De-Carbonization / DER Report for NYSRC Executive Committee Meeting 12/9/2022

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The December 2022 edition of the De-Carbonization / Distributed Energy Resources (DER) Report includes the following items:

- FERC Issues Proposals Regarding Inverter-Based Resources to Improve Grid Reliability
- NERC Warns Generation Resources Tight in Large Portion of North America this Winter
- NERC Inverter-Based Resource Performance Subcommittee - October Meeting Presentations:
    - System Performance with Grid-Forming IBRs
    - MW-Scale PHIL Tests of a Grid-Forming Inverter on the Maui Transmission System
    - Blackstart Capability of Offshore Wind Farms
- NYISO Blog: The Outlook: Unprecedented Capacity Investment Needed
  2022 Reliability Needs Assessment: Key Takeaways Datasheet
- Snapshot of the NYISO Interconnection Queue: Storage / Solar / Wind / Co-located Storage

FERC Issues Proposals Regarding Inverter-Based Resources to Improve Grid Reliability

This information is from the blog Washington Energy Report (Troutman Pepper).

On November 17, 2022, FERC issued three orders intended to address the reliability impacts of the rapid integration of inverter-based resources ("IBRs"), including solar, wind, fuel cell, and battery storage resources, on the Bulk-Power System ("BPS"). Specifically, in the first proceeding, FERC directed the North American Electric Reliability Corporation ("NERC") to develop a plan to register the entities that own and operate IBRs so that NERC may monitor their compliance with NERC's Reliability Standards. In the second proceeding, FERC issued a Notice of Proposed Rulemaking ("NOPR") to direct NERC to develop new or modified Reliability Standards that address reliability gaps related to IBRs. Lastly, in the final proceeding, FERC approved revisions to two of NERC's Reliability Standards.

In the first proceeding, in Docket No. RD22-4, FERC directed NERC to develop and submit a work plan to identify IBR operators that are connected to the BPS but not yet registered with NERC under the bulk electric system ("BES") definition and that have an "aggregate, material impact on the reliable operation" of the BPS. The BES identifies elements, and element groups, that are necessary for the reliable planning and operation of the BPS. The BES definition establishes a threshold for identifying all "transmission" elements; specifically, those operated at 100 kV or higher. The 100 kV threshold is applied to both real and reactive power resources. As FERC recognized, most of the newly interconnected IBRs are either connecting at voltages at less than 100 kV or with capacity less than 75 MVA, and thus do not meet the minimum size criteria under the BES definition. FERC noted that it issued the order because reports demonstrate the potential for IBRs, in the aggregate, to have a material impact on the reliable operation of the BPS. FERC's regulations require each user, owner, and operator of the BPS to be registered with NERC and to comply with its Reliability Standards. FERC noted that the work plan must detail how NERC plans to identify and register owners and operators that are not currently required to register with NERC under the BES definition but are connected to the BPS.

In the second proceeding, in Docket No. RM22-12, FERC issued a NOPR to direct NERC to develop Reliability Standards for IBRs covering:

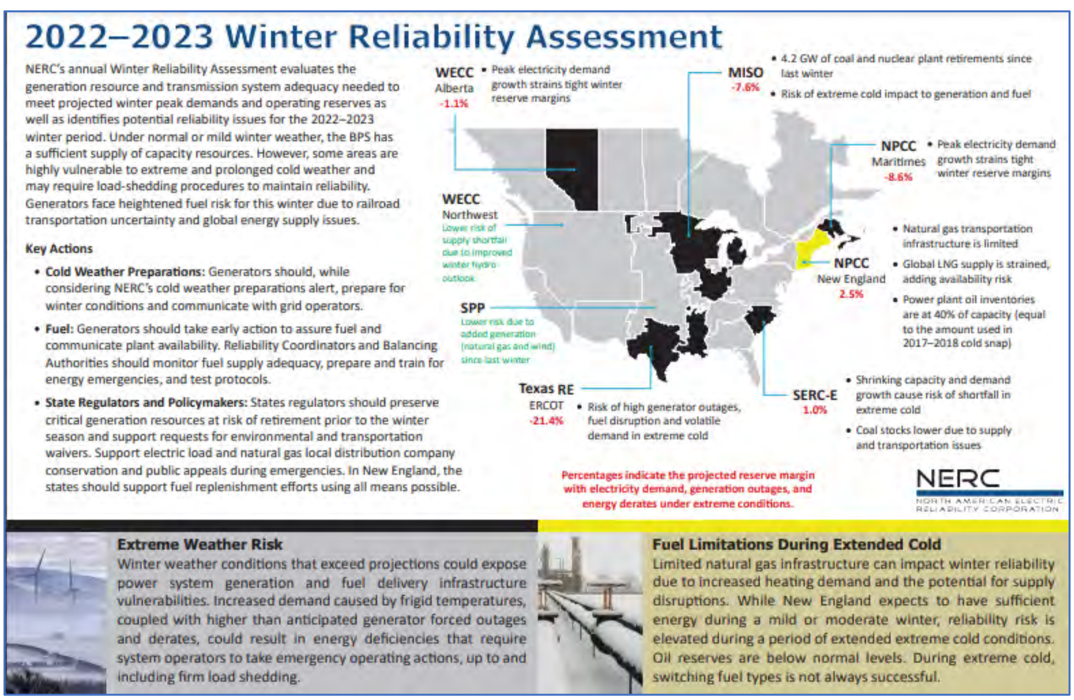
- Data sharing: Currently, IBR owners and operators do not consistently share IBR planning and operational data, and the information that is shared is often inaccurate or incomplete.
- Model validation: Once planners have IBR data, they must ensure the accuracy of such data to create valid system models.

- Planning and operational studies: Once planners and operators validate system models, they must include those models in planning and operational studies to assess the reliability impacts—both of individual and collective IBRs—on Bulk-Power System performance.
- Performance requirements: For example, IBRs' ability to ride through system disturbances.

FERC proposed that NERC submit a compliance filing within 90 days of the final rule's effective date containing its plan, which must include a detailed, comprehensive standards development and implementation plan to ensure all new or modified Reliability Standards identified in the final rule are submitted to FERC within 36 months of approval of the plan. Initial comments on the NOPR are due 60 days after the date of publication in the Federal Register, and reply comments are due 90 days thereafter.

In the last proceeding, in Docket No. RD22-5, FERC issued an order in response to a petition filed by NERC on June 14, 2022, in which NERC sought to revise FAC Reliability Standards FAC-001-4 (Facility Interconnection Requirements) and FAC-002-4 (Facility Interconnection Studies). In its petition, NERC requested that FERC approve the associated violation risk factors and violation severity levels of the proposed implementation plan and the retirement of the currently effective versions of the FAC Reliability Standards. FERC approved NERC's proposed revisions, noting that they improve on the current FAC Reliability Standards. FERC also found that the proposed Reliability Standard FAC-002-4 Requirement R6 will avoid potential disputes over changes to facilities by authorizing the planning coordinator to define the term "qualified change" and requiring the public posting of the definition. FERC additionally approved NERC's proposed clarifying revisions to the existing violation risk factor and violation severity level assignments for these FAC Reliability Standards.

NERC Warns Generation Resources Tight in Large Portion of North America this Winter
NERC's 2022-2023 Winter Reliability Assessment (Announcement / Report / Infographic also shown below) warns that a large portion of the North American bulk power system is at risk of having insufficient energy supplies during severe winter weather. NERC advises industry to be ready to implement operating plans to manage potential supply shortfalls and to ensure fuel supplies are secured, and generators and natural gas facilities are weatherized.



The assessment finds high peak-demand projections, inadequate generator weatherization, fuel supply risks and limited natural gas infrastructure are contributory factors to reliability risk. Regions at particular risk this winter include:

- Texas, SERC-East and southern parts of MISO risk a significant number of generator-forced outages in extreme and prolonged cold temperatures. Generators and fuel supply infrastructure are not designed for such conditions and remain vulnerable without weatherization upgrades. Peak electricity demand increases substantially during extreme cold which compounds the risk.
- Midcontinent ISO (MISO) has retired more than 4.2 GW of nuclear and coalfired generation since last winter, with few resources being added. Consequently, reserve margins in the region have fallen by more than 5%. An extreme cold-weather event that extends deep into MISO's area could lead to high generator outages from inadequate weatherization in southern units and unavailability of fuel for natural-gas-fired generators.
- New England has limited natural gas transportation capacity and relies on liquefied natural gas and oil-fired generators on peak demand days. Potential constraints on the fuel delivery systems, coupled with the limited inventory of liquid fuels, may exacerbate the risks for fuel-based generator outages and output reductions that result in energy emergencies during extreme weather.
- Alberta and NPCC-Maritimes both project that peak electricity demand will grow in these winter peaking systems. In the Maritimes, this could strain capacity for normal winter peak conditions. Alberta has sufficient capacity for normal winter peak demand; however, extreme conditions that cause high generator forced outages are likely to cause energy emergencies

To reduce the risks of energy shortfalls on the bulk power system this winter, NERC recommends the following actions:

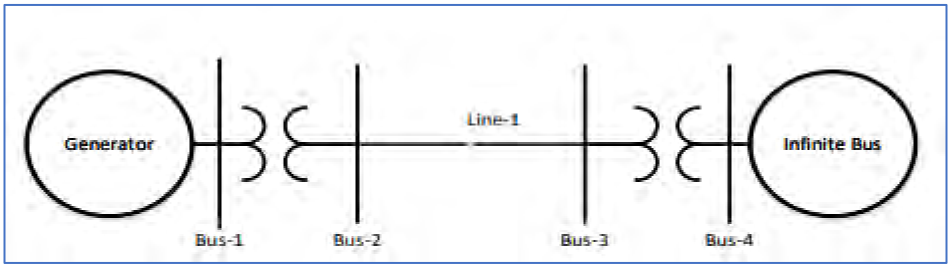
- Cold Weather Preparations: Generators should, while considering NERC's Cold Weather Preparations for Extreme Weather Events–II alert, prepare for winter conditions and communicate with grid operators.
- Fuel: Generators should take early action to assure fuel and communicate plant availability. Reliability Coordinators and Balancing Authorities should monitor fuel supply adequacy, prepare and train for energy emergencies, and test protocols.
- State Regulators and Policymakers: States regulators should preserve critical generation resources at risk of retirement prior to the winter season and support requests for environmental and transportation waivers.
- Support electric load and natural gas local distribution company conservation and public appeals during emergencies. In New England, the states should support fuel replenishment efforts using all means possible

Inverter-Based Resource Performance Subcommittee (IRPS)

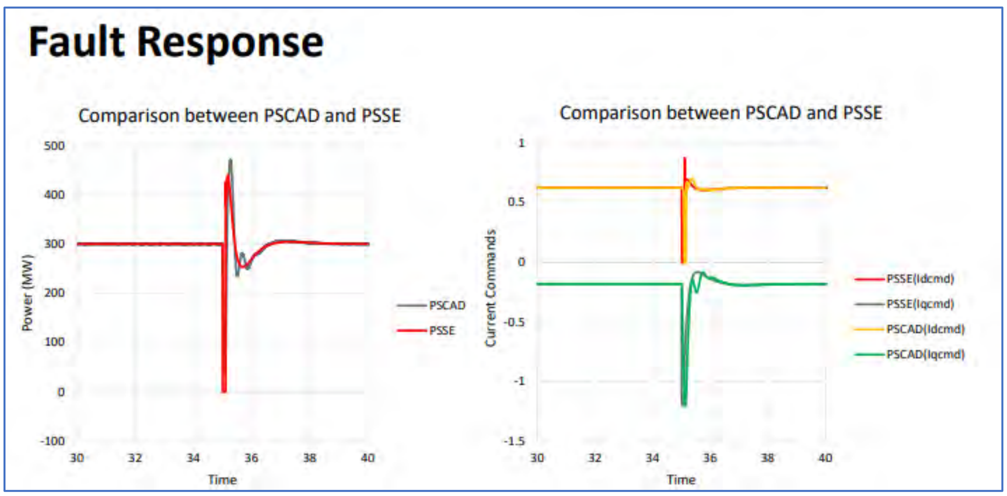
The purpose of the NERC Inverter-Based Resource Performance Subcommittee (IRPS – Landing Page) is to explore the performance characteristics of utility-scale inverter-based resources (e.g., solar photovoltaic (PV) and wind power resources) directly connected to the bulk power system (BPS). The technical materials are intended to support the utility industry, Generator Owners with inverter-based resources, and equipment manufacturers by clearly articulating recommended performance characteristics, ensuring reliability through detailed system studies, and ensuring dynamic modeling capability and practices that support BPS reliability. Links include: Summary of Activities, IPRS Work Plan, and Sub-Committee Roster.

The IRPS meeting from October 20th (Agenda / Minutes) had Three Presentations on a single slide deck, which are summarized on the following pages:

System Performance with Grid-Forming IBRs by ISO New England
ISO New England performed a series of PSS/e and PSCAD studies using a simple model known as "Single Machine Infinite Bus" (SMIB – see below) to validate the concepts of a Grid-Forming Control System without a Phase-Locked Loop (PLL). Scenarios included fault response, Island Response, and Blackstart response. Larger system studies were also performed for Spring light load and Summer peak conditions, as well as an Under Frequency Load Shedding (UFLS) scenario.



The presentation provided information on the control system configuration, followed by comparisons of the results as seen in the two computational systems. In many cases, the results were not significantly different, as shown in the example below.



Observations from the study include:

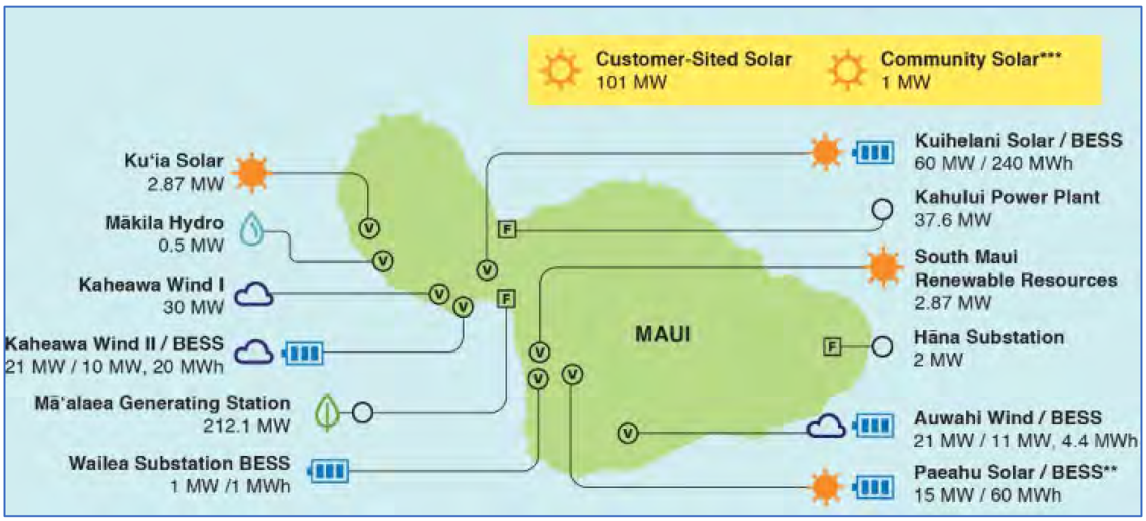
- There were differences in the response between PSCAD and PSSE results. Not all transfer function blocks that were included in PSCAD analysis were included in the PSSE model - this is one of the reasons for the differences in response between PSCAD and PSSE results
- Modeling all transfer function blocks that are in PSCAD GFM model in a positive-sequence program is not a reasonable assumption for conducting large-scale simulations. Based on the tests conducted, the GFM model analyzed in PSSE is a good approximation for a GFM converter and has been used in this study to conduct large-scale simulations
- The control structure analyzed for a GFM converter with no PLL can improve system performance with proper control settings
- A power system with GFM converters with no PLL operating with synchronous machines does not deteriorate system performance, although control settings play an important role in determining system performance
- Rate-of-frequency decline in a power system with high penetration of GFM converters can be modified with proper control settings for a GFM converter

MW-Scale PHIL (Power Hardware in the Loop) Tests: Grid-Forming Inverter on the Maui Transmission System

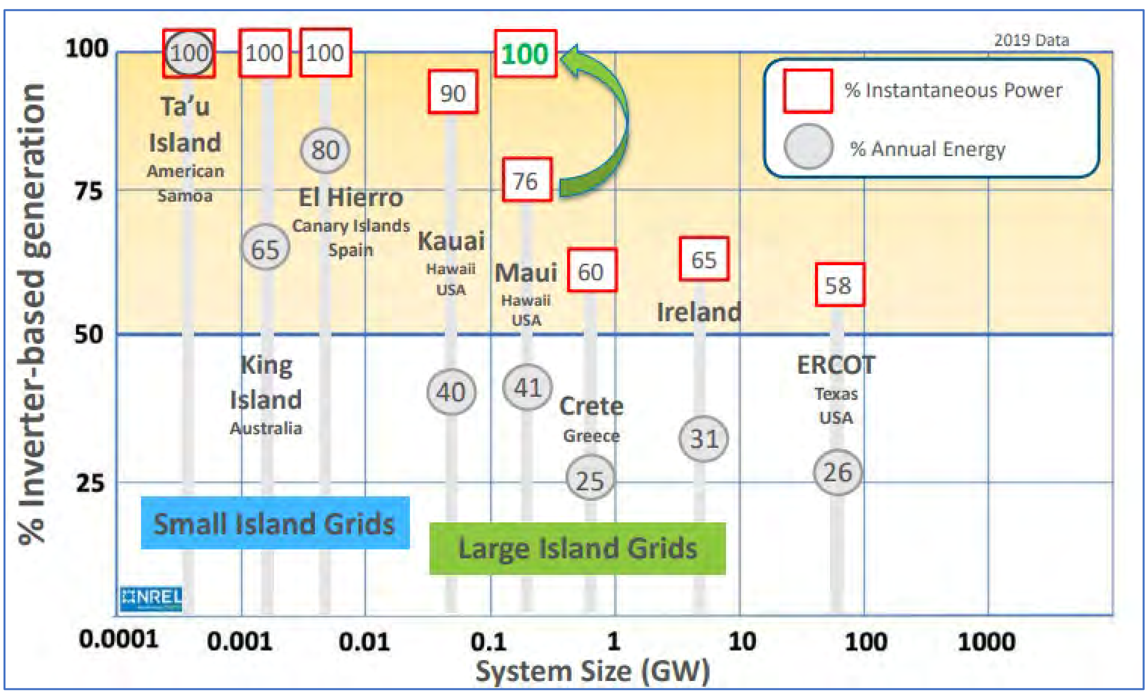
This study was presented by NREL and the Solar Technologies Office of the U.S. Department of Energy. Based on present conditions, Hawaiian Electric expects Maui to be their first large island to be capable of operating with 100% inverter-based power resources. Detailed background information includes:

- 2020 peak: ~89.5% IBR (DER and wind)
- 100% IBR operation expected to be possible for certain hours in 2023, from an energy balance perspective
- Maui would be the first interconnected power system of its size (~200 MW peak) with highly distributed utility-scale generation and 69 kV voltage levels to reach this milestone

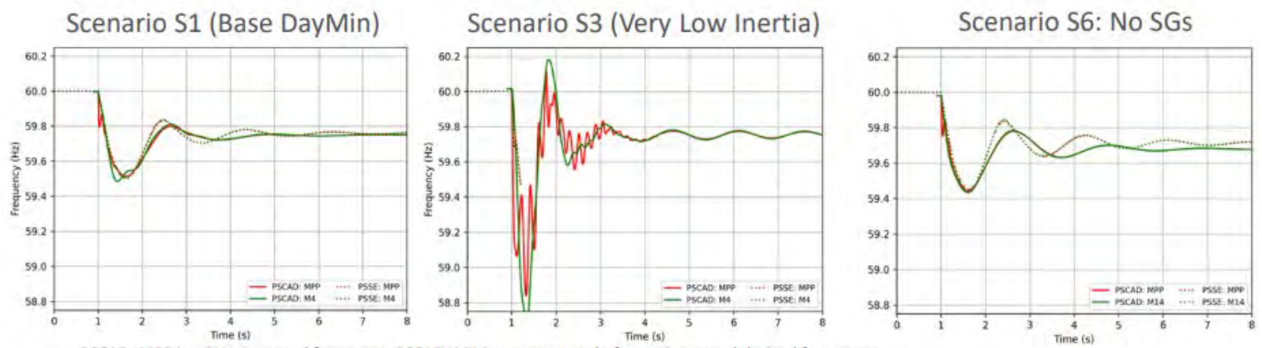
Overview Map of Maui, showing locations and capacities of the island's solar and wind facilities:



The graphic below compares various island grids with regards to the percentage of inverter-based resources contained within their Synchronous AC Power systems, for both instantaneous power, and annual energy:



The graphic below represents one of several tests comparing system response at 3 different levels of system inertia, indicating that a satisfactory response for stability issues can be attained with Grid Following Inverters (GFLs). The condition below is a frequency response to a loss of generation.



PSCAD: MPP is a PLL-measured frequency. PSCAD: M4 is a generator shaft rotation speed derived frequency

- Scenario S1 versus Scenario S3: reduced inertia and fewer voltage sources
  - Lower nadir, larger ROCOF, as expected
  - No voltage perturbation, yet large oscillations still present in PLL-derived frequency
- Scenario S6: all (3) synchronous generators taken offline
  - *Successful operation with all primary response from GFL devices*

Other scenarios were run to compare the differences between synchronous resources, low inertia, very low inertia and total inverter based.

Conclusions from the study include:

- A real hardware GFM inverter can stabilize otherwise unstable cases of a transmission electric power system, including zero-inertia cases
  - Stabilizes faster modes
  - Mitigates instability of remaining GFLs
  - MW-scale test validates detailed PSCAD simulations Modeling inverter control loops (power and current) of GFL devices (including small DERs if their aggregate capacity is large!) is required to detect faster modes in the system response under very weak grid conditions
- Amount of GFM capacity needed (observations):
  - Does not necessarily depend on percentage generation from IBRs
  - Does depend (inversely) on capacity of synchronous machines online
  - This considers oscillatory stability; major nonlinearities such as DER/IBR tripping or momentary cessation may drive higher GFM need

Note: These simulations focus on transient stability and do not consider other topics necessary for very high IBR operation, e.g.: protection, reserves, resource adequacy…

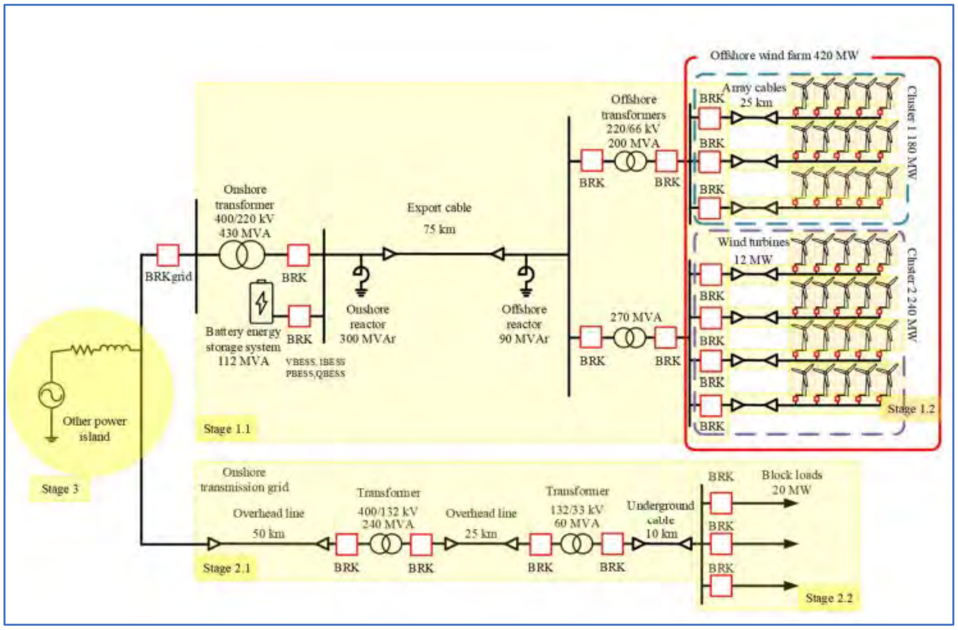
Other Links:

- NREL: Inverter-Based Operation of Maui: electromagnetic Transient Simulations
- Hawaiian Electric Island-Wide PSCAD Studies – Stage 2 System Impact Study

The studies utilized a setup similar to the AGILe configuration at NYPA (Power Hardware in the Loop or PHIL). Results appeared to correspond to expectations. Grid Forming Inverters were shown to have a superior capability and response, even under conditions where they represent a smaller proportion of total generation. This represents a very encouraging indicator for the ongoing transition of the grid to an inverter-based system.

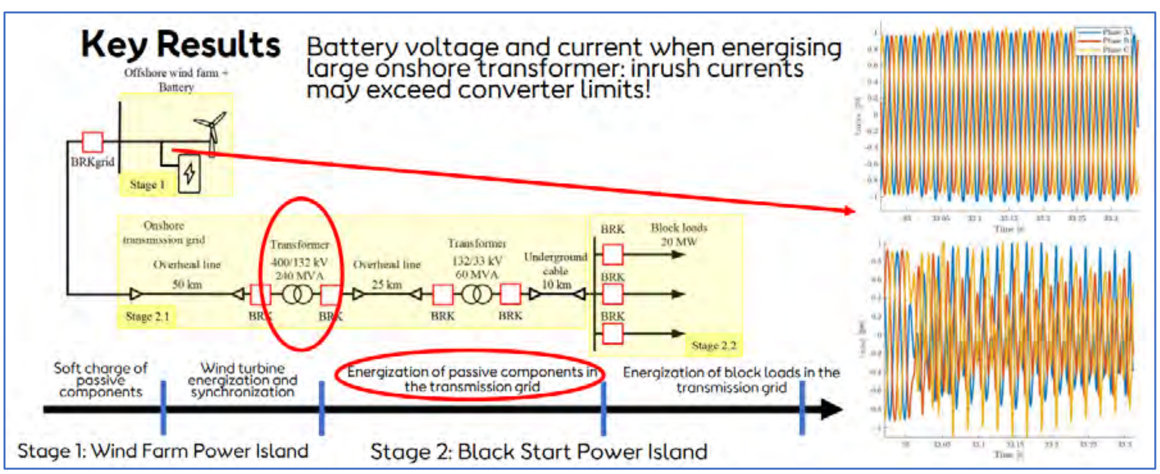
Blackstart Capability of Offshore Wind Farms by Orsted

With the massive number of conventional power plant retirements underway and anticipated for the near future, there is a growing need to find new black-start resources. Orsted proposes the utilization of Offshore Wind Farms (OWFs) combined with energy storage that uses grid-forming Inverters (GFMs).



For this configuration, the black-start process is envisioned in multiple stages:

- Soft Charge of passive components (lines and transformers)
- Wind Turbine energization and synchronization
- Energization of passive components in the transmission grid
- Energization of block loads in the transmission grid



One major concern is that battery capacities may not be sufficient to accommodate the energization of the portion of the transmission grid that would be necessary to reach other generation resources. For example, large onshore transformers may require inrush currents that may exceed converter limits. Orsted anticipates future studies that will look to identify methods to optimize storage sizing and operations to accommodate restoration requirements based on their grid configurations.

NYISO: Announcements on the Blog Page of the NYISO Website:

Features from the NYISO Blog Page include the following:

Findings from the Outlook: Unprecedented Capacity Investment Needed

The NYISO takes another look at the report entitled 2021-2040 System & Resource Outlook, this time with the concern that while unprecedented investment in renewable generation will be necessary to meet future demand, we will also need to invest in transmission capabilities to get that power delivered reliably and efficiently.

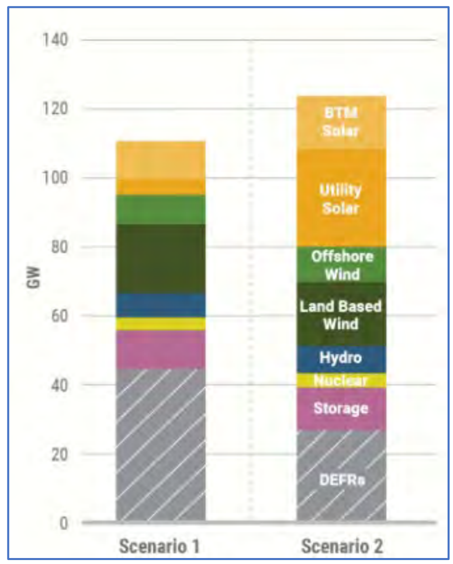
The Outlook finds there are different potential approaches to resource and transmission investment that can achieve New York's clean energy and climate change requirements. Each scenario analyzed looks at a variety of factors that will influence the level of investment in energy infrastructure.

Two scenarios examined in the Outlook make different assumptions about future peak demand and total electricity usage. The report found that consumer demand is forecasted to increase dramatically as a result of electrifying the state economy, and that the level of peak demand has the largest impact on capacity expansion requirements.

Scenario 1 - uses industry data and NYISO load forecasts, representing a future with high demand: 57,144 MW winter peak and 208,679 GWh energy demand in 2040

Scenario 2 - uses assumptions consistent with the Climate Action Council Integration Analysis. It represents a future with a moderate peak but a higher overall energy demand: 42,301 MW winter peak and 235,731 GWh energy demand in 2040.

The mix of resources shifts under these scenarios, with Scenario 1 consisting of greater land-based wind development while Scenario 2 results in greater utility-scale solar development. Scenario 1 also notably integrates a greater degree of Dispatchable Emissions-Free Resources (DEFRs), which will be needed to help balance the intermittency of renewable energy production to continuously maintain reliability.



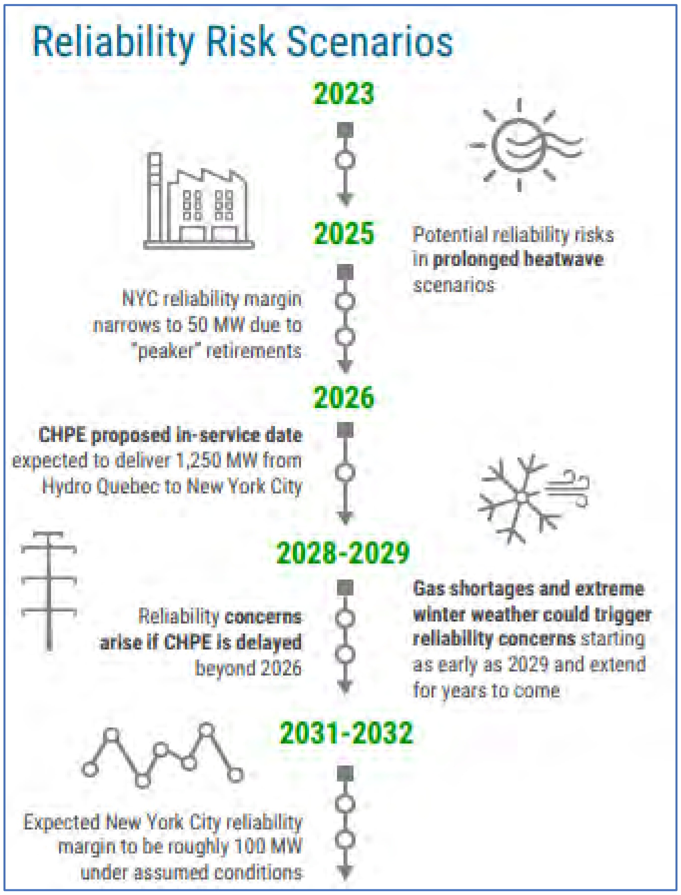
Both scenarios rely on having in place unprecedented levels of new supply for 2040. At least 95 GW of new or modified capacity will need to be added to the grid between now and 2040 to support existing resources.

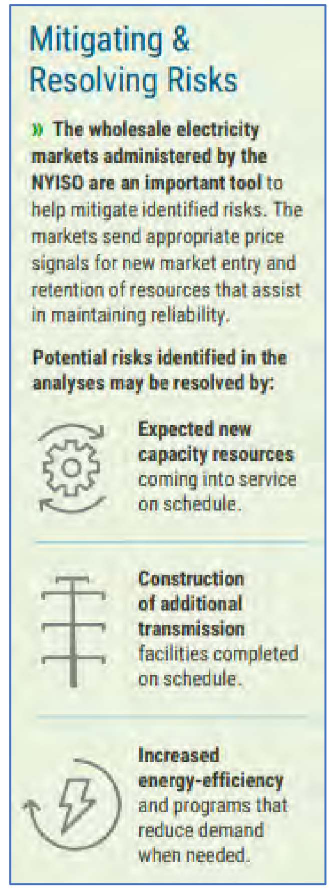
- Under Scenario 1, with higher peak demand but lower overall energy consumption, 111 GW of total renewable and other zero-emissions resources would be required to reliably supply load.
- In Scenario 2, which assumes lower peak demand but greater overall energy consumption, 124 GW of such resources would be required.

In comparison, approximately 12.9 GW of new generating capacity was added to the bulk power system since wholesale electricity markets began more than 20 years ago. Over the past five years, generation deactivation has outpaced new additions: 2.6 GW of renewable and fossil-fueled generators came on-line while 4.8 GW of generation deactivated.

2022 Reliability Needs Assessment (RNA): Key Takeaways Datasheet:

This Two-Page Datasheet highlights risks to future reliability in the state, which are presented in greater detail in the 2022 RNA Full Report. Out-takes from the page are shown below:





Of major note: As the grid transitions to intermittent generation and electrification of demand, at least 17,000 MW of fossil-fuel generating capacity may be needed in order to reliably supply electricity on high-demand, "peak" days.

Next steps include:

- The NYISO will continue to assess the reliability of the bulk grid through the quarterly Short-Term Assessment of Reliability (STAR).
- Although the 2022 RNA did not find immediate reliability needs, thinning reliability margins noted in the report require the NYISO to closely track changes and assumptions in future demand forecasts.
- In 2023, the NYISO will issue the 2022-2032 Comprehensive Reliability Plan and will continue to perform quarterly reliability assessments to capture any changes.

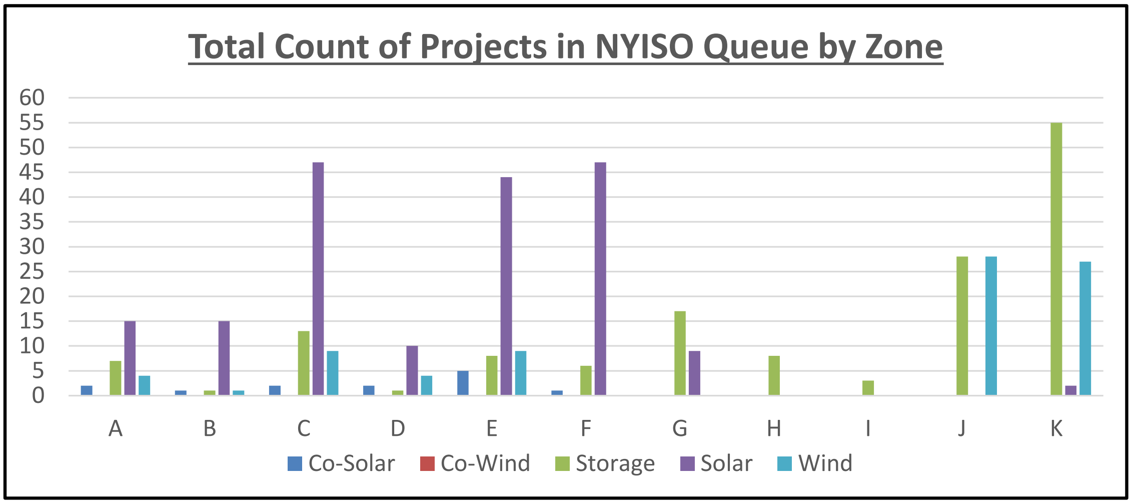
Interconnection Queue: Monthly Snapshot – Storage / Solar / Wind / CSRs (Co-located Storage)

The intent is to track the growth of Energy Storage, Wind, Solar and Co-Located Storage (Solar and Wind now in separate categories) 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 November 21st, and representing the Queue as of October 31st. Note that 11 projects were added, and 10 were withdrawn during the month of October. Results are tabulated below and shown graphically on the next page.

Total Count of Projects in NYISO Queue by Zone					
Zone	**Co-Solar**	**Co-Wind**	**Storage**	**Solar**	**Wind**
A	2		7	15	4
B	1		1	15	1
C	2		13	47	9
D	2		1	10	4
E	5		8	44	9
F	1		6	47	
G			17	9	
H			8		
I			3		
J			28		28
K			55	2	27
State	13		147	189	82

Total Project Size (MW) in NYISO Queue by Zone					
Zone	**Co-Solar**	**Co-Wind**	**Storage**	**Solar**	**Wind**
A	290		430	2,090	615
B	100		20	2,327	200
C	70		1,223	5,254	1,184
D	40		20	1,689	847
E	954		492	4,452	1,087
F	300		440	2,064	
G			1,786	250	
H			3,423		
I			1,000		
J			4,815		32,326
K			5,772	59	25,658
Grand Total	1,753		19,421	18,184	61,918

Average Size (MW) of Projects in NYISO Queue by Zone					
Zone	**Co-Solar**	**Co-Wind**	**Storage**	**Solar**	**Wind**
A	145		61	139	154
B	100		20	155	200
C	35		94	112	132
D	20		20	169	212
E	191		62	101	121
F	300		73	44	
G			105	28	
H			428		
I			333		
J			172		1,155
K			105	29	950
State	135		132	96	755


Total Count of Projects in NYISO Queue by Zone
60
55
50
45
40
35
30
25
20
15
10
5
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A
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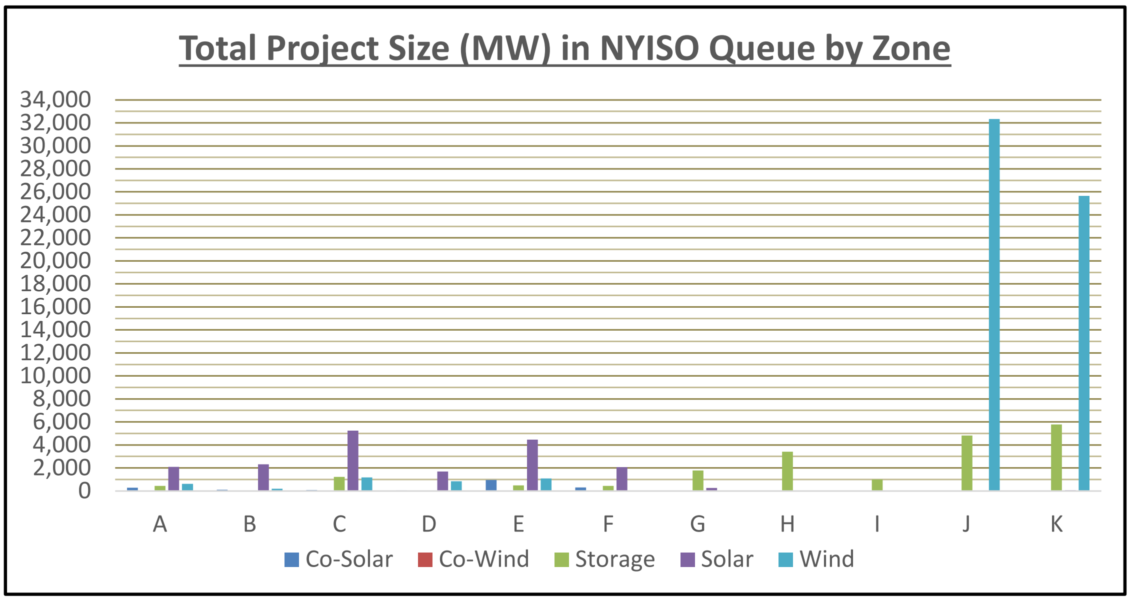
Co-Solar
Co-Wind
Storage
Solar
Wind


Total Project Size (MW) in NYISO Queue by Zone
34,000
32,000
30,000
28,000
26,000
24,000
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14,000
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Co-Wind
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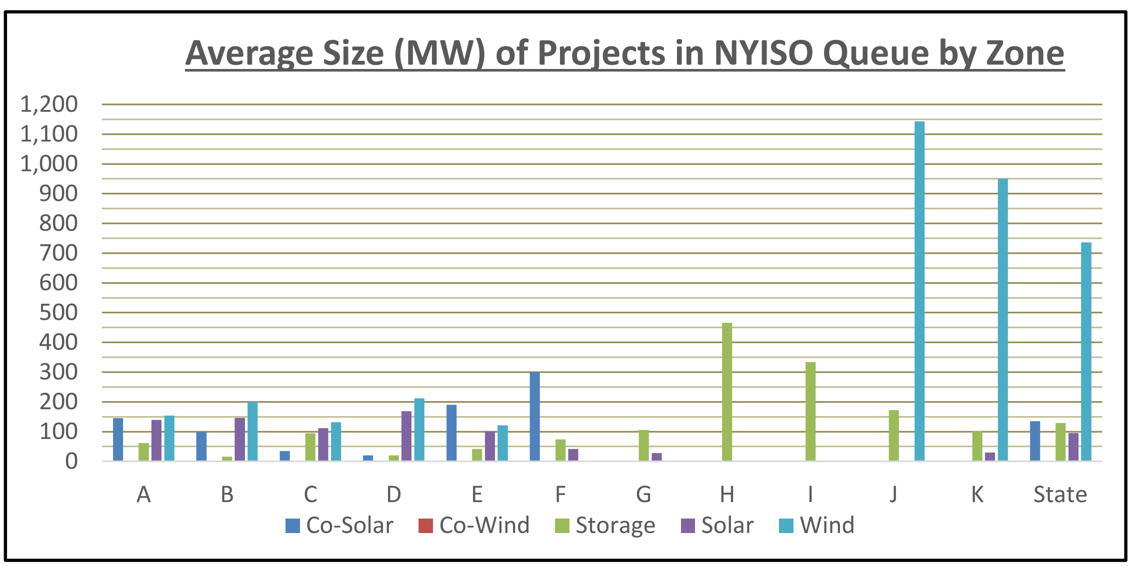
Solar
Wind


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