Role of OSW in ISO-NE and NYISO

Executive Findings

December 4, 2025

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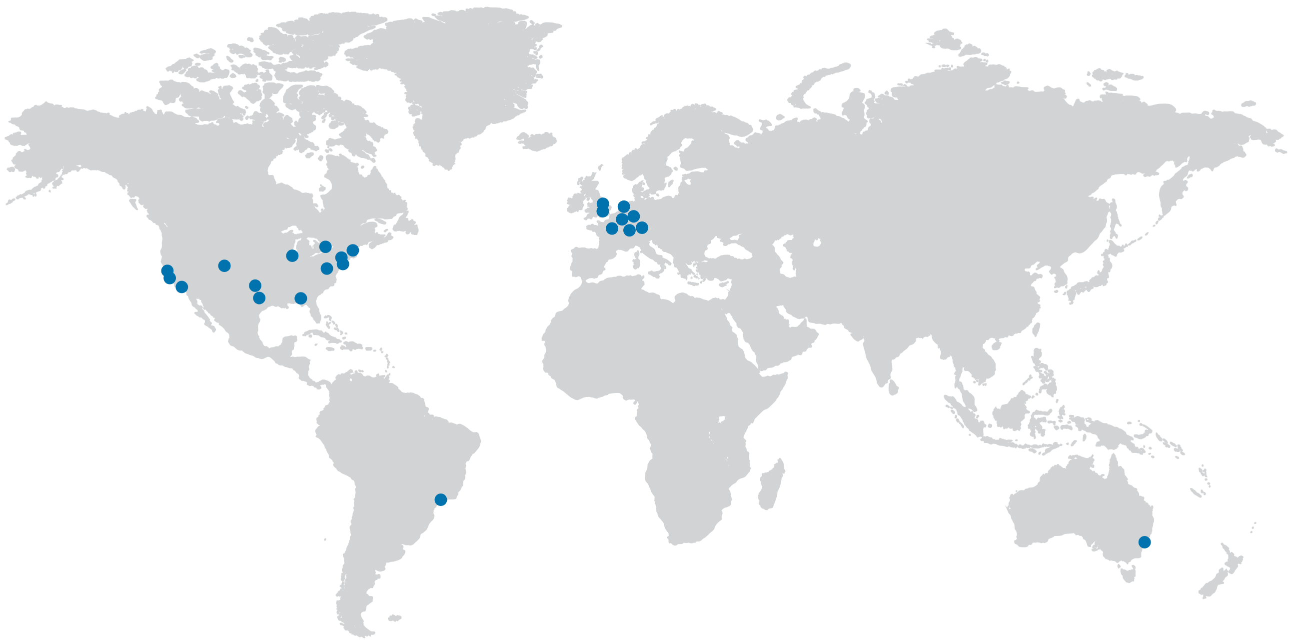

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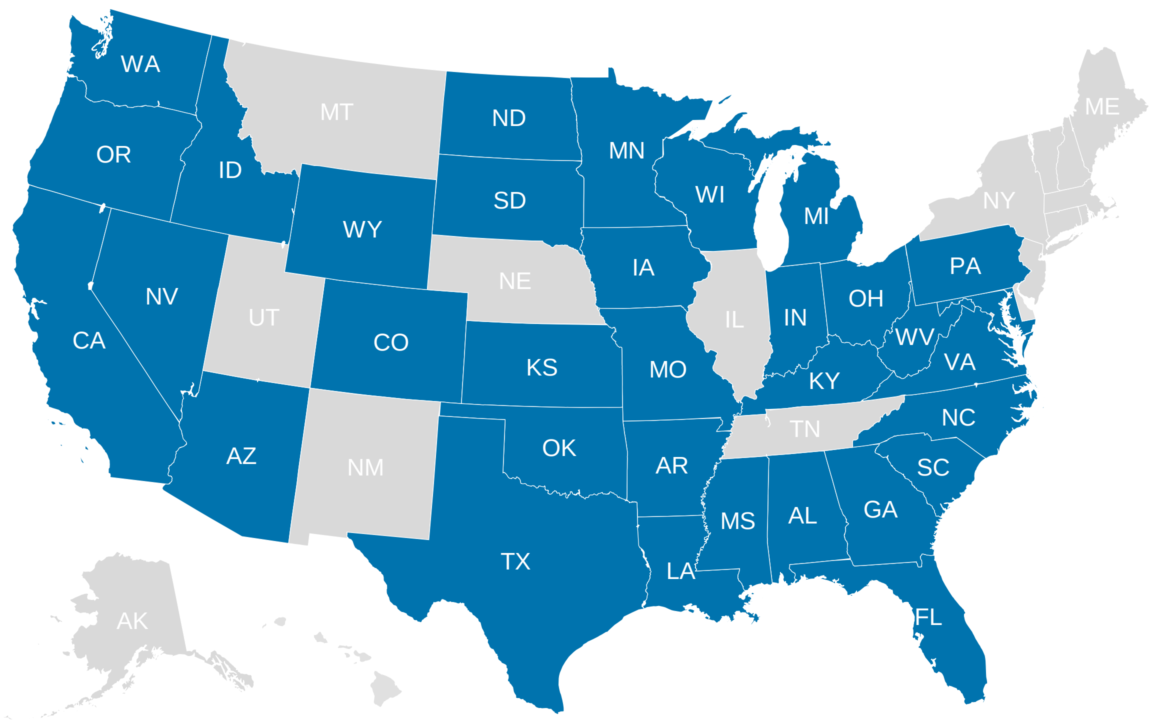
States Where CRA Has Recently Supported Utilities in Strategy, Resource and Investment Planning



Client Examples

NiSource
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Black Hills Energy
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IRP-style analysis finds potential benefits from OSW in the Northeast

However, regulators and resource planners should consider further factors including technology risks, capacity prices, and policy uncertainty when selecting a resource mix

1

Reliability risks are imminent in NYC without urgent action

Our findings align with concerns raised by NYISO

2

Portfolios with OSW have the best balance of performance (depending on capital costs)

Portfolios that include OSW drive down energy prices while maintaining or improving reliability but incurred higher capital costs

3

Exposure to region-wide tightening supply-demand

NYISO faces elevated risks if it cannot import from neighboring domestic and Canadian markets, which are also becoming stressed

4

Dependence on assumptions

Results are highly dependent on underlying assumptions, particularly portfolio build-out and ability to import. More analysis needed to understand regional risk

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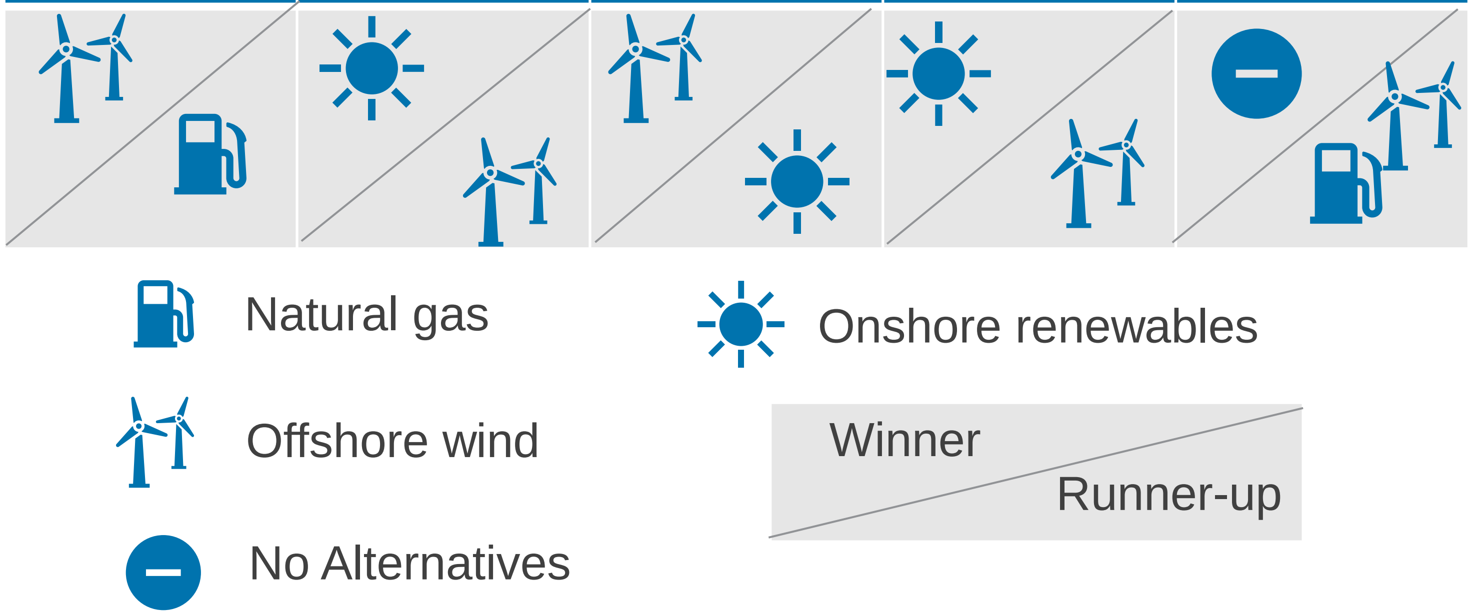
Including OSW resulted in lower energy prices and emissions, while maintaining reliability

Portfolios that include OSW have the most balanced performance and lead on most metrics, except for capital costs which were mixed across markets

Resource Adequacy	Energy price	Natural gas capacity factor	Emissions	Net Capital costs



Greatest output during **winter hours** when fuel systems and wider markets are stressed

Strategic siting near transmission-constrained urban centers, particularly NYC

All MWs are good MWs
Portfolios without new resources have the worst performance

Native investment mitigates but does not eliminate exposure to region-wide tightness

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Resource adequacy ensures there is enough – and the right kind of – generation

Resource adequacy is one element of maintaining grid reliability.

Resource adequacy ensures the generator portfolio mix can maintain reliability across a wide range of conditions.

If there is insufficient generating capacity in a given hour, operators will perform **load shedding**, intentionally disconnecting load, to maintain the stability of the grid.

Historically, load shedding risks were limited to a small number of peak hours, but it is increasingly spread across a range of hours.

Utility planners are incorporating increasingly complex planning methods to evaluate the resource adequacy of potential generation mixes. These models include the factors listed below.

Generator outages

Planned and unplanned

Load Uncertainty

Weather variability

Renewable variability

Weather variability

Extreme weather

Multi-hour and multi-day events

Common cause outages

Disruptions in fuel supplies

Integrated resource planning (IRP) evaluates risks and benefits of pursuing various generator technology paths

Future looking

Predict load (and shapes), energy, capacity needs, prices, and grid mix

Maintain feasibility

Only consider plans that are possible - given supply chain, land, labor, and tech constraints

Consider grid as a whole

Capture interactions between technologies

Hedge against uncertainty

Consider multiple possible future conditions

Perform Quantitative assessment

Use quantitative and robust modelling and metrics

Balance goals

Balance reliability, affordability, sustainability, and policy targets

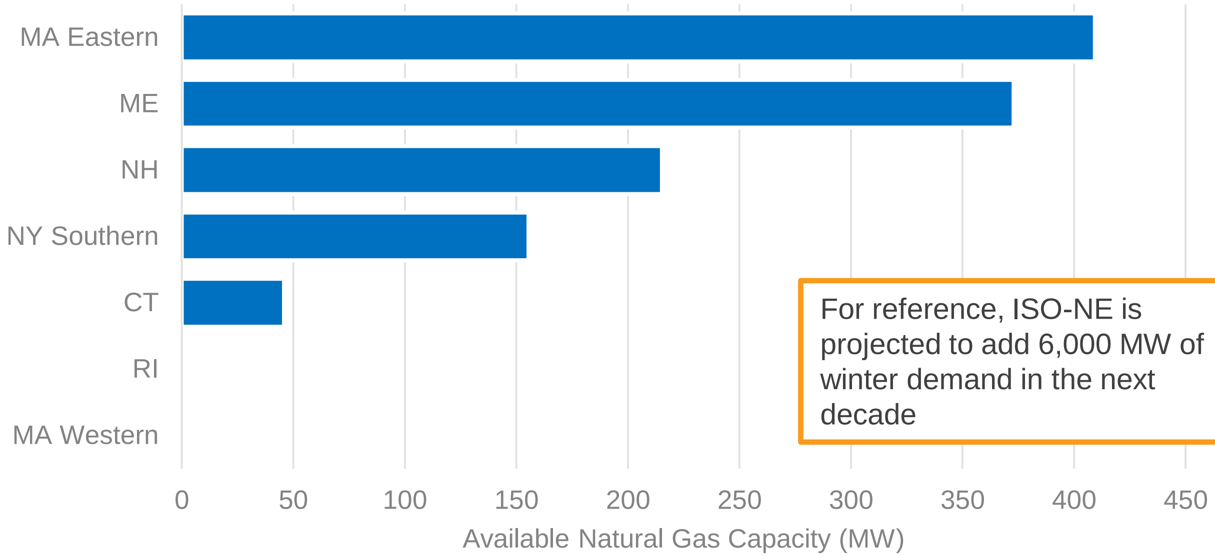
Long-term planning

IRP enables policy makers and decision makers to holistically evaluate generator investment decisions

NG fuels systems in New England and New York are uniquely stressed

Challenges	
Limited ability to add new resources	Complex permitting, limited land, and limited fuel make adding new NG generation challenging
Aging fleet	The existing NG and oil fleet is aging. Further stress on these resources could accelerate their retirement.
Competing for fuel	NG generators compete with building heating for fuel. While heating electrification will free up fuel, it also drives up winter electricity demand
Back-up fuel usage	Many NG generators are dual fuel. While using back-up fuel oil maintains resource adequacy, it increases wear, emissions, and costs
Timing mismatch	While investments are on their way to expand fuel systems, may not be soon enough to support imminent RA challenges

There is limited headroom on existing gas infrastructure to add new gas generators with firm contracts in the Northeast



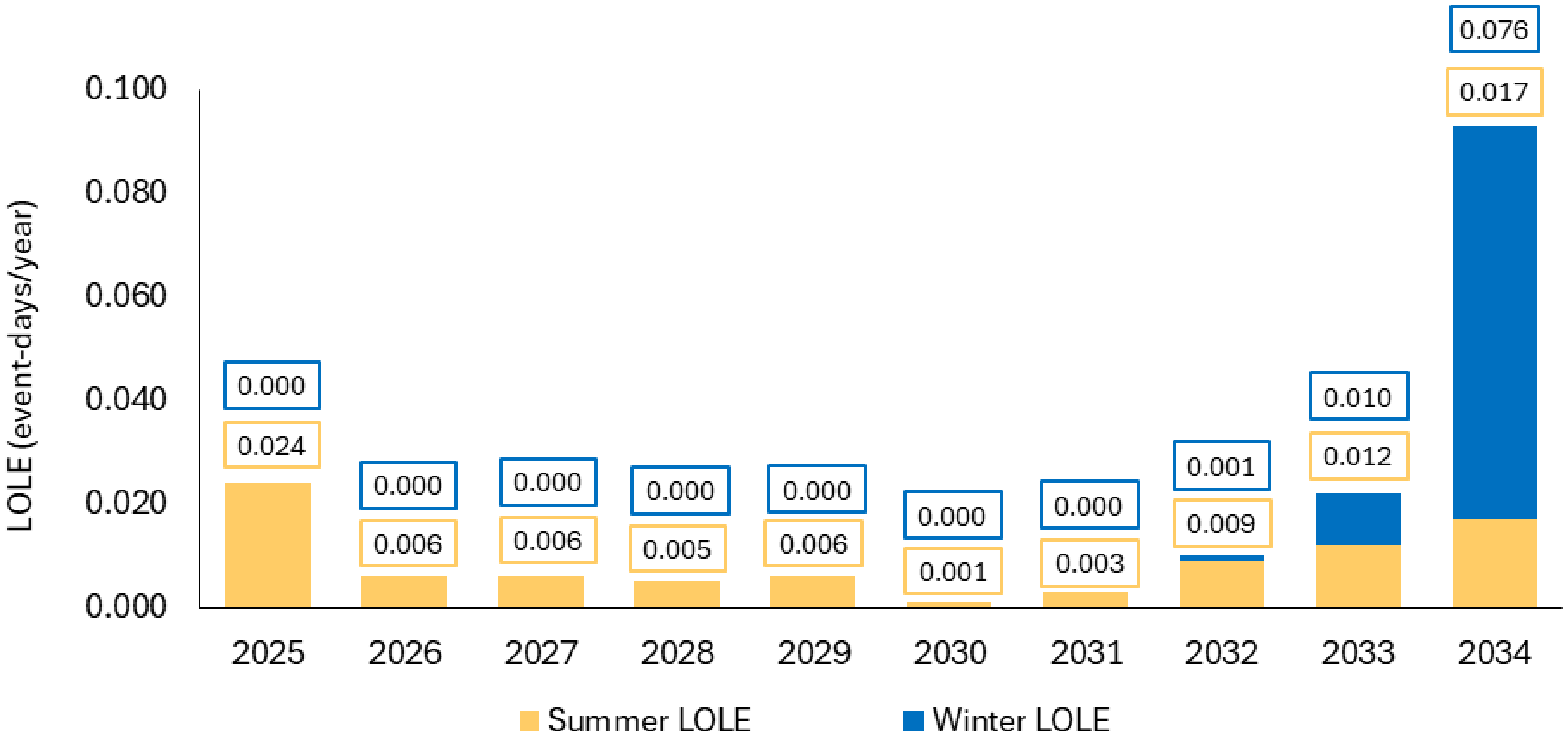
For reference, ISO-NE is projected to add 6,000 MW of winter demand in the next decade

From stakeholder feedback, Gas EPCs state that adding new natural gas resources is more challenging and expensive

Stakeholders pointed at strained supply chains, lengthy permitting process, and limited labor pools as key pain points. Manufacturing capacity is operating close to 90%, and prices have tripled between 2022 and 2025.

Sources:
1. https://gasoutlook.com/analysis/costs-to-build-gas-plants-triple-says-ceo-of-nextera-energy/
.2. CRA Analysis
3. ISO-NE CELT

NYISO projects elevated risk in coming years, with a shift toward winter risk



Of note, NYISO assumed imports from the Ontario Independent System Operator (IESO), PJM, and Hydro-Québec in its modeling. CRA matched this approach.

However, **all these markets are tightening and collectively shifting risk toward the winter months**. To understand this risk, we performed sensitivities with no imports.

Sources:
1. https://www.nyiso.com/documents/20142/2248793/2024-RNA-Report.pdf

We use a suite of modeling techniques to identify and evaluate system reliability and cost outcomes

1 LTCE

Long-term capacity expansion (LTCE) identifies a **Base Case** portfolio that meets policy and reliability needs at least cost. Includes announced builds and retirements and defines the foundation for subsequent analyses.

2 Develop scenarios

Using **market analysis**, we construct **counterfactual scenarios** that represent alternative generator portfolios that could credibly be brought onto the system if the markets choose to – or are forced to - pivot away from OSW development.

3 PCM + Capital

Production cost modeling (PCM) simulates the least-cost unit commitment and dispatch across representative operating conditions. Forecasts **energy prices, capacity factors, fuel usage, and energy flows.**

We also produce a simplified capital cost estimate.

4 Loss of Load

Loss of load analysis stress tests portfolios under a wide range of grid conditions, including **extreme weather** and **elevated outage events**, to assess **resource adequacy** and system reliability

5 Supplemental

Performed for NYISO only, this analysis **quantifies back-up fuel oil used in downstate New York**. It evaluates the impact of OSW on reducing reliance on expensive and emissions-intensive back-up fuels.

Scenarios enable us to evaluate multiple possible generator technology futures

Base Case (Including OSW) – Expected portfolio mix

Use ISO load forecast, CRA generator portfolio forecast including OSW and no retirements

Goal: Evaluate the current trajectory of the systems

Counterfactual Scenarios

No Alternatives – Base Case with OSW removed

Goal: Evaluate the impact of canceling or delaying OSW, without alternatives

Rationale: Many OSW projects are advanced. There may be limited time to pivot to alternative generator resources, given supply chain and permitting challenges

Renewables Only – Replace with onshore renewables (scaled based on equivalent clean energy)

Goal: Evaluate the performance of OSW relative to inland, onshore renewables

Rationale: Replacing OSW with in-load zone resources may result in worse reliability performance, given transmission congestion and worse alignment with key stress periods

Gas Only – Replace with gas peakers in load zone (scaled on capacity contribution)

Goal: Evaluate the performance of OSW relative to in-zone dispatchable resources

Rationale: NYISO has identified a continued need for dispatchable (gas or DEFR) resources, particularly down-state

We employ a suite of quantitative metrics to evaluate the generator scenarios with respect to reliability, affordability, and sustainability

Normalized Expected unserved energy (N-EUE)

EUE measures the expected amount of energy which is not served in a given year. Normalized EUE (N-EUE) divides the raw EUE by the total energy sales. Reported in parts per million. Computed for 2032 and 2036.

N-EUE and RA premium measure reliability

Energy & net capital price

Energy price computes the expected average market price. Also, produce capital cost estimate.

Computed as a net present value over 2026 to 2044.

Energy and capital price measures affordability

Natural Gas (NG) Capacity Factor

Average annual capacity factor for natural gas plants in the system.

Computed as an average value over 2026 to 2044.

NG capacity factor measures sustainability with leading indicators of reliability

Emissions

The total amount of annual CO2 emissions produced.

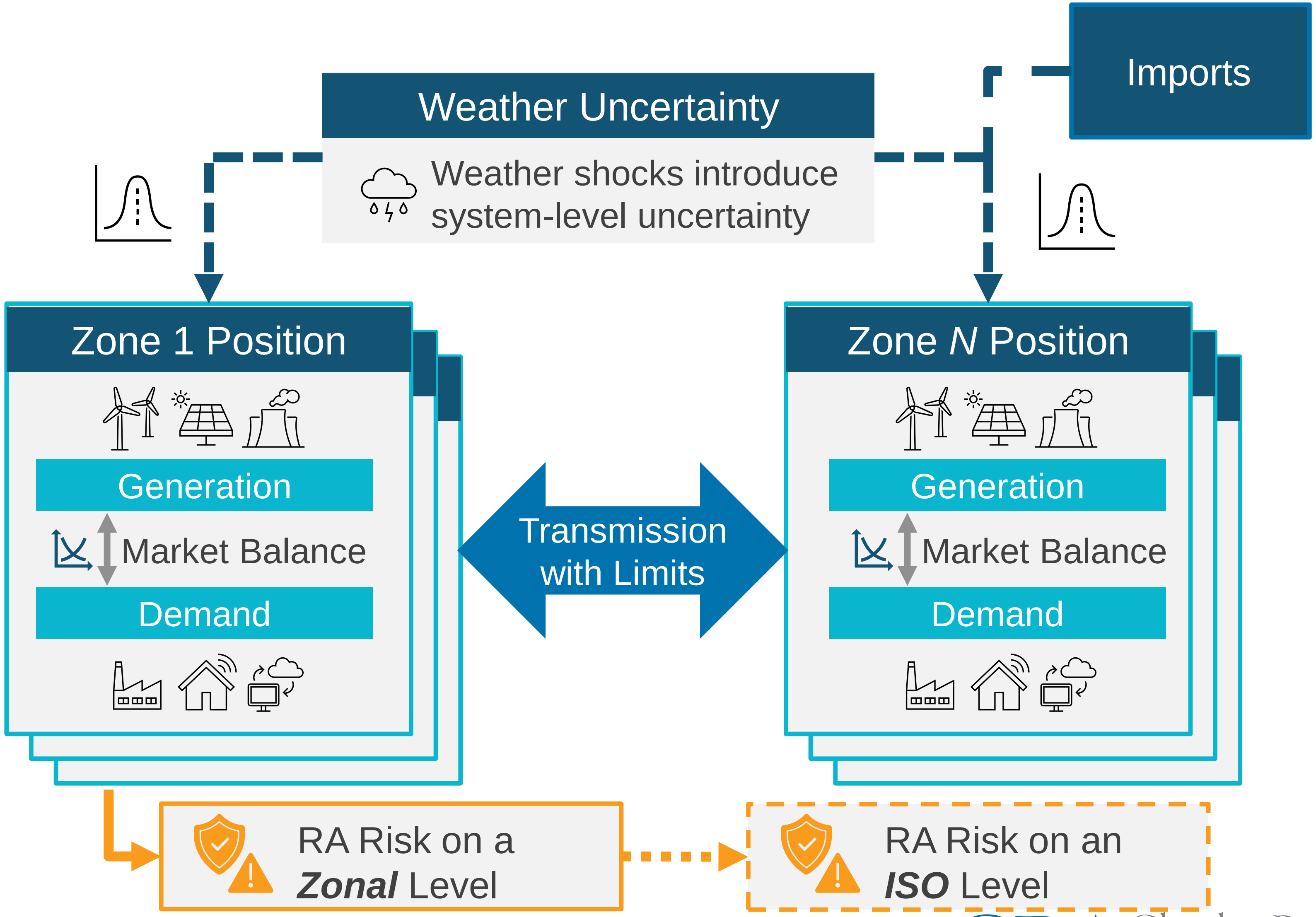
Computed as a total value over 2026 to 2044.

Emissions measures sustainability

Adequacy is used to diagnose the likelihood of load shedding events

Loss of Load Analysis

- ✓ AdequacyX mirrors analytical approaches performed by other ISOs
- ✓ Loss of load modeling is focused on identifying the frequency, magnitude, duration, and seasons of load shedding events
- ✓ We matched NYISO's assumptions for Hydro-Quebec, IESO, and PJM. We performed additional sensitivities with no imports



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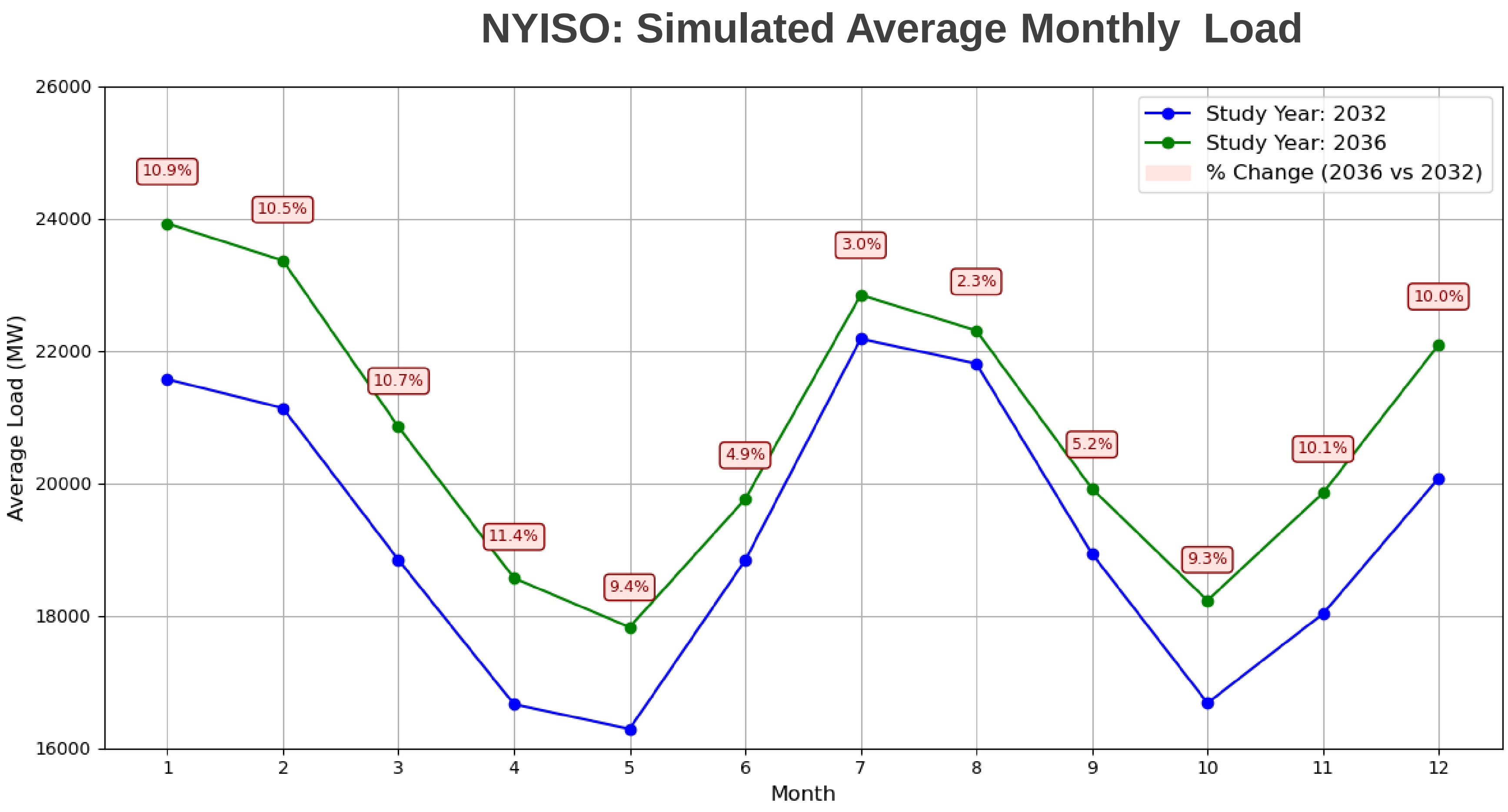
We use synthetic data to simulate the future load conditions that include electrification



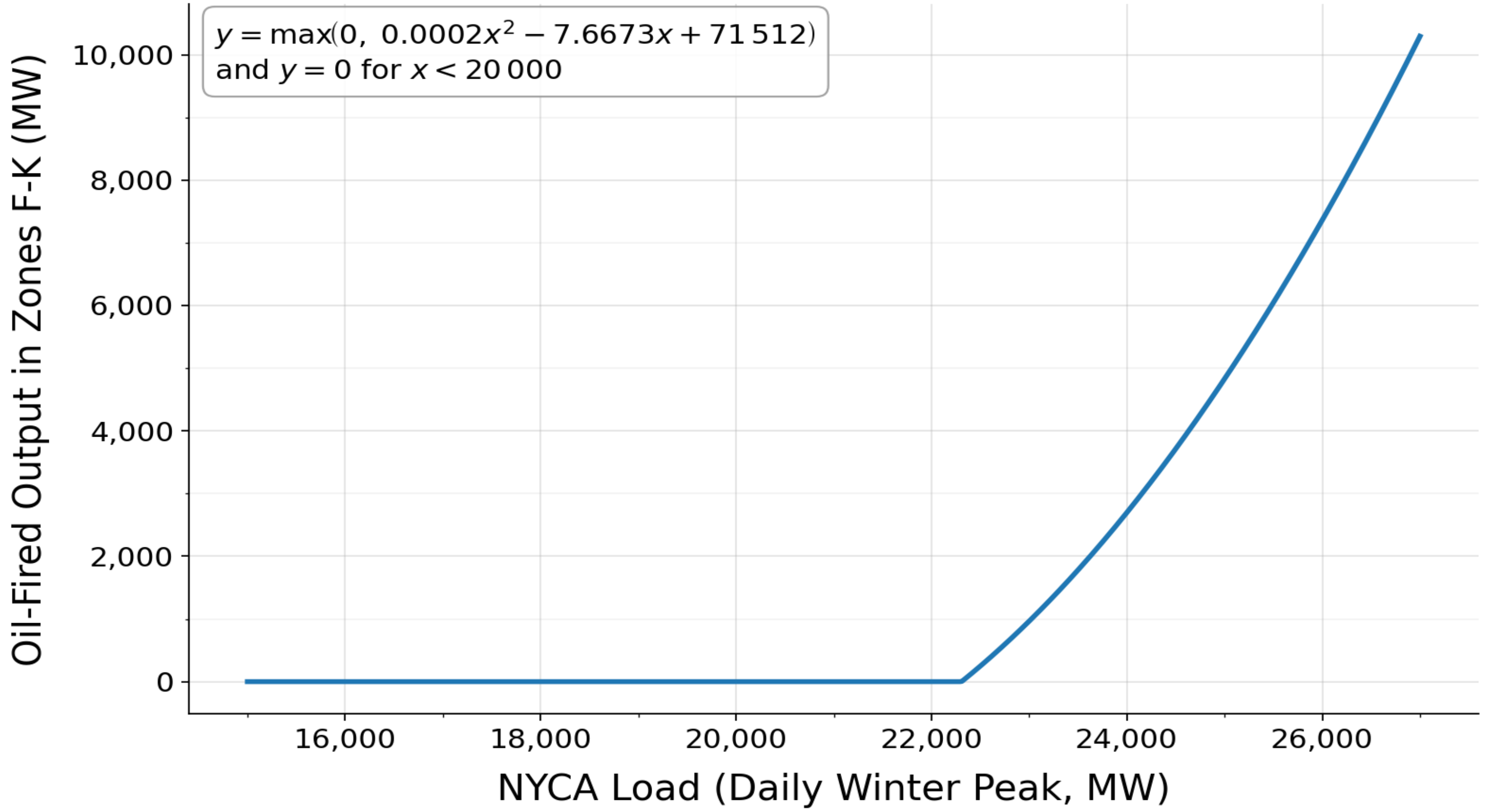
Electrification of heating and transit is driving higher load growth in the winter than summer.

In both NYISO and ISO-NE, winter load growth between 2032 and 2036 is over **3x** that of summer growth

Sources:
1. NYISO, Gold Book
2. CRA Analysis

Using relationships published by NYISO, we also examine the impact of OSW on the use of liquid back-up fuels (fuel oil) in downstate New York

Estimated Oil-Fired Generation in NYISO Zones F–K



Cold snaps divert gas to heating, pushing generators to liquid, back-up fuels. Liquid fuels drive higher emissions, costs, and maintenance burdens.

OSW can help drive down liquid fuels usage by meeting (some) of the growing winter load

Sources:
1. https://www.nysrc.org/wp-content/uploads/2025/03/Fuel-Availability-Constraints.pdf
2. CRA Analysis

Using IRP-style analysis, we use quantitative and holistic modeling to evaluate the risks and benefits of pursing OSW relative to credible alternatives

Using LTCE, we identify a Base Case outlook that includes OSW. We identify credible counterfactual scenarios if the markets pivot away from OSW.

Using PCM, capital costs, loss of load, and supplemental modellng, we forecast the energy cost, capital costs, natural gas usage, sustainability, resource adequacy of the various scenarios.

Using quantitative metrics, we evaluate each portfolio’s reliability, affordability, and sustainability.

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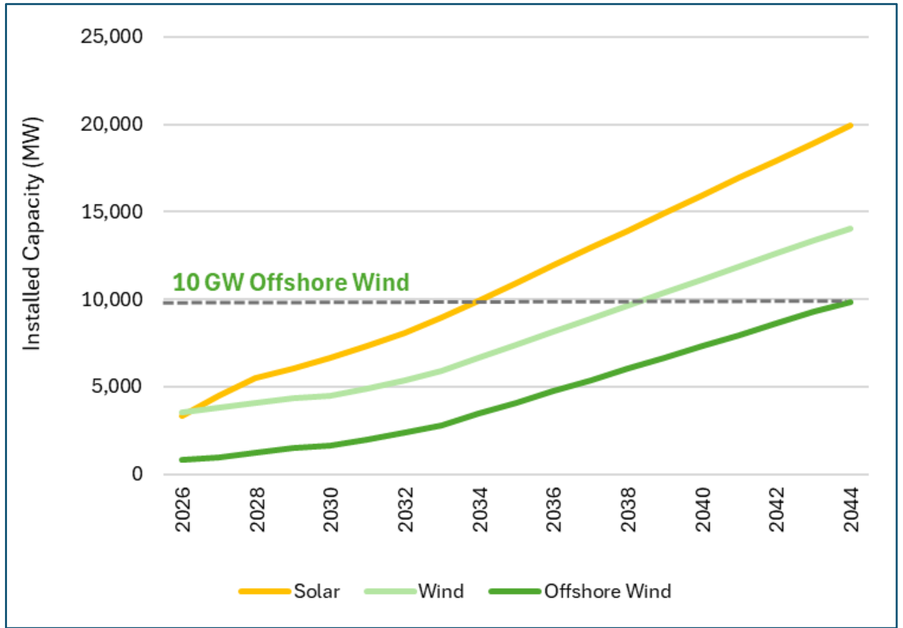
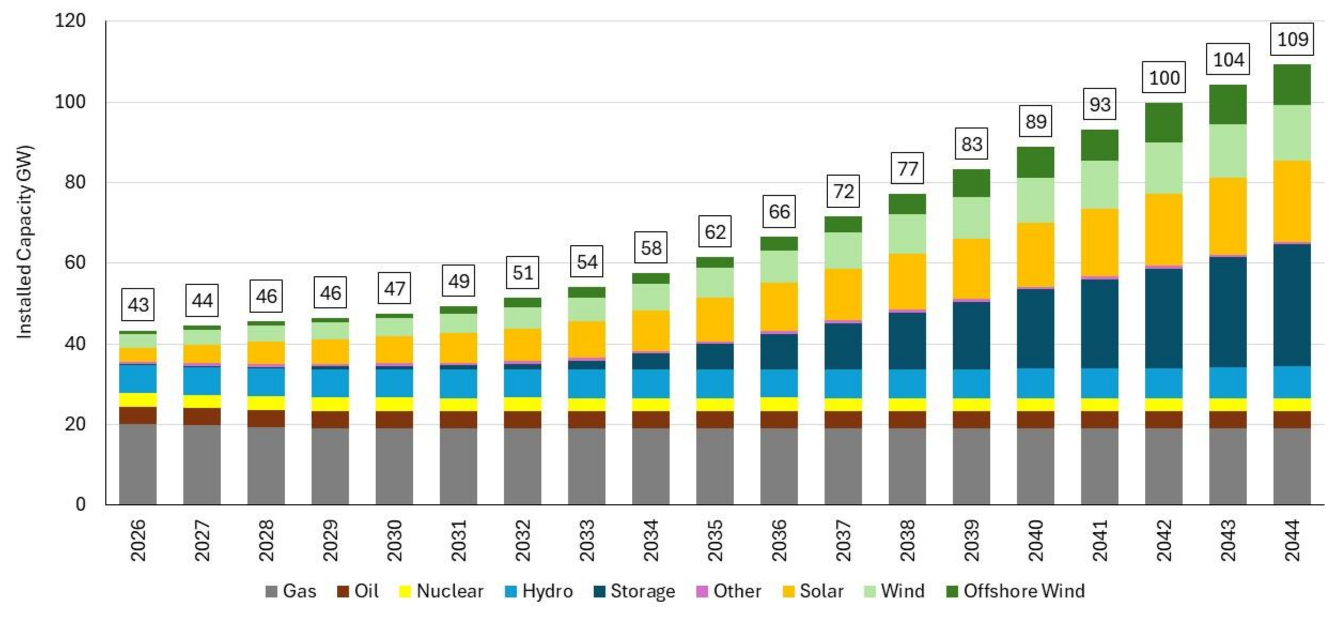
Base case for NYISO adds 66 GW of new generation, including 10 GW of OSW, by 2044

Renewable Build Out



NYISO Base Case Portfolio Outlook



Sources:
1. CRA Analysis

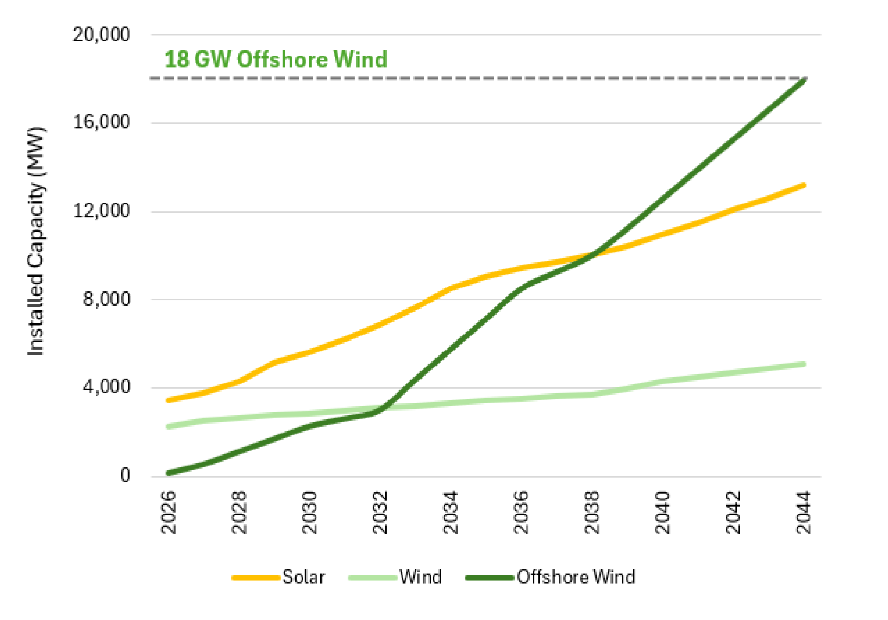
NYISO Scenarios (2032)

Scenario	OSW	Solar	Onshore Wind	Storage	Natural Gas
Base Case	2,234 MW	8,058 MW	5,388 MW	1,442 MW	18,971 MW
No Alternatives	-2,096 MW	+0 MW	+0 MW	+0 MW	+0 MW
Renewables Only	-2,096 MW	+725 MW (Upstate)	+3,075 MW (Upstate)	+920 MW (Downstate)	0
Gas Only	-2,030 MW	+0 MW	+0 MW	+0 MW	+637 MW (Downstate)

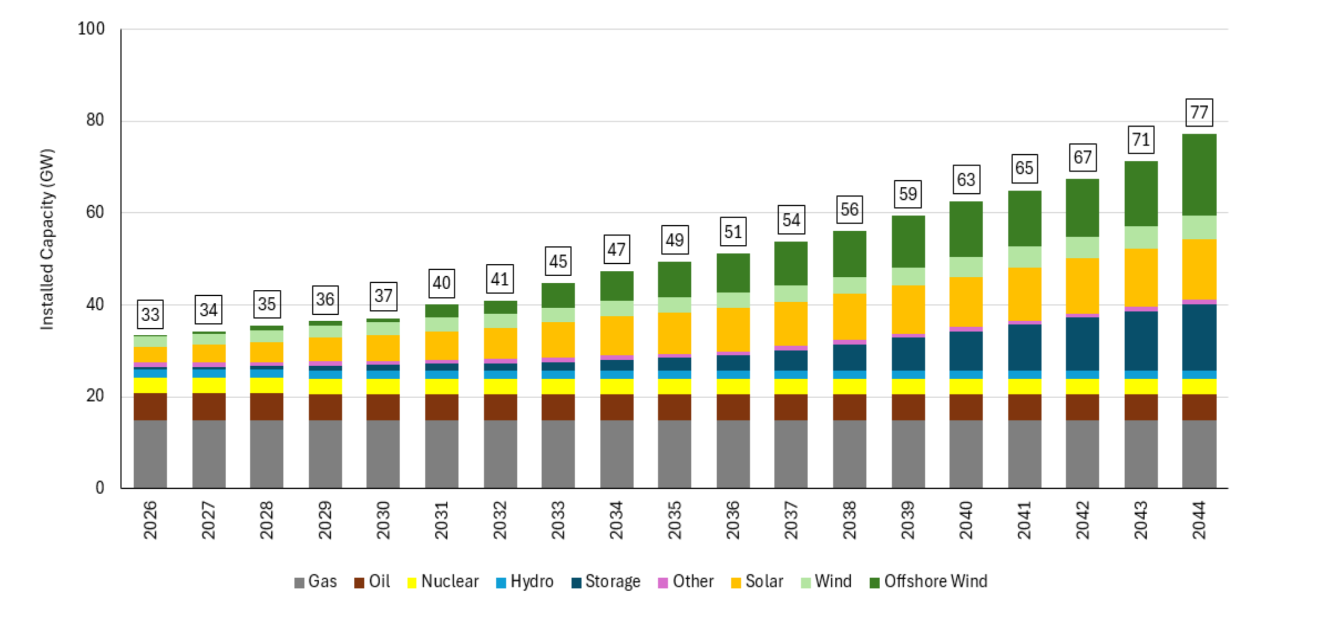
Sources:
1. CRA Analysis

Base case for ISO-NE adds 44 GW of new generation, including 18 GW of OSW, by 2044

Renewable Build Out



ISO-NE Base Case Portfolio Outlook



Sources:
1. CRA Analysis

ISO-NE Scenarios (2032)

Scenario	OSW	Solar	Onshore Wind	Storage	Natural Gas
Base Case	2,830 MW	6,855 MW	3,078 MW	1,498 MW	14,971 MW
No Alternatives	-2,030 MW	+0 MW	+0 MW	+0 MW	+0 MW
Renewables Only	-2,030 MW	+5,300 (ME, MA, RI, VT)	+925 (ME, MA, RI, NH)	+0 MW	+0 MW
Gas Only	-2,030 MW	+0 MW	+0 MW	+0 MW	+1,621 (Boston, SE MA)

Sources:
1. CRA Analysis

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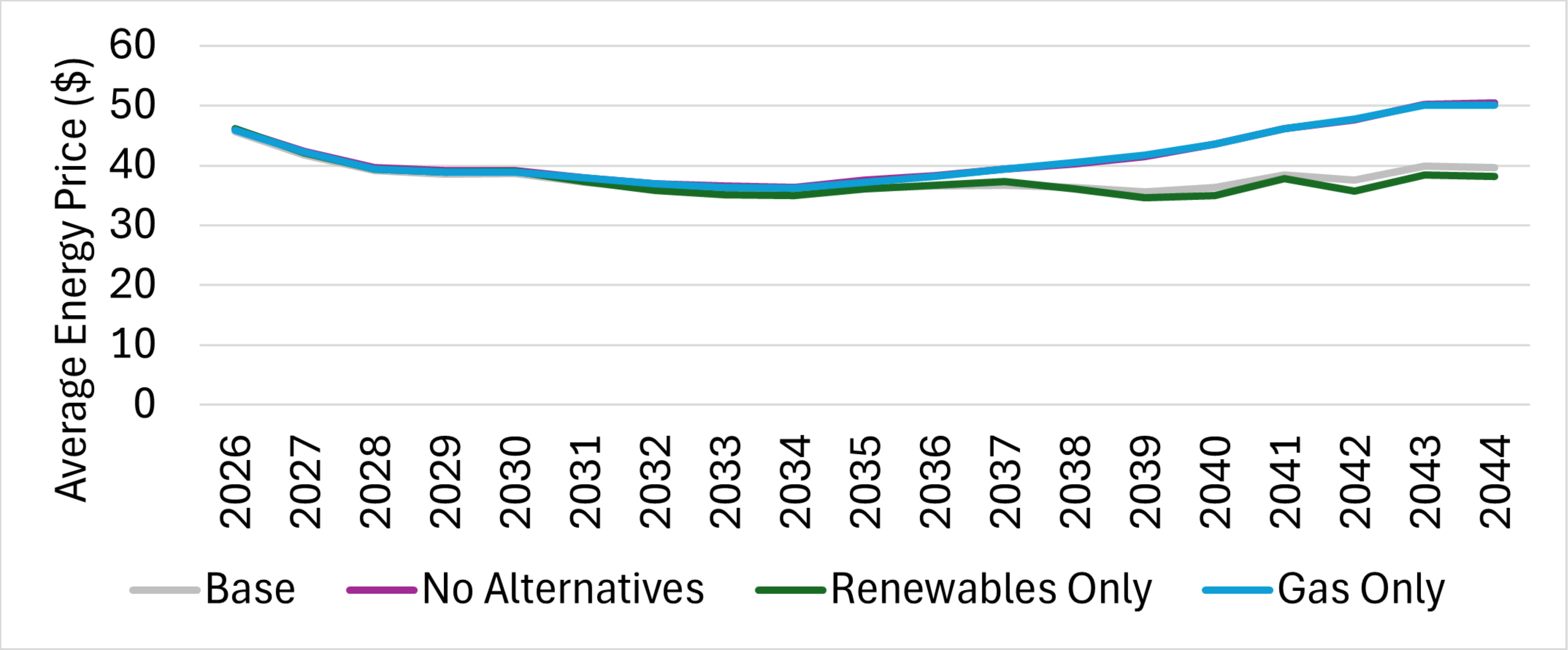
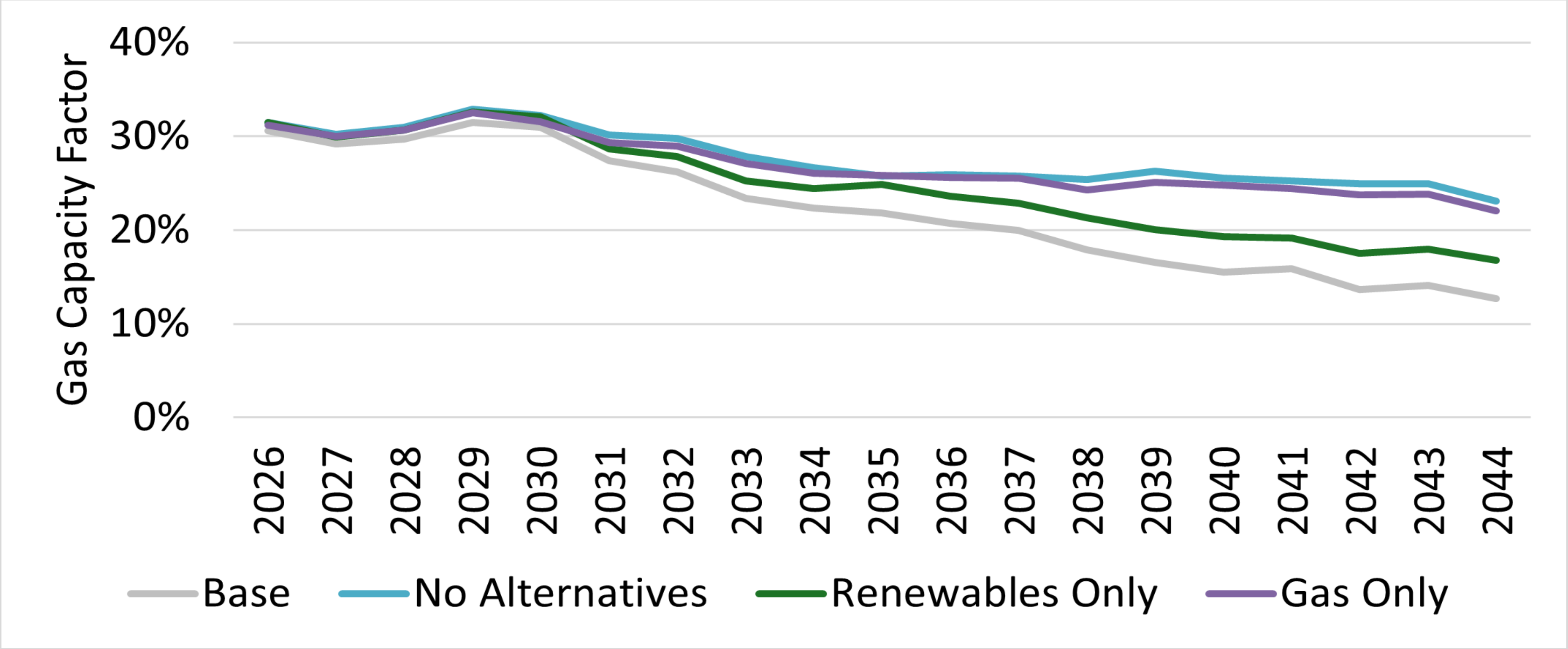
NYISO: Forecast for average annual power price



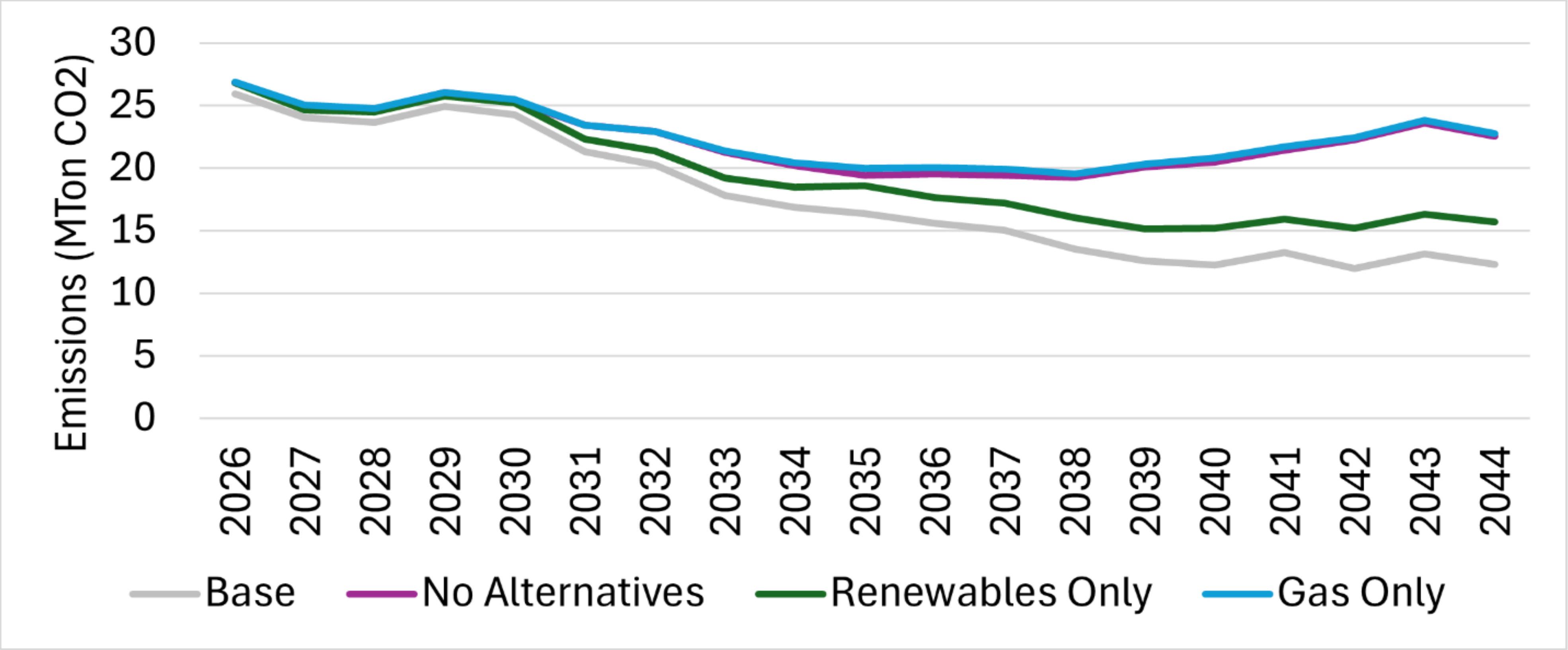
Additions of renewables – either onshore or offshore – drives down price while NG or no additions results in price increases

NYISO: Forecast for average annual natural gas capacity factor



Additions of renewables – either onshore or offshore – drives usage of natural gas plants. OSW has the greatest reduction in NG usage due to alignment strong winter generation and siting in constrained zones

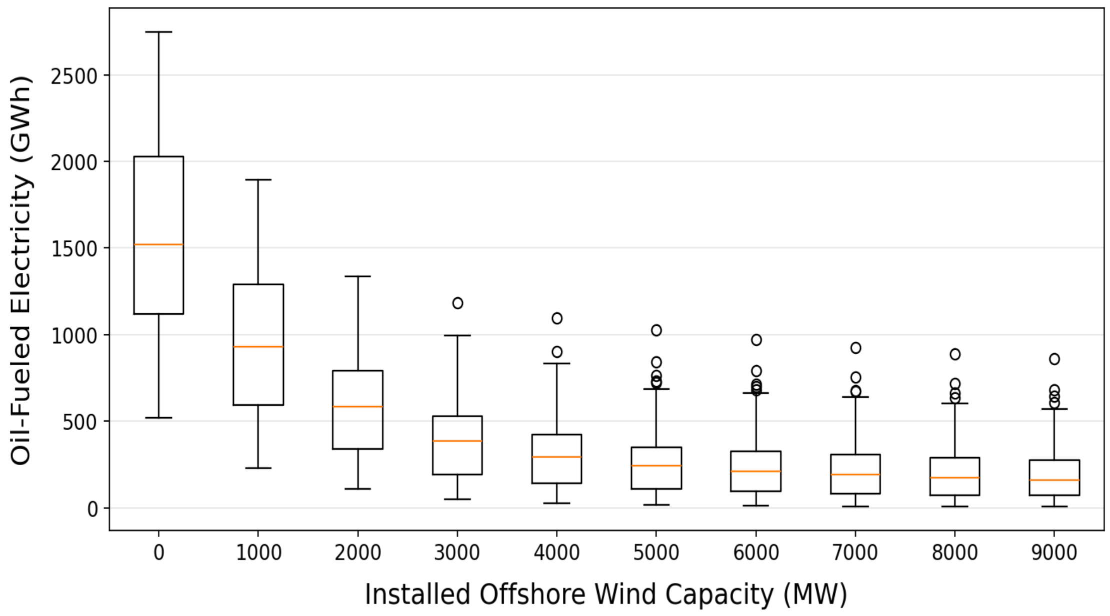
NYISO: Forecast for emissions



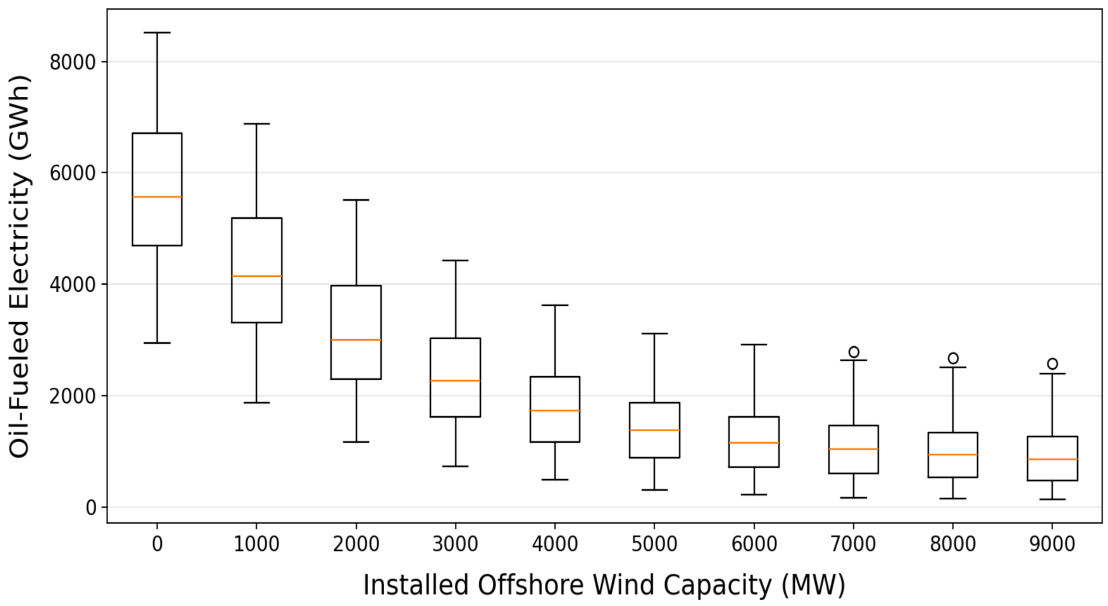
Reduced reliance on natural gas resources reduces emissions

NYISO: Forecast for oil-fired electricity generation

Estimated Oil-Fired Generation (2032)



Estimated Oil-Fired Generation (2036)



OSW drives down usage of oil-fired generation downstate. Its efficacy increases as winter generation grows. OSW's direct impact declines past ~5GW

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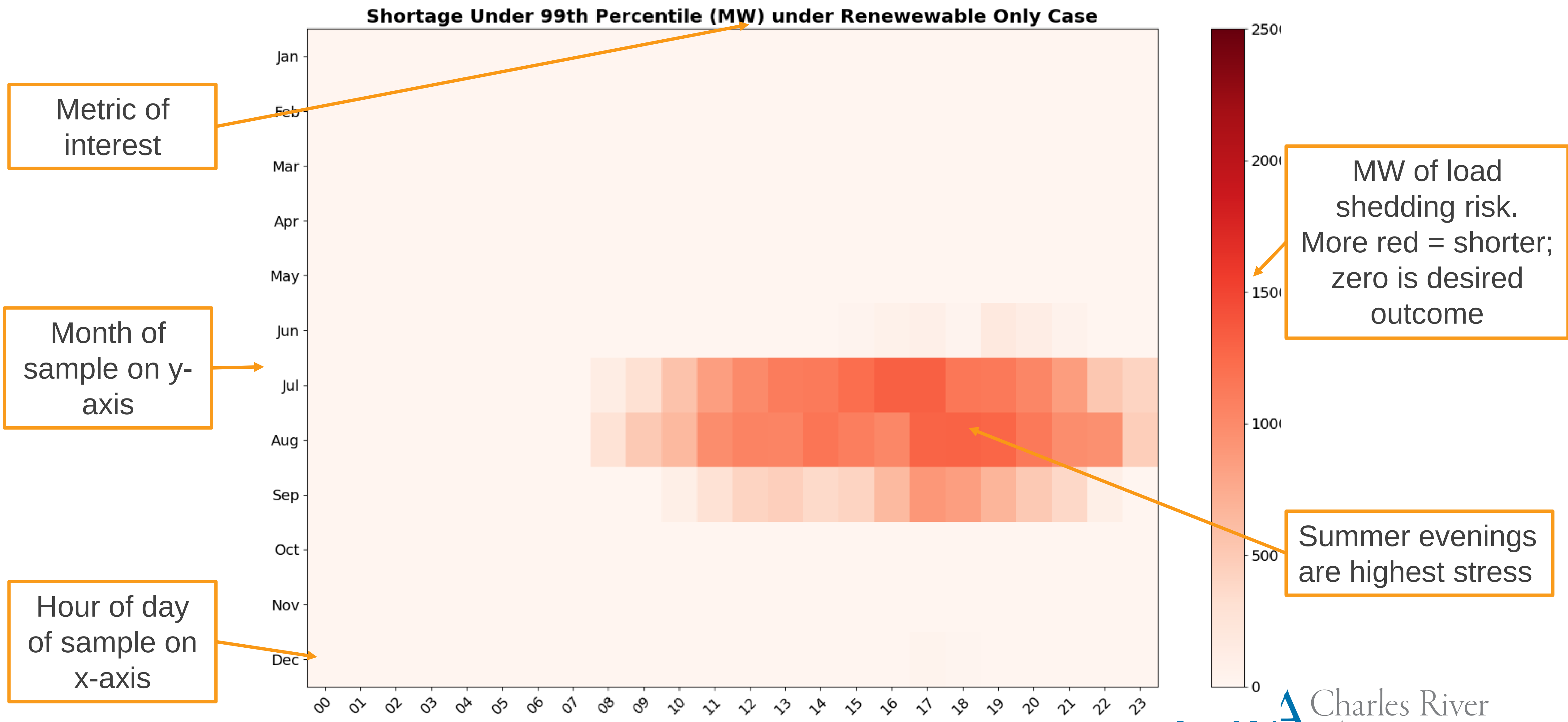
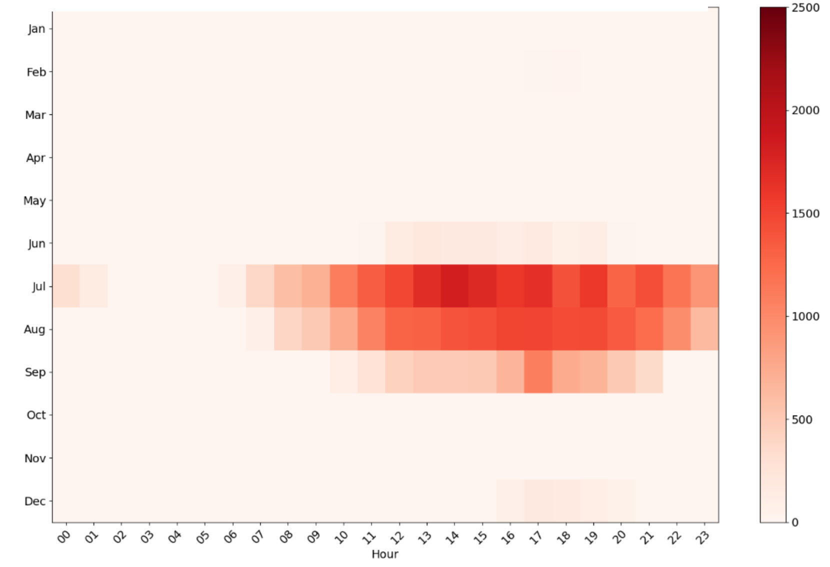
How to read results:

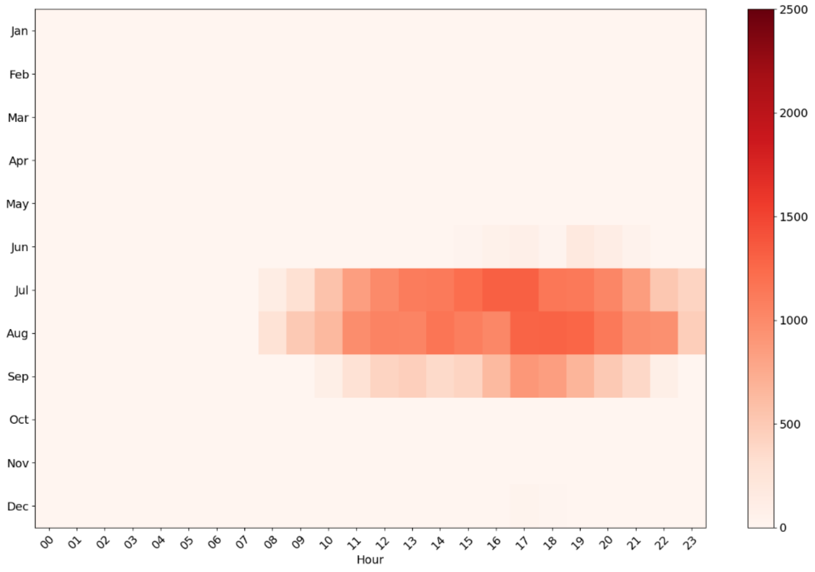


NYISO: Resource adequacy outlook (2032) – 99% Worst Load Shedding Outcome

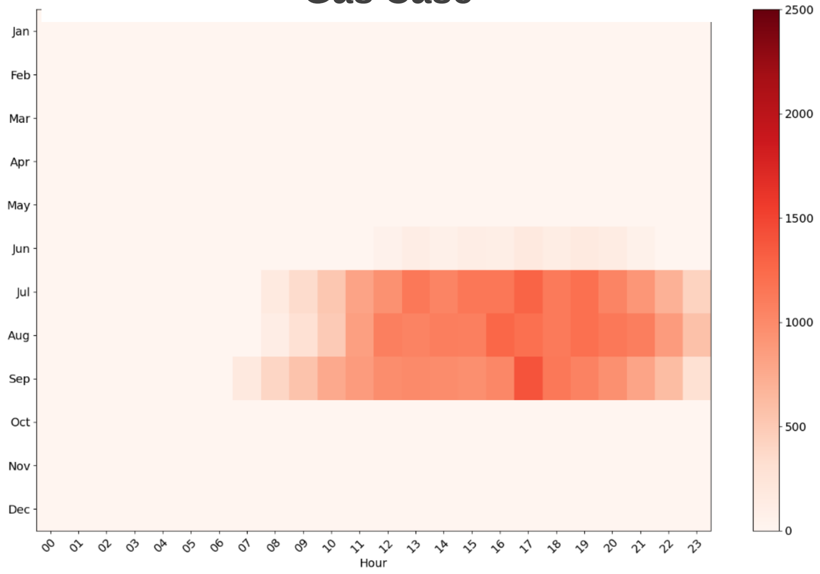
No Alternatives



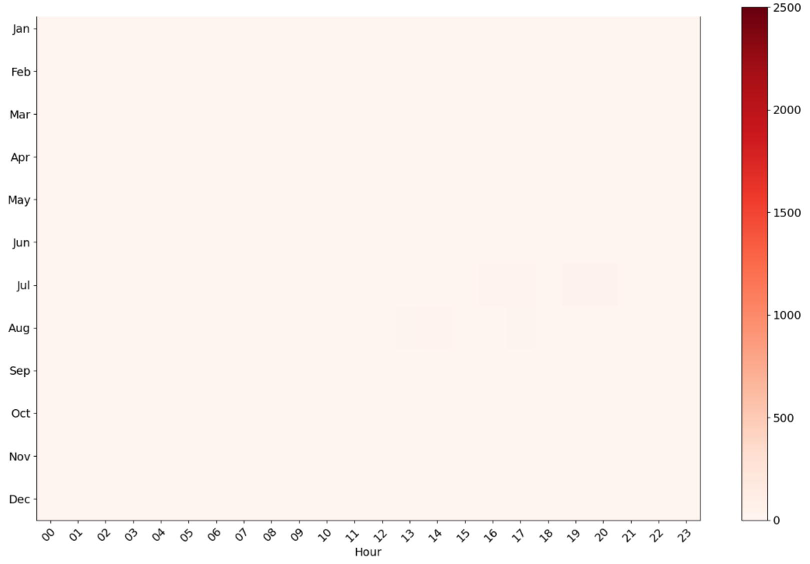
Renewables Only



Gas Case



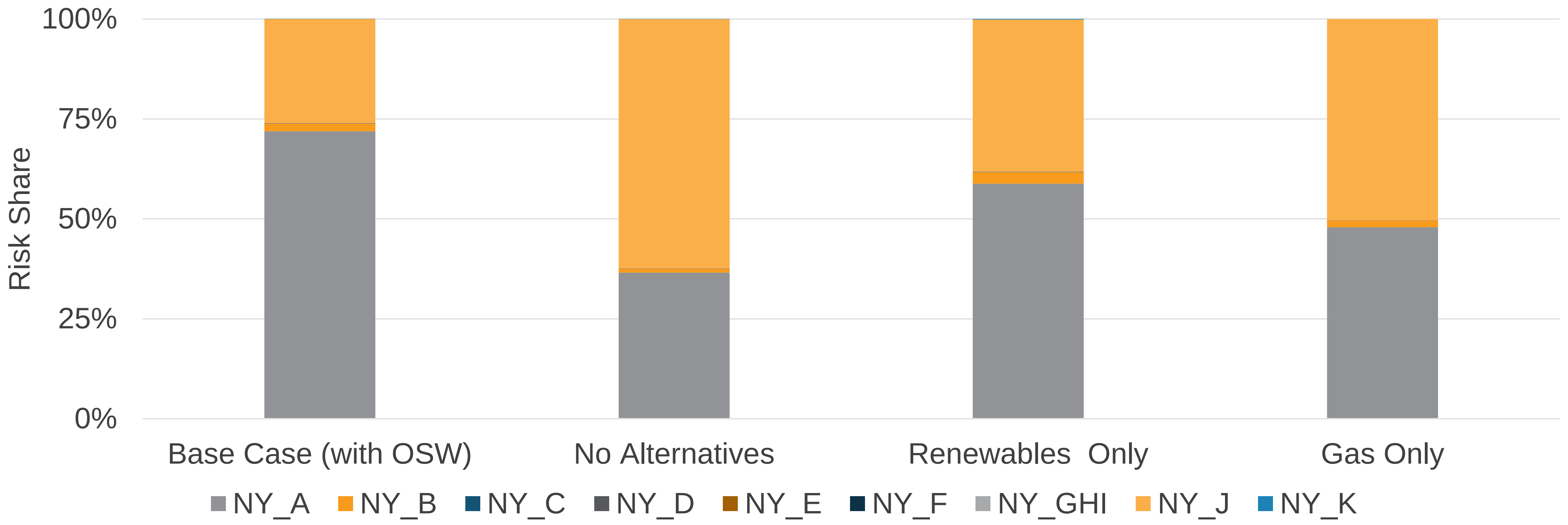
Base Case



Summer risk emerges in NYISO without new local additions.

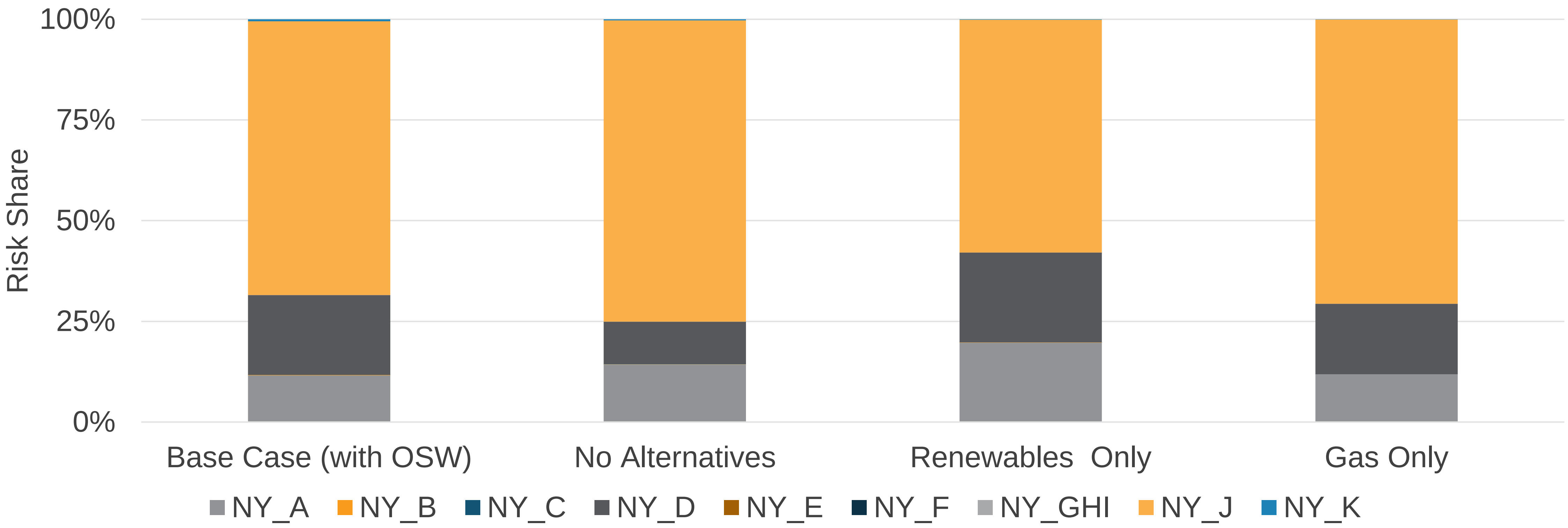
Onshore renewables and gas can help, but OSW provides biggest risk reduction.

NYISO Risk Distributions (with imports)



Risk is overwhelming concentrated downstate with additional risk in Zone A (West). Direct connection of OSW to downstate helps reduce risk downstate.

NYISO Risk Distributions (without imports)



Without imports, risks spread across the state. Downstate would be materially harmed without imports.

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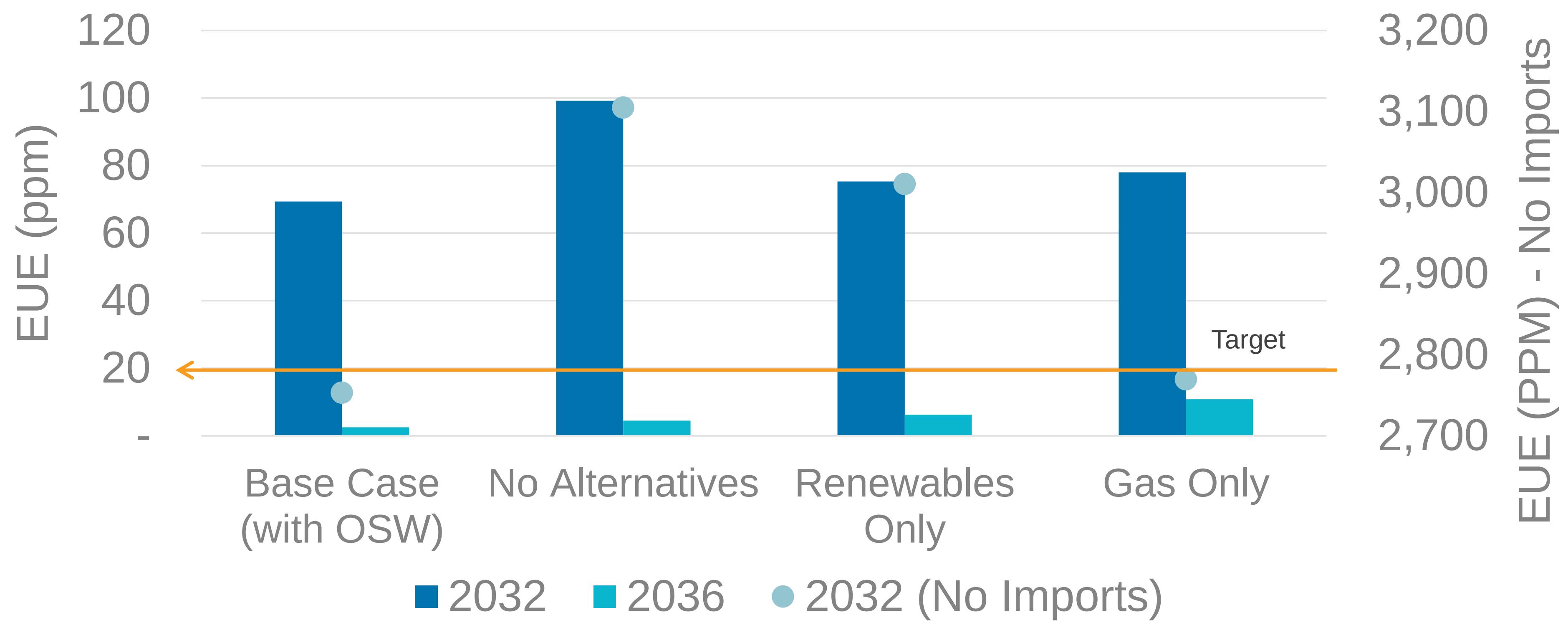
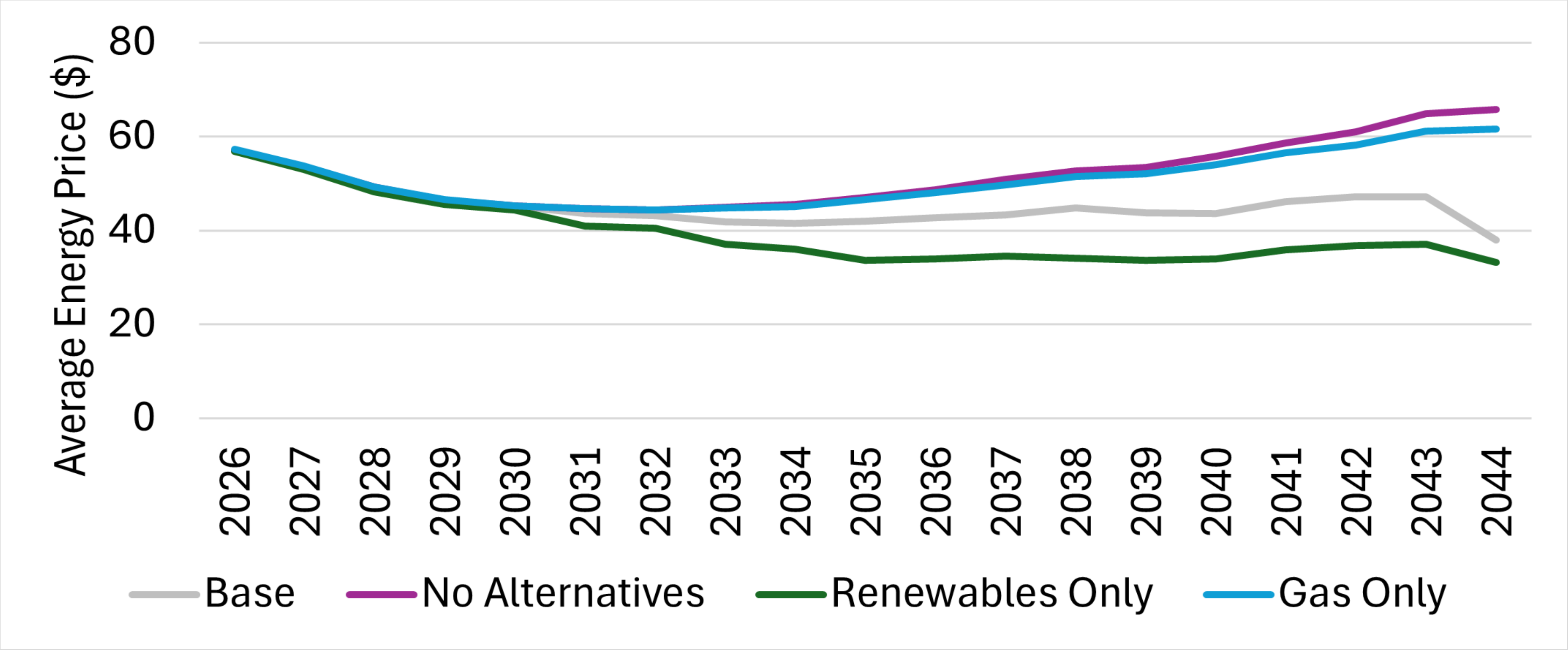
NYISO: Forecast for reliability risk



OSW maintains or improves reliability due to strong winter generation in NYC. OSW performance relative to gas is influenced based on the size and technology selected for the alternative gas resource.

ISO-NE: Forecast for average annual power price



Additions of renewables – either onshore or offshore – drives down price while NG or no additions results in price increases

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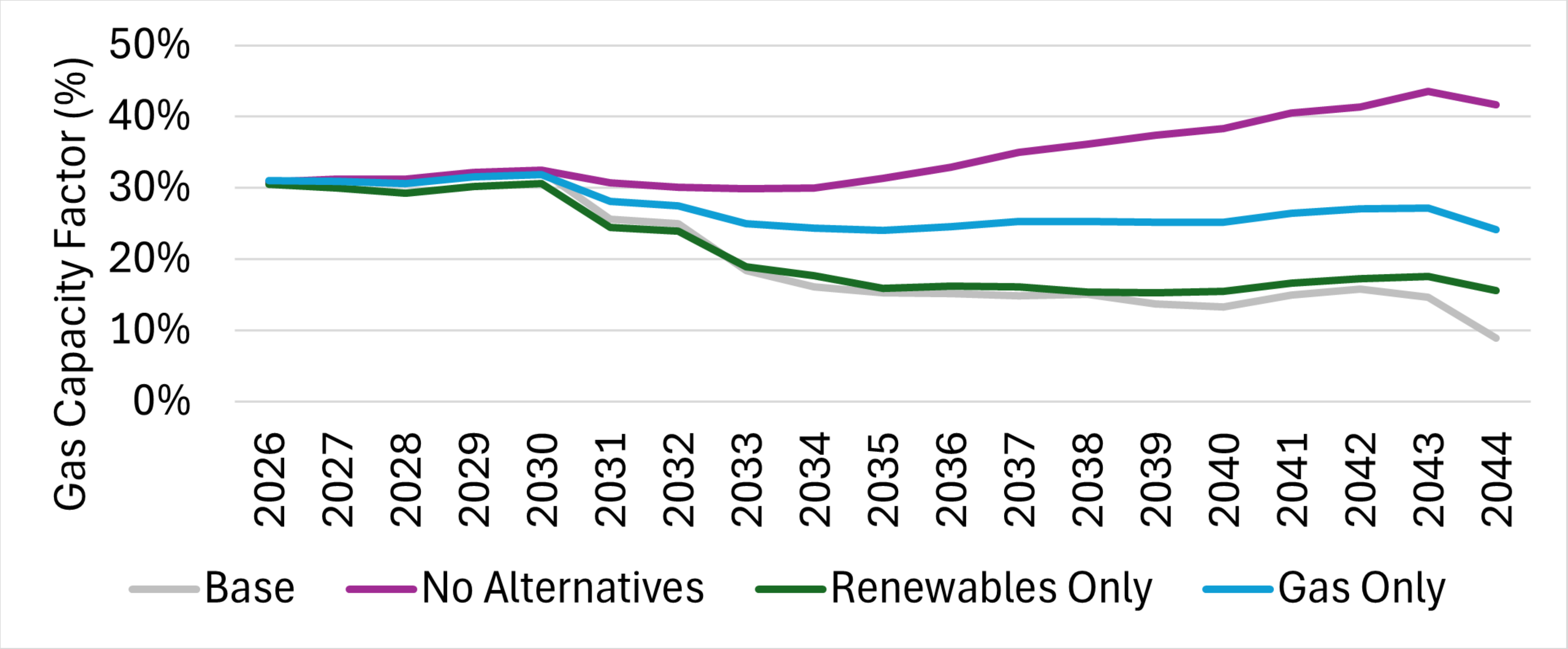
ISO-NE: Forecast for average annual natural gas capacity factor



Additions of renewables – either onshore or offshore – drives usage of natural gas plants. OSW has the greatest reduction in NG usage due to alignment strong winter generation and siting in constrained zones

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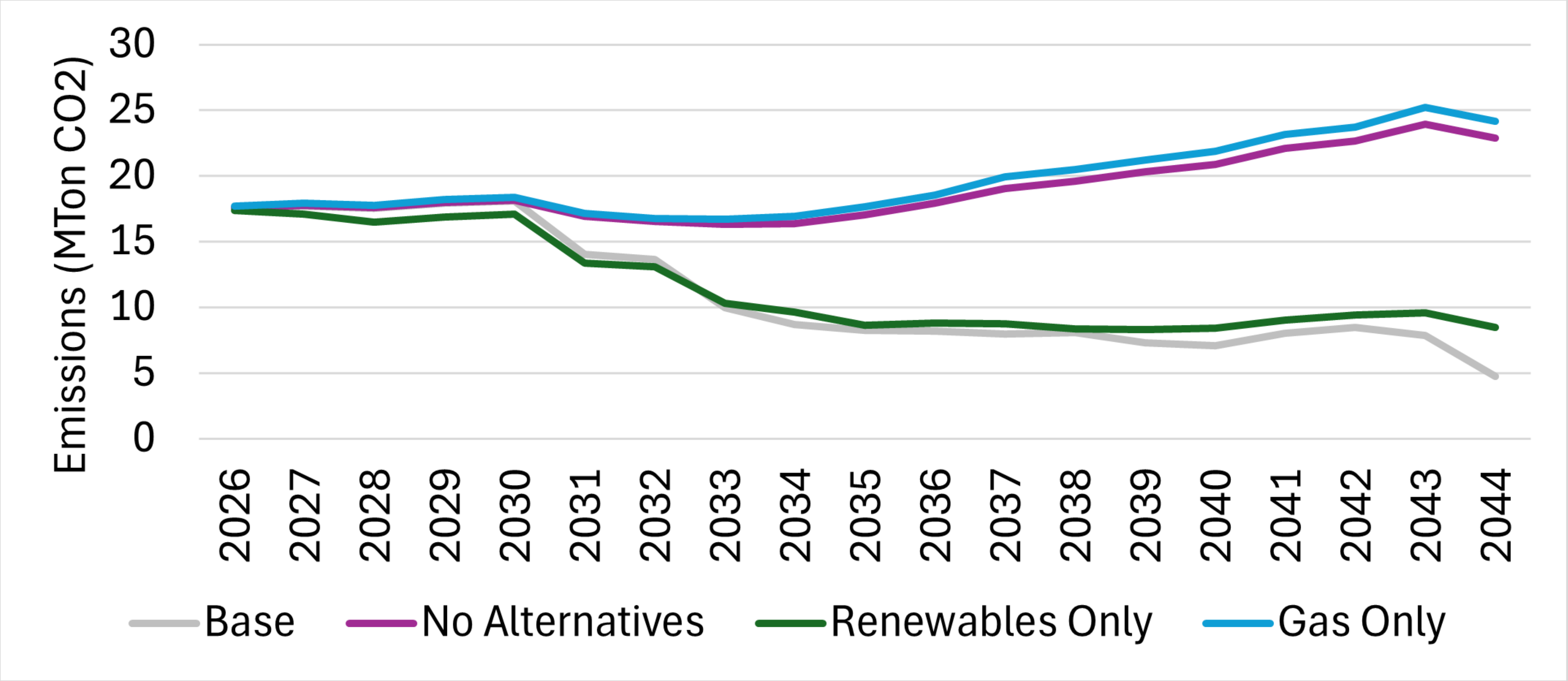
ISO-NE: Forecast for emissions



Reduced reliance on natural gas resources reduces emissions

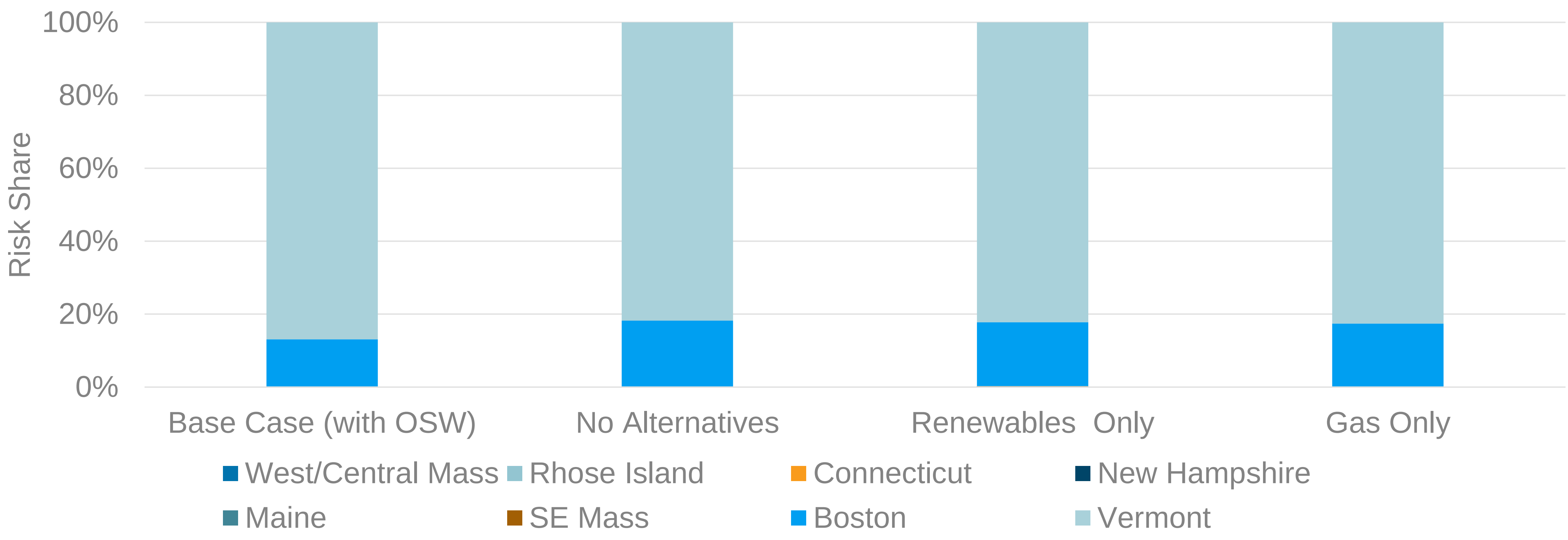
ISO-NE: Forecast for reliability risk

Target EUE: 20

Study Year	Imports?	Scenario	N-EUE (ppm)
2032	Yes	Base	0
		No Alternatives	0
		Renewables Only	0
		Gas Only	0
2036	Yes	Base	0
		No Alternatives	0
		Renewables Only	0
		Gas Only	0
2032	No (Results are **illustrative** and reflect highly conservative assumptions)	Base	3.49
		No Alternatives	4.09 (+17%)
		Renewables Only	3.55 (+2%)
		Gas Only	2.63 (24%)

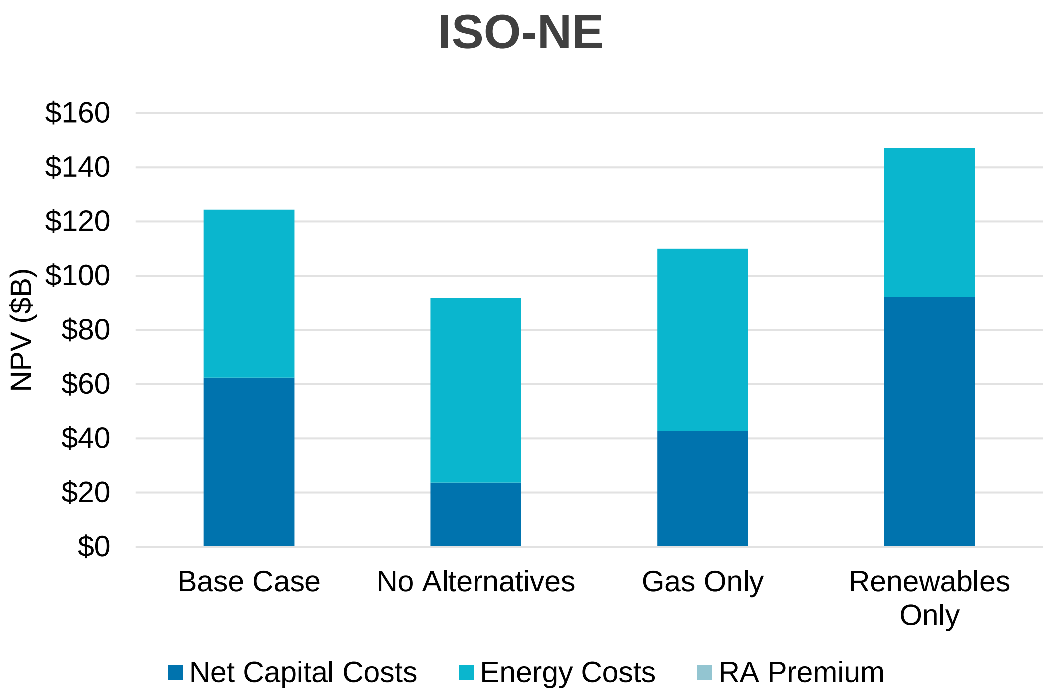
Load shedding risk is minimal, except in case with limited imports. In that case, Gas privies the best performance, but all portfolios are well within risk tolerance. Resource mix exceed resource adequacy need. Outlook will evolve as ISO-NE's capacity accreditation evolves

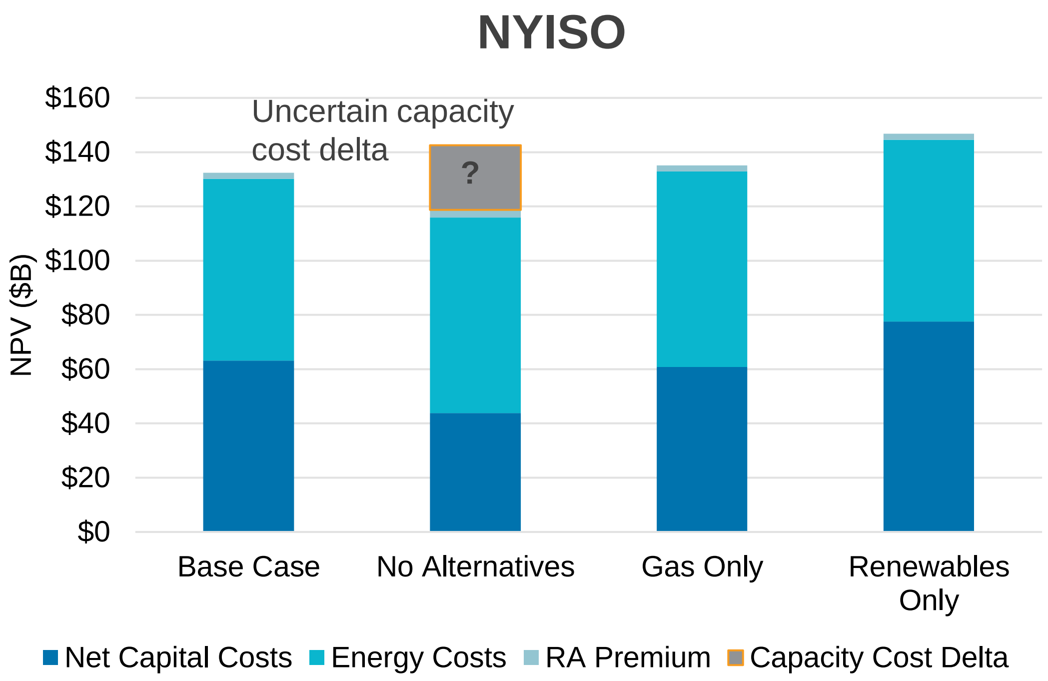
Load shedding risk distribution for ISO-NE (no Imports)



Load shedding risk is concentrated in Vermont and Boston

Capital, energy, and resource adequacy premium forecast





Capital costs are mixed and depend on the underlying assumptions including accreditations ad well as land, transmission, and pipeline upgrade costs. Capacity costs are assumed to be equal.

The US faces twin resource adequacy and affordability challenges due to aging infrastructure and load growth

Context

Load growth in winter months, the retirement of dispatchable generation, and stress of fuel supplies has created concerns for resource adequacy in Northeast. NYC is of particular concern for near-term reliability risks.

Action

Using IRP-style analyses, the authors provided a quantitative review of the risks and benefits a resource mix that include **OSW** versus credible alternatives.

Findings

Portfolios that include OSW drove down energy prices, usage of natural gas, and emissions while maintaining reliability. OSW portfolios had higher capital costs. NYC faces near-term reliability risks without investment in local generation.

Limits and implications

Capital costs are difficult to forecast. Buildability is also a significant factor in selecting resources. NYISO is exposed to region wide tightening. **Further region-wide modeling and coordination is recommended.**

While there is no one path to a reliable grid, OSW can play a meaningful role. It brings strong winter generation, offers siting advantages near constrained coastal regions, and consistently achieves high ELCC values. However, it may incur higher capital costs depending on local dynamics and learning rates.

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NYISO Scenarios (2036)

Scenario	OSW	Solar	Onshore Wind	Storage	Natural Gas
Base Case	3,314 MW	11,932 MW	8,138 MW	8,842 MW	18,971 MW
No Alternatives	-3,176 MW	0	0	0	0
Renewables Only	-3,176 MW	+1,125 MW (Zones C,F)	+3,950 MW (Zones A, C, E)	+1,310 MW (Zones J, K)	0
Gas Only	-3,176 MW	0	0	0	+751 MW (Zones J, K)

ISO-NE Scenarios (2036)

Scenario	OSW	Solar	Onshore Wind	Storage	Natural Gas
Base Case	8,497 MW	9,400 MW	3,514 MW	3,150 MW	14,971 MW
No Alternatives	–7,697MW	+0 MW	0	0	0
Renewables Only	–7,697MW	+18,350 (ME, MA, RI, VT)	+3,300 (ME, MA, RI, NH)	0	0
Gas Only	–7,697 MW	+0 MW	+0 MW	0	+5,558 (Boston, SE MA)

Resource adequacy is simulated using advanced statistical methods to test against the full range of possible grid conditions

This study evaluates the resource adequacy of the projected generator mix and assesses the impact of potential solutions

- **Load shedding:** The inability to serve demand due to insufficient available generation or transmission
- **Resource Adequacy:** Ensuring the system has enough—and the right type of—generation so that the risk of load shedding remains below an acceptable threshold

Industry best practice is to use models like Monte Carlo Simulation to quantify the risk of load shedding

- **Monte Carlo Simulation:** A way to test how the power grid performs under thousands of possible future scenarios, like rolling the dice many times to test against all possible outcomes
- **Uncertainty:** If there wasn't uncertainty, we could exactly plan the system. However, the exact load (both peak and across all hours), generator availability (due to planned, forced outages, and weather induced outages), wind generation, and solar generation are all unknown

These models are ultimately assessing the frequency, magnitude, duration, and timing of potential load shedding events

The resource adequacy of a proposed portfolios is measured using reliability risk metrics including:

Loss of load expectation (LOLE): Measures how often outages are expected, expressed in days per year with at least one outage event (regardless of size or duration). The typical target is 1 day in 10 years (i.e., 0.1 LOLE)

Expected Unserved Energy (EUE): Measures the total expected **megawatt-hours of load shedding** in a given year. No fixed target but around **0.001% - 0.003% has been used as an informal target**

Long-short position: A zone is considered **long** when it has surplus capacity and can buy and sell in the market. A **short** zone results in load shedding
Our model focuses solely on the long (negative) or short (positive) reliability balance, without considering economics

Examining the hour of day and month of year of risk can be useful when evaluating potential solutions

For example, solar has minimal benefit to solve risk exposure during Summer evening and winter mornings

CRA Charles River Associates

CRA follows the dispatch order used by many ISOs

1

Balance Within Zone

Frist, serve zonal load with in-zone resources

2

Apply Transmission

Subject to constraints, allow transmission to move capacity from long zones to short zones

3

Deploy Demand Response

Trigger demand response (24/7 availability) only in zones that are short after transmission transfers are applied

4

Charge & Discharge Storage

If surplus remains, charge storage subject to power limits

If shortage remains, discharge storage subject to power and energy constraints

Any remaining shortfall contributes to LOLE & EUE metrics