Introduction to GridSIM

MODELING TO INFORM THE GRID IN TRANSITION

PRESENTED TO

NYISO ICAP/MIWG/PRLWG STAKEHOLDERS

PRESENTED BY

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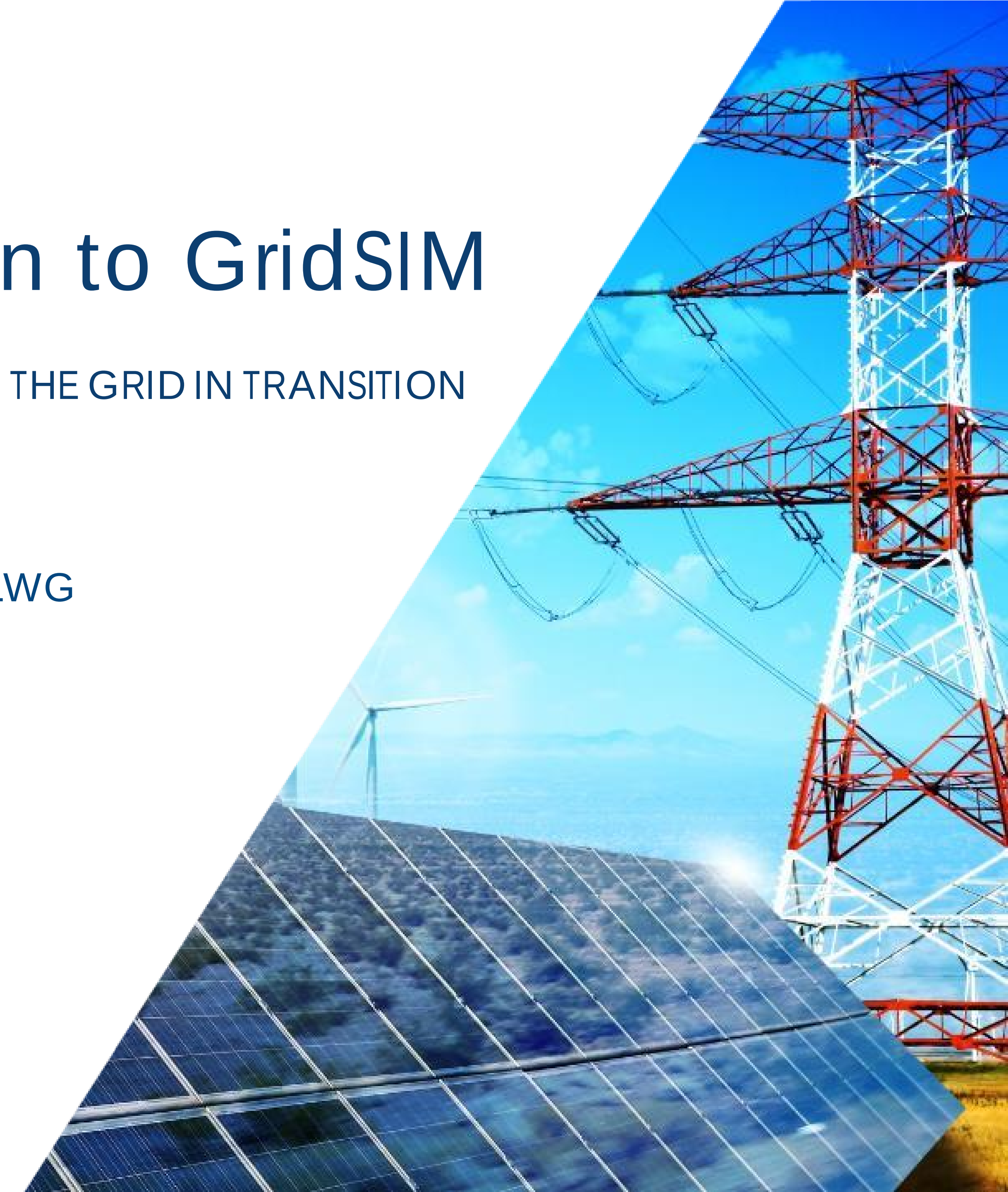
THE Brattle GROUP



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Agenda

- Introduction
- Introduction to GridSIM and Capacity Expansion Modeling
- Illustrative Analysis
- Overview of Modeling Assumptions
- Feedback and Next Steps

Project purpose and scope

NYISO has retained Brattle to develop **simulations of NYISO markets through 2040** to inform the **Grid in Transition effort.**

- New York has established aggressive clean energy and decarbonization goals, codified in the **Climate Leadership and Community Protection Act** (CLCPA).
- NYISO's **Grid in Transition** effort seeks to understand the reliability and market implications of the State's plans to transition to clean energy sources.
- NYISO has retained Brattle to **simulate NYISO market operations and investment through 2040** to inform NYISO staff and stakeholders on market evolution.

Key Questions to Address

- How many and what types of **renewable resources and storage** will be needed to achieve the 70% renewable standard?
- 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**?

We are requesting stakeholder feedback on Key Questions

High-level approach

With stakeholders, over coming weeks **Brattle and NYISO will develop simulations of the future New York power system**.

1.	**Model Setup** End of March	Develop model inputs and vet assumptions with stakeholders
2.	**Benchmarking** April	Calibrate and validate model by comparing to recent history (2018)
3.	**Base Case** April & May	Develop Base Case simulations of NYISO markets through 2040
4.	**Alternative Cases** May & June	Develop Alternative Cases through 2040, varying assumptions such as resource costs, load growth, and demand-side flexibility.

Introduction to GridSIM and Capacity Expansion Modeling

What are "capacity expansion models"?

Capacity expansion models simulate **optimal generation investment and operations** over a **multi-year horizon**.

- **In traditionally regulated areas,** commonly used by utilities for IRP
- **In organized markets with merchant investment**, simulate how investment and market conditions may evolve over time
- **Especially valuable for exploring alternative futures in times of uncertainty and major change** in market fundamentals, policies, and market design, as in New York
- **Example models** include PLEXOS, Aurora, Strategist, and Resource Planning Model (NREL)

GridSIM: Brattle's next-gen capacity expansion model

GridSIM Features

- Designed to simulate **highly-decarbonized systems**
- Implemented with detailed representation of **NY power system** and **NYISO markets**
- **Co-optimized** treatment of energy, ancillary service, and capacity markets
- Chronological commitment and dispatch to robustly model **storage**.

Example Insights

- How to balance a **100% carbon-free** grid?
- How are **nuclear** revenues affected by 70% renewable energy?
- How does the cost of **offshore wind** influence the future NY resource mix?

gridSIM

Previous uses of GridSIM

- **NYISO Grid in Transition.** For NYISO, supported Grid in Transition effort to understand potential market revenue shifts for the NYISO's recommended market enhancements.
- **Ontario Clean Energy Study.** For IESO, evaluated the costs and benefits of alternative clean energy procurement mechanisms.
- **Clean Energy Attribute Product Design & Procurement.** For NEPOOL, evaluated benefits of a dynamic clean energy market in ISO-NE.
- **Evaluation of Future Flexibility Needs.** For an investor, evaluating the future value of flexible resources within ERCOT.
- **Market Design Enhancement Study.** For an RTO, evaluated the benefits and costs of enhancements to energy and capacity markets.
- **DR and EE Assessment.** For EPRI and DOE, evaluated the potential benefits of enhanced DR and EE treatment within resource planning models.
- **Nuclear Valuation.** For a Southeast utility, evaluated the value of a nuclear plant within a resource planning context.

GridSIM model framework

Inputs

Supply

Existing resources
Fuel prices
Investment/fixed costs
Variable costs

Demand

Representative day hourly demand
Capacity needs

Transmission

Zonal limits
Intertie limits

Regulations, Policies, Market Design

Capacity market
Carbon pricing
Procurement mandates

GridSIM Optimization Engine

Objective Function

Minimize NPV of Investment & Operational Costs

gridSIM

Constraints

- Market Design and Co-Optimized Operations
  - *Capacity*
  - *Energy*
  - *Ancillary Services*
- Regulatory & Policy Constraints
- Resource Operational Constraints
- Transmission Constraints

Outputs

Annual Investments and Retirements

Hourly Operations

System and Customer Costs

Supplier Revenues

Emissions and Clean Energy Additions

Market Prices

Objective function

GridSIM minimizes the present value of **total system costs** across a multi-year horizon, subject to **constraints**.

Components of Total System Cost:

- **Operating costs:** Objective to dispatch its system in a least-cost manner across E&AS markets to minimize **production costs**, including fuel, variable operations and maintenance, startup, and emission costs
- **Investment costs:** A new resource built only when its total revenues exceed its total costs, such that **investment and fixed costs** are minimized

Constraints considered

GridSIM simulates system operations subject to **technical, market design, and policy constraints.**

Market Design & Operations

- Must retain sufficient supply to **meet resource adequacy requirements,** per ICAP market
- Each hour, **generation must equal load**

Regulatory and Policy Constraints

- **Emission caps and carbon pricing**
- **Technology mandates**, e.g. Renewable Portfolio Standards or storage mandates

Resource Operational Constraints

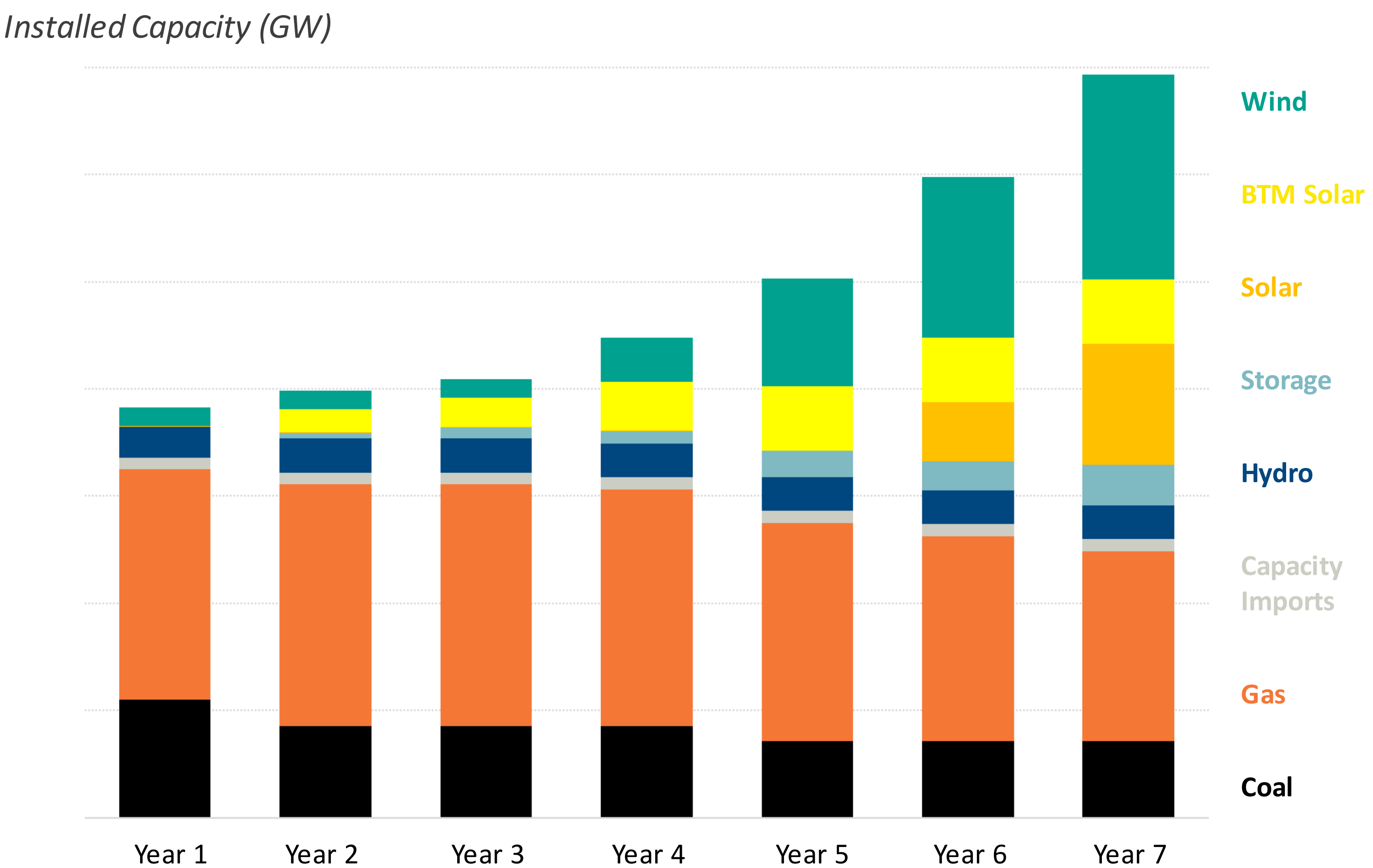
- Supply resources subject to **technical constraints** that vary by resource type, e.g. ramp rates, unit commitment, min/max gen, hydropower flow limits, lifetime
- Availability of **import supply & exports** can be treated in a variety of ways

Transmission Constraints

- Internal and external flows limited by pre-specified **transmission limits** (pipe and bubble model)

Illustrative Analysis

Illustrative Analysis
Changes in capacity

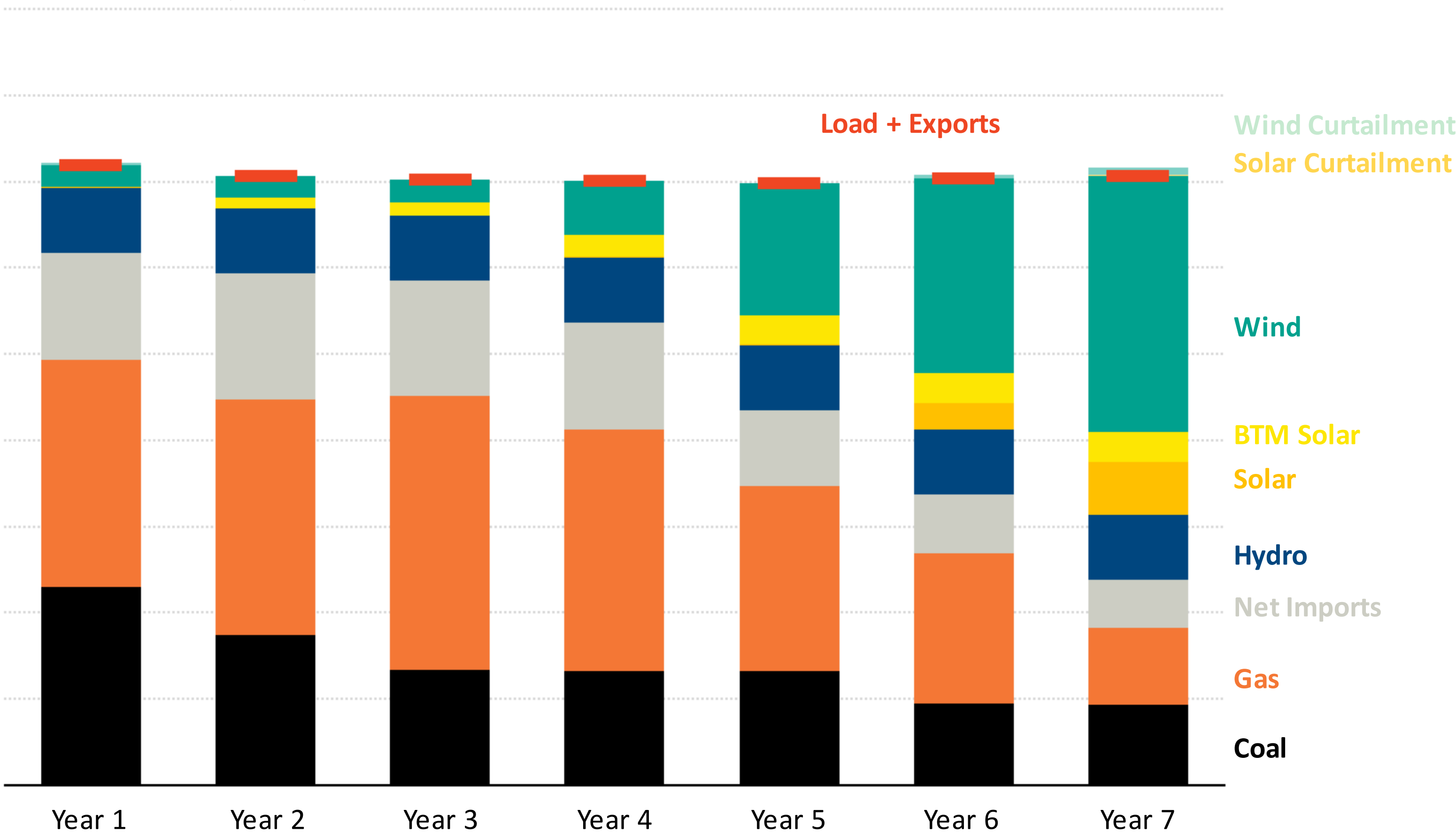


Illustrative Analysis

Illustrative Analysis

Changes in generation

Annual Generation (TWh)

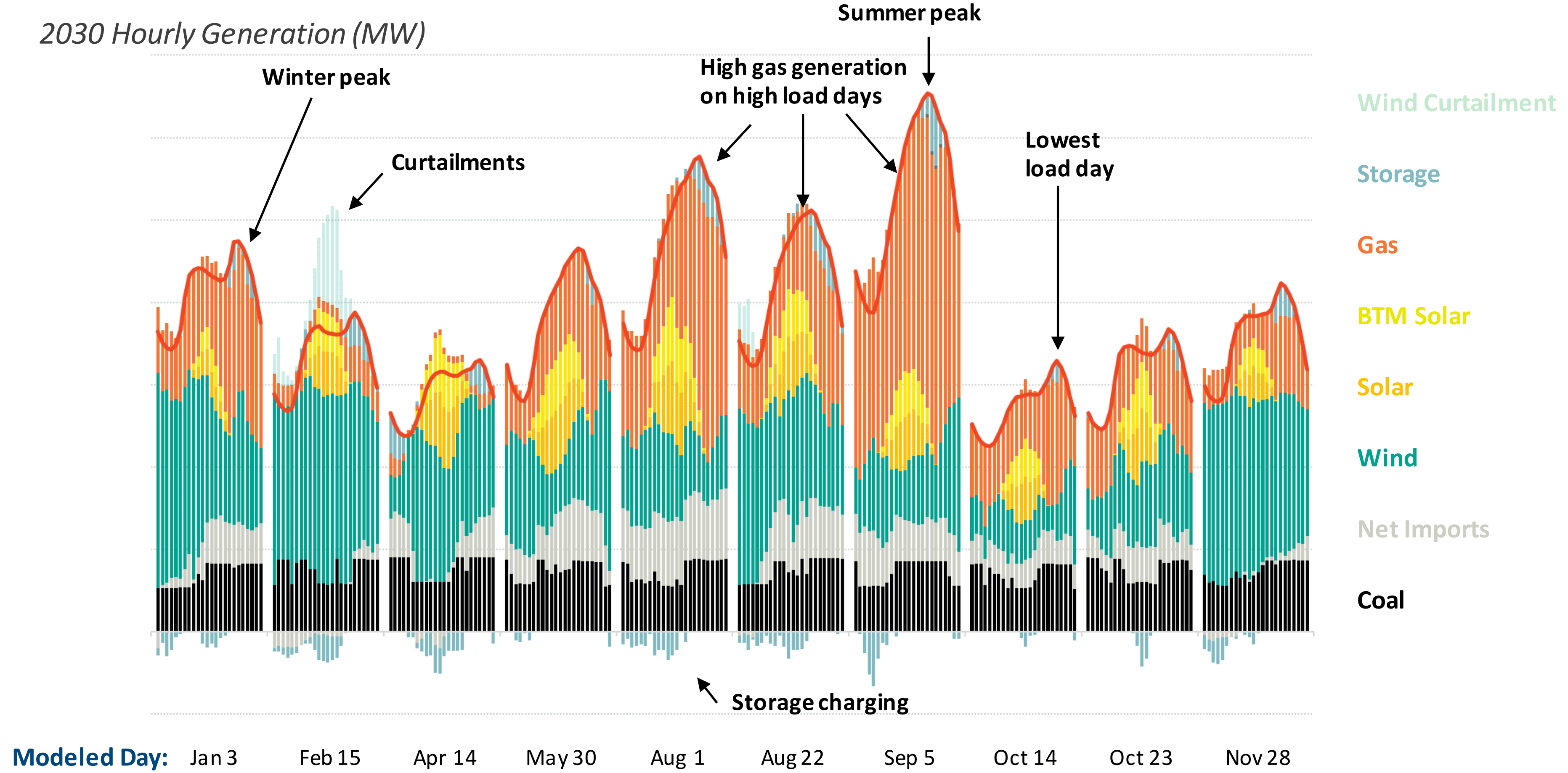


Illustrative Analysis

Illustrative Analysis

Hourly dispatch in 2030

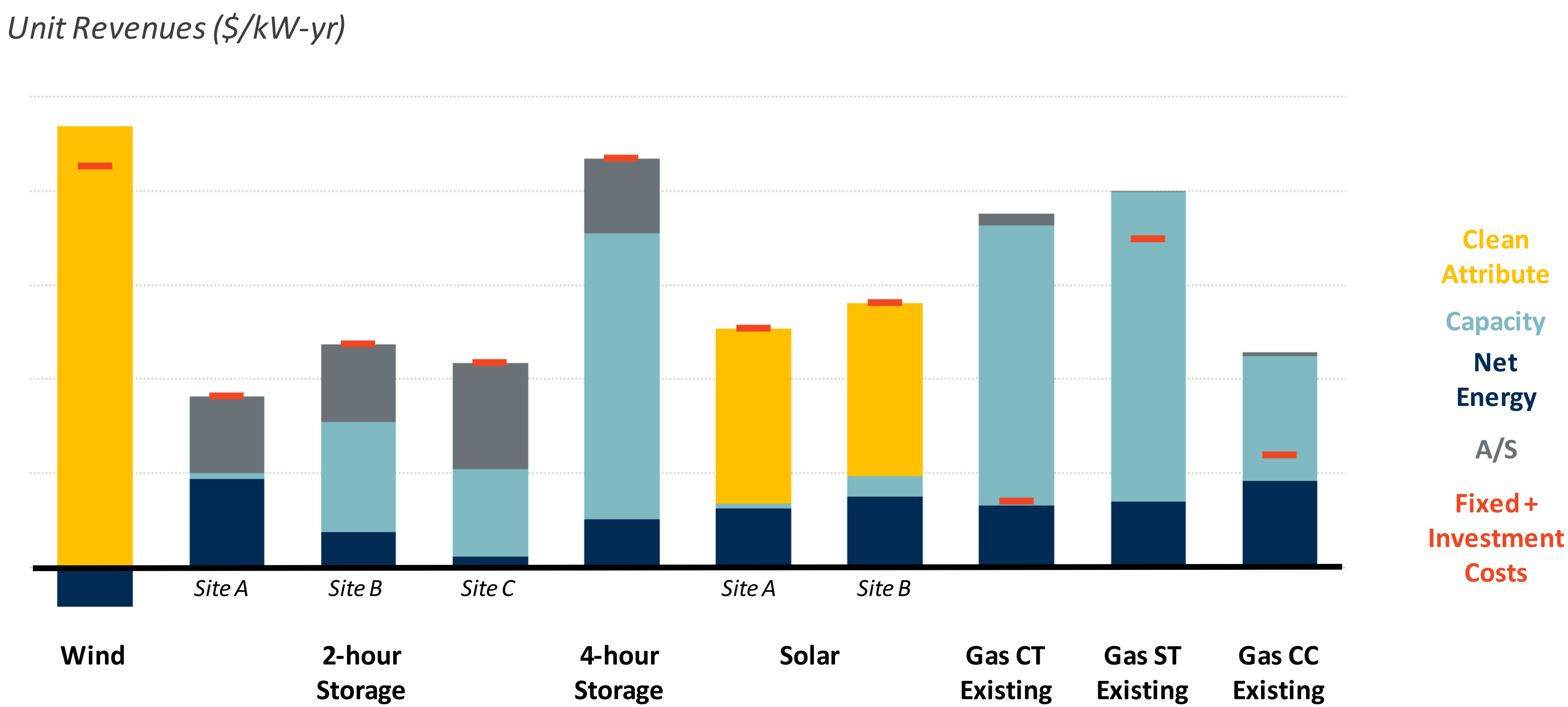
2030 Hourly Generation (MW)



Illustrative Analysis

Illustrative Analysis

Sources of supplier revenues



Illustrative Analysis

Overview of Modeling Assumptions

Key assumptions

		Key Input Assumption
1	System Model	• Internal and external transmission constraints (pipe/bubble model)
2	Supply Resources	• All existing supply resources and planned builds/retirements • New supply resource costs and technical constraints • Available supply from neighbors (can be modeled in several ways)
3	Demand	• Hourly load shapes • Future load forecast, including electrification and climate impacts • Flexibility of demand side
4	Temporal Representation	• 10 representative days modeled at hourly granularity, selected and weighted to reflect average annual system conditions • 2020 – 2040 time horizon
5	Market Design	• NYISO ICAP market design • Ancillary service requirements & shortage pricing
6	Financial Assumptions	• Cost of capital

Modeled clean energy policies

Description of Key Policies

CLCPA	• **Renewable generation:** 70% of NY annual electricity supplied from renewables (solar, wind, hydro) by 2030 • **100% carbon-free electricity** by 2040 • **Solar:** 6,000 MW distributed solar by 2025 • **Offshore wind:** 9,000 MW by 2035 • **Storage:** 3,000 MW by 2030 • **Economy-wide emissions:** 85% reduction by 2050 and 40% reduction by 2030 from 1990 levels
RGGI	• Northeast regional cap-and-trade program • Avg. 2019 price: $5.4/ton; expected to reach $12.6 by 2030
ZEC Program	• Zero emission credit payments to New York nuclear plants • Program expires March 2029
DEC NO_X rule	• DEC rule to reduce NO_X emissions from peakers • Peakers built pre-1986 may retire instead of retrofitting to meet emissions requirements

Policy Timeline

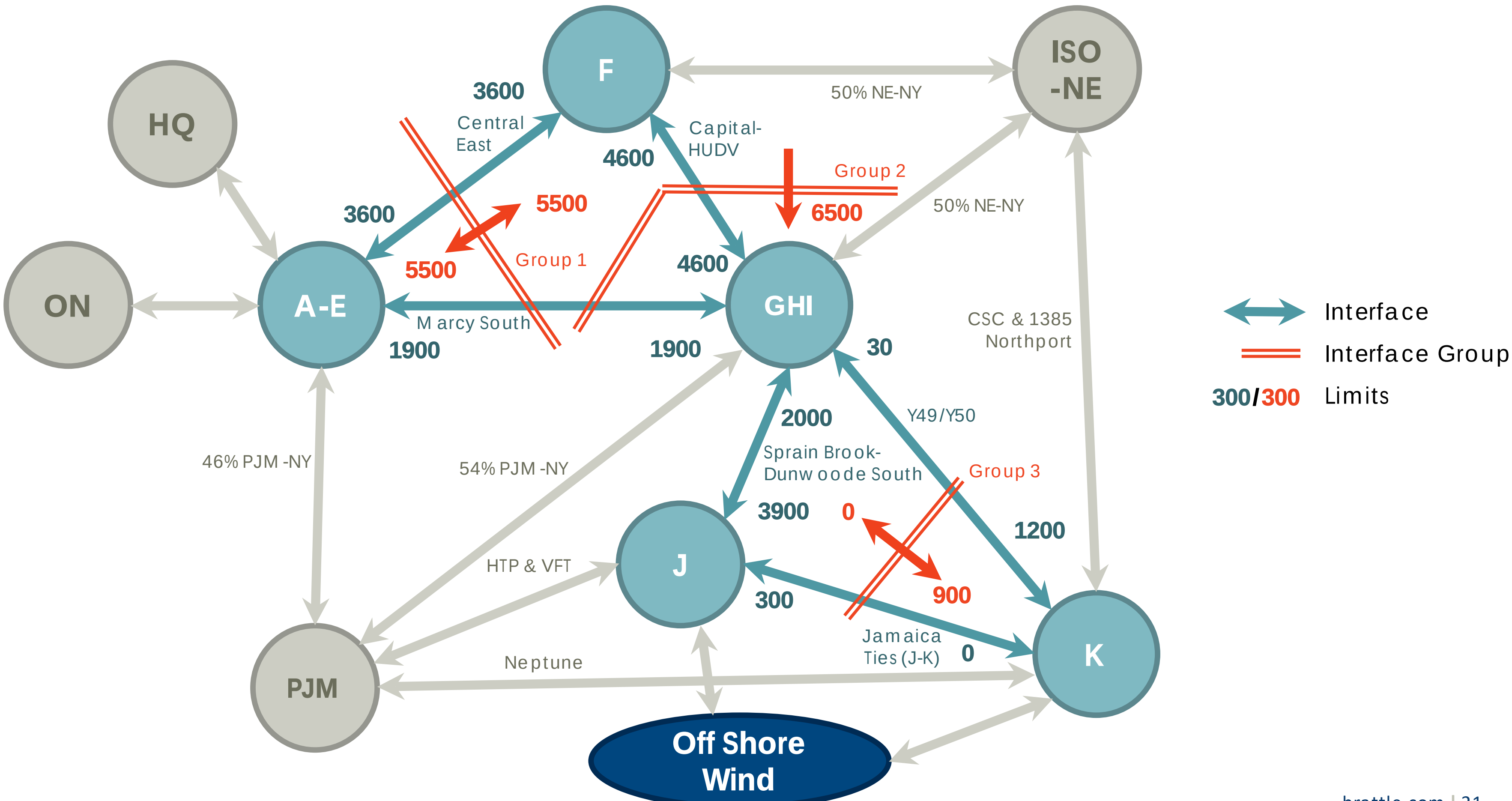
- **2009** — **RGGI:** First control period
- **2016** — **ZEC:** Program in effect
- **2025** — **Solar:** 6,000 MW mandate; **NO_X Rule:** In full effect
- **2029** — **ZEC:** Program expires
- **2030** — **CLCPA:** 70% renewable electricity; **Storage:** 3,000 MW mandate
- **2035** — **OSW:** 9,000 MW mandate
- **2040** — **CLCPA:** 100% carbon-free electricity
- **2050** — **CLCPA:** 85% NY economy-wide decarbonization

Sources and Notes:

RGGI Auction Allowance Price and Volumes Results
New York Public Service Commission Order Adopting a Clean Energy Standard. August 1, 2016
New York DEC Adopted Subpart 227-3
New York Senate Bill S6599

Representation of New York grid

In conjunction with NYISO, **Brattle developed a 5-zone "pipe-and-bubble" representation of the New York grid**.



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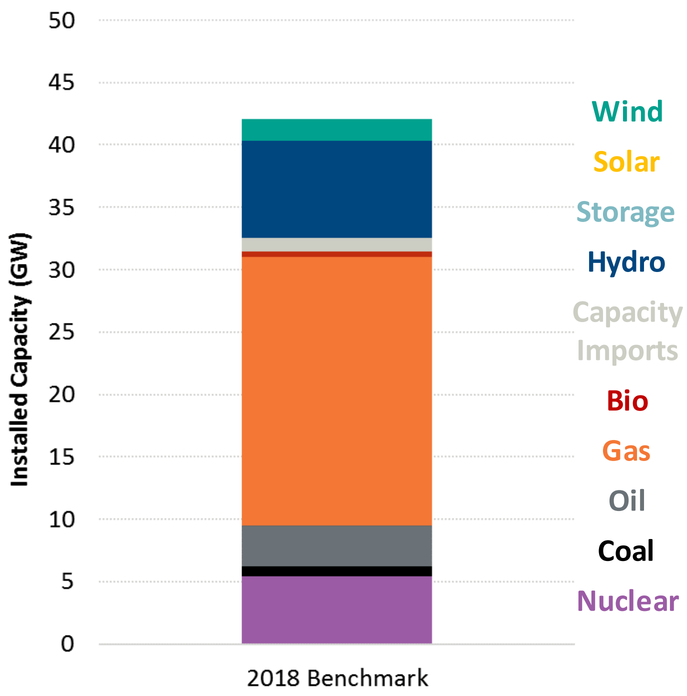
Existing supply resources

We model all existing generators in New York, consistent with the 2018 Gold Book and other sources of data.

- 2018 Gold Book primary source of generator data
- Most generators aggregated by zone and type (e.g., gas CC & CT, nuclear, OSW)
- Subset of generators modeled independently due to unique characteristics
- Generator characteristics (e.g., heat rate, VOM) developed w/ NYISO input
- UCAP value of renewables modeled dynamically

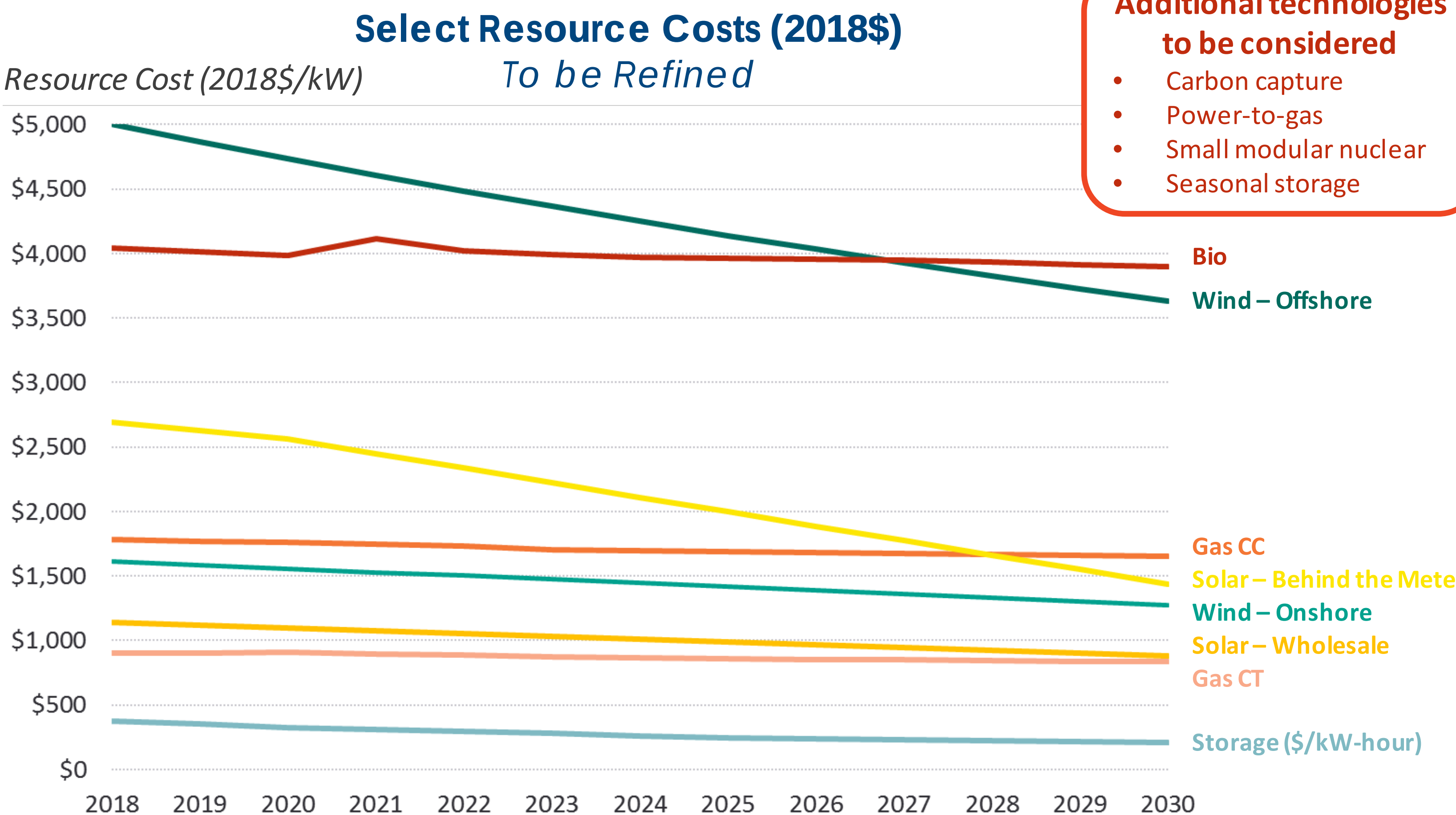
2018 Installed Capacity



New supply resources

Future generator investment costs based on review of multiple sources, including NREL, EIA, and NYISO DCR study.

Additional technologies to be considered
- Carbon capture
- Power-to-gas
- Small modular nuclear
- Seasonal storage



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Load Shapes

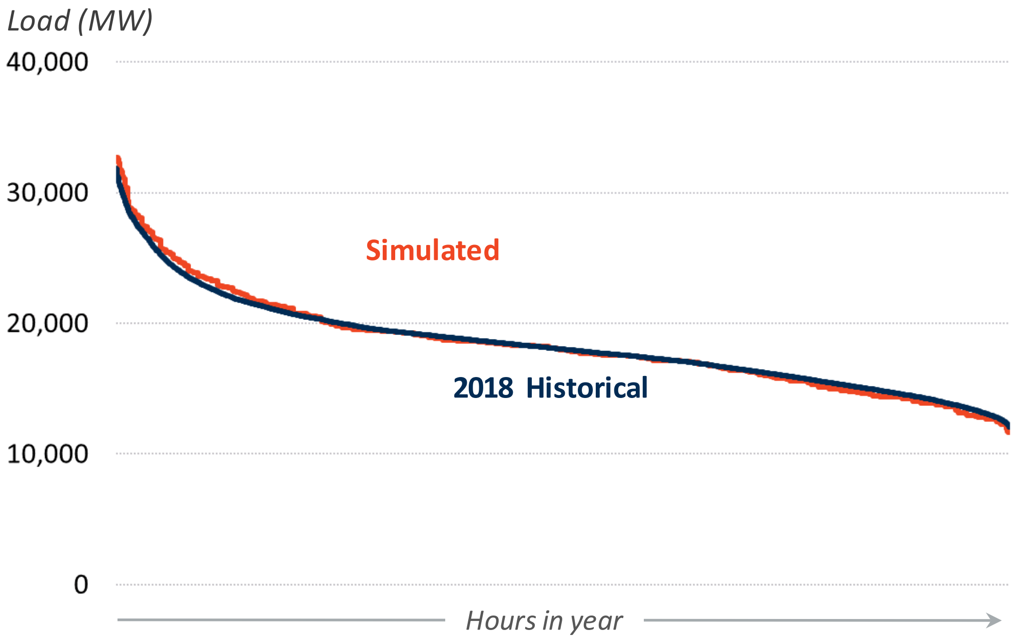
We select and weight representative days to reflect NYISO's 2018 hourly load duration curves.

- Day selection and weighting considers seasonality, gas price, and renewable generation
- Will evaluate how representative load shapes may evolve with electrification

Representative Days

Day	Weight	
1/3/2018	14	Winter Peak
2/15/2018	76	
4/14/2018	28	
5/30/2018	39	
8/1/2018	27	
8/22/2018	23	
9/5/2018	12	Summer Peak
10/14/2018	6	Low Load Day
10/23/2018	76	
11/28/2018	64	

2018 NYISO Load Historical vs. Simulated

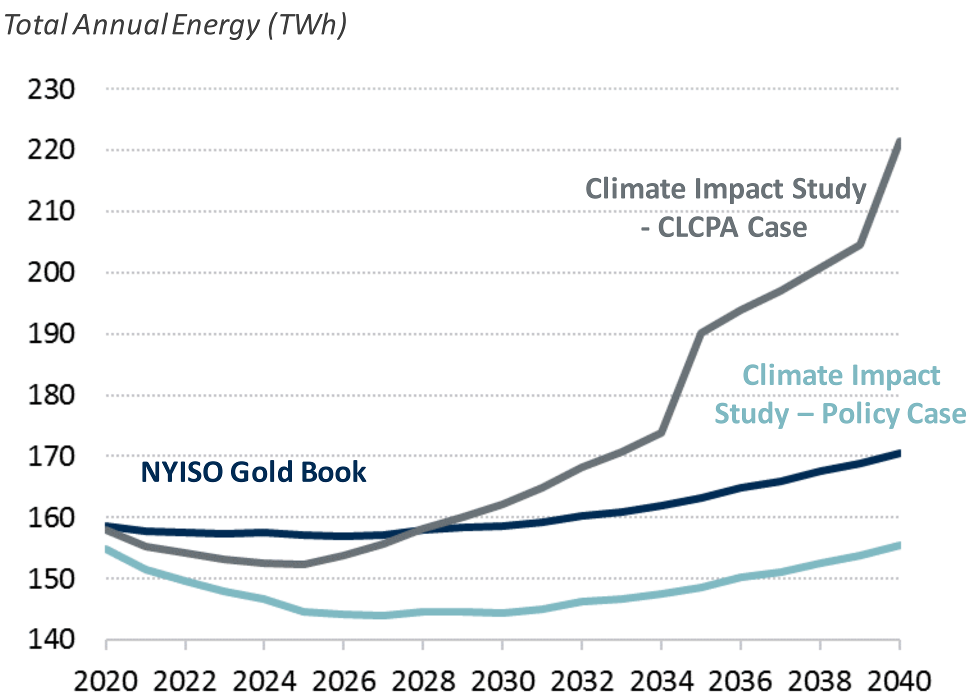


Modeling Assumptions
Load Forecasts

We will utilize load forecasts consistent with current NYISO outlooks.

- Initial modeling utilized load forecasts from 2018 Gold Book
- Will update forecasts to be consistent with most recent NYISO outlook and leverage Climate Change Phase 1 forecast
- Will consider impacts of electrification and climate change

NYISO Forecasted Load

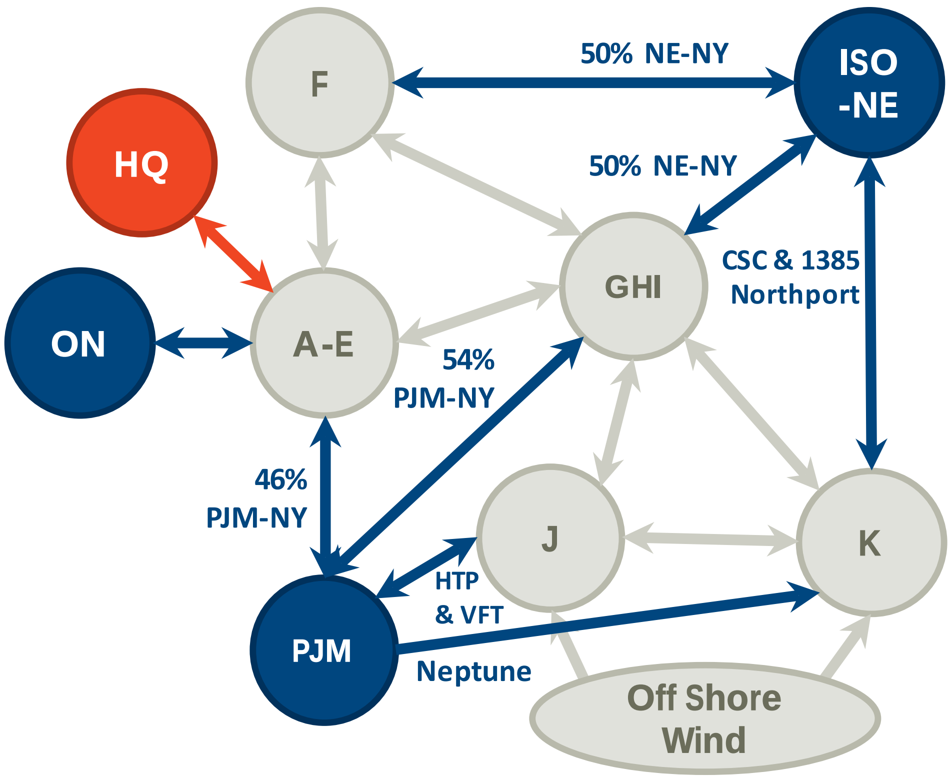


Imports and exports

We model New York interties consistent with historical flows, but reflect some ability of neighboring systems to help balance NY renewable generation.

- **Hydro Quebec** modeled as fully flexible
  - Reflects HQ's hydro storage potential
  - In all hours, allow flows up to line limit (1500 MW import, 1000 MW export)
- **All other interties** modeled as less flexible
  - Reflects similar balancing challenges in neighboring systems
  - Lock **hourly exports** at 2018 levels
  - **Hourly imports** allowed to flex between zero and 2018 levels (e.g. model can reduce imports if uneconomic)

Treatment of New York Interties



Feedback and Next Steps

Feedback & Next Steps

Study timeline and workplan

March 6 (today)	**MIWG:** Introduction to GridSIM, stakeholder feedback
	Brattle & NYISO: Develop initial assumptions
March 30	**MIWG:** Discuss modeling & assumptions, stakeholder feedback
	Brattle & NYISO: Finalize assumptions, develop base case
Mid-May	**MIWG:** Initial results, finalize alternative cases
	Brattle & NYISO: Develop alternative cases
Early June	**MIWG:** Alternative case results

Alternative cases

Brattle and NYISO will develop two alternative cases that vary key assumptions.

Potential cases:

- **High load growth** due to electrification
- Increased **demand-side flexibility** and market participation
- **Rapid technology improvement** for wind, solar, other clean resources
- **Increased transmission** capacity
- Continued **nuclear support** after expiration of ZEC program in 2029

What alternative cases would stakeholders find most valuable?

Request for stakeholder input

What questions would be most helpful for this study to answer?

What feedback do you have on inputs and assumptions?

Detailed inputs and assumptions to be presented March 30.

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