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What Does it Take to Achieve Carbon Neutrality in the Electric Network?

Presented to:

FERC Technical Conference

Hank He

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Agenda

Pursuit of Green Energy and Carbon Neutrality

What it means to be carbon neutral?

Locational Marginal Emission Rate

Definition and computation of LMER

NYISO Case Study

*Modeling nodal LMRE in a NYISO back cast simulation
and study the effectiveness of different decarbonization
strategies*



Pursuit of Carbon Free Electricity and Carbon Neutrality

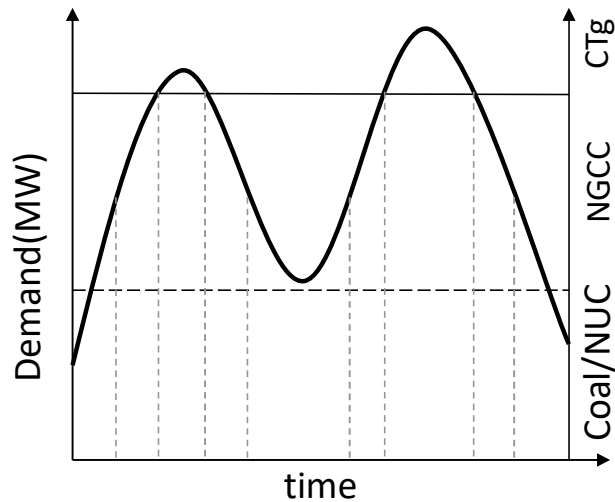
- There has been a growing appetite for 100% carbon free energy in local government and private sector
 - Nine states and more than 100 cities and communities
 - 200+ enterprise energy buyers have engaged in some level of carbon offsetting
- However, a true definition of carbon neutrality has yet to be defined
 - Most popular strategy is to match REC with load either annually or hourly
 - However, that is not true carbon neutrality
- True Carbon Neutrality means 0 net carbon emission



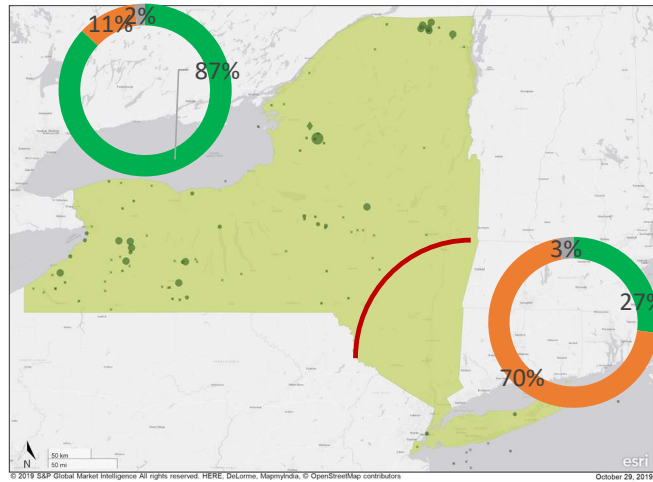
Electrons are not Created Equal (From a Carbon Perspective)

- Factors Impacting Emission Rates

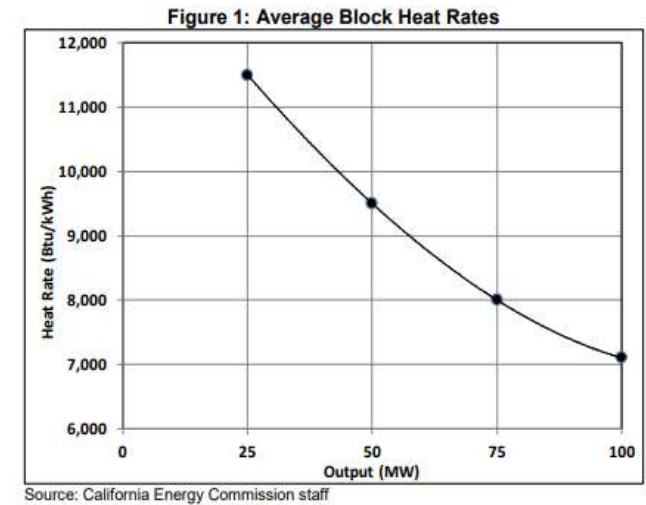
Temporal Impact



Locational Impact



Asset Data Impact



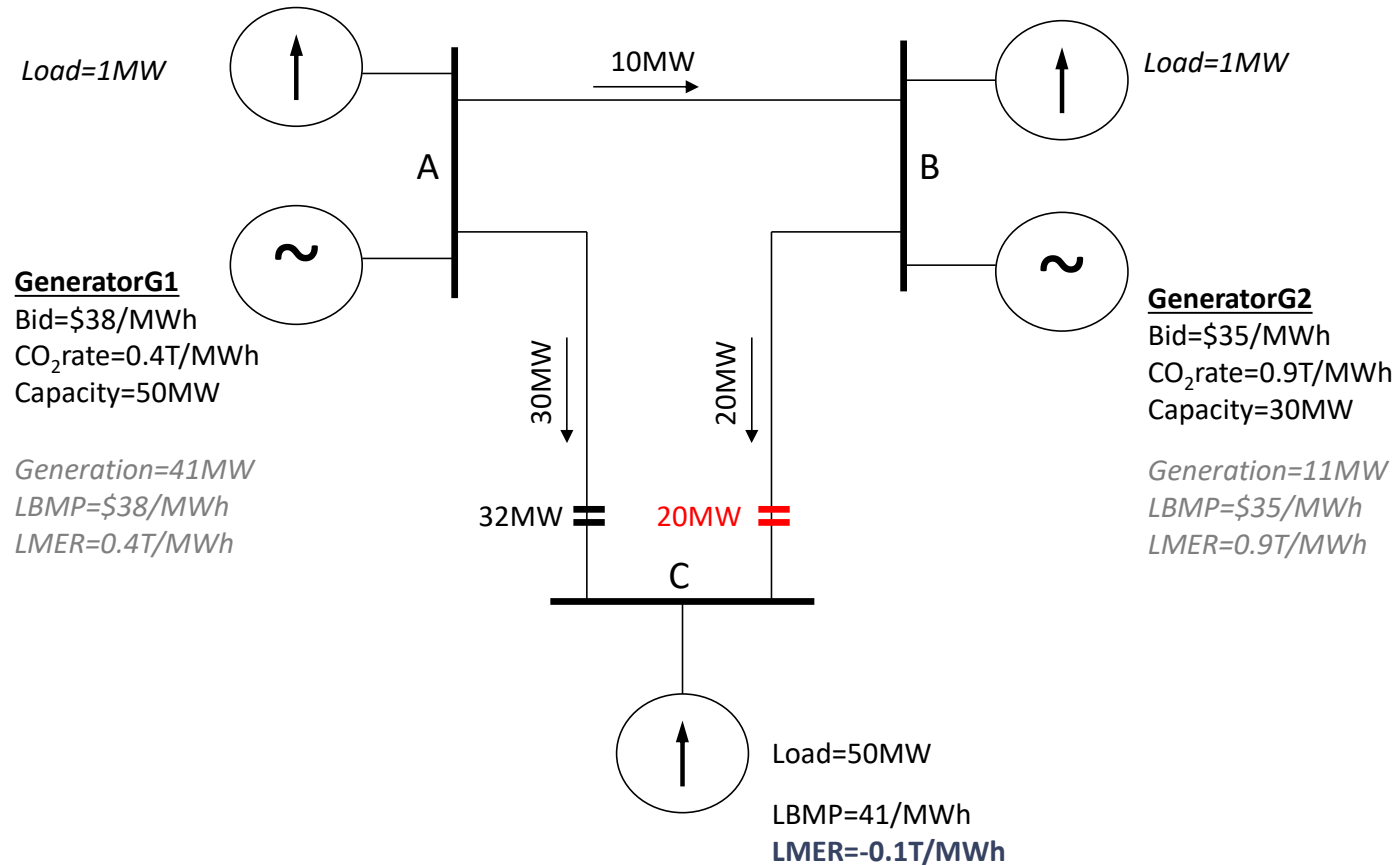
Locational Marginal Emission Rate Definition

$$MER_{node} = \frac{\Delta(CO_2)_{system}}{\Delta(Demand)_{node}}$$

Change in system CO₂ emissions for an incremental MW of load at

1. A given location; and
2. A given time

LMER Can be Determined from Marginal Unit and Binding Constraints



Computation of LMER in a Large System

- The Grid is much more complex than the example:
 - Marginal for energy vs. marginal for reserves
 - Inter-temporal constraints for energy limited hydro and pumped storage
 - Effect of optimized phased shifters
- Nodal LMER can be derived by changing emission price:

LBMP changes in response to small variations in CO₂ Price in proportion to LMER at that location

$$LMER = \frac{\Delta LBMP}{\Delta CO_2 Price}$$

$$LBMP_C = LMER \times CO_2 Price$$



Computational Approach to MER Calculation – an Example

Scenario1:\$0/tonCO₂Price

Scenario2:\$1/tonCO₂Price

GeneratorG1
 Bid=\$38.4/MWh
 CO₂rate=0.4T/MWh
 Capacity=50MW

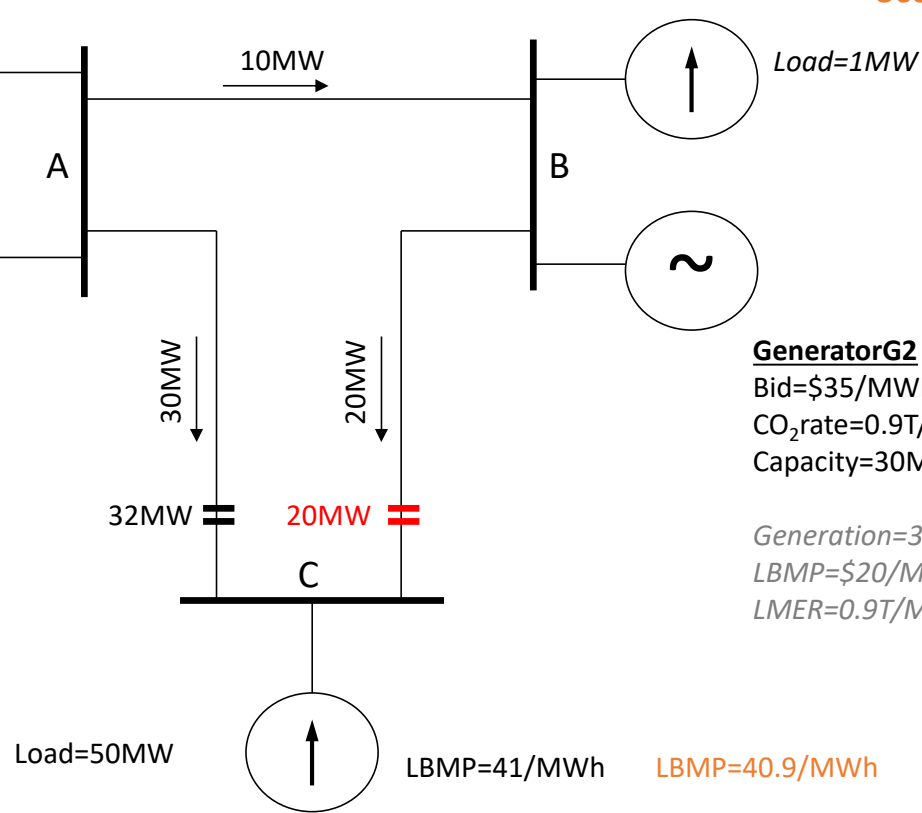
GeneratorG1
 Bid=\$38/MWh
 CO₂rate=0.4T/MWh
 Capacity=50MW

GeneratorG2
 Bid=\$35/MWh
 CO₂rate=0.9T/MWh
 Capacity=30MW

GeneratorG2
 Bid=\$35.9/MWh
 CO₂rate=0.9T/MWh
 Capacity=30MW

Generation=41MW
 LBMP=\$38/MWh
 LMER=0.4T/MWh

Generation=35MW
 LBMP=\$20/MWh
 LMER=0.9T/MWh



$$LMER = \frac{(40.9 - 41) \frac{\$}{MWh}}{(1 - 0) \frac{\$}{ton}} = -0.1 \text{ ton/MWh}$$



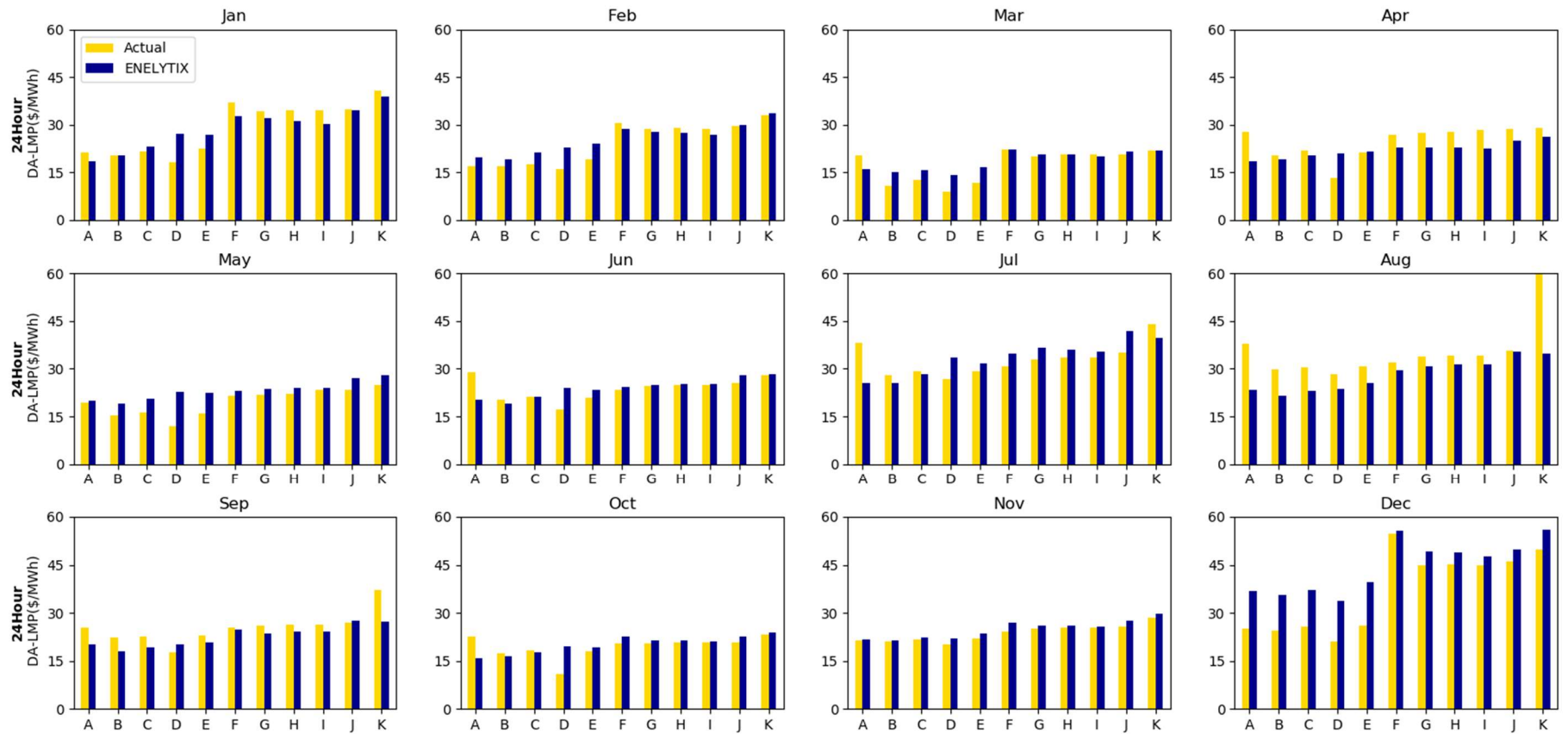
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A Case Study for NYISO

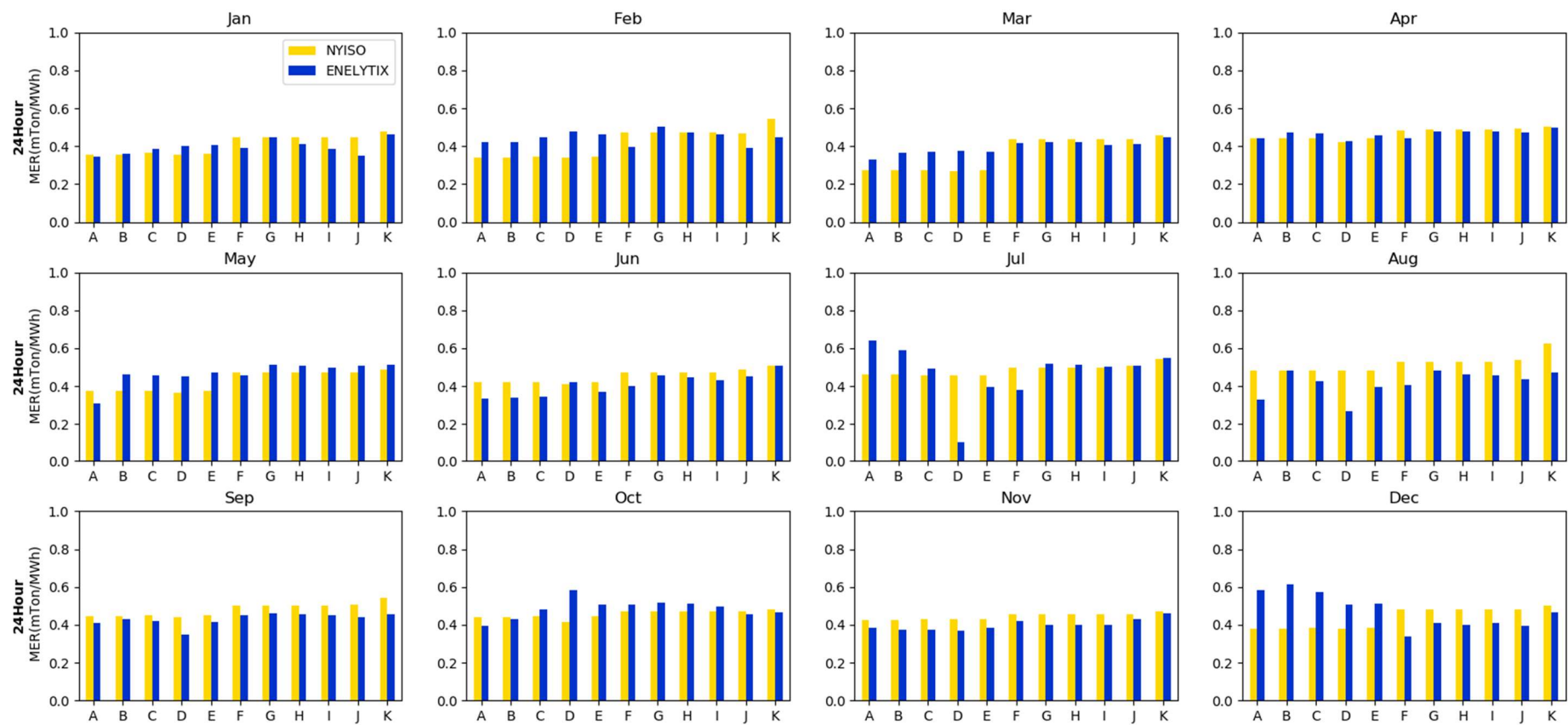
- Start with a NYISO back cast simulation
 - Nodal SCUC and SCED model
 - Historic NYISO data
- Examine net carbon footprint of a small load under different decarbonization strategies
 - A hypothetical load in N.Y.C following zonal shape (8.76GWh/year)



Model was Calibrated with Historic Zonal Prices



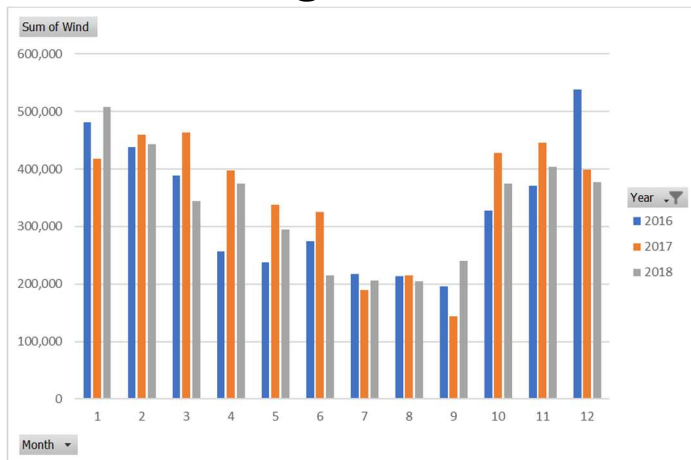
LMER Benchmarked Against NYISO Study for 2016



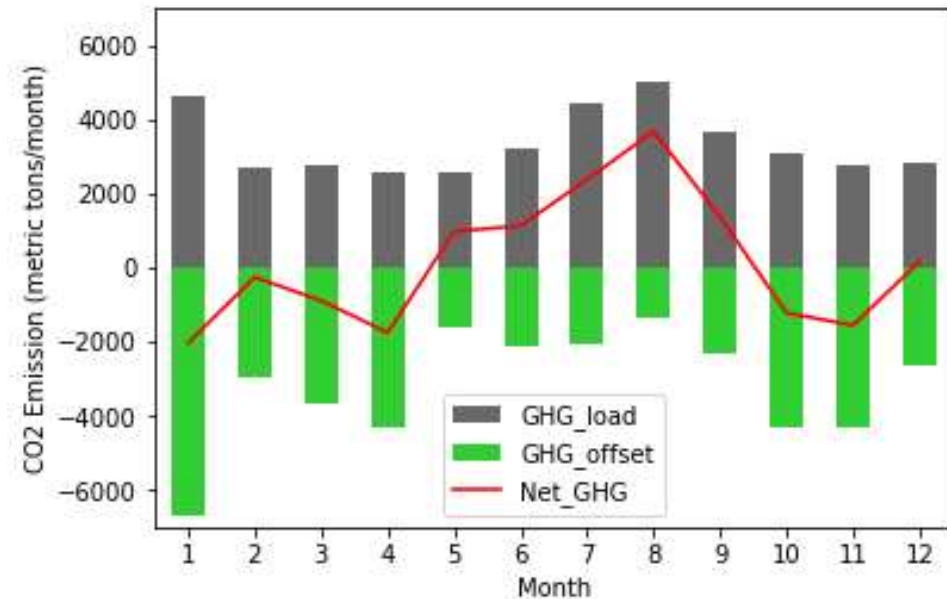
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Annual MWh Matching Strategy Still Leaves a Large GHG Footprint

- Results:
 - Net emission: 2,045 ton/year
 - Balanced by a large wind plant in upstate
- Wind production is low in the summer when LMER is high and load is high

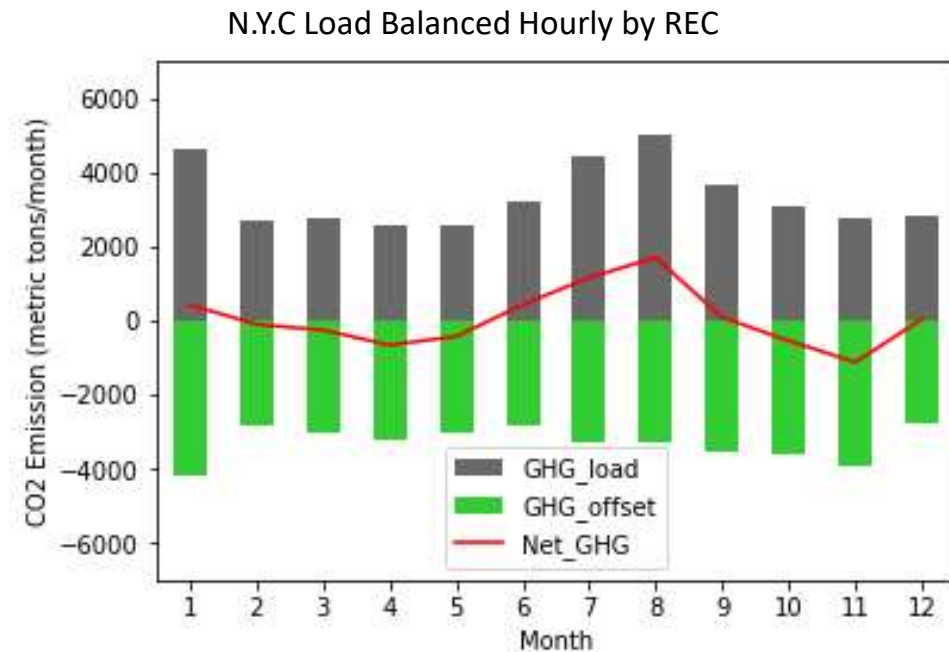


N.Y.C Load Balanced by Annual REC



Hourly Matching is not Cost Effective

- Results:
 - Net emission: 787 ton/year
 - Hourly balance could not be achieved even with all NYISO wind and PV plants
 - Total wind generation was less than 10 MW for more than 200 hours in 2018(NYISO)
- Net positive carbon driven by locational difference in LMER
 - Upstate resource vs. N.Y.C load

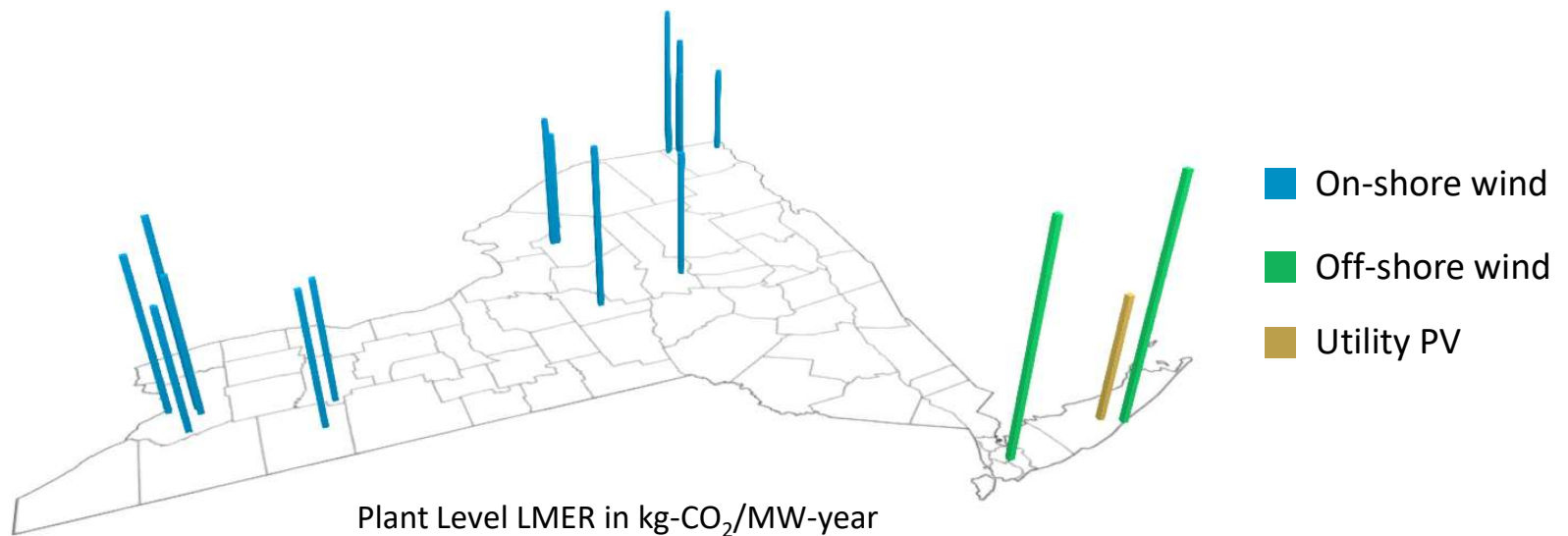


Use LMER to Achieve True Carbon Neutrality

- Nodal LMER allows us to measure how much energy is needed to offset the load's carbon footprint
 - 87,600 MWh/year
 - 40,334 tons-CO₂/year

Power Plant	Type	Plant Capacity	Plant Carbon Offset (tons/year)	Plant MW Required to Neutralize Load
Long Island Solar Farm	Utility PV	31.5	28,539	NA
Moses Niagara (Fleet)	Hydro	2860	6,979,103	16.5
St Lawrence - FDR (Fleet)	Hydro	1088	3,212,120	13.7
Maple Ridge Wind 1	Wind	231	246,489	37.8
Marble River Wind	Wind	215.5	225,332	38.5
Wethersfield Wind Power	Wind	126	126,473	40.2

LMER Enables a Wide Range of Carbon Management Options



- By quantifying carbon intensity of load and generators on a nodal basis, LMRE enables a wider range of decarbonization strategy that is efficient both economically and operationally:
 - Carbon offset in other emission areas (i.e. Transportation, heating etc.)
 - Use LMER to quantify carbon offset capability of transmission projects



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