Carbon Charge Proposal Evaluation

PREPARED BY: MARC D MONTALVO & MATTHEW LOIACONO
PREPARED FOR: IPPTF MEETING
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Overview

- Background
- Work Plan
- Methodology
- Input Assumptions
- Results
- Questions

Background

- New York ISO (NYISO) is considering incorporating the price of carbon emissions into the wholesale energy markets
- New York State has three public policy goals that will have a direct impact on wholesale market:
  1. Ambitious greenhouse gas reduction targets
  2. Meeting at least 50% of the state's energy demand with renewable resources
  3. Proposed reduction of electricity consumption by 3% over the 2015 baseline by 2025

Work plan

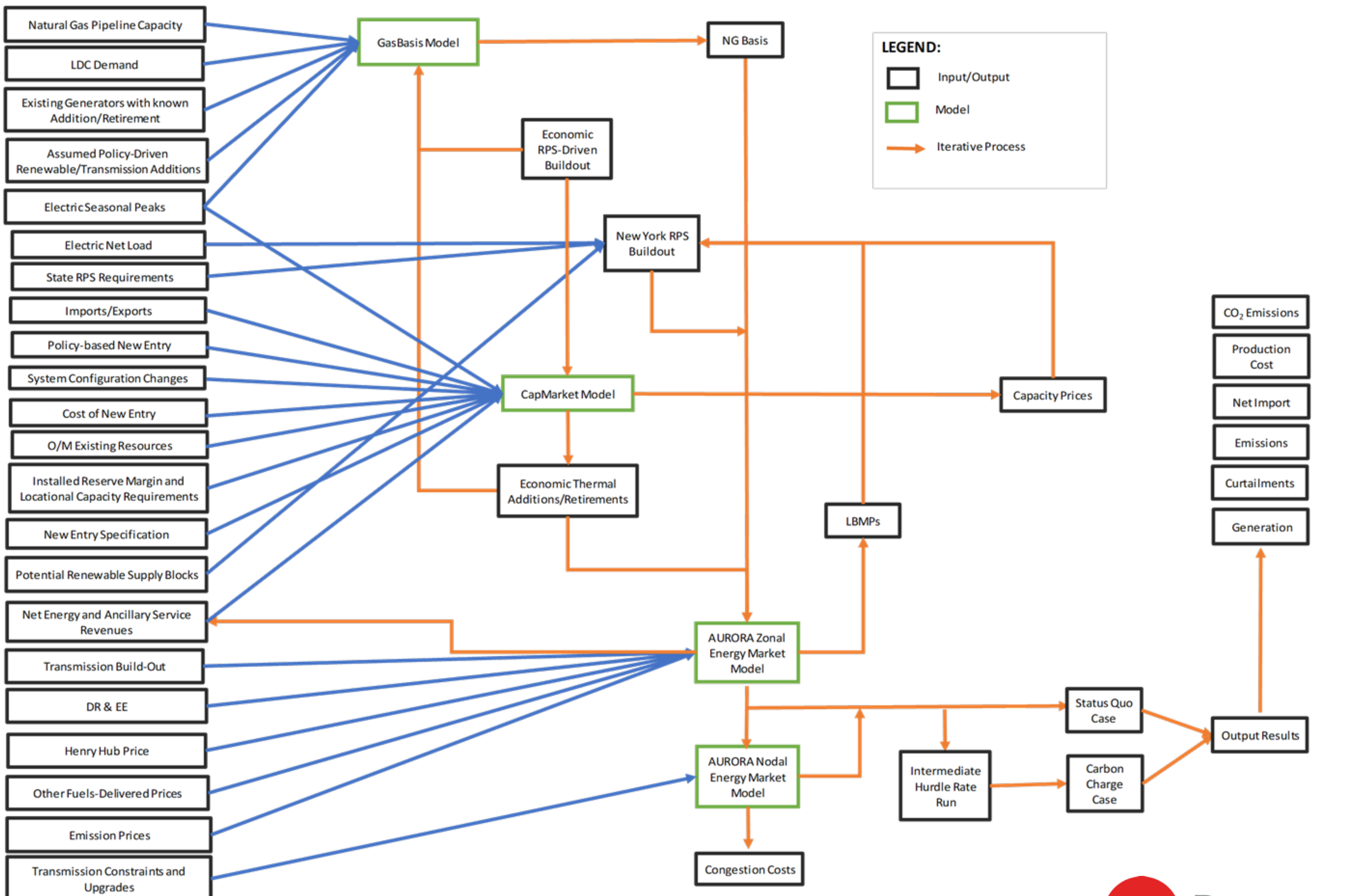
- Evaluate direct economic impacts of implementing a carbon charge through the NYISO markets.
- Study focuses on the delta in outcomes between two cases:
  1. A “status quo” case assuming state policies are met and the carbon charge is not implemented.
  2. A “with carbon charge” case featuring the addition of the proposed carbon charge.
- Study period includes each year between 2020 and 2025 inclusive, 2030, and 2035.
- Performance metrics selected to characterize the impact of carbon charge on the market, consumers, and economic efficiency.
- Inputs tested to assess sensitivity of metrics to assumptions.

METHODOLOGY

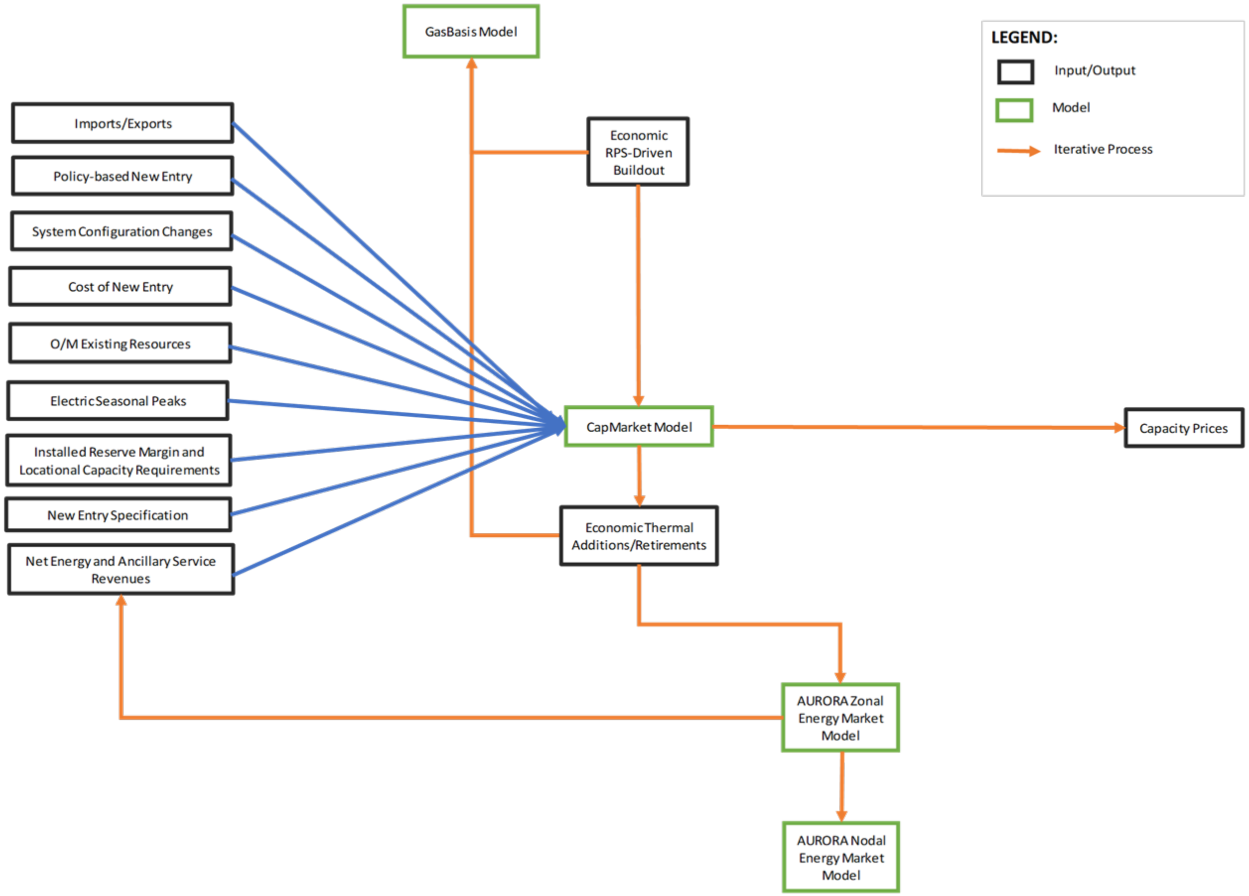
Models

DaymarkEA CapMarket Model	Simulates NYISO capacity auctions to forecast capacity prices and economic entry and exit
DaymarkEA GasBasis Model	Simulates natural gas basis prices at market trading locations based on supply and demand and delivery constraints
EPIS AURORA Zonal Model	Zonal level (bubble and pipe representation) production cost model run hourly to simulate economic dispatch of power plants within a competitive framework
EPIS AURORA Nodal Model	Nodal level production cost model that includes the full system topology down to individual level nodes and transmission lines run hourly to simulate security constrained economic dispatch of power plants within a competitive framework

Carbon charge analysis schematic



CapMarket Model schematic



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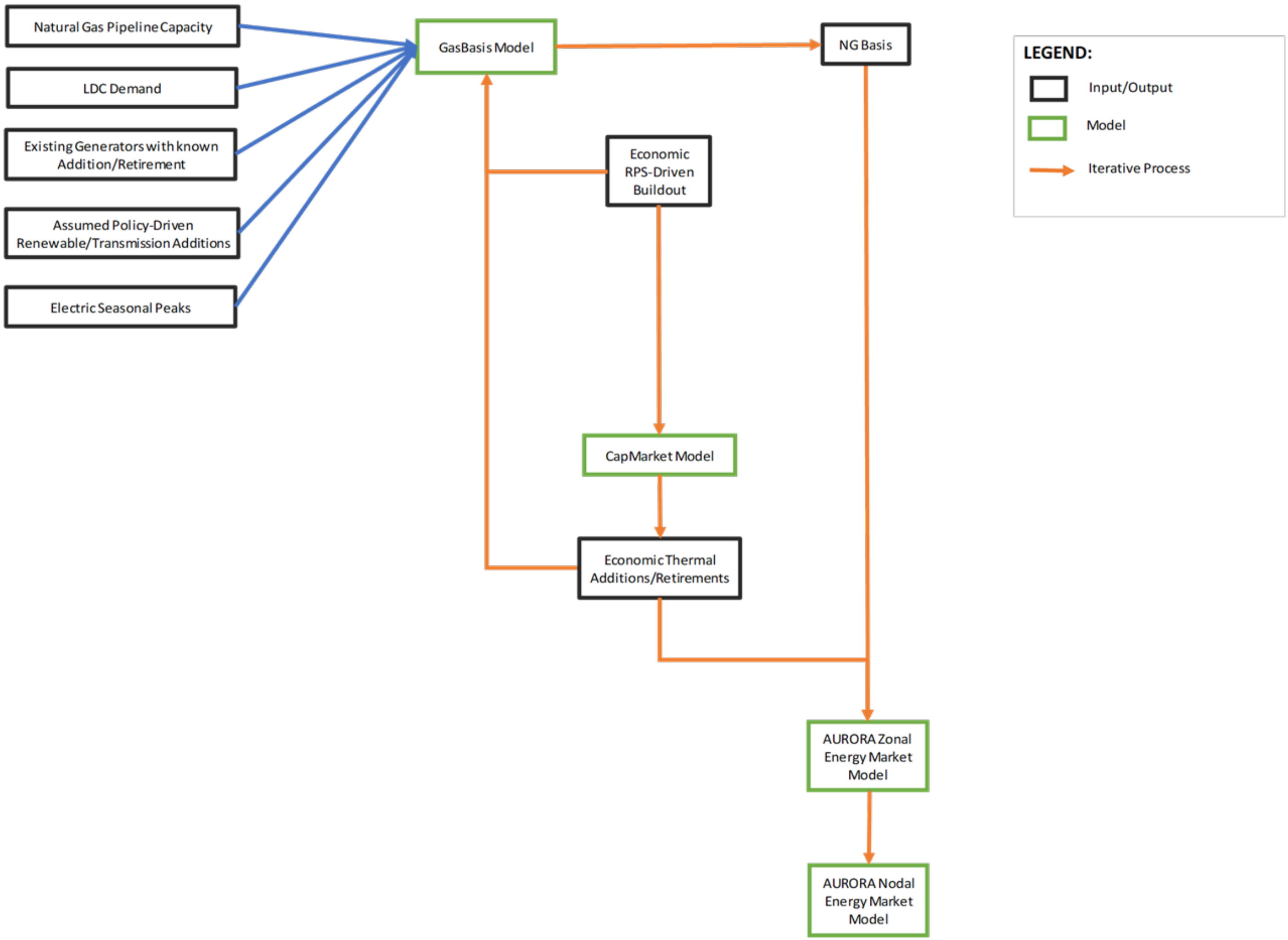
Create demand and supply curves

- Update Demand Curve characteristics (IRM, LCR, CONE and Reference Points)
  - NYCA IRM assumed to be around 18% across study period
  - Adjust for net Energy and Ancillary Service revenues
- Create supply curve
  - Estimate going forward costs for new and existing units
  - Incorporate Must Offer Renewables – Federal and State incentives
  - Estimate net imports (Note impact of expected prices in neighboring regions)

Simulate ICAP market and assess incremental changes

- The model outputs zonal capacity prices
- Add/remove resources based on historical behavior
  - Resources do not enter and exit solely based on capacity market spot prices
  - Uneconomic units tend to delay exit
  - New resources tend to enter the market at prices below administrative net CONE
- Iterative process: added and retired resources are inputs for the AURORA Models and resulting power sector gas demand in GasBasis Model

GasBasis Model schematic



Forecast natural gas basis against Henry Hub for NY market trading locations

- Forecast basis prices for pricing locations: Algonquin Citygate, NY Transco Zone 6, TETCO M3, Iroquois Zone 2, and Dominion South
- Model as distributions: natural gas pipeline capacity, LDC demand, electric demand, imports and renewable additions, historical natural gas basis and historical pipeline capacity utilization
- Calculate pipeline headroom (hourly available natural gas pipeline capacity) based on forecasted natural gas supply and demand for relevant trading regions

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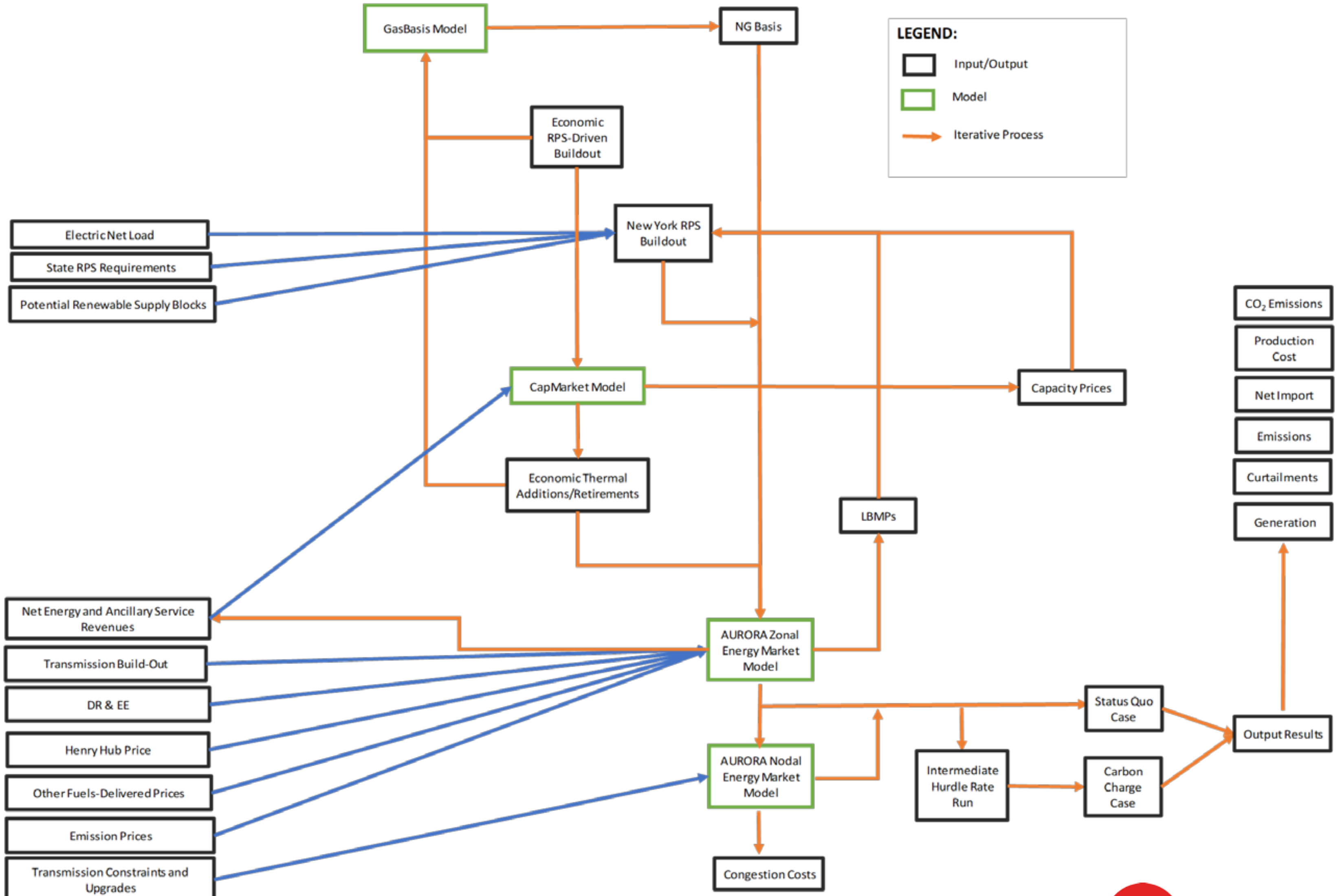
Forecast delivered natural gas prices

- Simulate future basis prices using relationship between headroom and natural gas basis
- Power sector gas demand is linked to AURORA-modeled gas-fired electric supply and is adjusted by iteration
- Add basis prices to Henry Hub prices
- Average gas prices for generation in NY use the same gas trading location weights as assumed in the most recent CARIS study

AURORA Zonal and Nodal Model schematic



Build New York energy market at the zonal level

- Collect input data on demand, transmission, renewables, fuel prices, and new and existing resources
- Break Eastern Interconnection into zones and interfaces that reflect underlying topology
  - Includes nested interface constraints among multiple zones
  - Interfaces to PJM, ISONE, Ontario, and HydroQuebec
  - NY is divided into 11 zones (A-K)
- Hourly production data and clearing prices determined for each zone

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Simulate New York energy market at the zonal level

- Iterative process:
  - Net Energy and Ancillary Service revenues are output to CapMarket Model
  - AURORA Zonal Model receives economic-based resource entry and exit from the CapMarket Model
  - Power sector gas demand is input to the GasBasis Model
  - Natural gas prices input to AURORA Zonal Model
- Run models and produce outputs for the Status Quo case

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Add Carbon Charge

Key challenge: Marginal Carbon Charge (MCC) border adjustment

- Dynamic modeling of actual proposed border adjustment mechanism is infeasible
- Used a two stage approach:
  - **Stage 1:** Apply carbon charge to all modeled resources to calculate hourly marginal unit carbon charges (MCC) that apply to transactions at the boarder
  - **Stage 2:** Apply carbon charge to NYISO units only; input the schedule of border charges established in Stage 1
- Apply a schedule of boarder charges, rather fixing net imports, allows the model to estimate changes in external transaction due to the carbon charge

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Stage 1

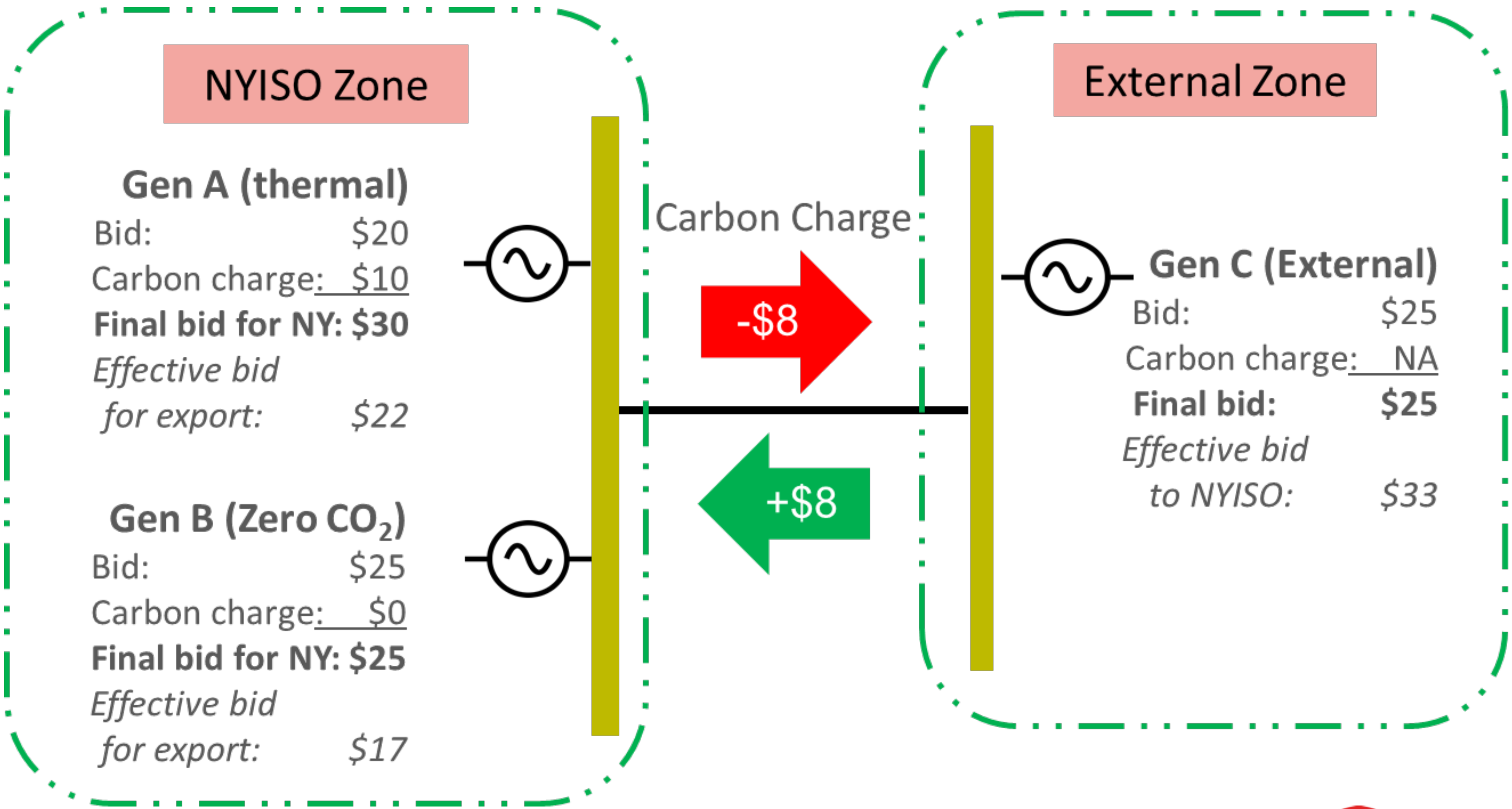
- All carbon emitting resources are charged the Gross Social Cost of Carbon (SCC) on CO2 emissions
- Model is run to simulate commitment and dispatch with “universal” carbon charge
- NYISO Upstate (Zones A-F) and Downstate (Zones G-K) proxy marginal units are identified for each hourly interval
- The emission rate for the proxy unit times the net SCC (Gross SCC minus RGGI price) is recorded as the marginal cost of carbon (MCC) for each hourly period

Stage 2

- Hourly schedule of MCCs ($/MWh) from Stage 1 is input border adjustments between NYISO and external zones
  - Positive adjustments for flows into NYISO zones
  - Negative adjustments for flows out of NYISO zones
- Carbon charges are removed for external resources (only RGGI as applicable remains)
- NYISO resources are charged gross SCC on CO_2 emissions
- Model run to simulate commitment and dispatch for carbon charge case

Example of Carbon Charge Modeling

- For interval, Marginal Cost of Carbon (MCC) in Stage 1 was \$8/MWh. This becomes the Border Adjustment on interfaces connecting the NYISO zone to the external zone in that interval
- Imports into NY *add* Border Adjustment to offers
- Exports from NY *subtract* Border Adjustment from offers



Nodal modeling

Simulate New York energy market at the bus level and assess incremental changes

- Evaluate changes in congestion, technical curtailments, and LBMPs due to changes in power flow with a carbon charge
- All inputs and iterative modeling used with the AURORA Zonal Model plus complete transmission topology
- Requires mapping injection and withdrawal points to pricing nodes
- Run a security constrained economic commitment and dispatch
- We examine 2030 at the nodal level

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INPUT ASSUMPTIONS

Common assumptions

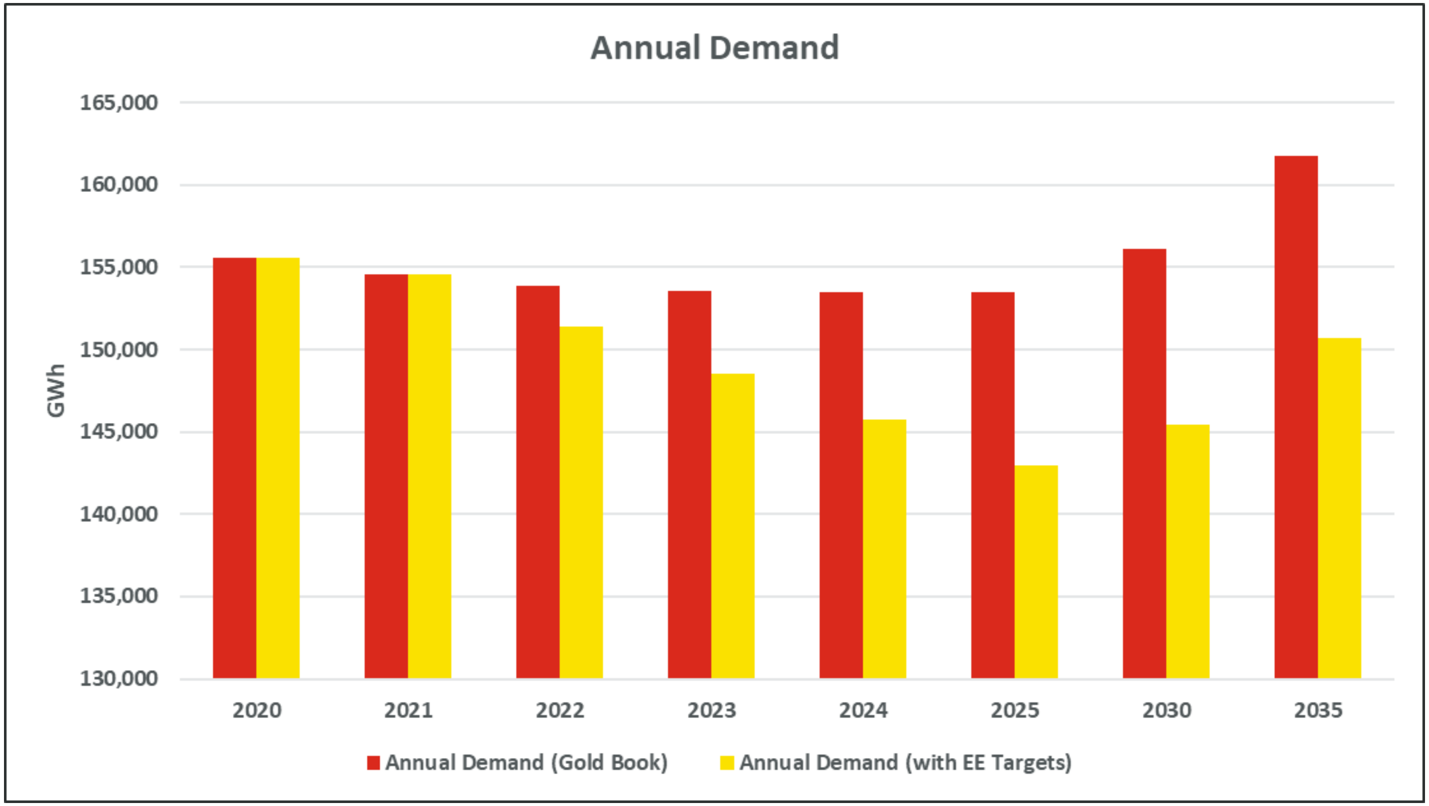
- Demand Net of BTM/EE (Peak and Base) (2018 Gold Book/NYISO EE Assumptions by 2025)
- Internal/External Transmission (2018 Gold Book)
- Existing Capacity and Specific New Units (2018 Gold Book)
- Renewable Buildout (CARIS Shift Case adjusted to include new off-shore wind and EE targets)
- Fixed O&M for existing resources (SNL Financial)
- Capital and operating costs of new technologies (2018 AEO)
- Installed Reserve Margin and Locational Capacity Requirements (NYISO ICAP Manual-Demand Curve Reset)
- Planned Retirements (2018 Gold Book)
- Oil Prices (NYISO Assumptions)
- Henry Hub prices (Futures prices escalated at 2018 AEO growth rate)
- Historical spot natural gas indexes (SNL Financial)
- Pipeline capacity, historical LDC and power sector natural gas demand (SNL Financial)
- Solar Shapes (NREL PV Watts)
- Onshore Wind Shapes (NREL SAM)
- Offshore Wind Shape (NREL SAM)
- Emission Prices – RGGI and SCC (NYISO)

Nodal Model assumptions

- Power Flow Inputs and Topology (FERC 715 Base Case)
- Interface Definitions and Limits (Reliability Needs Assessment Report and NYCA IRM Report)
- Future Transmission Upgrades (Gold Book and System Planning Studies)
- Future Generation and Network Upgrades (Gold Book, Interconnection Queue, and System Planning Studies)
- Transmission buildout only includes firm upgrades (same as NYISO)
- All transmission upgrades and renewable additions to meet 50 by 2030 goals will be part of this model for both case runs

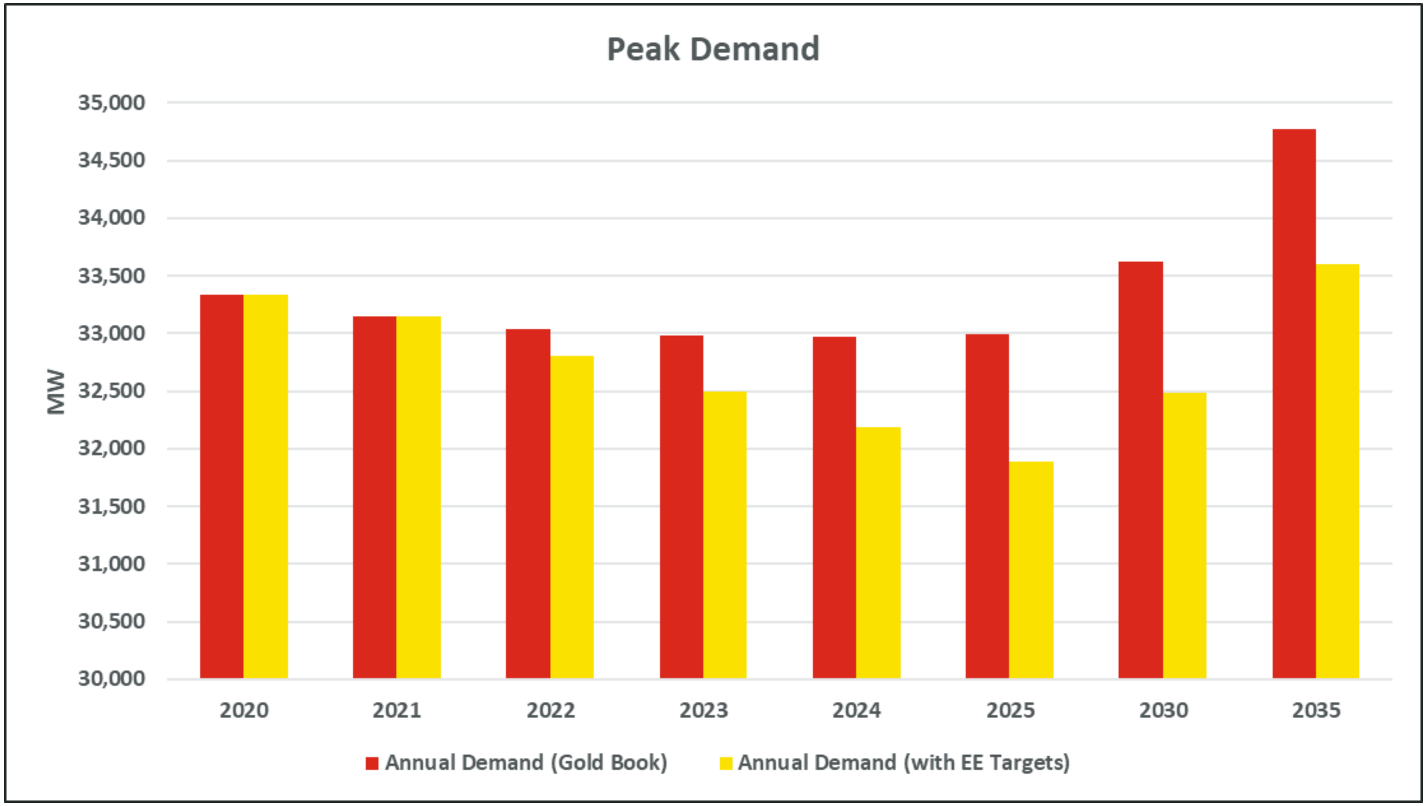
Annual energy load

- Annual energy load from 2018 Gold Book net of EE and BTM
- Quantity of energy efficiency is increased from the baseline load forecast in 2018 Gold Book to reach NY State reduction target of 3% by 2025 (matches NYISO forecast)



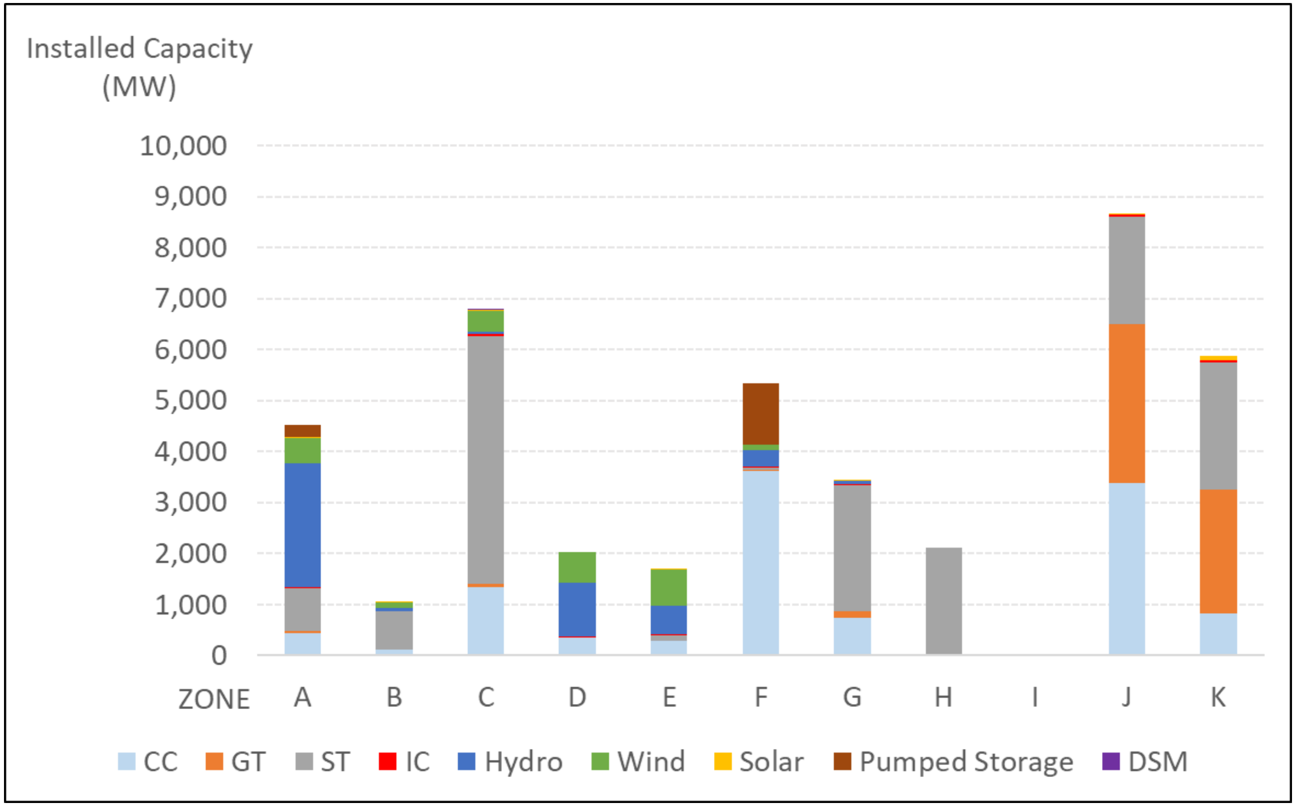
Annual peak demand

- Annual peak demand from 2018 Gold Book net of EE and BTM
- Energy efficiency is increased from the baseline forecast in 2018 Gold Book to reach NY State reduction target of 3% by 2025 (Matches NYISO Forecast)



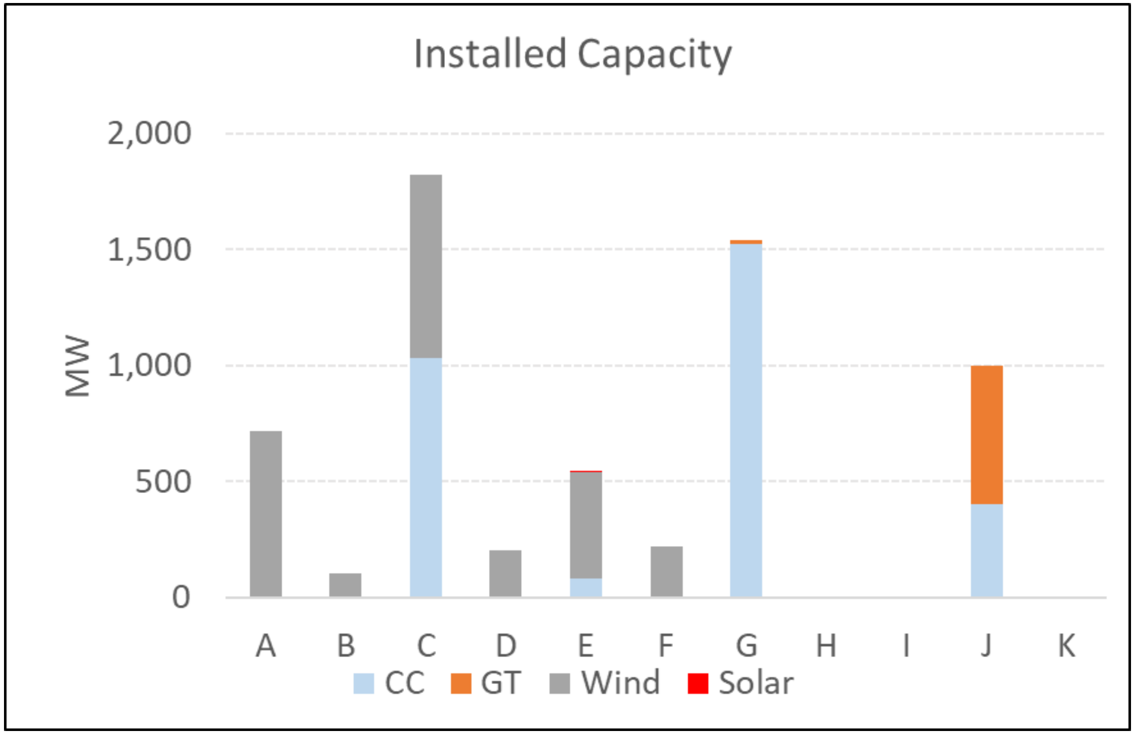
Existing resources

- Per 2018 NYISO Gold Book for capacity MW, type, and location existing resources in NYCA



Planned resource additions

- Per 2018 NYISO Gold Book for capacity MW, type, and location of planned resources in NYCA



Planned retirements

NAME	NAMEPLATE CAPACITY (MW)	ZONE	FUEL	RETIREMENT YEAR
Ravenswood (GT7)	22	J	Natural Gas	2017
Hawkeye Energy Greenport LLC	54	K	Kerosene	2018
Hofstra University (GEN1)	1.1	K	Natural Gas	2019
Hofstra University (GEN2)	1.1	K	Natural Gas	2019
Indian Point 2	1,299	H	Nuclear	2020
Indian Point 3	1,012	H	Nuclear	2021

We assume all coal units retire before start of study period.

Renewable and storage additions

- Three types of renewable resources are added in the model to achieve the 50 by 30 policy:
  - Land-based wind energy resources
  - Offshore wind energy resources
  - Utility-scale solar energy resources
- After 2030, we add renewable resources sufficient to meet approximately 50% of the incremental annual energy load.
- Offshore wind is added in Zone J and Zone K
- A 100 MW battery energy storage systems each with 4 hours of energy storage capability are added to Zone F and Zone J in 2020.

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Renewable and storage additions (cont'd)

TECHNOLOGY	NAMEPLATE CAPACITY[2] (MW)	ANNUAL CAPACITY FACTOR (%)	COMMENTS
Utility-Scale Solar	11,189	20%	
Land-Based Wind	1,976	35%	Only added in Zones A, C, E, F, G
Offshore Wind	2,400	45%	Only added in Zone J and Zone K
Battery Energy Storage[1]	200	NA	100 MW each added in Zone F and Zone J in year 2020

YEAR	OFFSHORE WIND ADDED IN ZONE J[2] (MW)	OFFSHORE WIND ADDED IN ZONE K[2] (MW)
2025	500	300
2030	1,100	500

[1] Battery Energy Storage base assumptions being revised to reflect storage roadmap.
[2] 2020 – 2035 Renewable Buildout Total Nameplate (MW)

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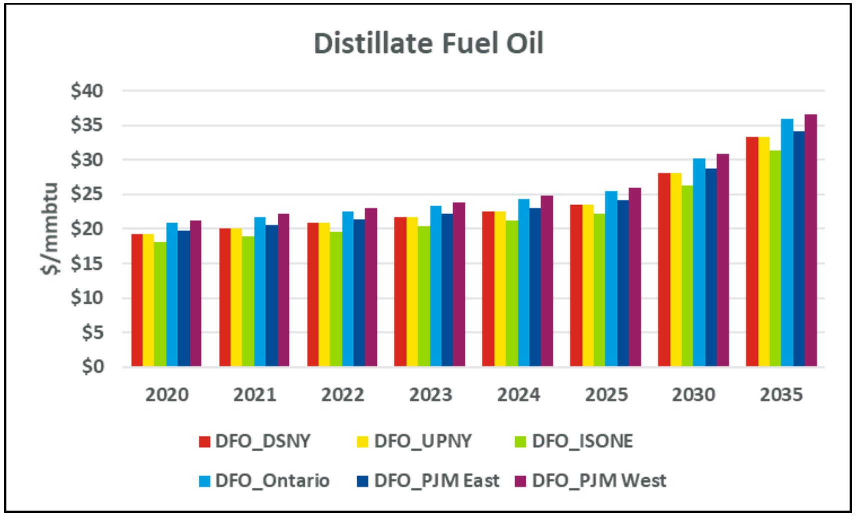
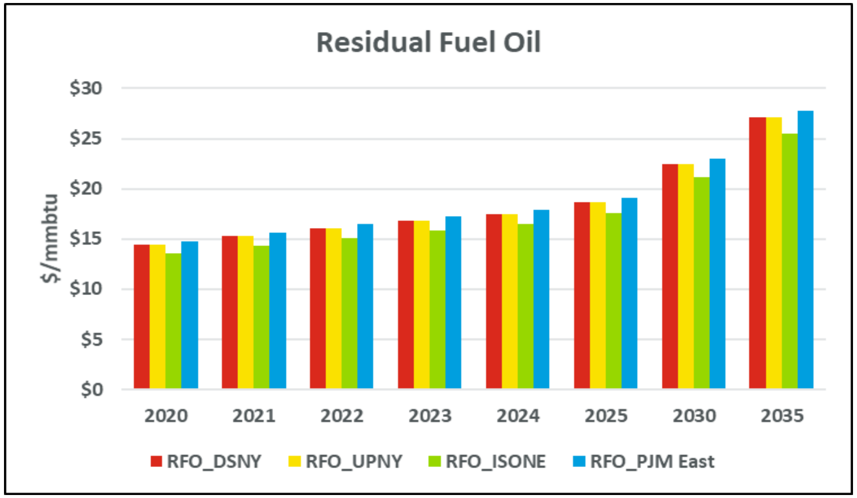
Oil prices





- We use NYISO's assumption through 2030
- After 2030, prices increase at rate equal to 2020 – 2030 CAGR:
  - Distillate Fuel Oil prices increase at 3.5% per year
  - Residual Fuel Oil prices increase at 3.8% per year

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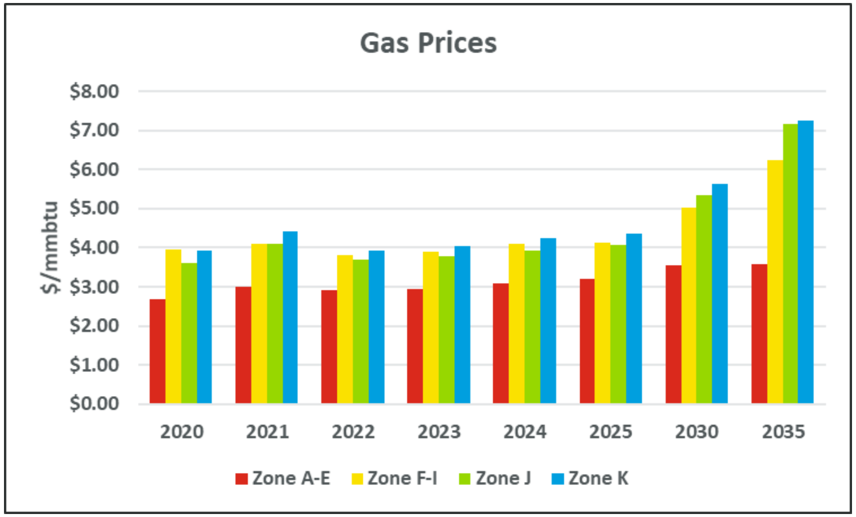
Gas prices



- Modeled gas basis for Transco Zone 6 NY, TETCO M3, Iroquois Zone 2, Dominion South, and Algonquin Citygate
- Added calculated basis to Henry Hub
- Zonal gas prices use weights assumed in CARIS study

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Planned gas pipeline buildout

PROJECT	PIPELINE	MMcf/d
CPV Valley Lateral Project	Millennium Pipeline	127
New Market Project	Dominion Transmission	82
Atlantic Bridge Project	Algonquin Gas Transmission	133
Eastern System Upgrade Project	Millennium Pipeline	223
Lambertville-East Project	Texas Eastern Transmission	180

Carbon prices

Gross and Net Social Cost of Carbon in nominal $/US-ton

YEAR	GROSS SCC	RGGI	NET SCC
2020	$47.3	$5.6	$41.7
2021	$48.3	$6.3	$42.0
2022	$50.5	$6.7	$43.7
2023	$52.7	$7.2	$45.5
2024	$55.1	$7.7	$47.4
2025	$57.5	$8.3	$49.2
2026	$60.0	$8.8	$51.1
2027	$62.5	$19.5	$43.0
2028	$65.2	$20.9	$44.3
2029	$66.5	$22.3	$44.2
2030	$69.3	$23.9	$45.4
2031	$72.0	$25.6	$46.4
2032	$74.8	$27.4	$47.5
2033	$77.7	$29.3	$48.5
2034	$80.8	$31.3	$49.4
2035	$83.9	$33.5	$50.4

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PRELIMINARY RESULTS

Metrics

- Metrics reported for New York and by Zone are the change in the following between the Status Quo and Carbon Charge cases:
  - Production Costs
  - Renewable production
  - CO_2 Emissions
  - Average LBMPs
  - Zonal Capacity Prices
  - Resource Profitability (calculated as contribution margin by proxy resource for each resource class by year)
  - Net Imports
  - Quantity and Location of Market-based Entry

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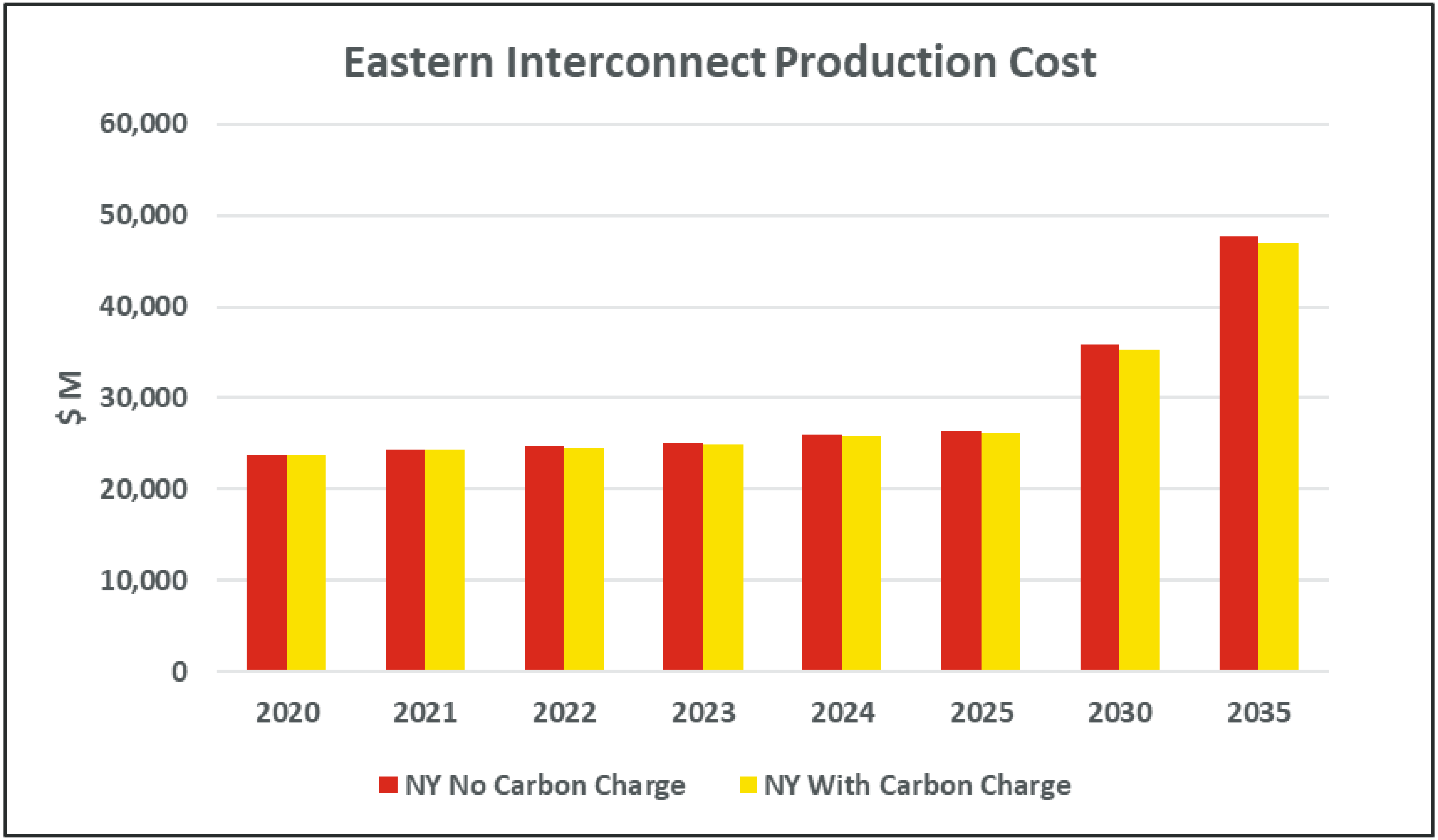
Eastern Interconnect production costs

PRELIMINARY RESULTS



Results for NY, NE, PJM, ONT, HQ, NB, Maritimes

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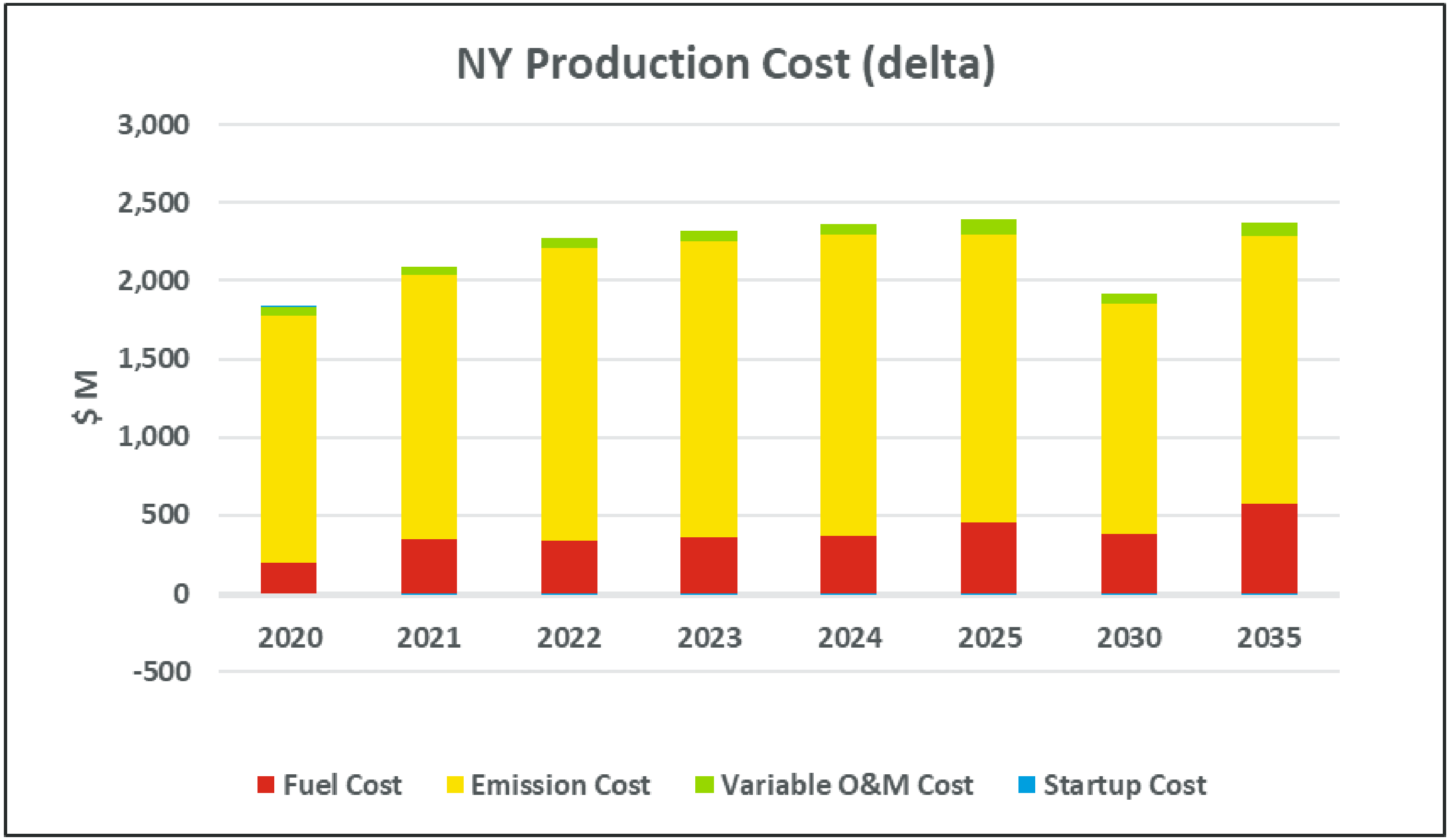
Change in New York production costs

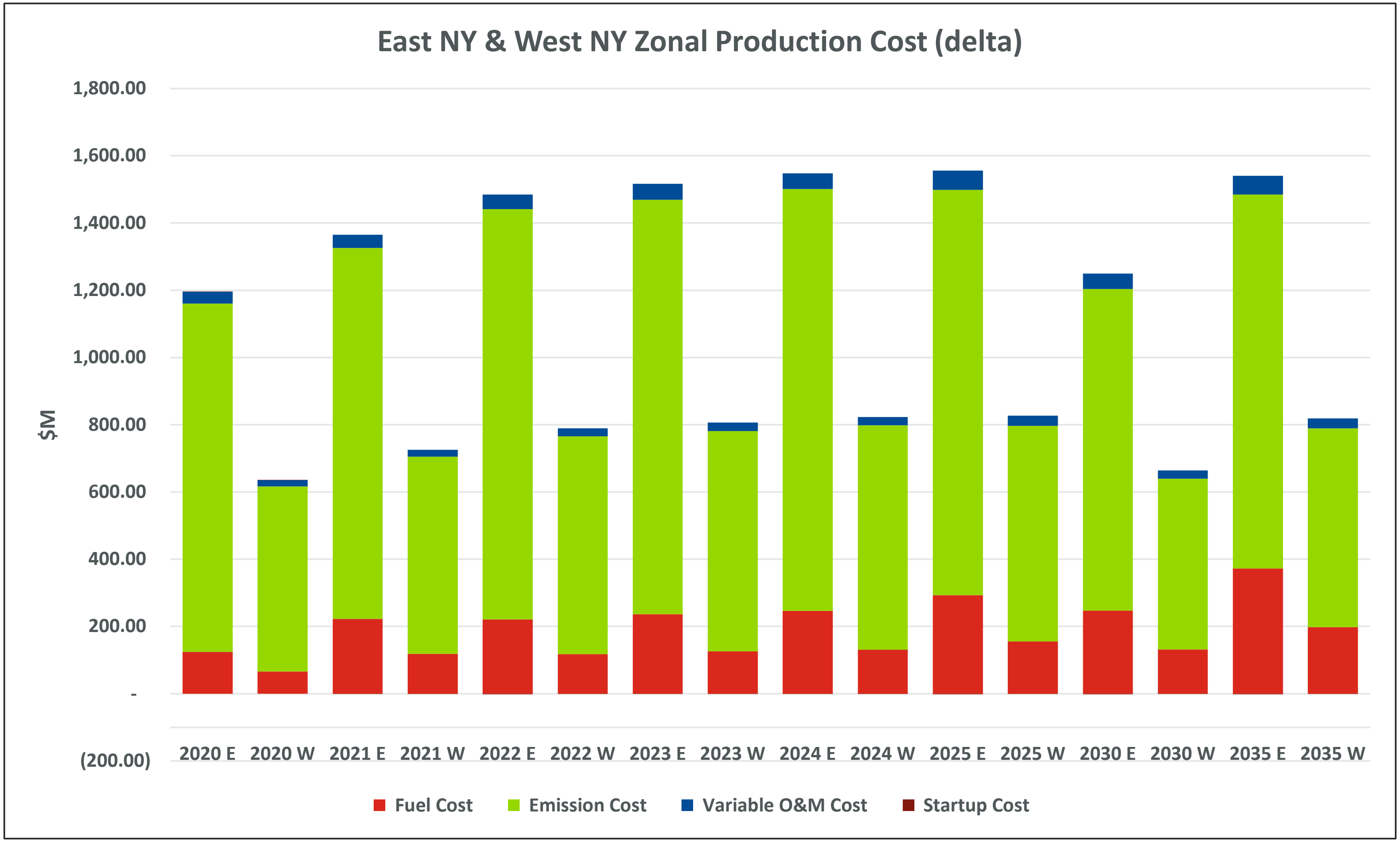
PRELIMINARY RESULTS

- Emission costs are the largest portion of the production cost change



Change in NY production costs (West Zones A-E; East Zones F-K)

PRELIMINARY RESULTS



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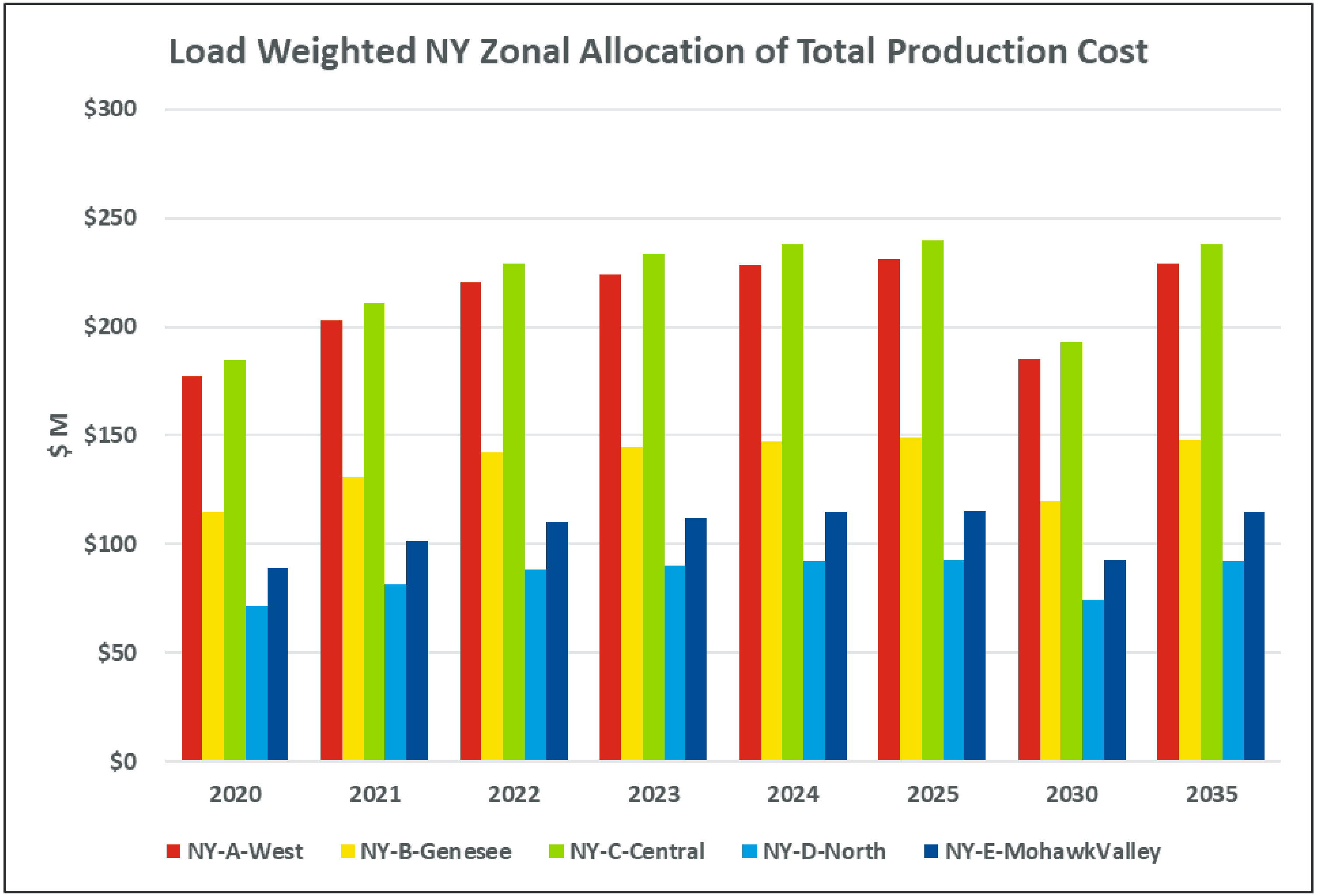
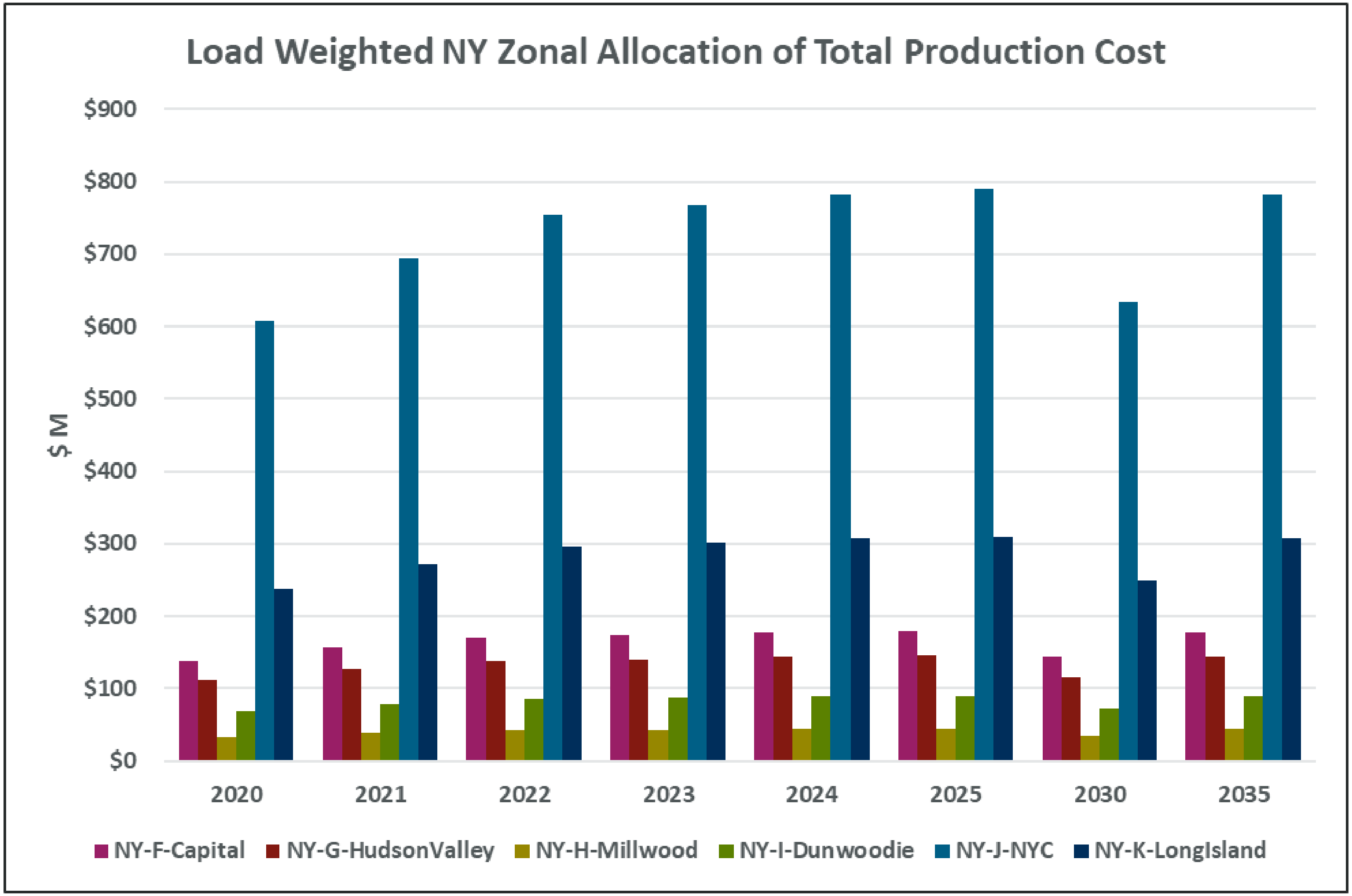
Change in NY Zonal production costs (Zones A-E)

PRELIMINARY RESULTS



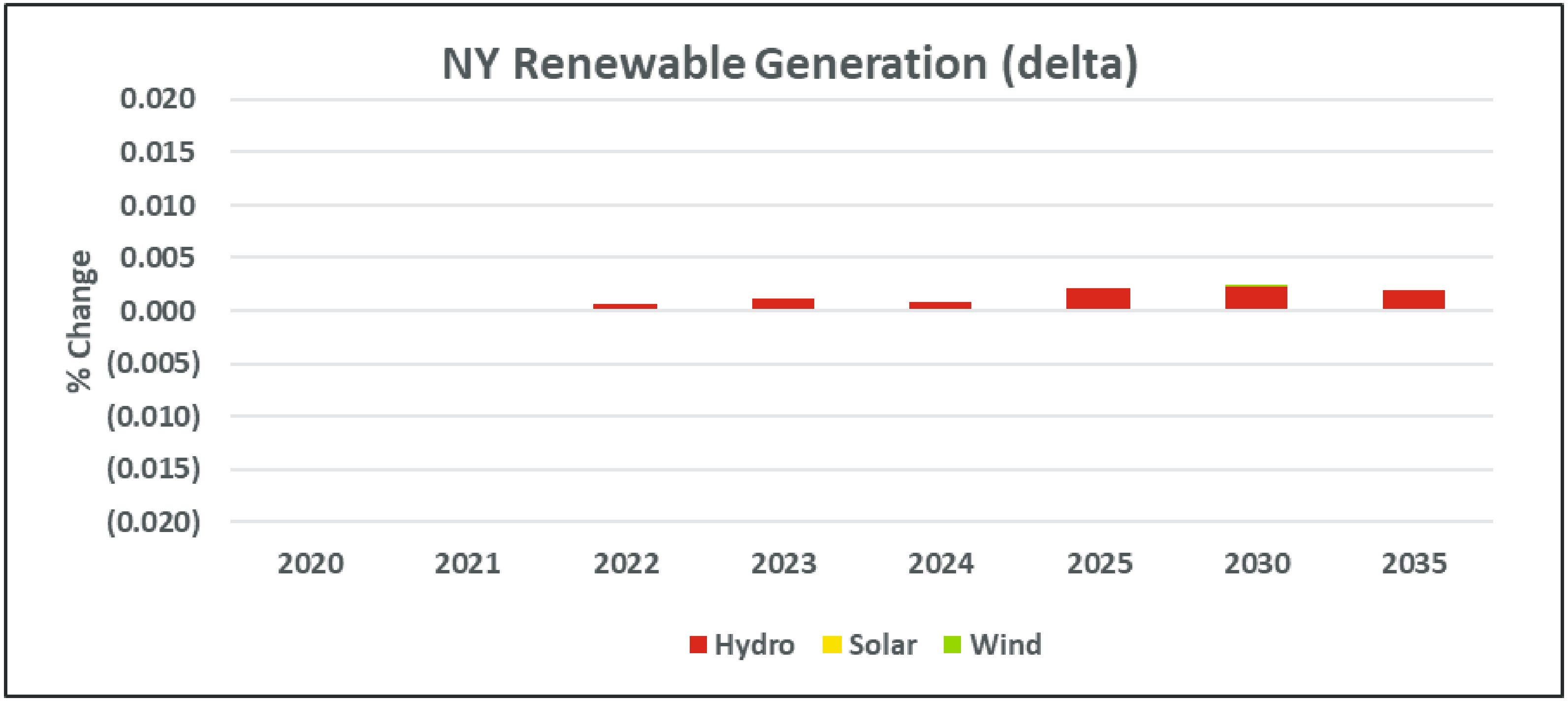
Change in NY Zonal production costs (Zones F-K)

PRELIMINARY RESULTS



Change in NY renewable generation

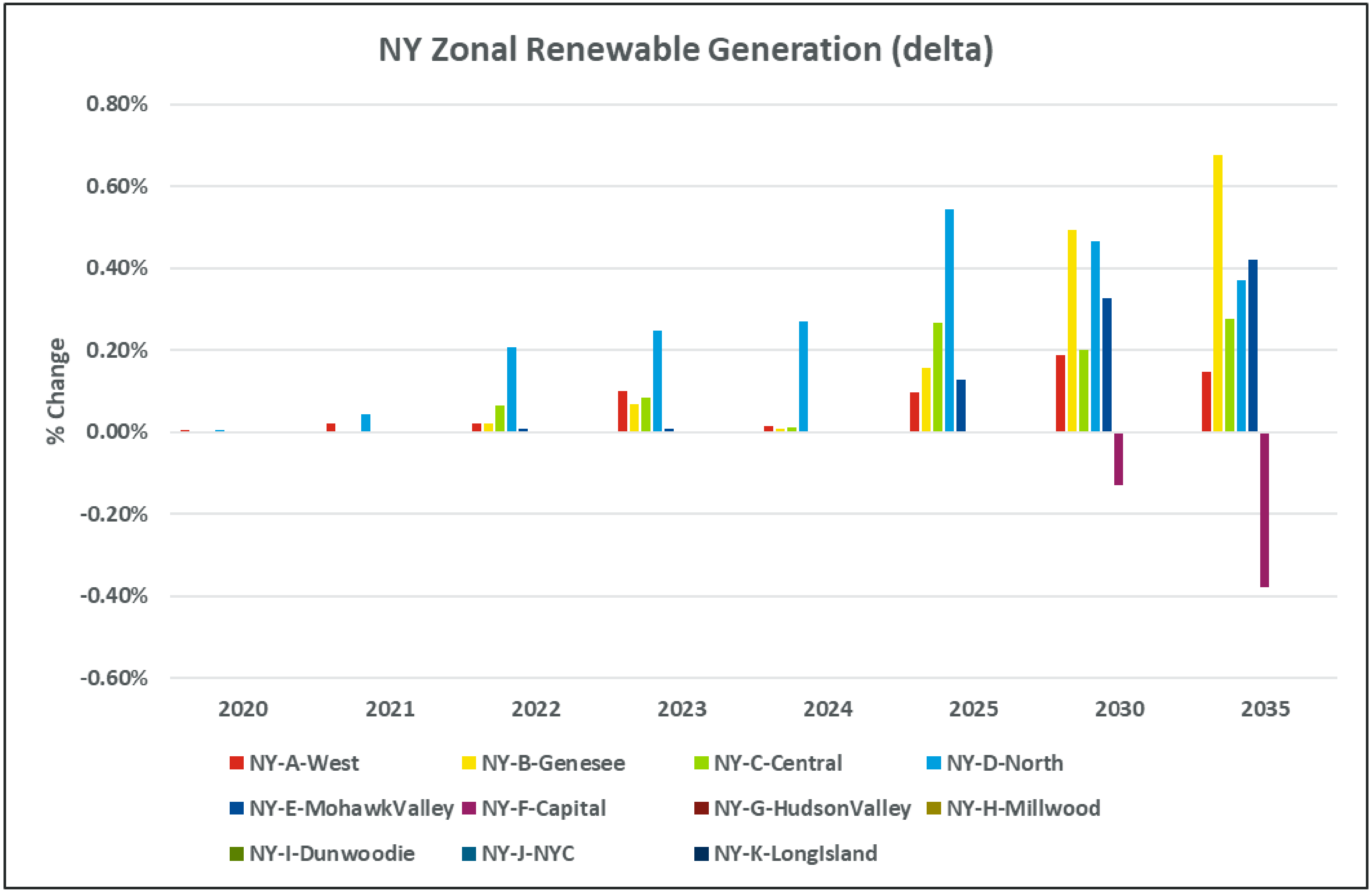
PRELIMINARY RESULTS



- No change in solar generation
- Small change in hydro generation
- Negligible change in wind generation

Change in NY Zonal renewable generation

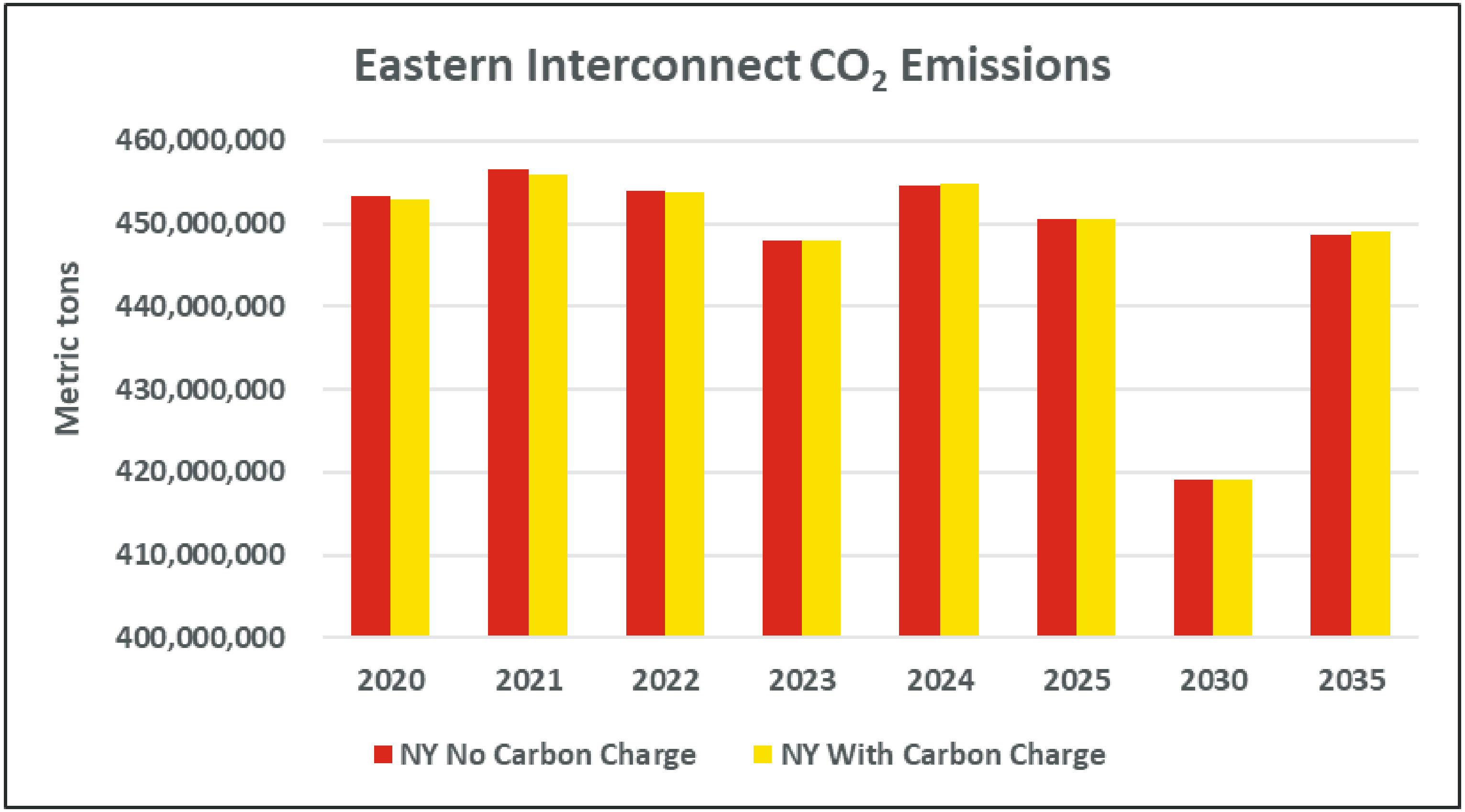
PRELIMINARY RESULTS



Eastern Interconnect CO_2 emissions

PRELIMINARY RESULTS

- Carbon Charge Case has lower total emissions over the study period



Results for NY, NE, PJM, ONT, HQ, NB, Maritimes

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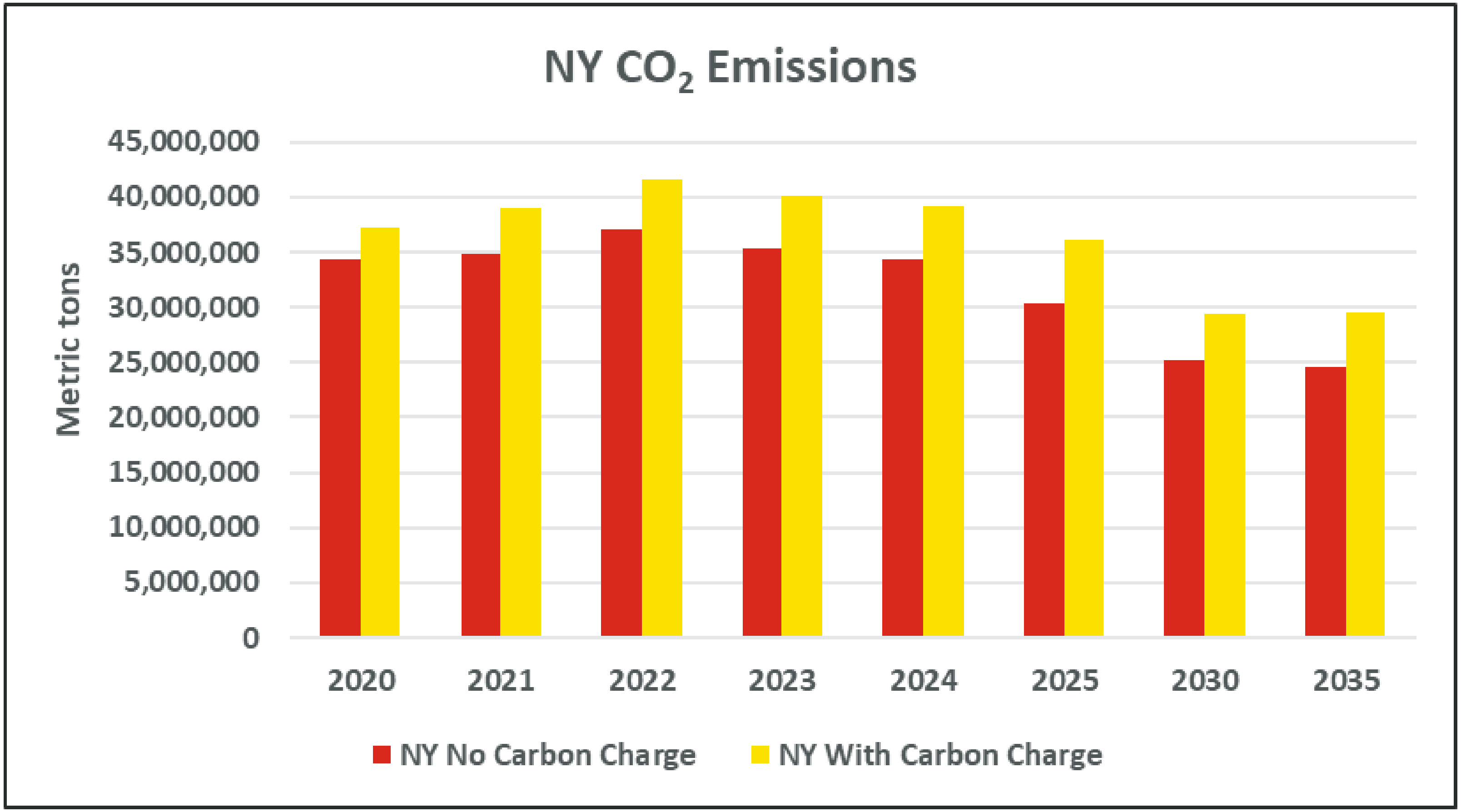
Total NY CO_2 emissions

PRELIMINARY RESULTS

- Carbon Charge Case has higher total emissions in NY over the study period



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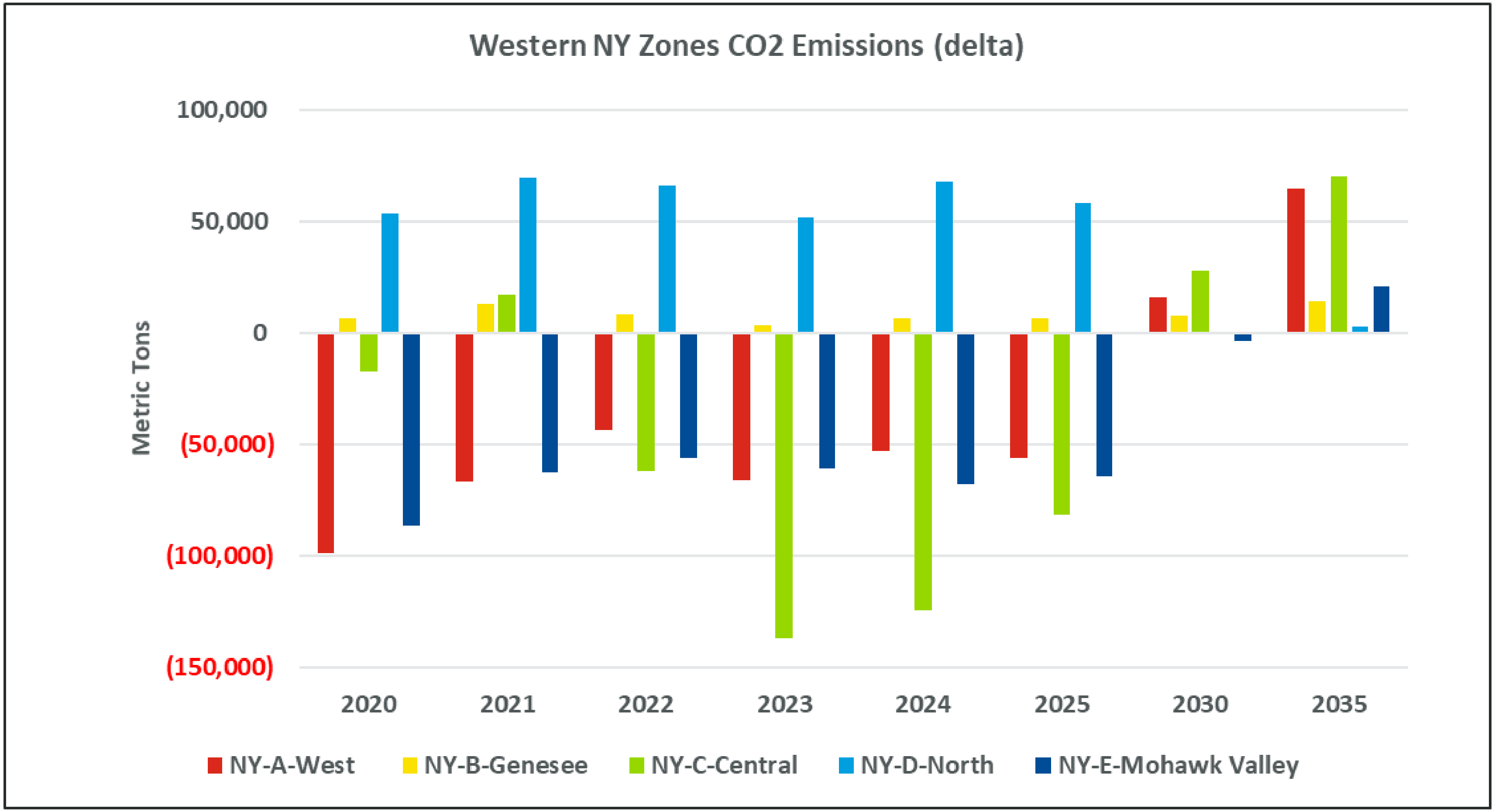
Change in NY CO_2 emissions by Western Zones A-E

PRELIMINARY RESULTS



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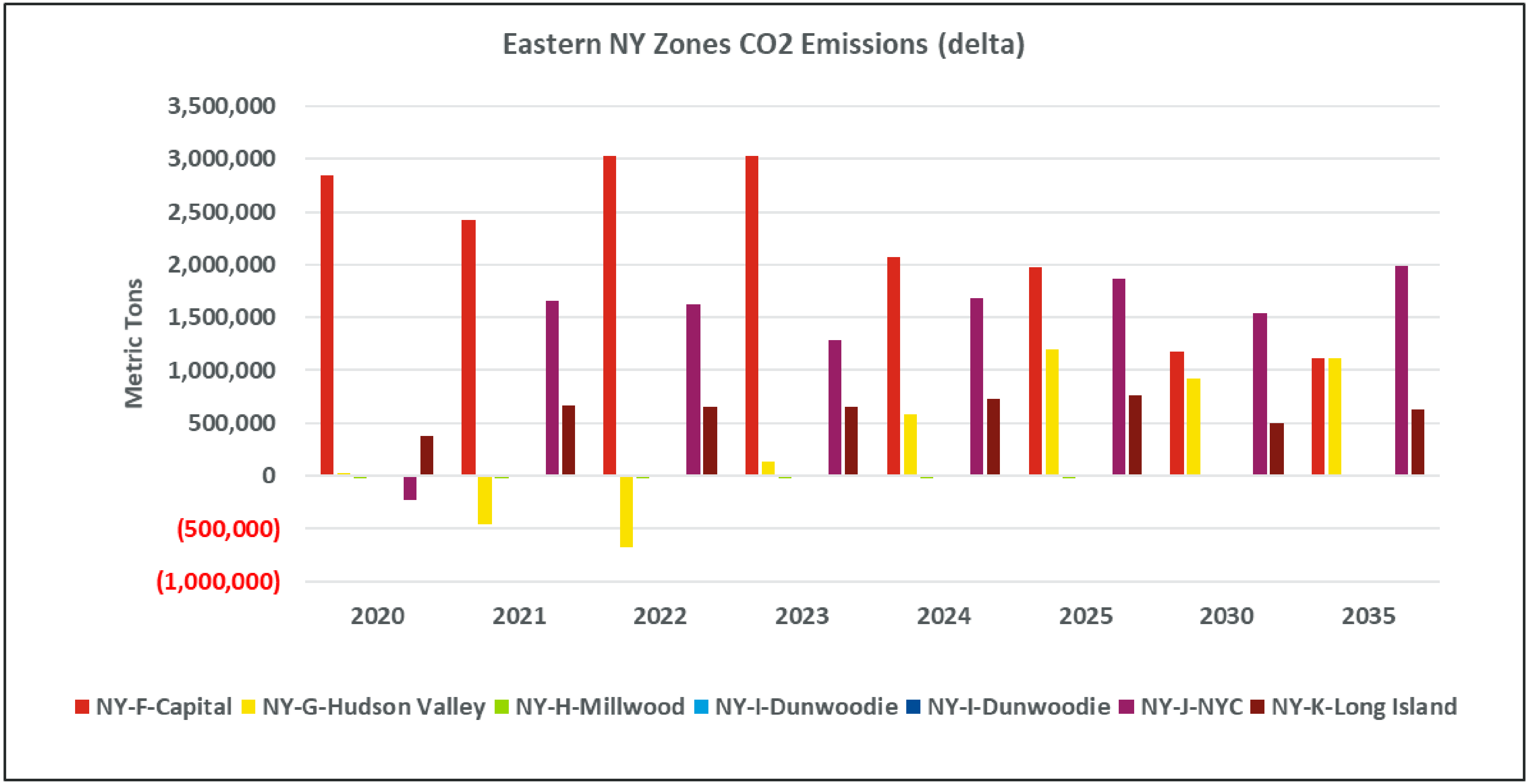
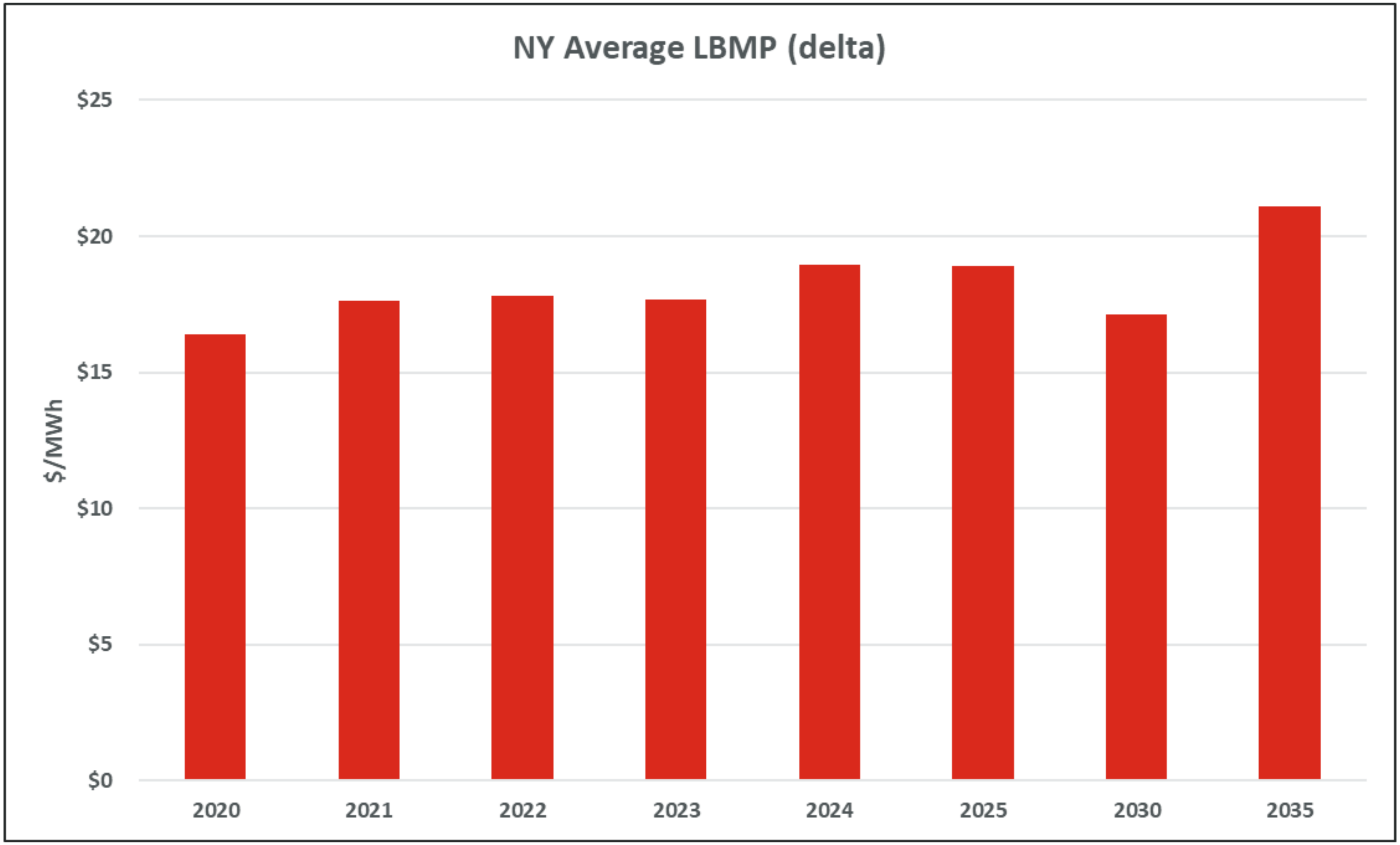
Change in NY CO_2 emissions by Eastern Zones F-K

PRELIMINARY RESULTS



Change in NY average LBMPs

PRELIMINARY RESULTS



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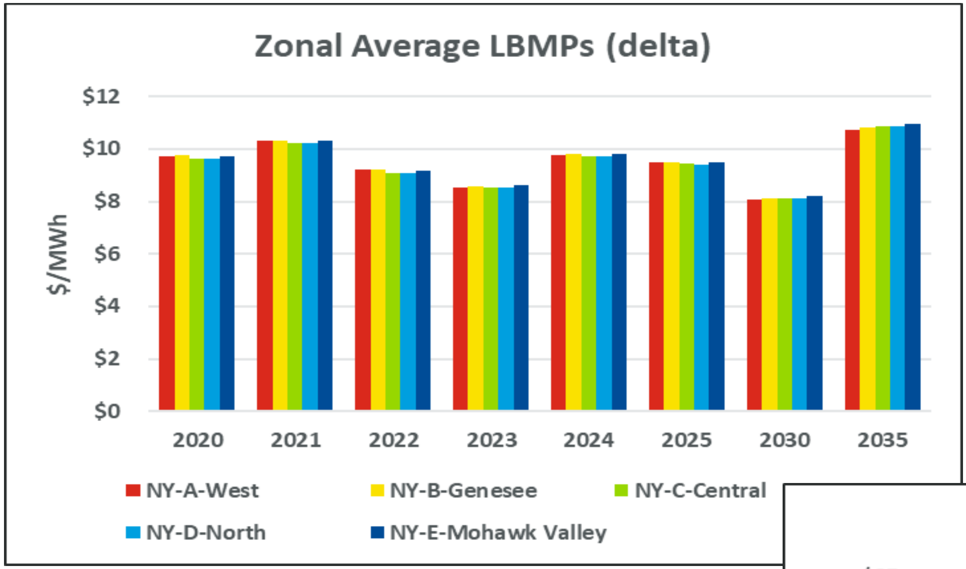
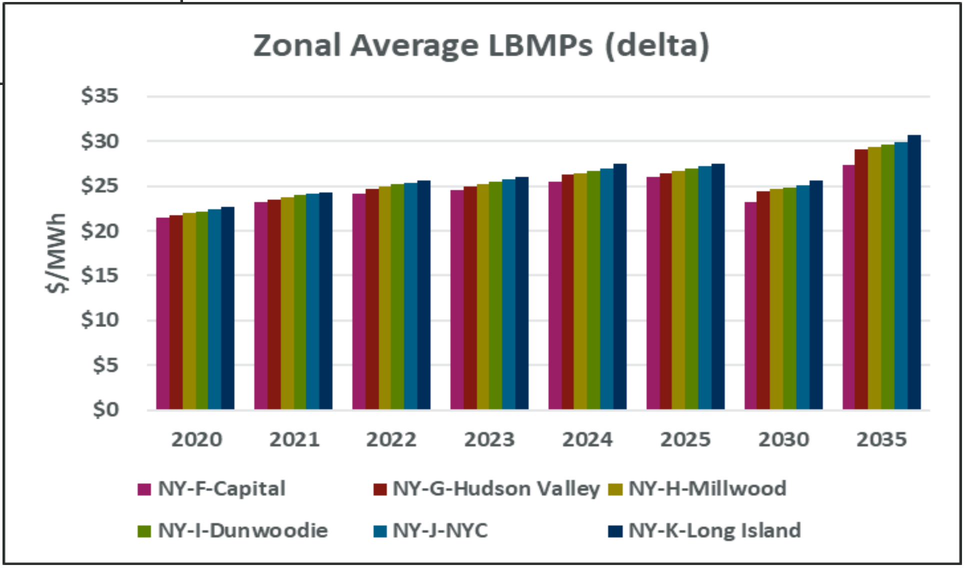
Change in NY Zonal average LBMPs

PRELIMINARY RESULTS

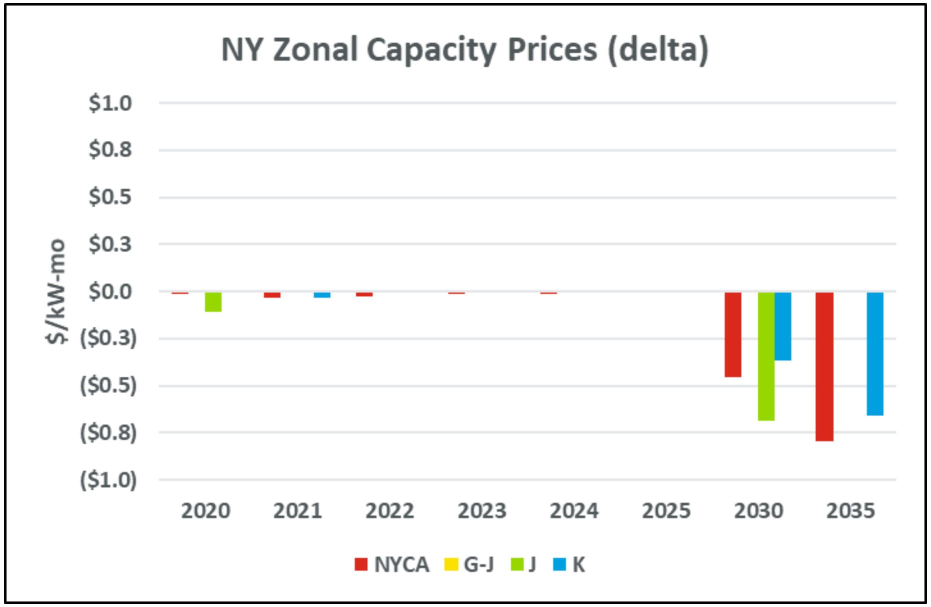


- Incremental average LBMPs in Eastern Zones (F-K) are about $16 higher than Western Zones (A-E) over the study period



Change in Zonal capacity prices

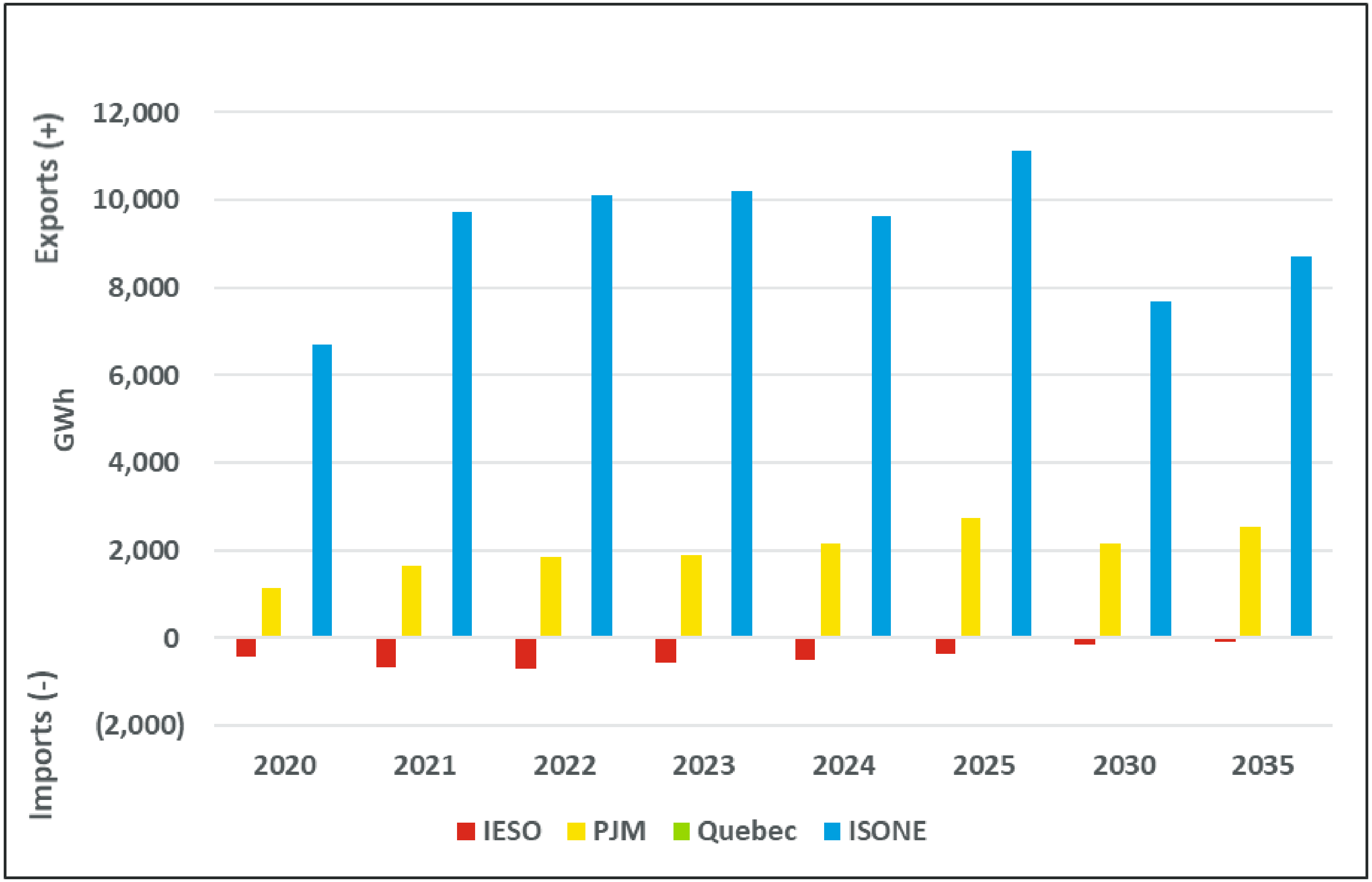
PRELIMINARY RESULTS



- The change in zonal capacity prices for all four regions remain about $0 until 2030
- NYCA and Zone K decrease by about $0.8/kW-mo in 2035

Change in net exports

PRELIMINARY RESULTS



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Change in quantity and location of market-based entry

PRELIMINARY RESULTS

- Due to low capacity prices and large amount of renewables added to the system, it was determined that prices are too low to support new entry within the study period.

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QUESTIONS

Thank you

Let’s continue the conversation

Marc D Montalvo
617-778-2434
mmontalvo@daymarkea.com

Matthew Loiacono
617-778-2466
mloiacono@daymarkea.com

DAYMARKEA.COM