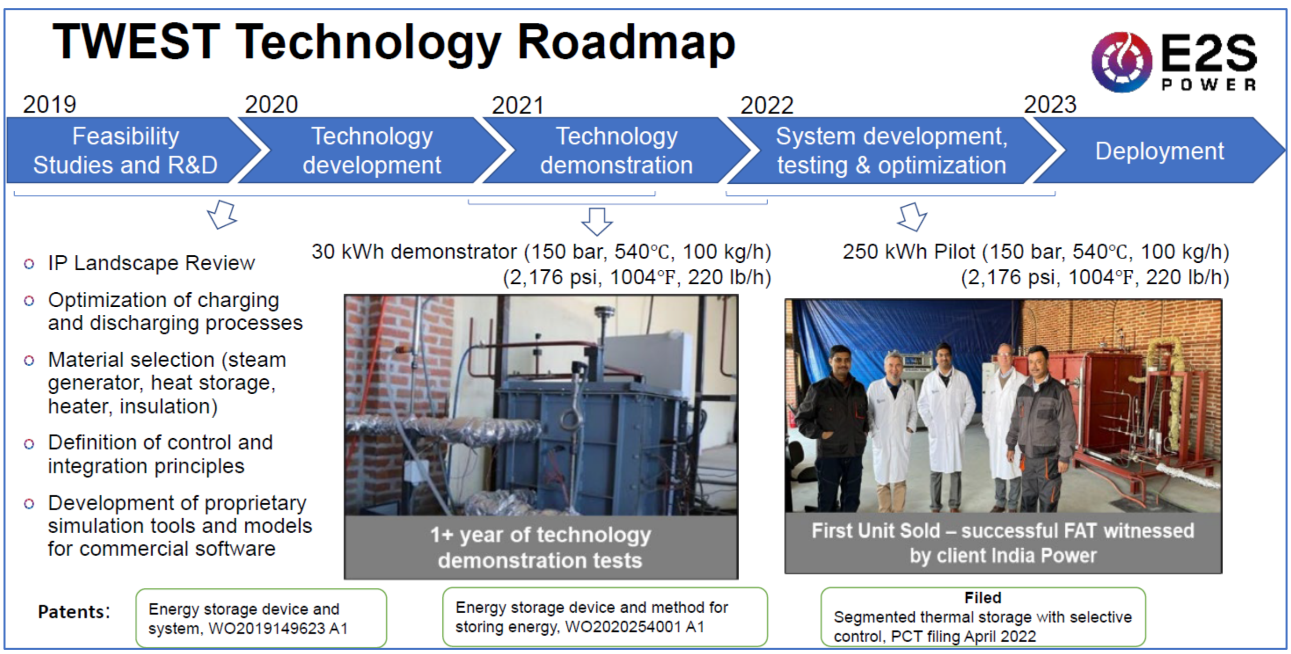
The system would be configured in individual 2.5 MWh modules for ease of shipping, handling, and assembly. The modules would be assembled into a containment structure with 24 modules totaling 50 MWh, which can be stacked for additional space savings. The company estimates that 1 GWH can be stored within a 2-acre site.

During the storage cycle:

- One set of storage blocks is charged to about 700°C (1300°F)
- A second set of storage blocks is charged to near the steam turbine temperature requirements
- During discharge, the heat moves from the first set of blocks to the second while the steam exit temperature is maintained

Performance Characteristics are described below:

- Charging by electrical power
  - Charging duration is optimized for operation and based on available capacity.
  - Charging possible in 1-2 hours.
  - Full and partial charging is permitted.
- Discharging by generating superheated or supercritical steam
  - Discharge duration is optimized for operation. Typically, 4-8 hours and longer for full discharging.
  - Start-up time is 2-3 minutes. Ramp-up time is 1 minute.
  - Full and partial discharging is permitted.
- Charging and discharging times can be independently optimized.
- Charging and discharging can be done at the same time.
- Thermal losses below 2-3% per day.
- The round-trip efficiency based on steam plant, 40 - 44% according to the stage efficiencies below
  - Power-to-storage: 99%
  - Storage-to-heat: 99%
  - Heat-to-power: 40-45% (steam cycle at the host plant not including boiler)
- Performance degradation is less than 1% per year (250-300 cycles).
- Design Life: 30 years

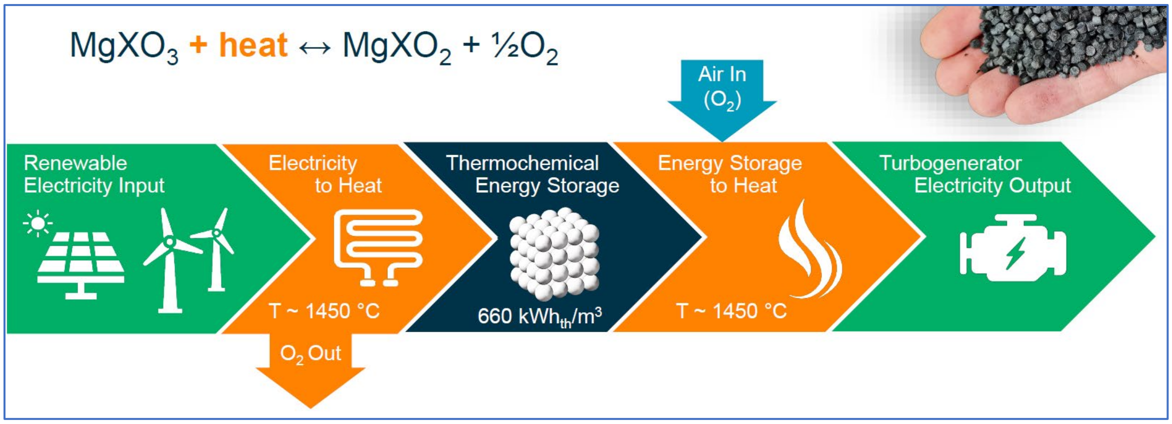


Possible future applications include:

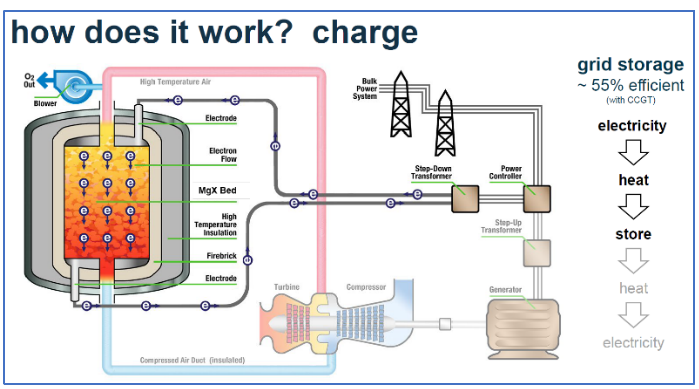
- Integration with existing fossil fuel plants, including reheat cycles. Up to 600°C (1,100oF)
  - Operation alongside boiler for improved flexibility – load following (first phase)
  - Repurpose steam plant with thermal energy storage (second phase)
- Integration with gas turbine combined cycle
  - Improve operational flexibility - reduce gas turbine part load operation and cycling
  - Peak power without supplementary firing
  - Provide process steam independently from power production

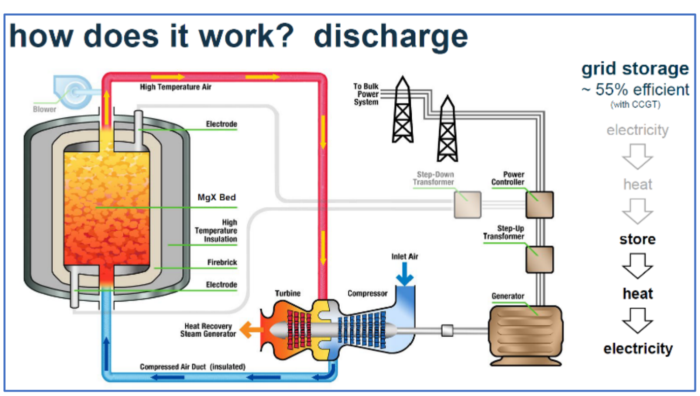
EPRI Program 221: Webcast #2 by RedoxBlox: Thermochemical Energy Storage Technology

This [Presentation] (Free for Funding Members) from RedoxBlox describes a thermochemical energy storage technology based on a packed bed of magnesium oxide pellets that support reversible oxidation and reduction reactions. To charge the system, electricity is used to resistively heat the pellets up to 2730°F (1500°C) in a highly endothermic reaction that stores heat in the form of chemical and thermal energy. To discharge the system, pressurized air from the compressor section of a gas turbine (GT) is passed through the pellet bed, where it consumes oxygen from the air, reverses the reaction, and releases heat to the oxygen-depleted air. The hot compressed air is then delivered to the expander section of the GT to generate electricity.



The system is intended to be compatible with commercial turbomachinery as a decarbonizing retrofit solution for conversion of the GTs in natural gas combined cycle plants. The energy is stored at extremely high density, allowing for compact designs. In the current proposed arrangement, the material is held in a pressure vessel and interfaced with a Brayton cycle; the cost incurred of containing the material at appropriate pressures and temperatures for this kind of application will likely be the determining factor on deployment opportunities.





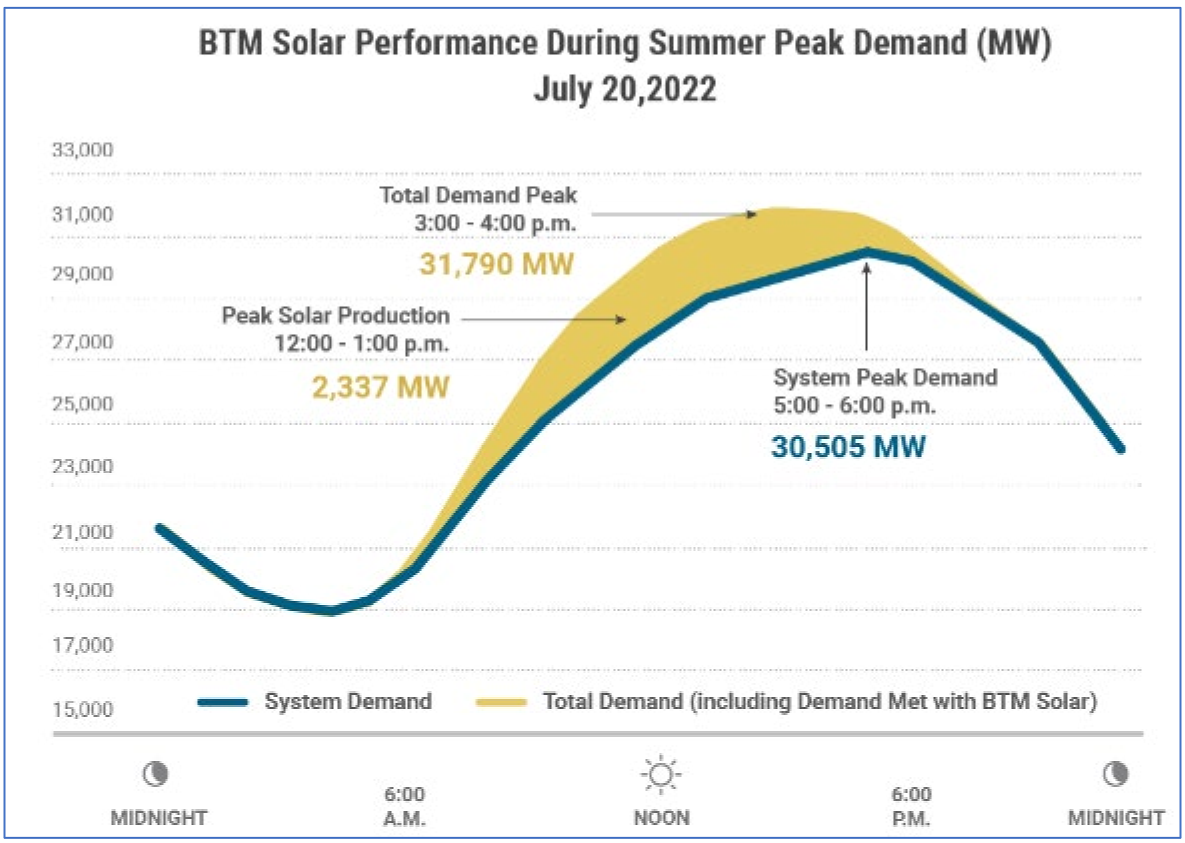
Features from the NYISO Press Release Page include the following:

Shaving Peaks from the Sun

New York State established a goal of installing 10,000 MW of distributed solar resources by 2030. As of 2022, there were more than 4,200 MW installed – a number that is growing rapidly.

The figure below shows the contribution of distributed solar resources during the peak demand day observed on July 20, 2022. The first thing to note is how distributed solar energy production contributes to electricity demand throughout the daytime, supplying electricity directly to customers above and beyond what is being supplied by the grid.

The second thing to note is how the energy production from these distributed solar resources changes throughout the day. The first indication of production begins around 5:00 AM as the sun emerges from behind the horizon. As the sun sets at the end of the day, these solar resources produce their last megawatts of energy from 8:00-9:00 PM. What happens in between these hours is significant.



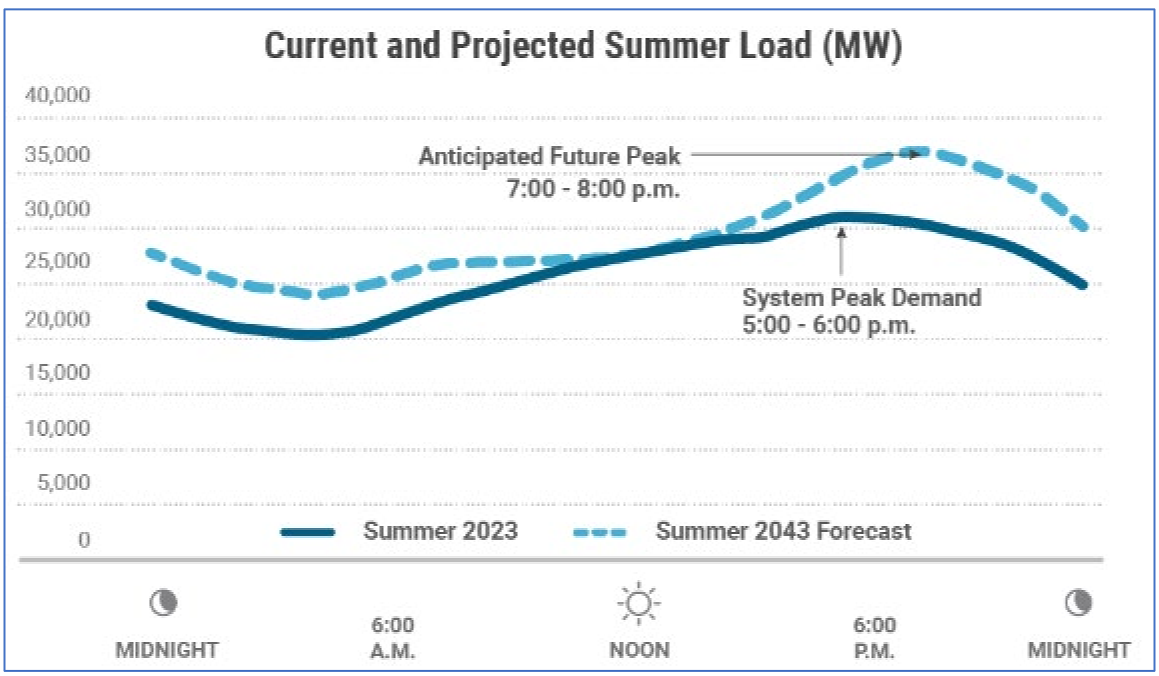
On May 18, 2023, New York's distributed solar resources achieved a record production of 3,200 MW, accounting for roughly 20% of New York's electricity demand at that time. But while it displaces fossil fuel generation throughout the day, it cannot replace the need for dispatchable generation resources to meet the system's reliability needs.

Noontime: Solar Energy Production Peaks
From noon to 1:00 PM, distributed solar energy production peaked at more than 2,300 MW, meaning the NYISO did not have to dispatch 2,300 MW of generation during that timeframe. For perspective, of the hundreds of generators that the NYISO can dispatch to supply the grid, only one is capable of producing that much power all at once – the Niagara hydro project, which has a nameplate capacity of more than 2,800 MW.

3:00-4:00 PM: Total Consumer Demand Peaks
While solar production began to gradually diminish after noontime, consumer demand for electricity continued to climb. By 3:00 PM, total demand for electricity, represented by the system demand plus the contribution of distributed solar resources, peaked for the day at 31,790 MW. The contribution from distributed solar installations declined from its noon-time peak, but still shaved nearly 2,000 MW from the total load that the NYISO would otherwise supply by dispatching generation. As a result, system demand at this time remained below 30,000 MW.

5:00-6:00 PM: System Demand Peaks
As the afternoon progressed, both solar energy output and total electricity demand declined. But the decline in solar output has the effect of shifting the demand being met by distributed solar resources back to the grid. So, even as total demand for electricity is declining, demand for electricity supplied by the grid is rising. On this day, demand for electricity supplied by the grid peaked at 30,505 MW in the 5:00-6:00 PM timeframe. During this time, production from distributed solar resources declined to little more than 1,000 MW.

As distributed solar resources continue to expand in New York, they will reshape demand patterns and alter how the NYISO dispatches generation to satisfy demand. For instance, models of the grid of the future suggest that distributed solar resources will contribute towards shifting system peak demand periods later in the day. The figure below compares present-day system demand in the summer with system demand anticipated in 2043, when more than 10,000 MW of distributed solar is assumed to be installed throughout the state. The combination of distributed solar and new demands due to electrification will lead to peak demand periods occurring later in the day when solar resource production is greatly diminished.



Press Release: NYISO Board Selects Transmission Project to Deliver Offshore Wind Energy

On June 20th, the New York Independent System Operator (NYISO) announced that its Board of Directors has selected a transmission project to meet the Long Island Offshore Wind Export Public Policy Transmission Need (Long Island Need).

The selected transmission project, Propel Alternate Solution 5, will ultimately benefit energy consumers by providing transmission capability to deliver at least 3,000 megawatts (MW) from offshore wind projects – advancing the state closer to its goal of 9,000 MW of offshore wind energy by 2035. The project will be developed by the New York Power Authority and New York Transco – a partnership called Propel NY.

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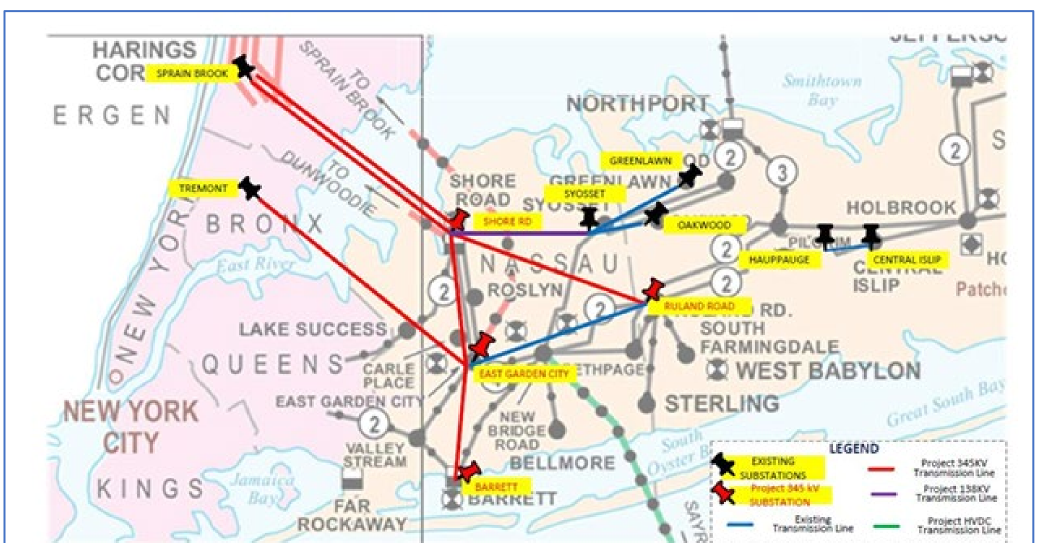
The Long Island Need was initially declared by the New York State Public Service Commission (PSC) in a March 2021 order. That order began a multi-year, joint effort by NYISO's team of experts, the New York State Department of Public Service, developers, and stakeholders to address transmission needs in and around Long Island driven by the Climate Leadership and Community Protection Act (CLCPA).

Propel Alternate Solution 5 will add three new underground cables connecting Long Island with the rest of the state and a 345 kV transmission backbone across western/central Long Island (see map below). The project is required to be in service by May 2030 with an estimated capital cost of $3.26 billion. Per the NYISO's extensive project analysis, the economic benefits are estimated to be comparable with the project cost over 20 years.

Moving forward, Propel NY is responsible for submitting this project to the appropriate governmental agencies and authorities to obtain approvals and permits to site, construct, and operate the project. This includes the PSC's process for siting of major utility transmission facilities under Article VII of the Public Service Law.

The NYISO has prepared an informational packet which includes the final Long Island Need report, a fact sheet and background public policy blogs. Download the informational packet here.



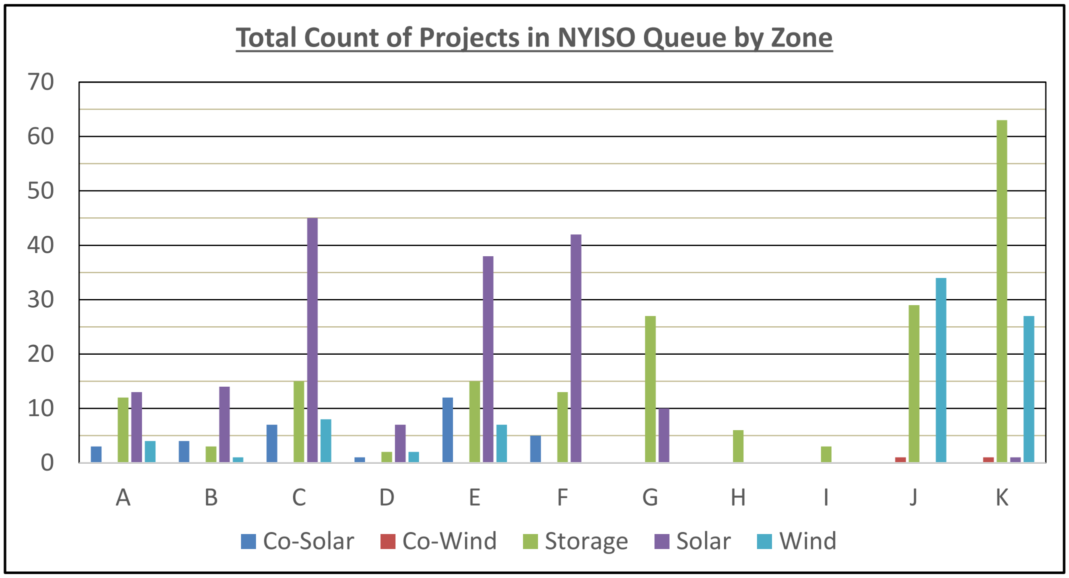
Interconnection Queue: Monthly Snapshot – Storage / Solar / Wind / CSRs (Co-located Storage)

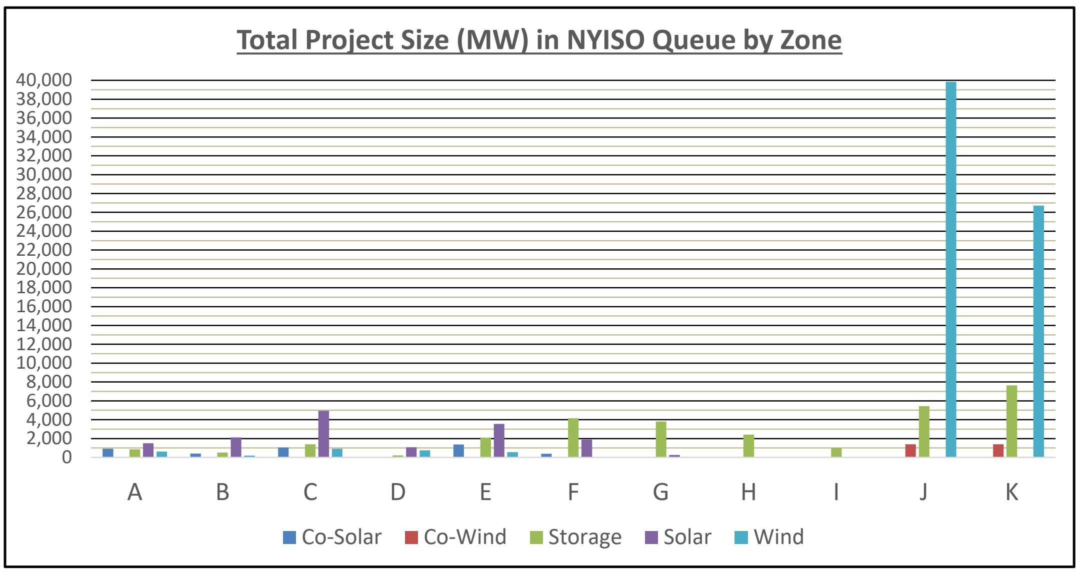
The intent is to track the growth of Energy Storage, Wind, Solar and Co-Located Storage (Solar and Wind) projects in the NYISO Interconnection Queue, looking to identify trends and patterns by zone and in total for the state. The information was obtained from the NYISO Interconnection Website, based on information published on June 20th, and representing the Interconnection Queue as of May 31st. Note that 11 projects were added, and 9 were withdrawn during the month of May.

Total Count of Projects in NYISO Queue by Zone					
Zone	Co-Solar	Co-Wind	Storage	Solar	Wind
A	3		12	13	4
B	4		3	14	1
C	7		15	45	8
D	1		2	7	2
E	12		15	38	7
F	5		13	42	
G			27	10	
H			6		
I			3		
J		1	29		34
K		1	63	1	27
State	32	2	188	170	83

Total Project Size (MW) in NYISO Queue by Zone					
Zone	Co-Solar	Co-Wind	Storage	Solar	Wind
A	920		861	1,508	615
B	408		520	2,125	200
C	1,045		1,399	4,948	921
D	20		220	1,062	747
E	1,367		2,094	3,551	565
F	380		4,155	1,881	
G			3,802	263	
H			2,416		
I			1,000		
J		1,400	5,439		39,866
K		1,400	7,638	36	26,724
State	4,140	2,800	29,543	15,374	69,639

Average Size (MW) of Projects in NYISO Queue by Zone					
Zone	Co-Solar	Co-Wind	Storage	Solar	Wind
A	307		72	116	154
B	102		173	152	200
C	149		93	110	115
D	20		110	152	374
E	114		140	93	81
F	76		320	45	
G			141	26	
H			403		
I			333		
J		1,400	188		1,173
K		1,400	121	36	990
State	129	1,400	157	90	839


Total Count of Projects in NYISO Queue by Zone
70
60
50
40
30
20
10
0
A
B
C
D
E
F
G
H
I
J
K
Co-Solar
Co-Wind
Storage
Solar
Wind


Total Project Size (MW) in NYISO Queue by Zone
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
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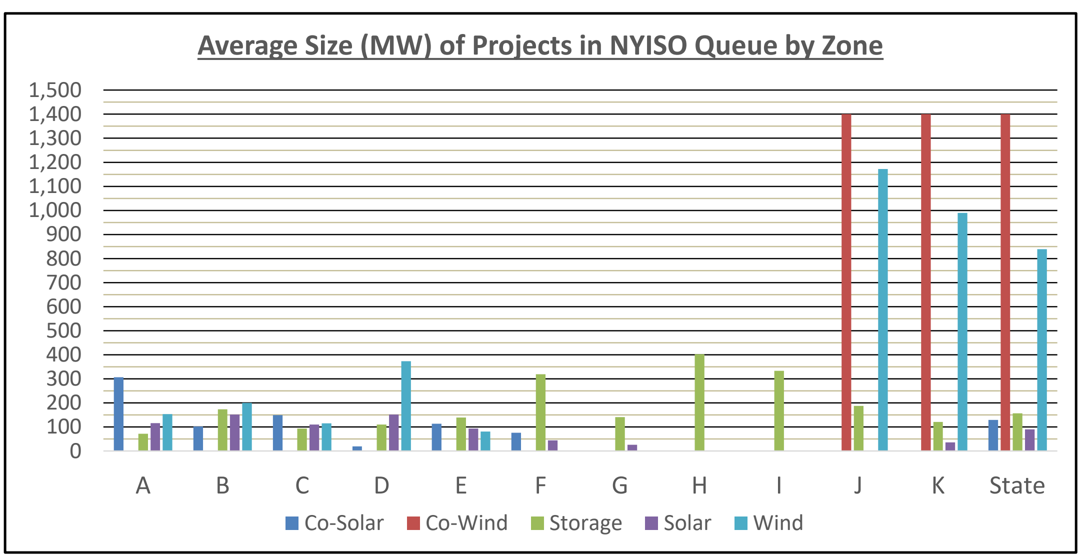
Wind


Average Size (MW) of Projects in NYISO Queue by Zone
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
A
B
C
D
E
F
G
H
I
J
K
State
Co-Solar
Co-Wind
Storage
Solar
Wind