Attachment #7.2.1
Return to Agenda

Reliability and Market Considerations for a Grid in Transition:

Modeling Operations and Investment Through 2040 Including Alternative Scenarios

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NYSRC Executive Committee Meeting
July 17, 2020

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Agenda

- Background
- Overview of the study & overall conclusions

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Background

New York's Climate Leadership and Community Protection Act

- 70 x 30: 70% of electricity from renewable resources by 2030
- 6,000 MW of solar by 2025
- 3,000 MW of energy storage by 2030
- 9,000 MW offshore wind by 2035
- 100 x 40: by the year 2040, the statewide electrical demand system will be zero emissions
- Greenhous gas emissions across all sectors reduced by ~20% in 2030 and ~80% in 2050
  - Expected to require significant electrification of transportation and heating

A Grid in Transition

- The NYISO's competitive wholesale markets provide a framework for a changing grid
- The NYISO's Grid in Transition Report:
  - Describes emerging reliability and economic challenges facing New York's electricity sector
  - Identifies gaps to address
  - Proposes a path forward
- The NYISO and its stakeholders also need to understand the impact of the changes on the resource mix

The Reliability and Market Considerations for a Grid in Transition report was published on December 20, 2019, and can be viewed here: https://www.nyiso.com/documents/20142/2224547/Reliability-and-Market-Considerations-for-a-Grid-in-Transition-20191220%20Final.pdf/61a69b2e-0ca3-f18c-cc39-88a793469d50

Study Purpose and Scope

- **NYISO retained The Brattle Group to simulate the resources that can meet state policy objectives and energy needs through 2040, in order to inform separate inquiries into reliability and market design issues.**
- **This study focuses on the following questions about resource mix:**
  - How many and what types of **renewable resources and storage** will be needed to achieve New York's decarbonization mandates?
  - What types of **flexible resources and storage** will be needed to match variable renewable output and load?
  - What is the future of **current New York generation** (e.g., nuclear and gas)?
  - How might **electrification** affect market operations and investments?
  - What is the role of a flexible and market-engaged **demand side**?

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The Study:

Key Issues in Decarbonizing Systems

Meeting demand in low wind and solar periods

Planning for a zero-emission system

New wind and **solar** provide clean but intermittent power

Load grows with economy-wide electrification

Challenge: Meeting demand when wind and solar are low, hour-to-hour and seasonally

Note: predictable and unpredictable changes in net load may also create ramping challenges requiring flexibility, but this is not addressed in this study.

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Flexibility needed to always balance supply and demand when wind and solar are low

- **Today**, gas-fired generators, dispatchable hydro and pumped hydro storage are a key source of flexibility. Gas-fired generators can be used less in the future due to carbon mandates.
- **A clean future system** will include large amounts of wind and solar generation, whose output is primarily driven by weather, thus reducing the amount of flexibility provided by generation.
- **The future system** will require more flexibility across all timescales (hourly, multi-day, seasonal) to balance intermittent renewables and more volatile load.
- **Short-duration storage**, such as batteries, can help provide balancing across hourly and daily timescales.
- **Flexible loads**, such as controllable electric vehicles and HVAC, can provide limited balancing in the hourly timeframe.
- **New technologies** will be needed to provide seasonal storage or zero-emission, dispatchable supply.

Paradigm Shift: Transition from controlling generation to adjusting load and using storage to shift excess renewables to match supply and demand.

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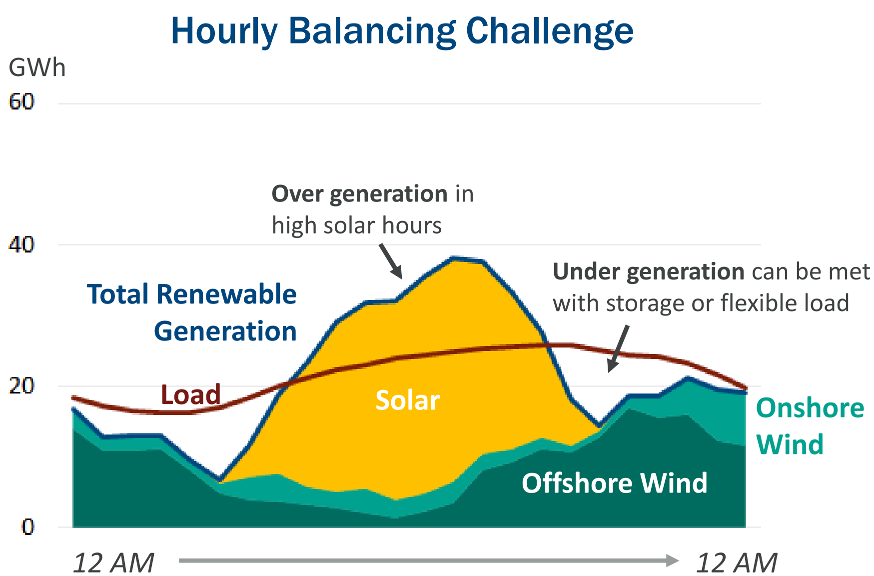
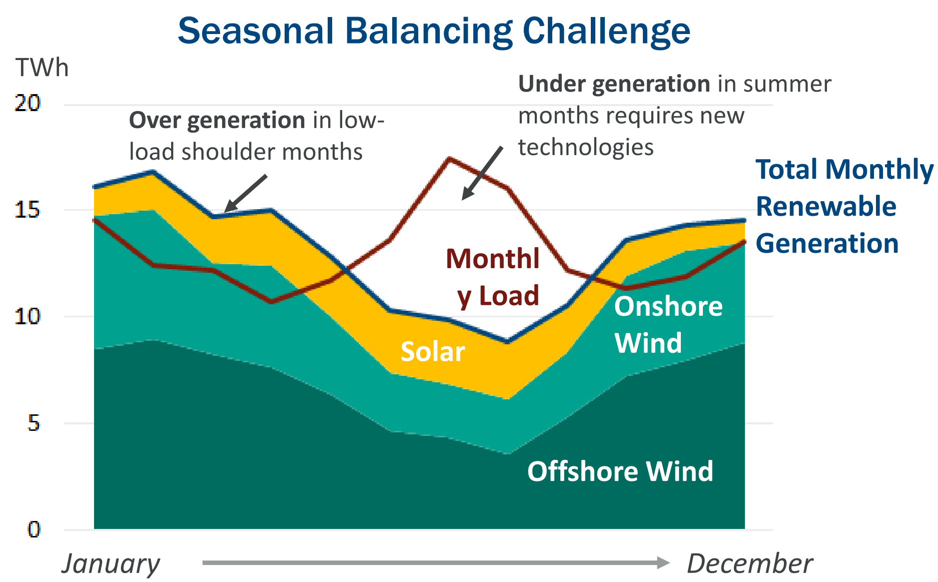
The balancing challenge is across multiple timescales



Batteries and load flexibility can provide short-term balancing.



Seasonal balancing is the more difficult challenge, requiring <u>new technologies</u> such as seasonal storage or zero-emission dispatchable generation.

Sources and Notes: Illustrative examples. Load data is from NYISO's 2020 "High Electrification" CLCPA Load Case forecast. Generation capacities in both examples set such that total renewable generation over the period matches load. Left: Forecast for 8/19/2020; capacity of 63 GW assumed of each renewable type. Right: Capacity of 22 GW assumed for each type.

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The role of new technologies to provide flexibility and resource adequacy

- **Several new technologies are under development that could potentially be considered under zero-emission requirement, including:**
  - Hydrogen
  - Renewable natural gas (RNG)
  - Flow batteries
  - Gravity storage
  - Carbon capture and sequestration
  - New nuclear technologies
- **The costs and capabilities of these technologies are uncertain. We modeled RNG as a proxy for potential future zero-emission technology to illustrate the potential role of these technologies. RNG is utilized as a proxy due to availability of various cost estimates for such technology.**
  - RNG used as fuel in existing and new gas-fired plants during peak periods
  - RNG produced in NY from electrolyzer and methanation plants using clean electricity in low cost periods
  - Additional RNG can be purchased from interstate pipeline system
- **We did not model carbon capture and sequestration or new nuclear.**
- **RNG cost assumptions drawn from multiple sources, but given the degree of uncertainty in technology costs we recommend further scenario analysis to develop more robust understanding of role of long-duration storage.**

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Analytical Approach

Modeling the grid's evolution with GridSIM

High-level approach

Brattle has used the **GridSIM model** to simulate investment and operations through 2040, consistent with assumptions developed in conjunction with NYISO staff and stakeholders.

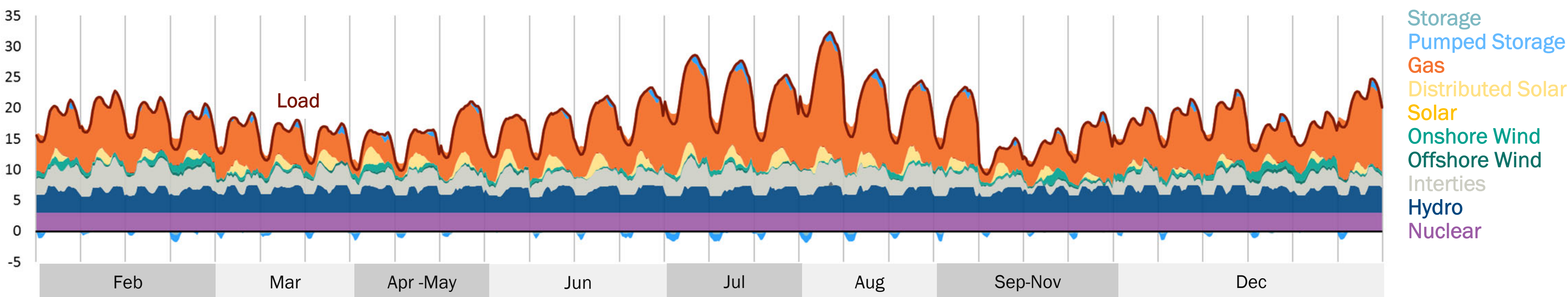
1.	**Construct Scenarios**	Develop model inputs and vet assumptions with stakeholders.
2.	**Base Case GridSIM Modeling**	Use GridSIM to identify cost-effective investment path through 2040
3.	**Alternative Cases**	Simulate operations and investments under different future scenarios.

- **Study makes several simplifying assumptions:**
  - Climate Change CLCPA "High Electrification" load forecast
  - Zonal "pipe and bubble" transmission topology
  - Stylized representation of generators
    - Aggregated generators by zones and types
    - Economic additions and retirements in continuous increments, not "lumpy"
  - Current market rules and policies
  - Model 30 representative days each year (10 summer, 10 winter, 10 spring/fall)

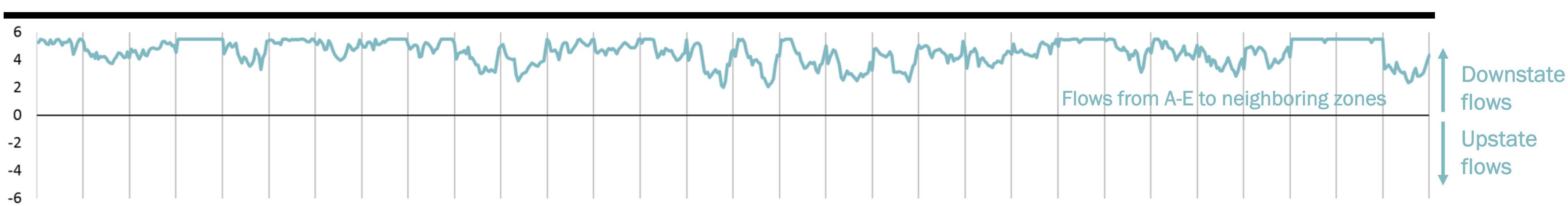
Near term (2024): Supply Mix and Operations Similar to Today

Hourly operations across 30 representative days

Generation and Load, GW

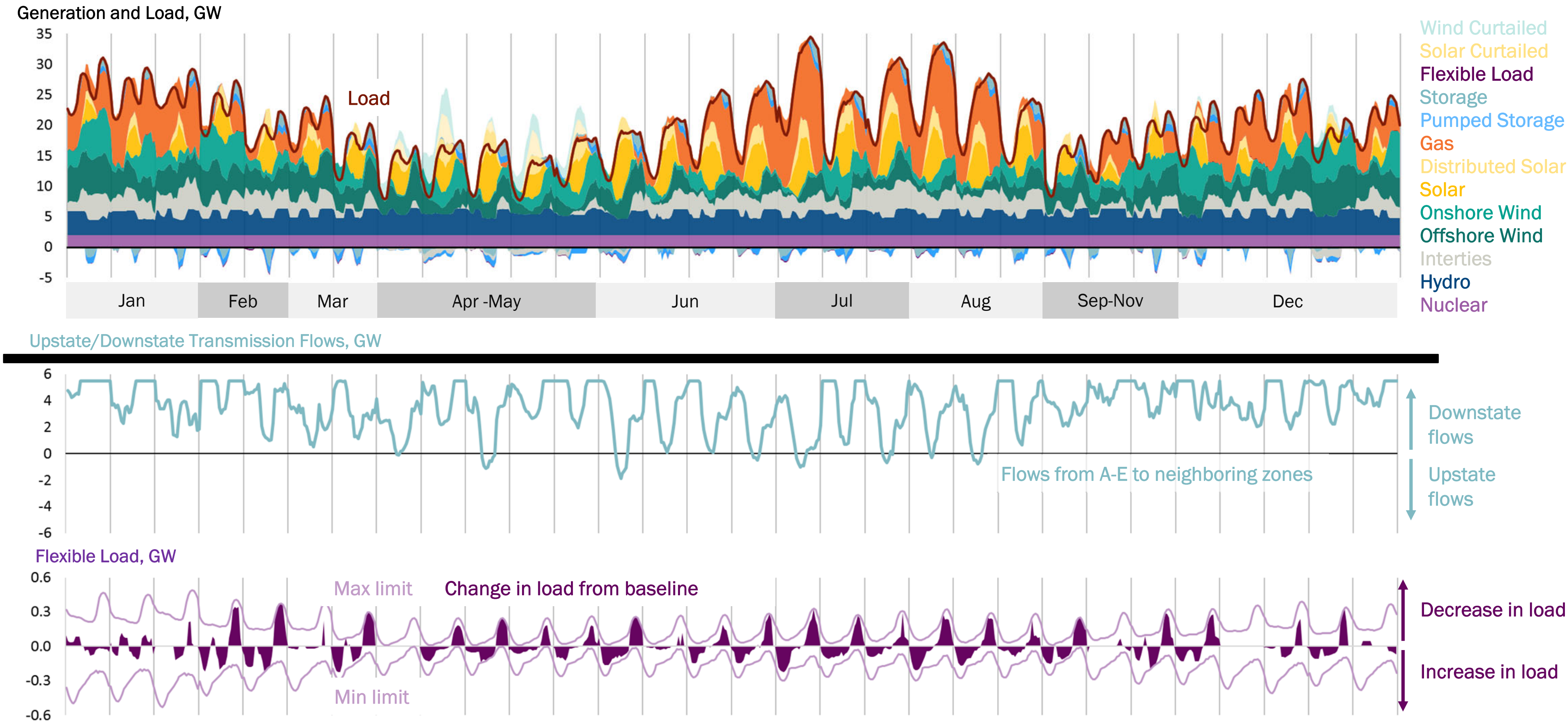


Upstate/Downstate Transmission Flows, GW



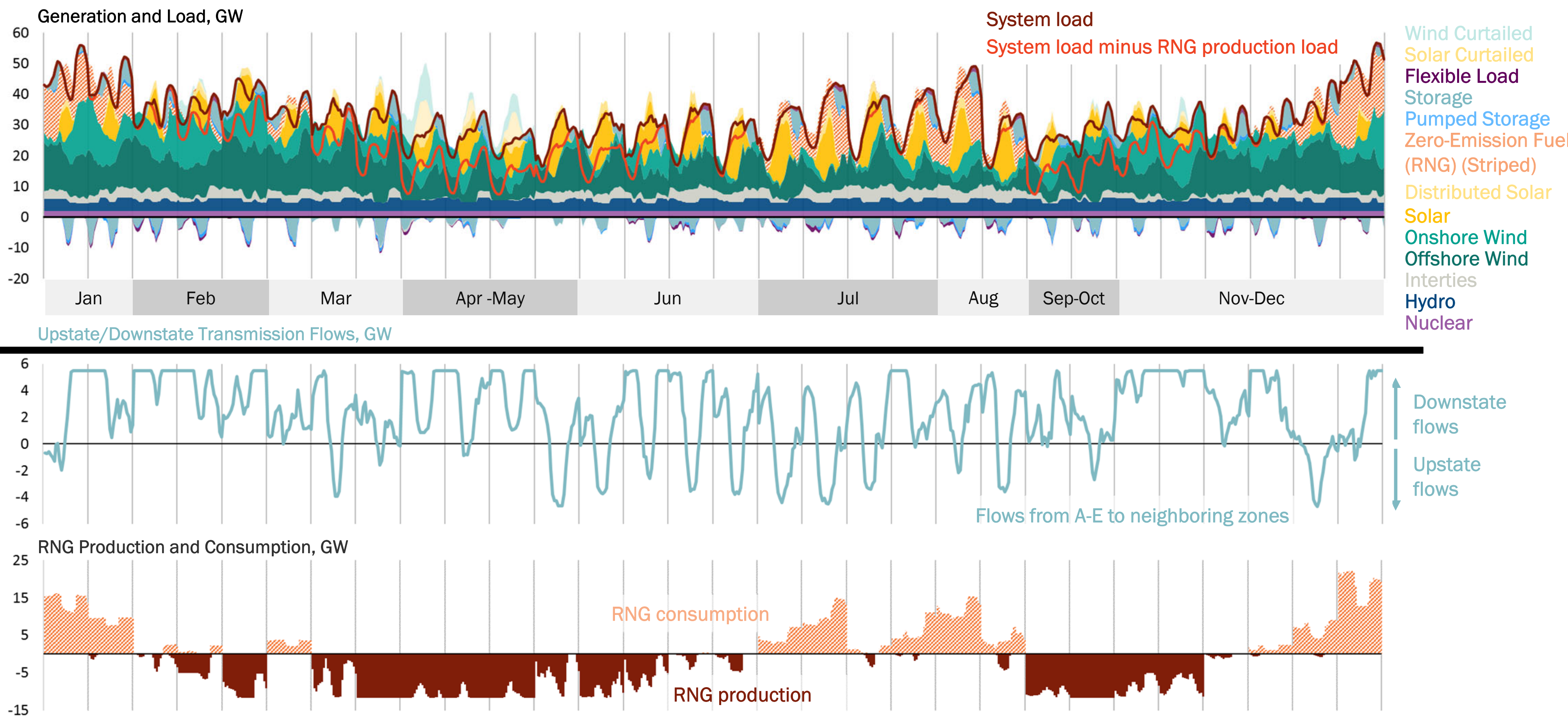
Mid-term (2030): Managing a 70% Renewable System

Hourly operations across 30 representative days

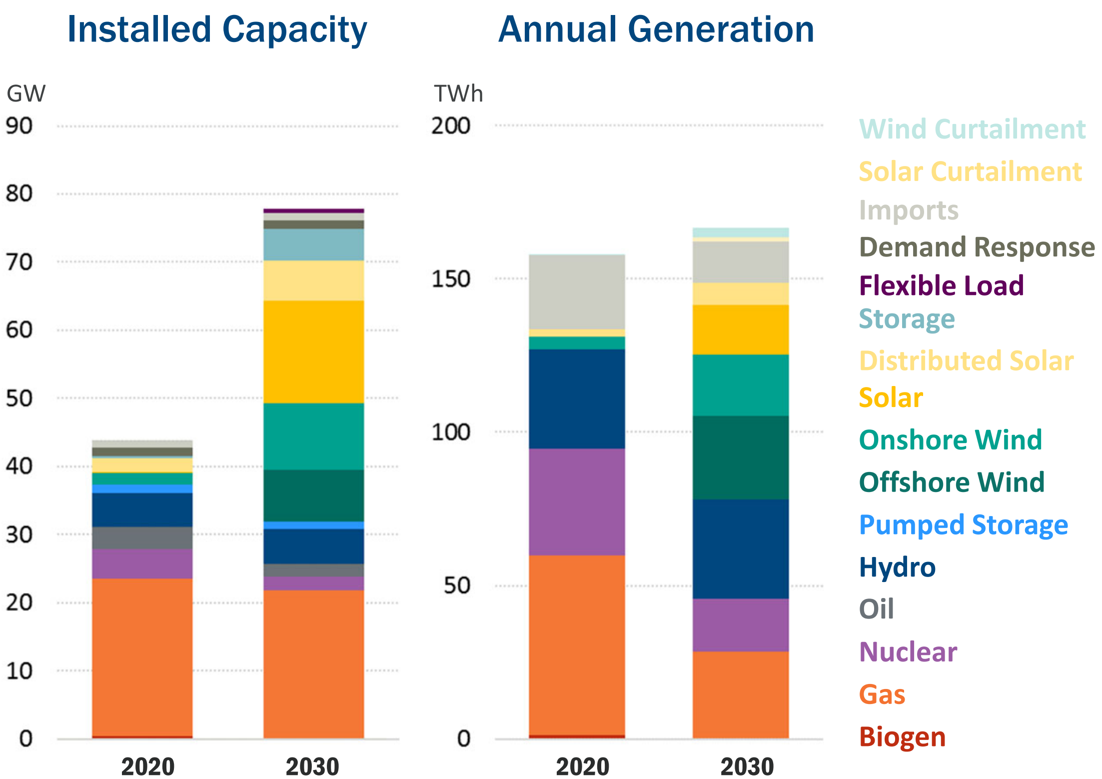


Long-term (2040): Realizing a Zero-Emission System

Hourly operations across 30 representative days



Mid-term (2030): Managing a 70% Renewable System Resource Mix



- Renewable resources provide 70% of energy
  - Solar deployments grow to 20 GW
  - Offshore wind deployments grow to 8 GW
  - Onshore wind deployments grow to 10 GW
- Nuclear capacity and generation falls with 1 GW of Upstate nuclear retirement after expiration of ZEC program in 2029.
- Energy storage deployments grow by 4 GW with procurement mandates and provide balancing.
- Gas-fired and oil capacities fall due to DEC NOx rule. Gas capacity factors fall from 29% in 2020 to 15% in 2030.

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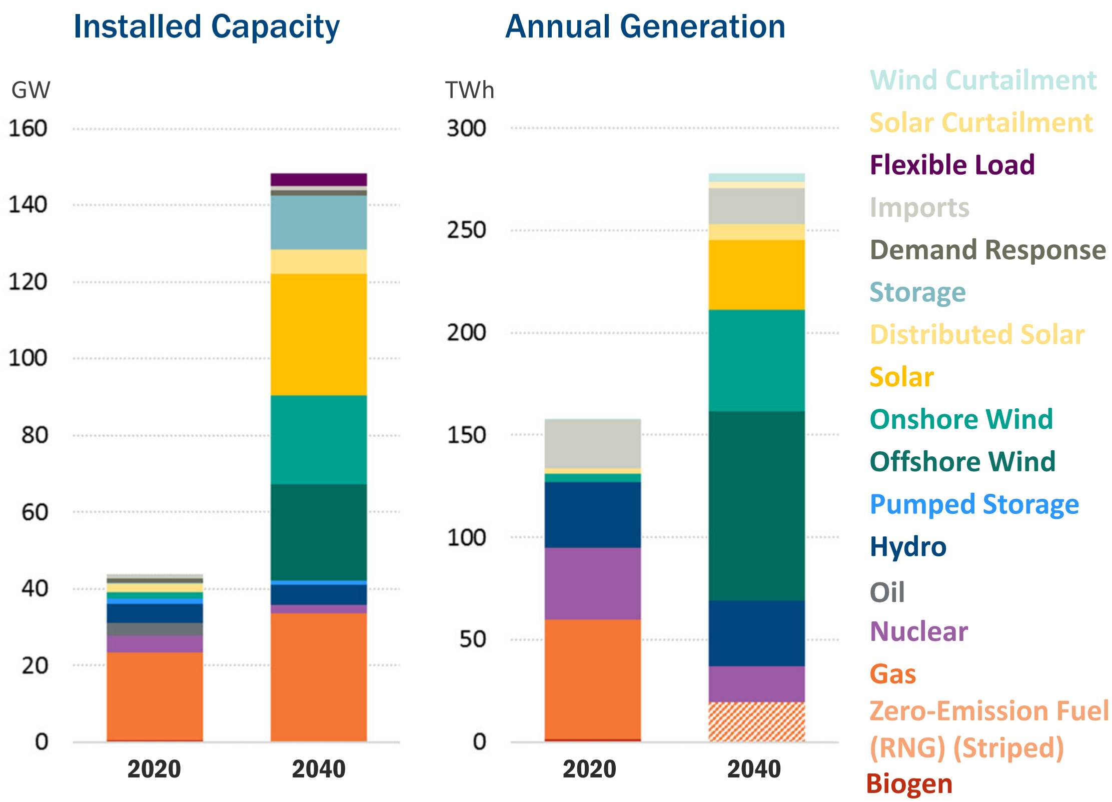
Long-term (2040): Realizing a Zero-Emission System Resource Mix



- **Nuclear experiences** no further retirements between 2030 and 2040
- **Solar capacity** grows to 38 GW; solar generation supplies 15% of New York load in 2040
- **Offshore wind** capacity grows to 25 GW; offshore wind generation supplies 34% of New York load in 2040
- **Onshore wind capacity** grows to 23 GW; onshore wind generation supplies 18% of New York load in 2040
- **Energy storage** deployments grow to 14 GW
- **Gas-fired capacity** grows, but switches to zero-emission fuel sources (RNG). Gas capacity factors fall from 29% in 2020 to 7% in 2040

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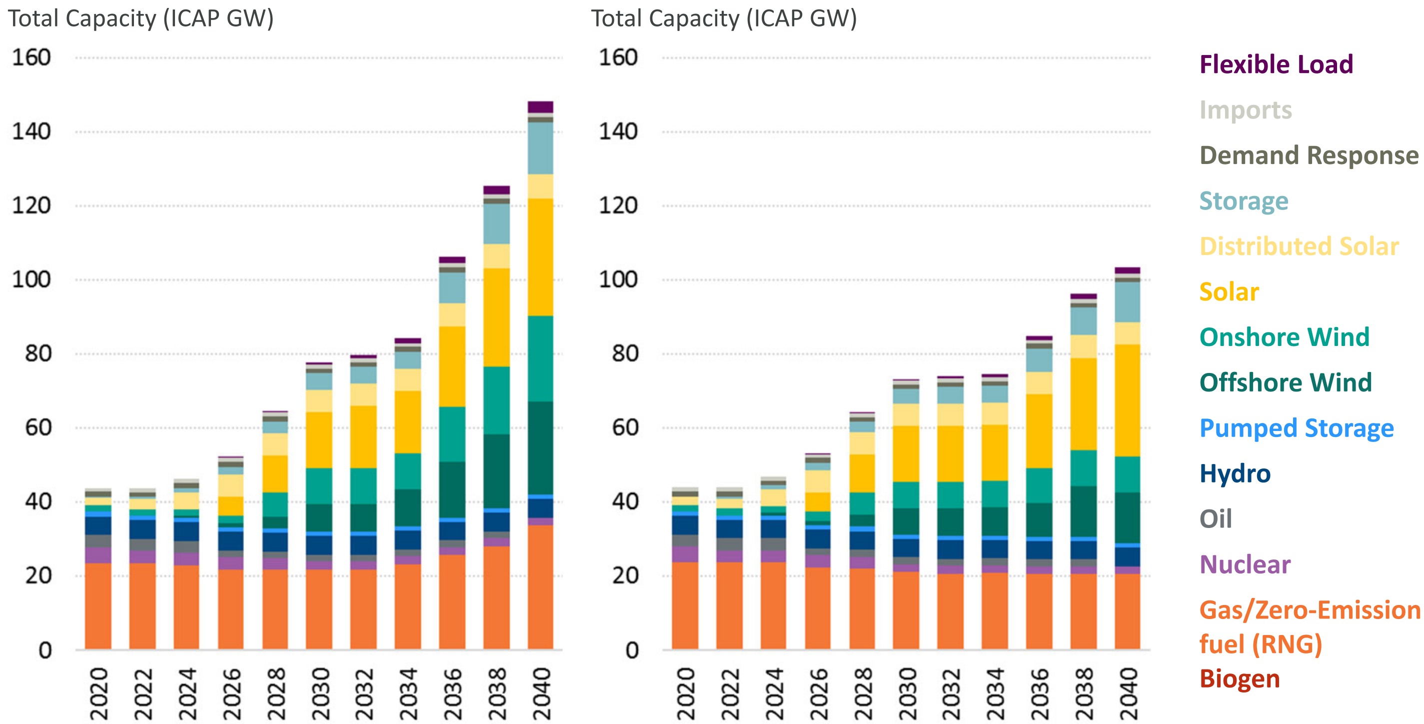
Effects of Electrification

Comparison of high electrification and reference load cases from the Climate Change Phase 1 project

Installed capacity

- High electrification case sees **43 GW more capacity** by 2040
  - +13 GW gas
  - +11 GW offshore wind
  - +14 GW onshore wind
  - +2 GW solar
  - +3 GW storage
- More capacity needed to support electrification and RNG production loads
- **Two cases diverge starting in 2030;** before then two cases are similar

High Electrification Case | **Reference Load Case**



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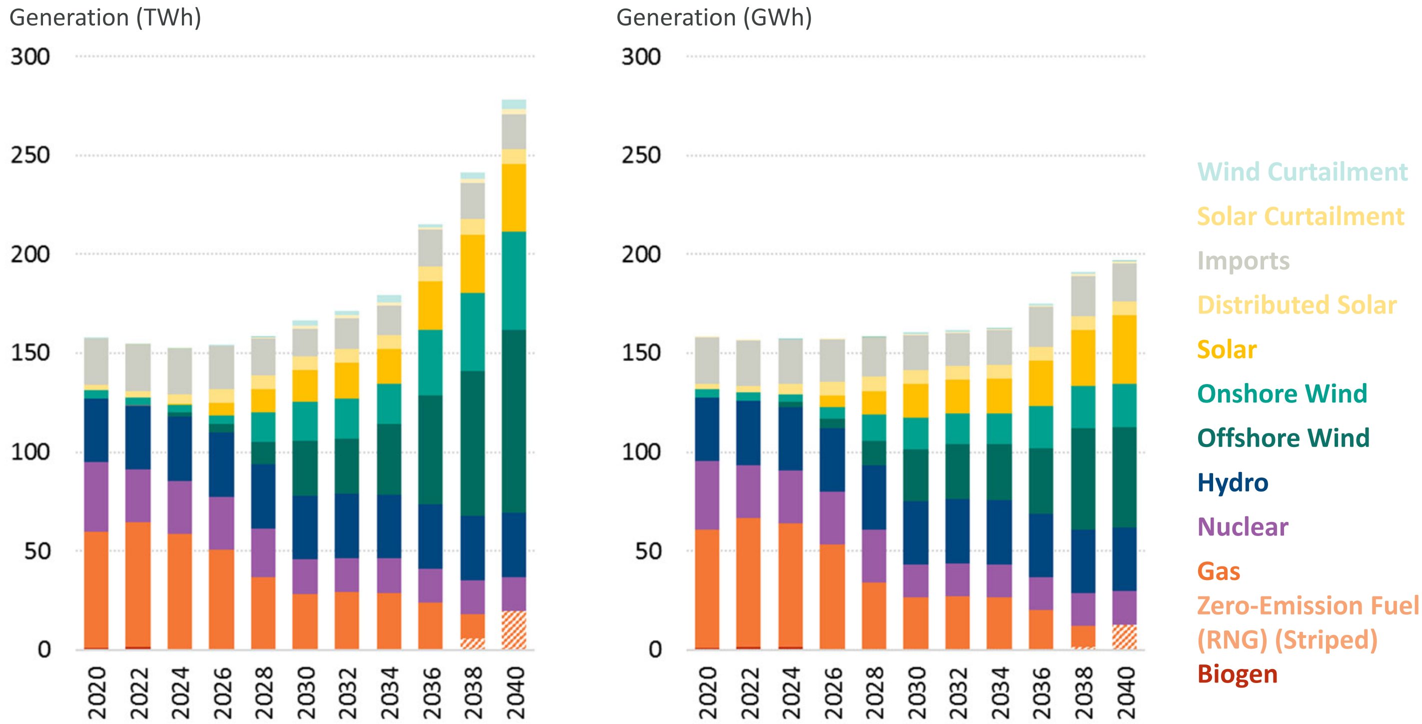
Annual generation

- Electrification and RNG production result in **75 TWh more generation** by 2040
  - **+69 TWh wind generation**
  - +7 TWh gas generation
  - -2 TWh net imports
  - Generation from other sources largely unchanged

High Electrification Case **Reference Load Case**



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Alternative Scenarios

Introduction to Alternative Scenarios

- Because future market conditions are very uncertain, we model multiple alternative future scenarios to understand key drivers of results
- Based on feedback from NYISO and stakeholders, we developed 3 scenarios to address a range of concerns
  - Existing Technologies
  - Increased Flexibility
  - Expanded Transmission
- We compared each scenario to the High Electrification Case (referred to as "Base Case"). Used "High Electrification Case" load forecast in all scenarios
- All changes to create Alternative Scenarios (e.g., expanded transmission) are fixed inputs to the model, not economic decisions by the model. Costs of implementing these changes are not considered.

1.	**Existing Technologies**	Only existing technologies (wind, solar, storage) can be built • RNG production and consumption disallowed • All fossil plants must retire by 2040 • Capacity value of wind, solar, and storage heavily derated at high deployment levels
2.	**Increased Flexibility**	More flexibility provided by expanded interties to HQ and expanded flexible load supply • +1,300 MW intertie between HQ and Zone J • +1,500 MW import capacity (+1,000 MW export capacity) between HQ and Zone D, doubling existing capacity • +1,800 MW load shift potential from flexible EVs • +5,300 MW load shift potential from flexible HVAC
3.	**Expanded Transmission**	Expanded transmission along key corridors • +2,000 MW transmission A-E -> GHI • +2,000 MW transmission GHI -> J • +1,000 MW transmission between J & K (bidirectional)

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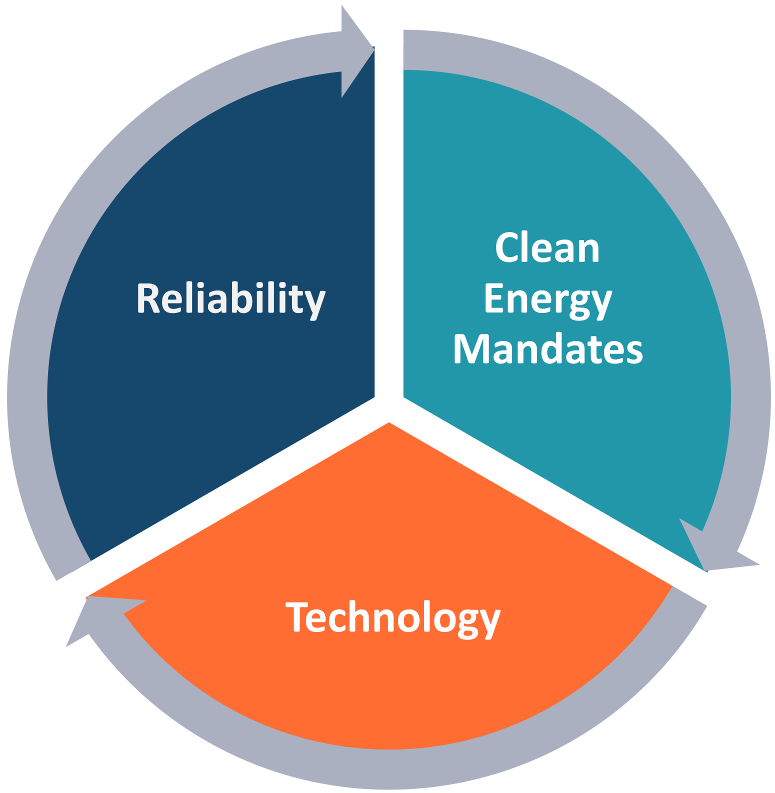
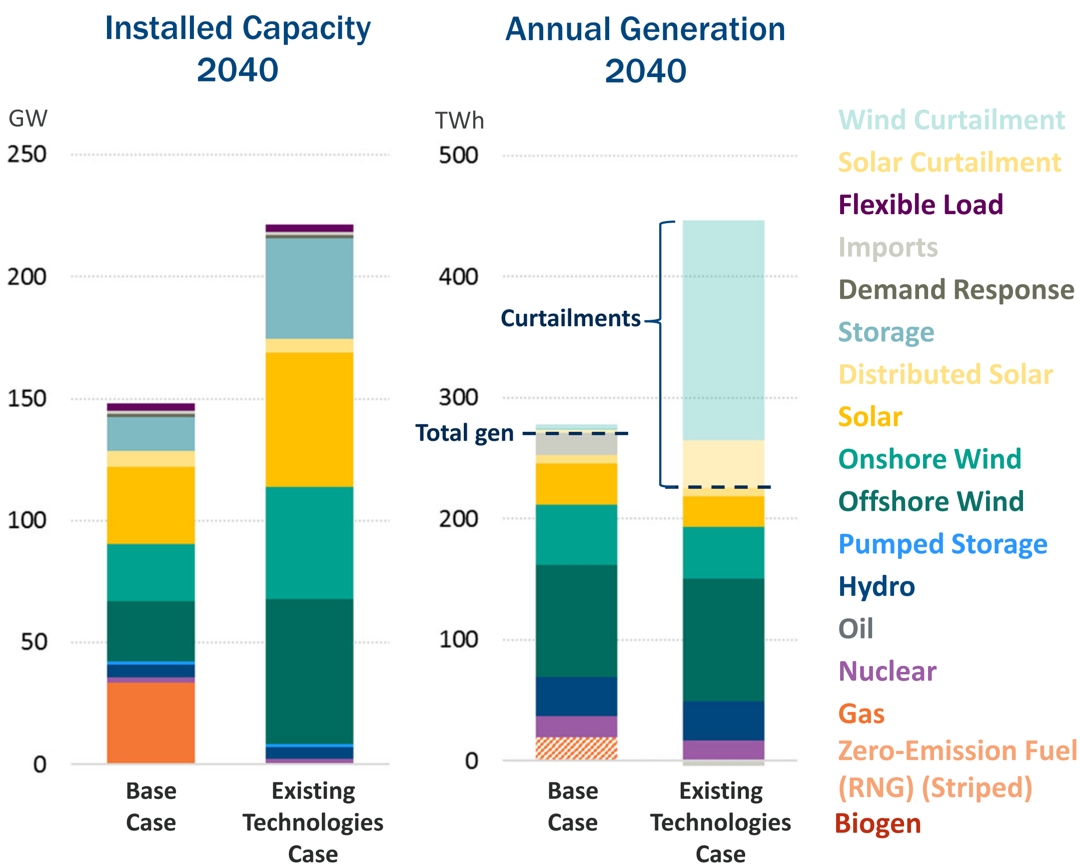
Three aspects of the future fleet must be in alignment

- Changing assumptions regarding one aspect (assuming no new technology) has consequences for other aspects (meeting clean energy and reliability mandates).



Existing Technologies Case



- **Changes from Base Case: Only existing technologies (wind, solar, storage) can be built**
  - RNG production and consumption disallowed
  - All fossil plants must retire by 2040
  - Capacity value of wind, solar, and storage heavily derated at high deployment levels
- **High-Level Insights**
  - **Large overbuild of renewables** (+80 GW) and storage (+27 GW) to meet load in all hours
  - **Large curtailments:** 221 TWh (50% of generation)
  - **Retirement of gas plants** by 2040 causes UCAP reserve margins to fall below planning reserve margin
  - **Load falls** by 50 TWh without in-state RNG production

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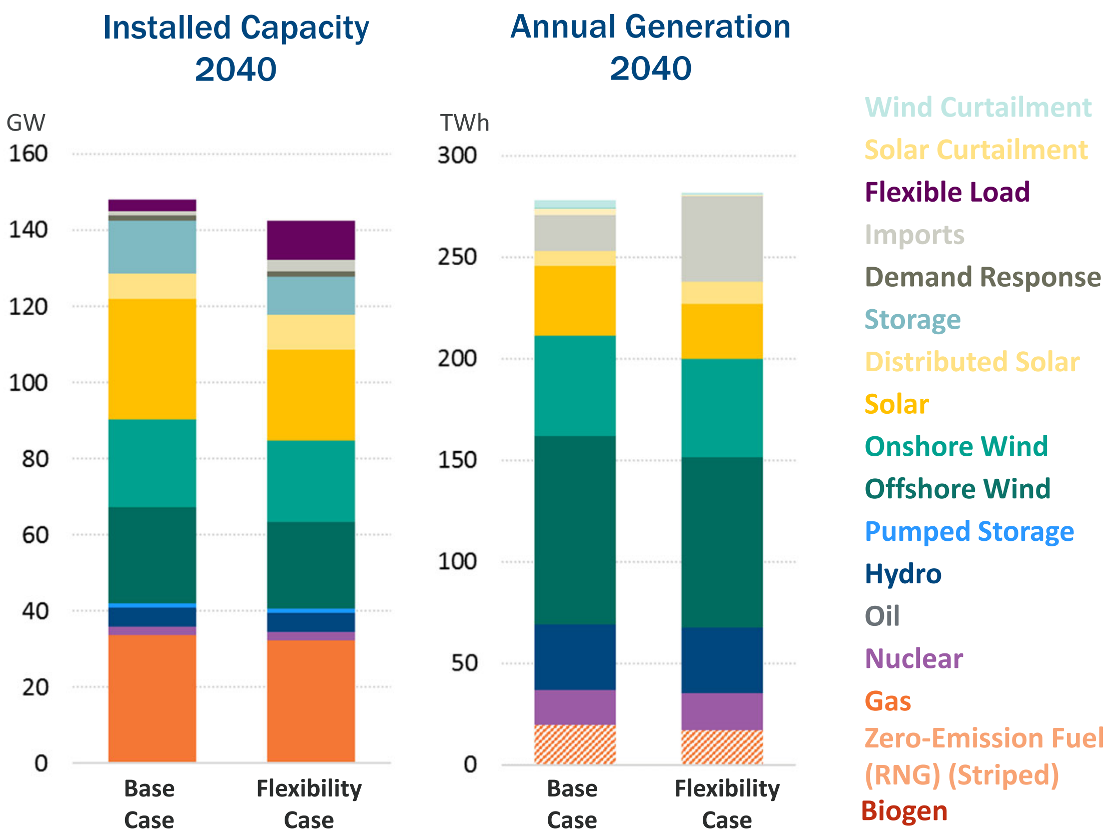
Increased Flexibility Case



- **Changes from Base Case: More flexibility from expanded HQ interties and more flexible load (does not include costs of building transmission or flex load)**
  - +1,300 MW intertie between HQ and Zone J
  - +1,500 MW import capacity (+1,000 MW export capacity) between HQ and Zone D, doubling existing capacity
  - +1,800 MW load shift potential from flexible EVs
  - +5,300 MW load shift potential from flexible HVAC
- **High-Level Insights**
  - **Increased HQ imports** (+24 TWh net) help satisfy RPS mandate, reducing in-state renewable capacity by 9 GW
  - **Zero-emission fuel generation** largely unchanged, indicating more clean imports would be necessary to displace it
  - **Increased flexible load capacity** results in less storage capacity because both provide diurnal energy shifting

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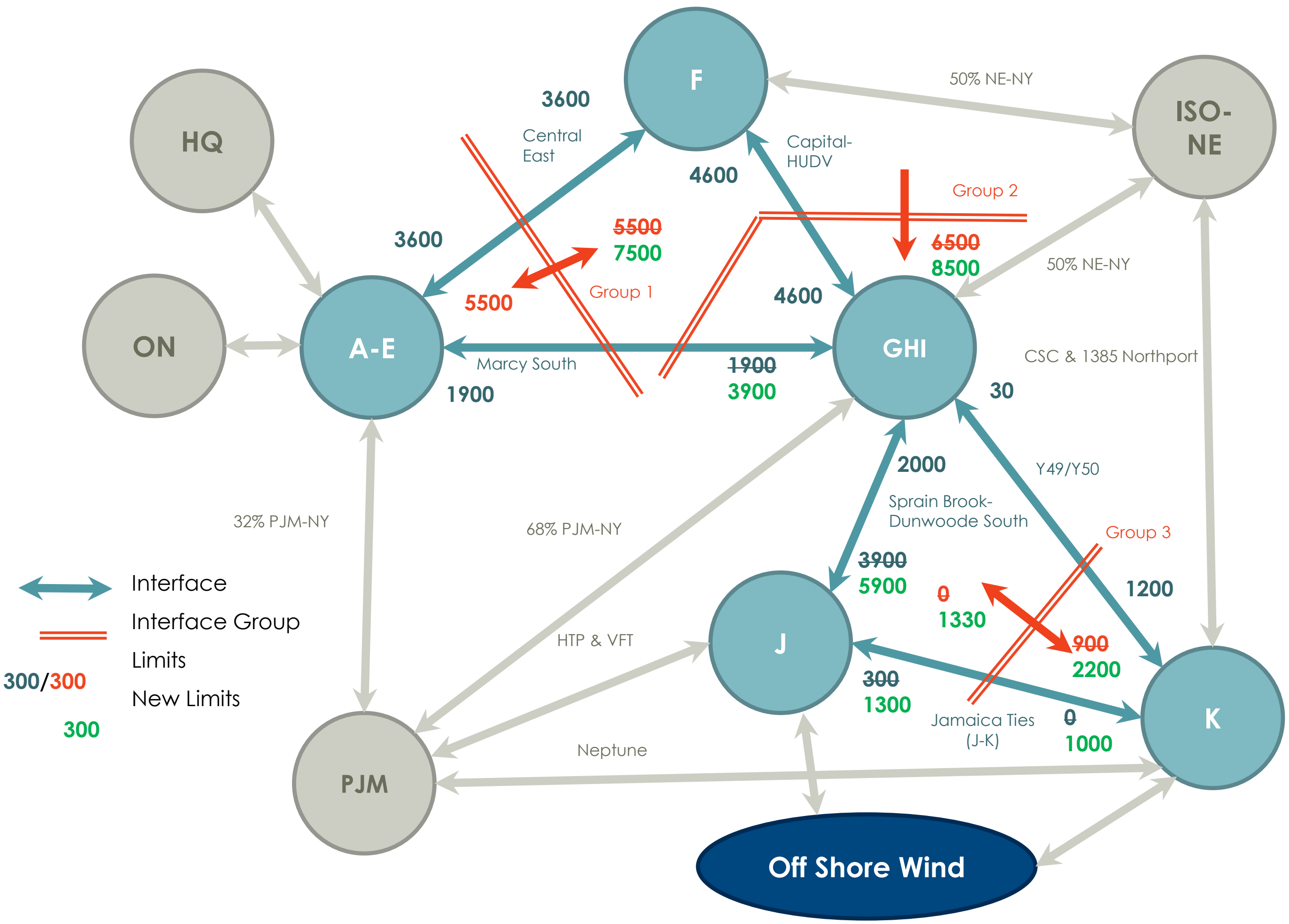
Expanded Transmission Case

- Expanded transmission along key corridors
  - +2,000 MW from A-E -> GHI
  - +2,000 MW from GHI -> J
  - +1,000 MW between J & K (bidirectional)



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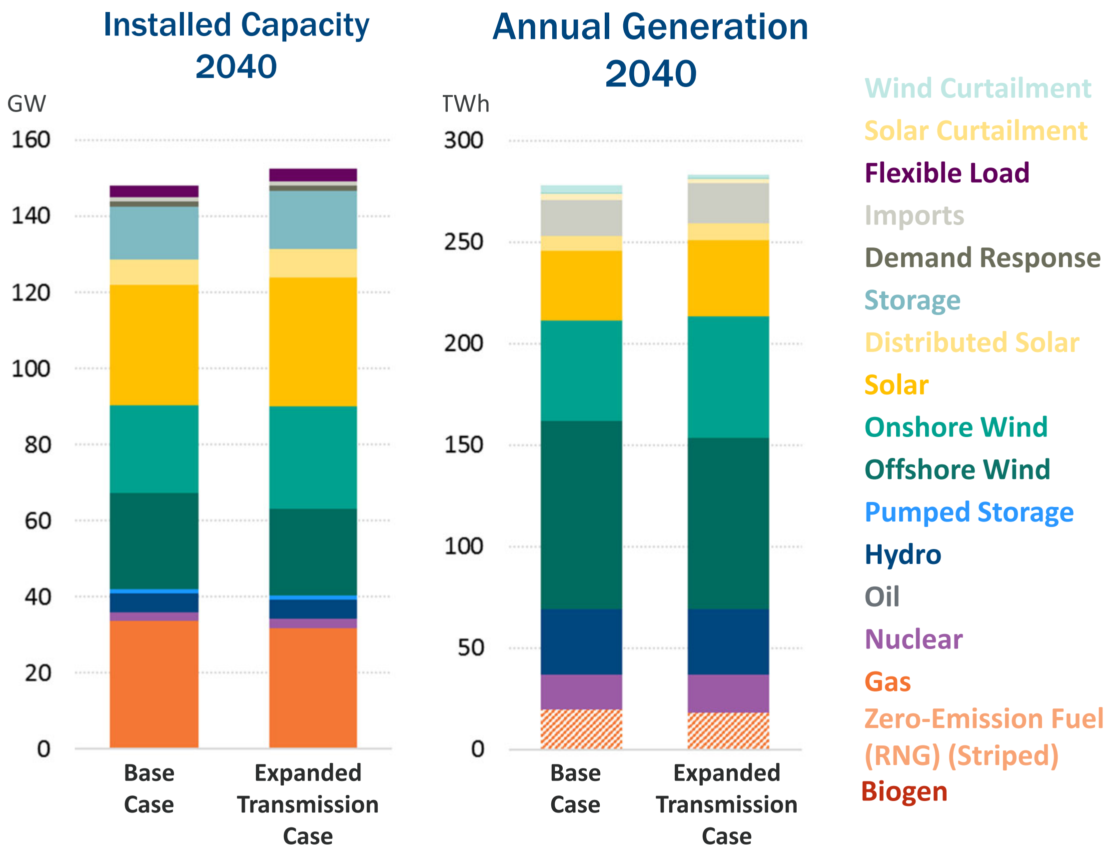
Expanded Transmission Case: 2040 High-Level Insights



- Additional 7 TWh of Upstate generation transferred Downstate
- In general, less capacity is built Downstate and more Upstate (see next slide)
- Offshore wind capacity decreases (-2.4 GW), while onshore wind capacity increases (+3.7 GW)
- Solar capacity increases (+3.1 GW)
- Gas capacity decreases (-1.9 GW)
- Zero-emission fuel generation largely unchanged because of system's continued need for firm generation (or long-duration storage)

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Alternative Scenarios: High-level Insights

1.	**Existing Technologies (Only)**	• **Large overbuild** of renewables (+80 GW) and storage (+27 GW) to meet load in all hours; likely exceeds technical limits • **Large curtailments:** 221 TWh annually (50% of renewable generation) • **Retirement of gas-fired plants** in 2040 due to zero-emission mandate causes UCAP reserve margins to fall below planning reserve margin levels
2.	**Increased Flexibility**	• **Increased HQ imports** help satisfy RPS mandate, reducing in-state renewable capacity • **Zero-emission fuel generation** largely unchanged, indicating more clean imports would be necessary to displace it • **Increased flexible load capacity** results in less storage capacity because both provide diurnal energy shifting
3.	**Expanded Transmission**	• **New resource builds shift** from Downstate to Upstate • **Offshore wind capacity decreases** (-2.4 GW), replaced by onshore wind (+3.7 GW) and solar (+2.3 GW) • **Zero-emission fuel** continues to be used, reflecting the system's continued need for firm generation (or long-duration storage)

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The complete Brattle slide deck can be found with the material for the June 22 ICAP/MIWG and at

https://www.nyiso.com/documents/20142/13245925/Brattle%20New%20York%20Electric%20Grid%20Evolution%20Study%20-%20June%202020.pdf/69397029-ffed-6fa9-cff8-c49240eb6f9d

Our mission, in collaboration with our stakeholders, is to serve the public interest and provide benefit to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the power system