MMU Review of 2023-2042 System & Resource Outlook

Presented by:

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Introduction

- The Tariff requires that a copy of the Outlook study be provided to the MMU for its review and consideration.
- The MMU performed an analysis of data from the 2023-2042 Outlook study
  - ✓ Our review focuses on NYISO market incentives in the scenarios modeled in the Outlook study. It will also suggest improvements to certain Outlook models and processes.
- This presentation provides a brief overview of our review.
  - ✓ Our full review including results and methodology can be found as an appendix to this presentation.

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Evaluating Curtailment and Investment Incentives

- The Outlook report provides for each scenario:
  - ✓ Total curtailment of renewables; and
  - ✓ Average curtailment rates.
- We use LBMP data from the Outlook MAPS cases to evaluate:
  - ✓ Market incentives for various clean technologies in a high-renewable system;
  - ✓ Market risks to project owners participating in NYISO markets with state contracts;
  - ✓ Opportunities for battery storage to support renewable integration;
  - ✓ Comparative marginal cost of supplying clean energy from alternative projects.

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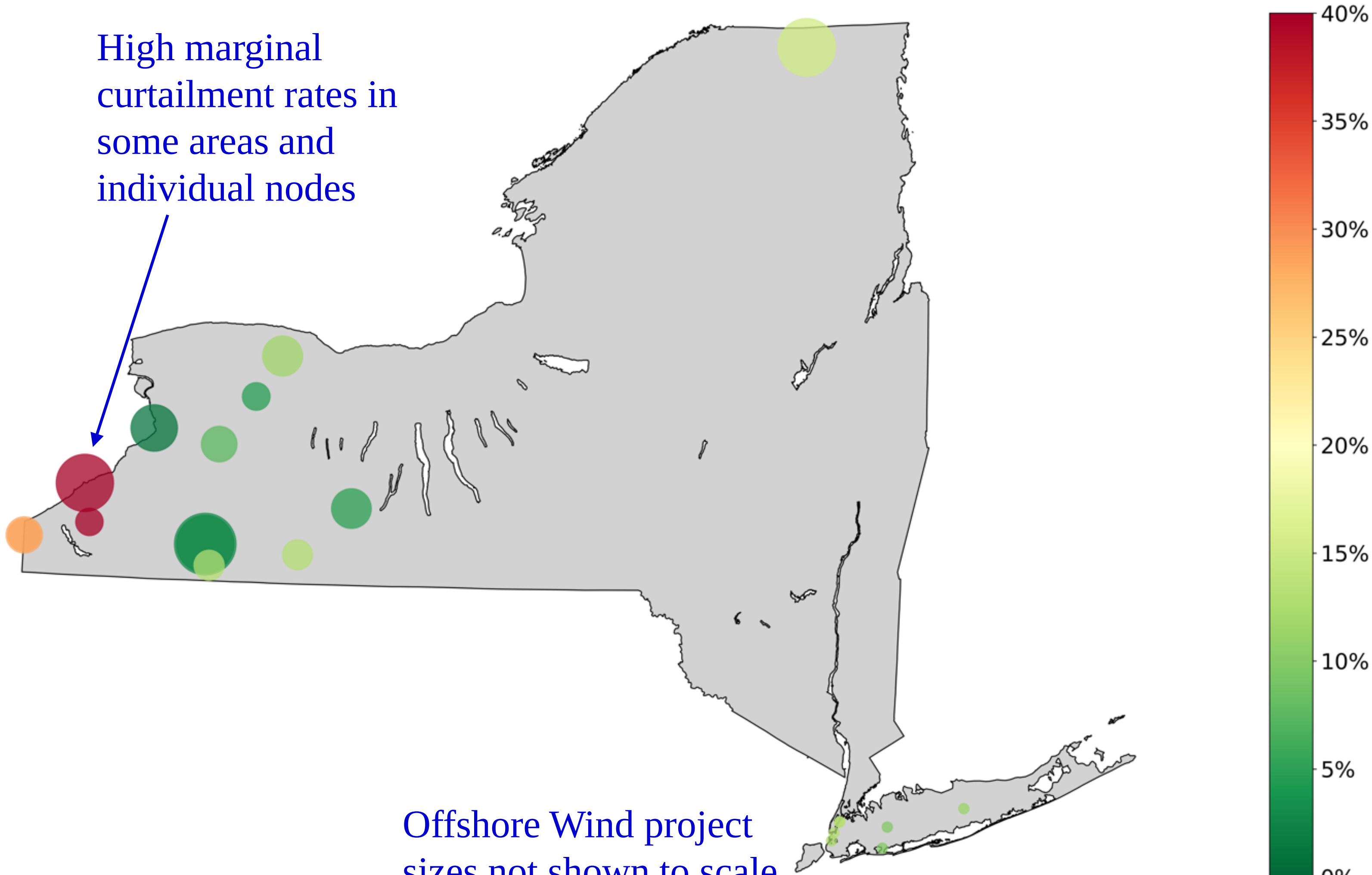
MMU Metrics for Analyzing Curtailment and Investment Incentives

- We evaluate Outlook model results using these metrics:
  - ✓ *Marginal Curtailment Rate* – Share of an incremental renewable unit's generation that would result in curtailment;
  - ✓ *Technology and Nodal Discount* – Difference between zonal average LBMP and generation-weighted zonal or nodal averages;
  - ✓ *Renewable Deliverability Improvement* – Number of MWh of curtailment avoided per MW of additional storage per year;
  - ✓ *Implied Net REC Cost* – The net cost of incremental renewable energy deliveries from an investment in generation, storage, or transmission.

See full review in Appendix for details and results by case

Marginal Curtailment Rate
Policy Low Case 2035 - Wind



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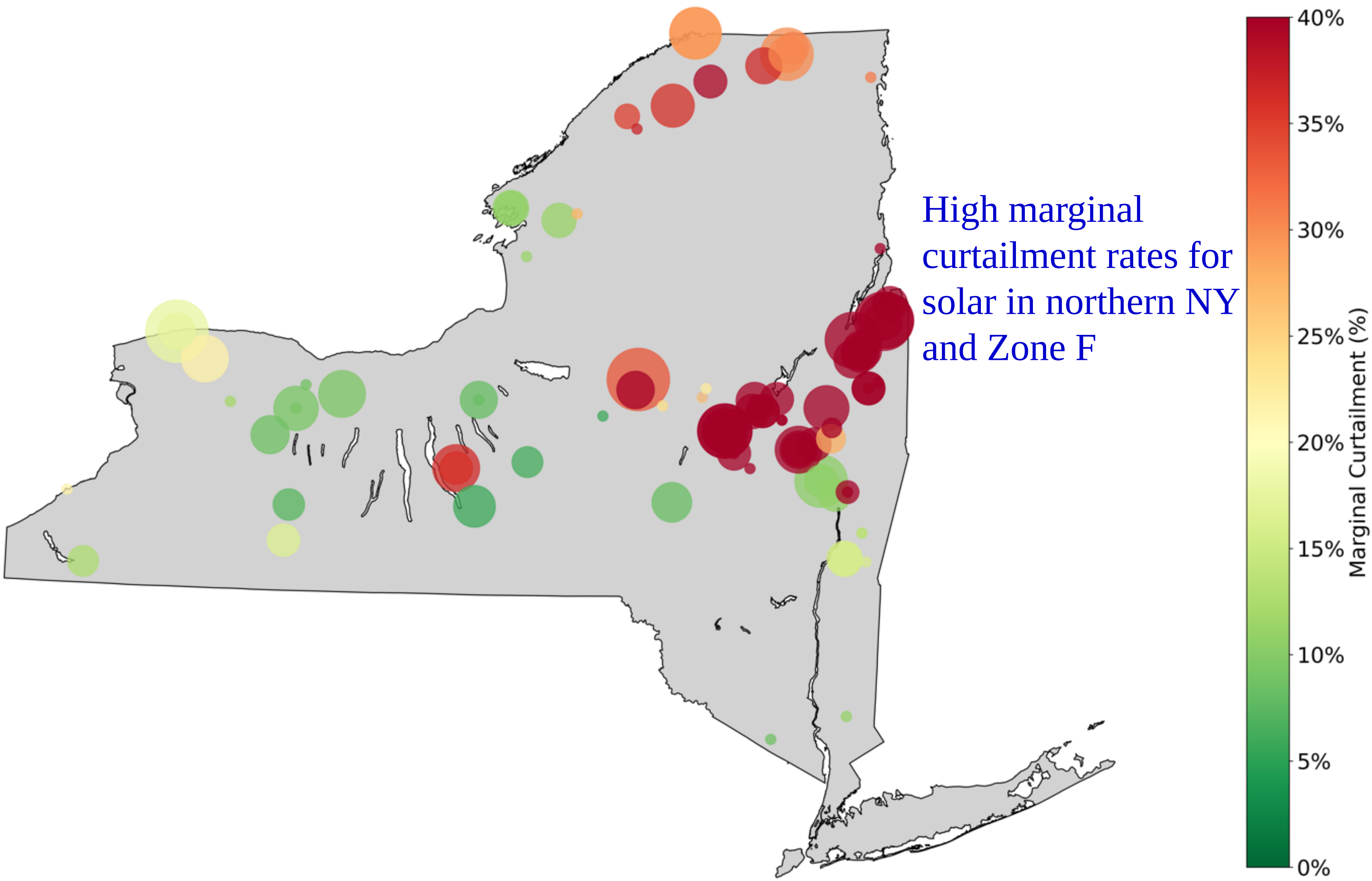
Marginal Curtailment Rate
Policy High Case 2035 – Solar PV



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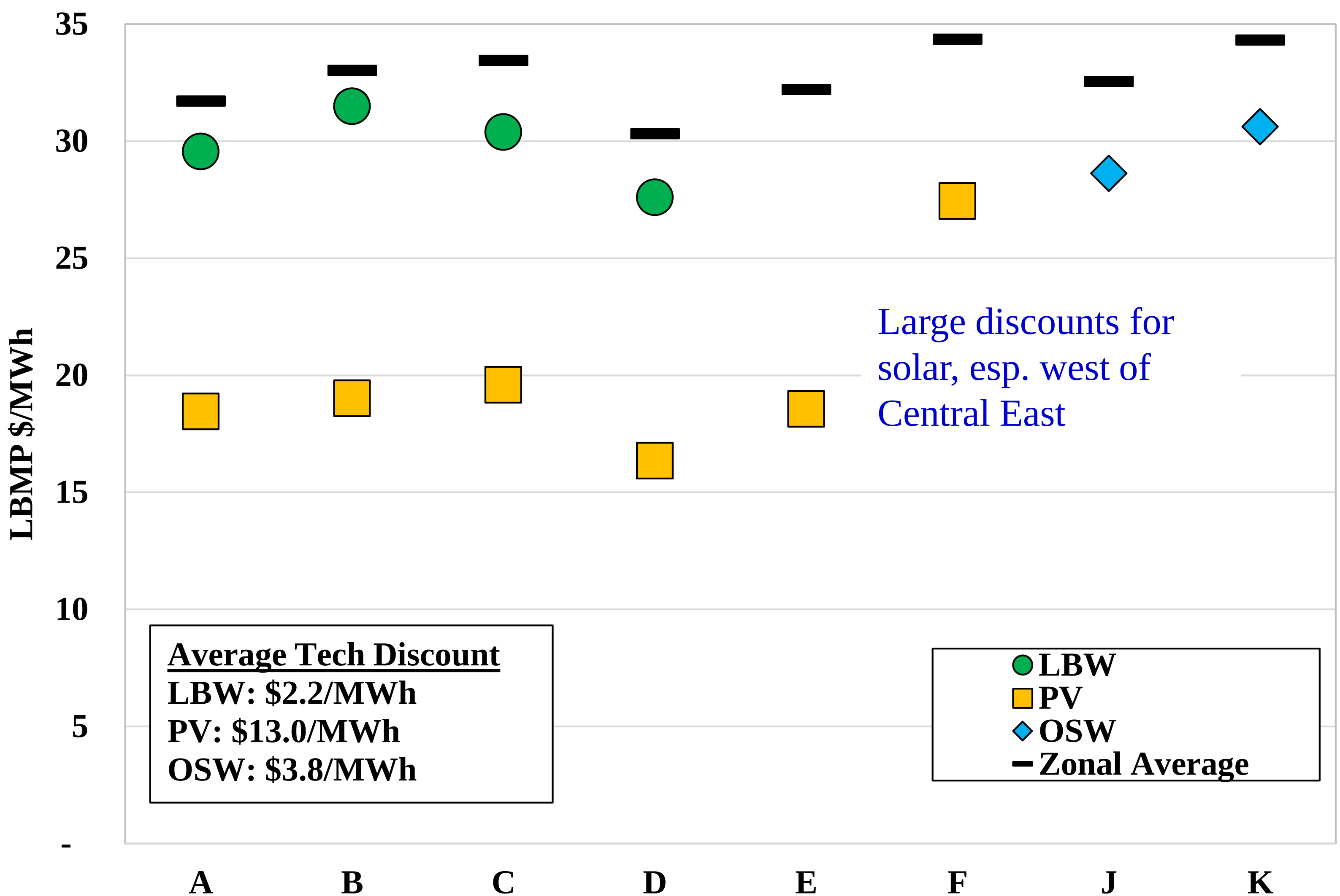
Technology Discounts
Policy Low Case 2035

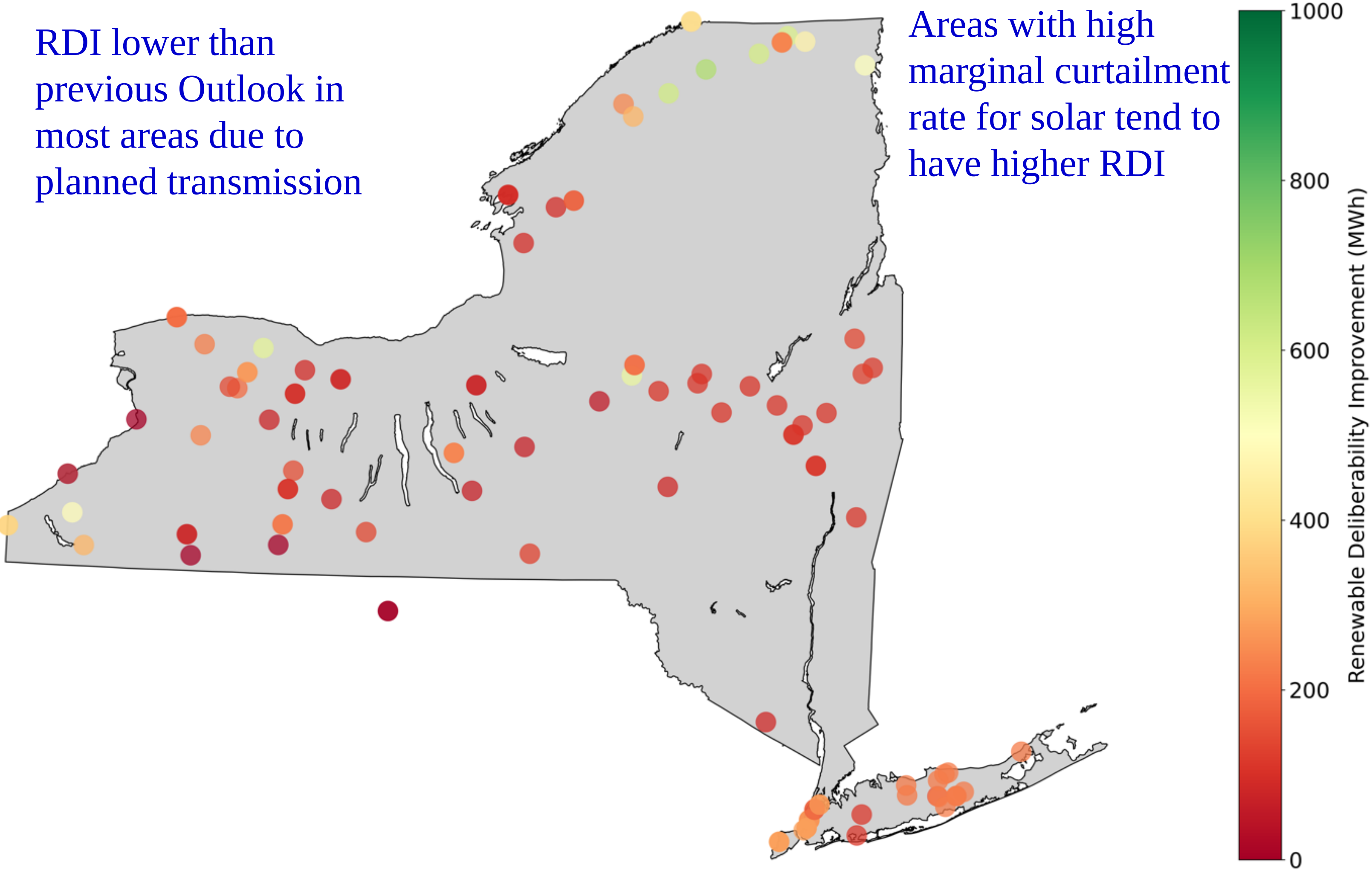


See full review in Appendix for details and results by case

Renewable Deliverability Improvement (RDI)
Policy Low Case 2035 – 4 Hour Battery

RDI lower than previous Outlook in most areas due to planned transmission

Areas with high marginal curtailment rate for solar tend to have higher RDI



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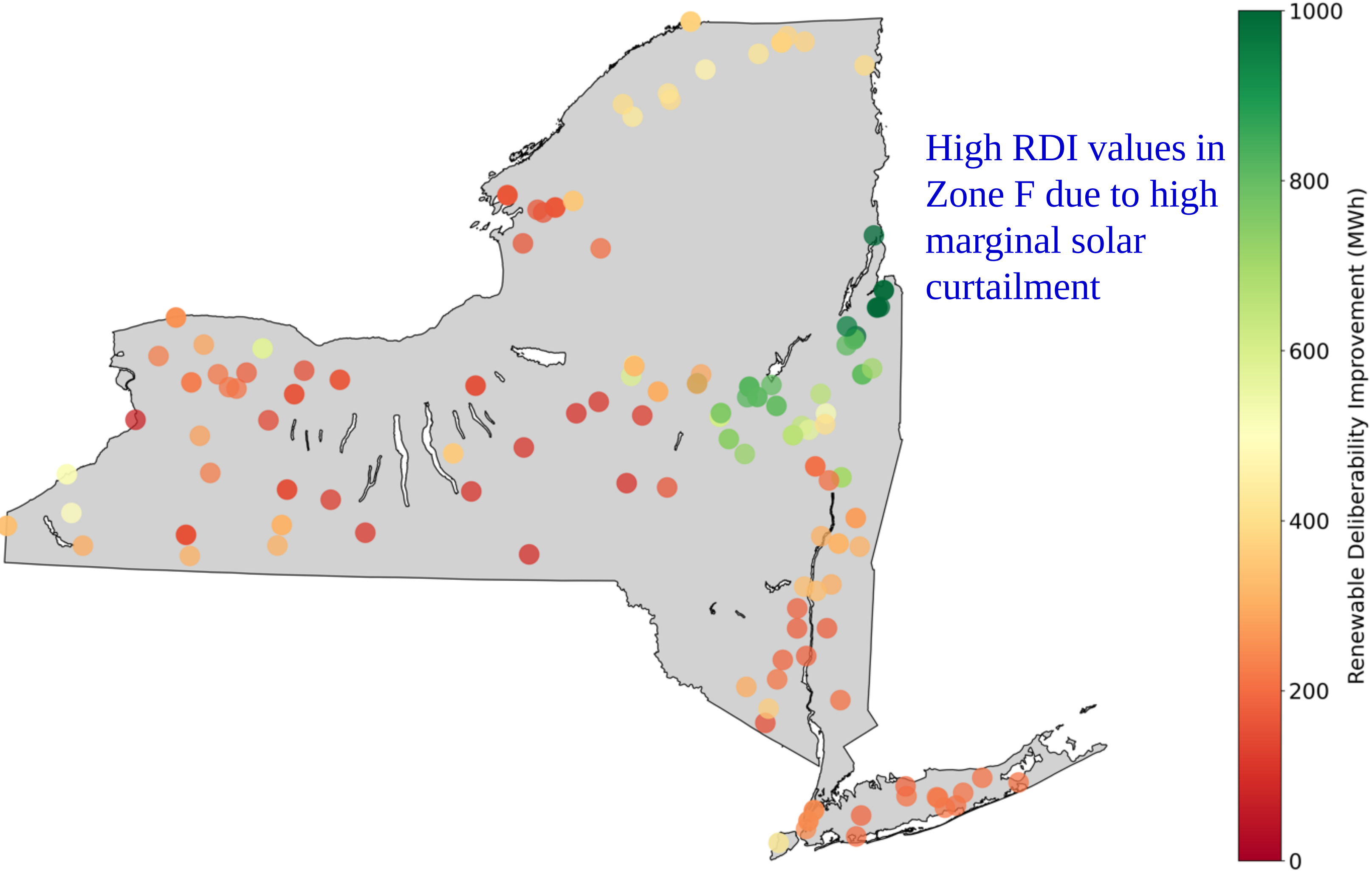
Renewable Deliverability Improvement (RDI)
Policy High Case 2035 – 4 Hour Battery



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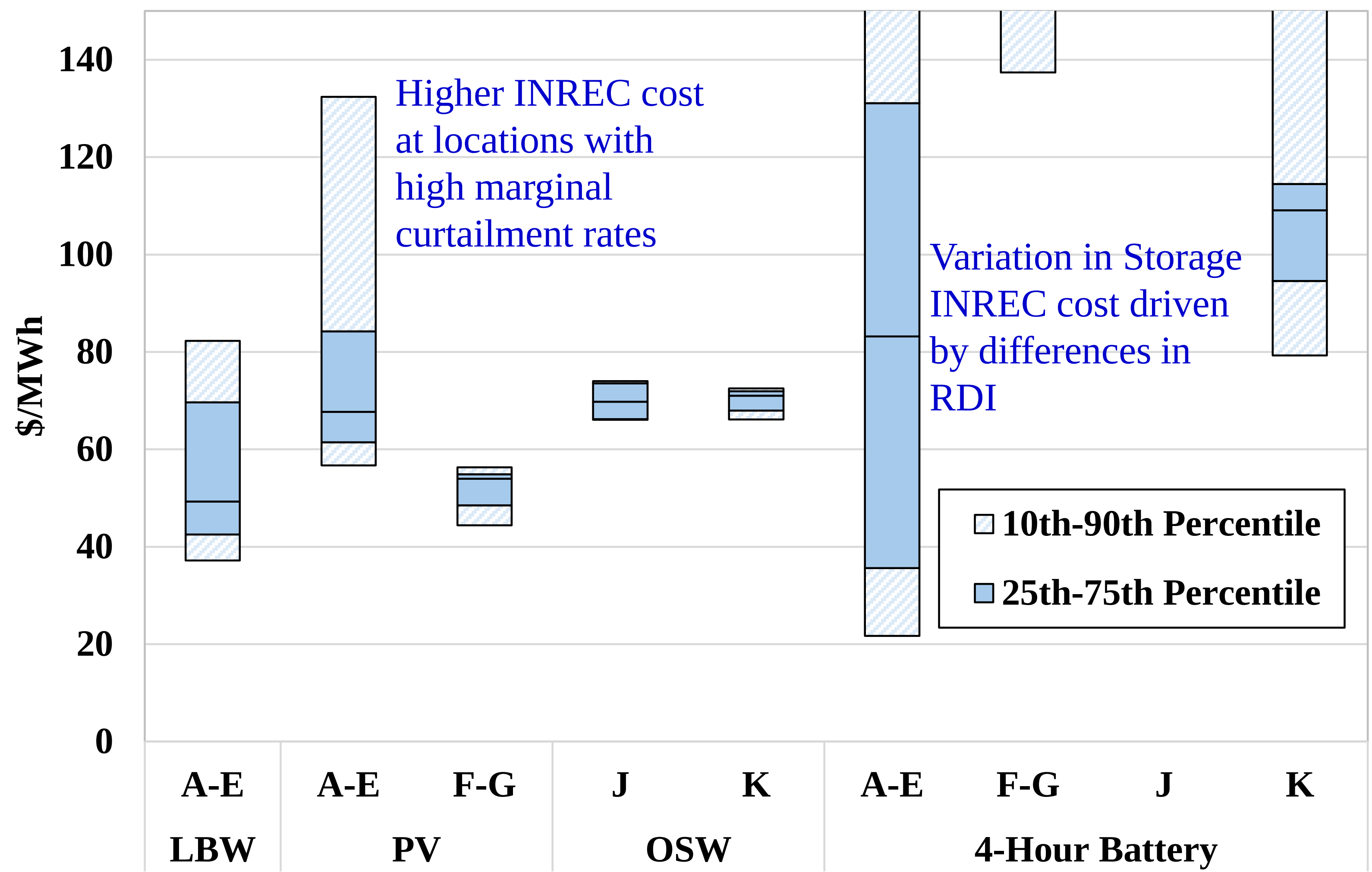
Implied Net REC Cost
Policy Low Case 2035



Conclusions

- Marginal curtailment rates are high near localized constraints.
  - ✓ Market signals discourage investing at these locations without transmission upgrades.
- Technology discounts large for solar projects due to saturation.
  - ✓ High risk of earning below Index REC strike price for solar.
  - ✓ This saturation leads some storage projects to be economic.
- Storage RDI values are mostly low, except in Policy High case.
  - ✓ Opportunities for storage to improve deliverability in previous Outlook have been reduced by planned transmission.
- Implied Net REC costs of storage are competitive with renewables at some locations by 2035.
  - ✓ Storage is generally less economic than in the previous Outlook because of local transmission & distribution upgrades.

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Key Recommendations

- *P22-2:* Perform ‘optimized’ production cost run relocating resources placed at locations with high marginal curtailment if possible
- *P22-1:* Model procurement of ancillary services in production cost models, considering how future needs will be driven by resource mix changes
- Improve capacity expansion model to account for:
  - ✓ *P23-1:* Emergence of cross-state transmission bottlenecks not captured by current process to derive LCR assumptions based on TSL approach
  - ✓ *P24-1:* Emergence of winter reliability needs driven by fuel unavailability

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Analysis of Curtailment and Net Revenues

- The Outlook report provides information on total curtailment of renewables and average curtailment rates in each scenario.
- Analysis of LBMP data from the Outlook MAPS cases can also shed light on the following:
  - ✓ Market incentives for various clean technologies in a high-renewable system;
  - ✓ Market risks to project owners participating in NYISO markets with state contracts;
  - ✓ Opportunities for battery storage to support renewable integration;
  - ✓ Comparative marginal cost of supplying clean energy from alternative projects.

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Analysis of Curtailment and Net Revenues

The following slides discuss and present results for each of the following at various locations:

- *Marginal Curtailment Rate* – percentage of an incremental renewable unit's generation that would result in curtailment;
- *Technology* and *Nodal Discount* – difference between zonal average LBMP and generation-weighted zonal or nodal averages;
- *Renewable Deliverability Improvement* – amount of MWh that an additional MW of storage would save from being curtailed annually;
- *Implied Net REC Cost* – The net cost of incremental renewable energy deliveries from an investment in generation, storage, or transmission.

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Marginal Curtailment Rate

Definition:

- Percentage of output from an incremental MW of a renewable resource that would be curtailed or cause other renewable resources to be curtailed.
- Calculated as the percentage of the resource's annual potential generation (based on modeled capacity factor profile) that occurs in hours with LBMP of $0 or negative.
- For example, output occurring in hour where LBMP is negative $20 and the resource offers negative $40 counts as marginal curtailment even though the resource is not curtailed, because it causes curtailment of another negatively priced resource.

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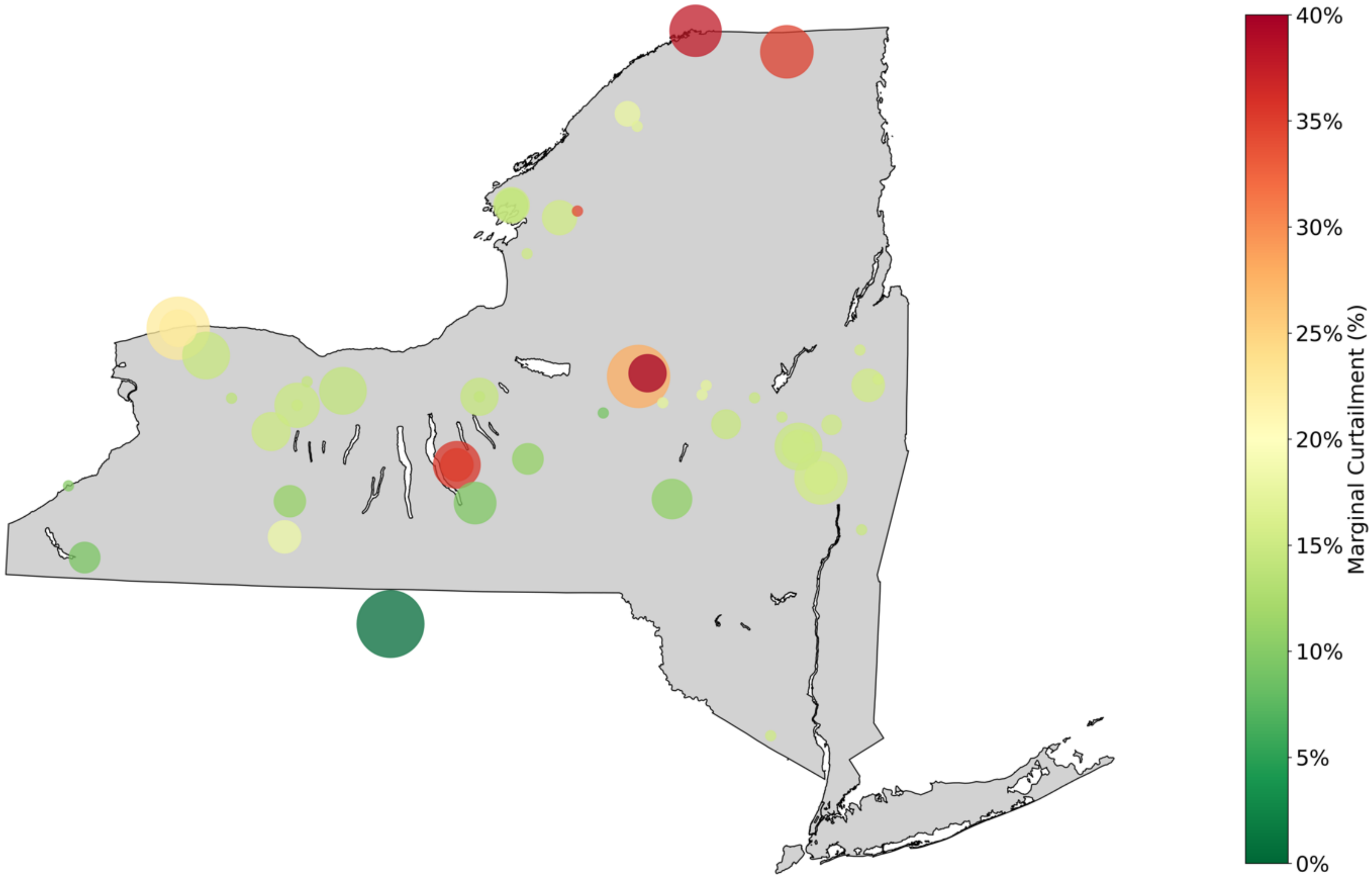
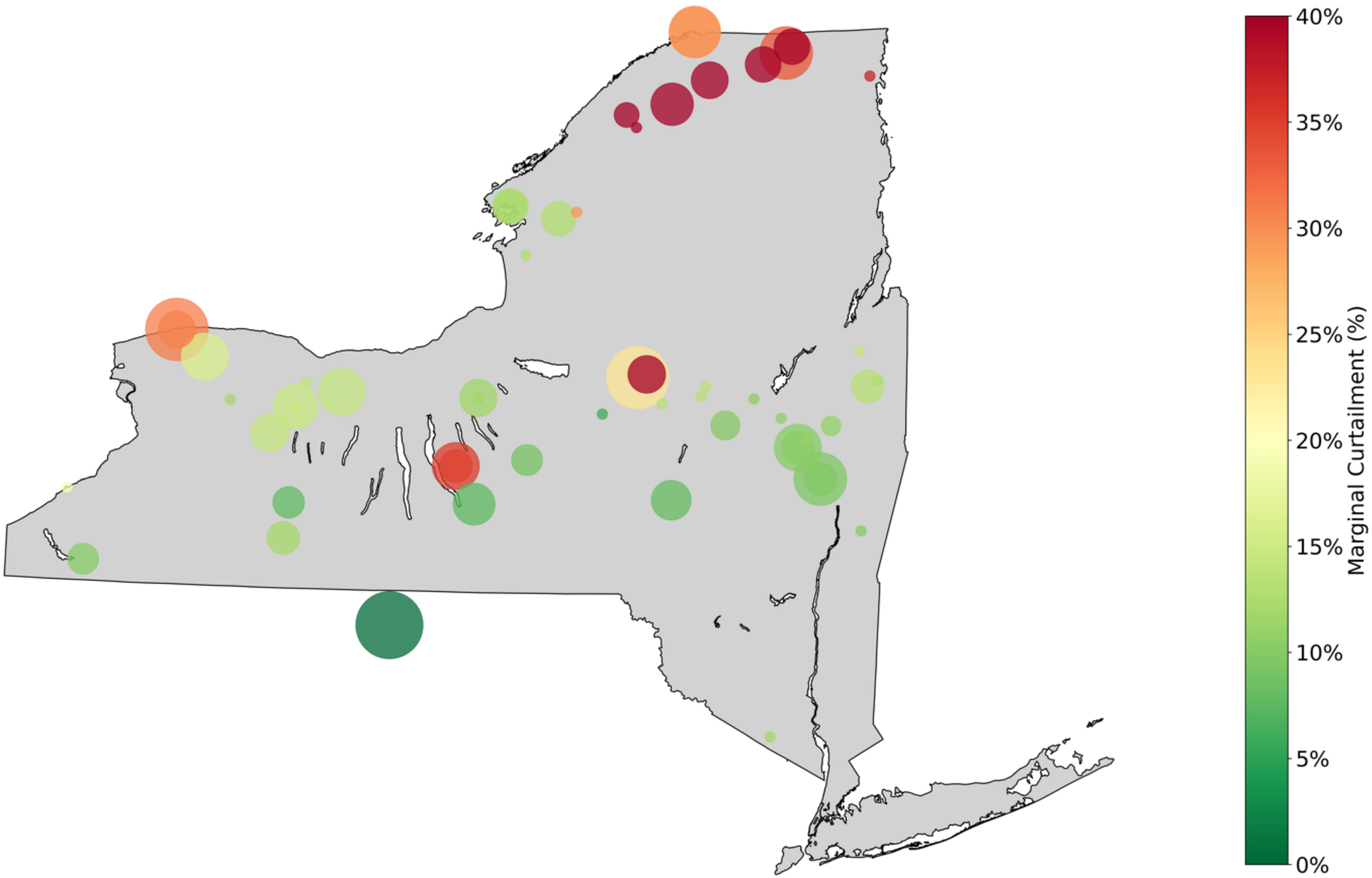
Marginal Curtailment Rate Overview

- The following slides show results for each case by technology:
  - ✓ All locations at which capacity of solar (UPV), land-based wind, and offshore wind are shown
  - ✓ Bubble sizes indicate amount of capacity added at location
  - ✓ Offshore wind bubbles are not shown to scale
- Conclusions:
  - ✓ In the Contract and Policy Low cases, solar projects face marginal curtailment rates above 10% at most locations
  - ✓ In some cases, high curtailment rates occur when excess capacity is sited at particular nodes (often on 115 kV system)
  - ✓ Solar in Northern NY and wind at some locations in Western NY have higher marginal curtailment rates
  - ✓ Overbuilt solar on 115 kV system in Zone F in Policy High case results in very high marginal curtailment rates

Marginal Curtailment Rate
Contract Case 2030 – UPV

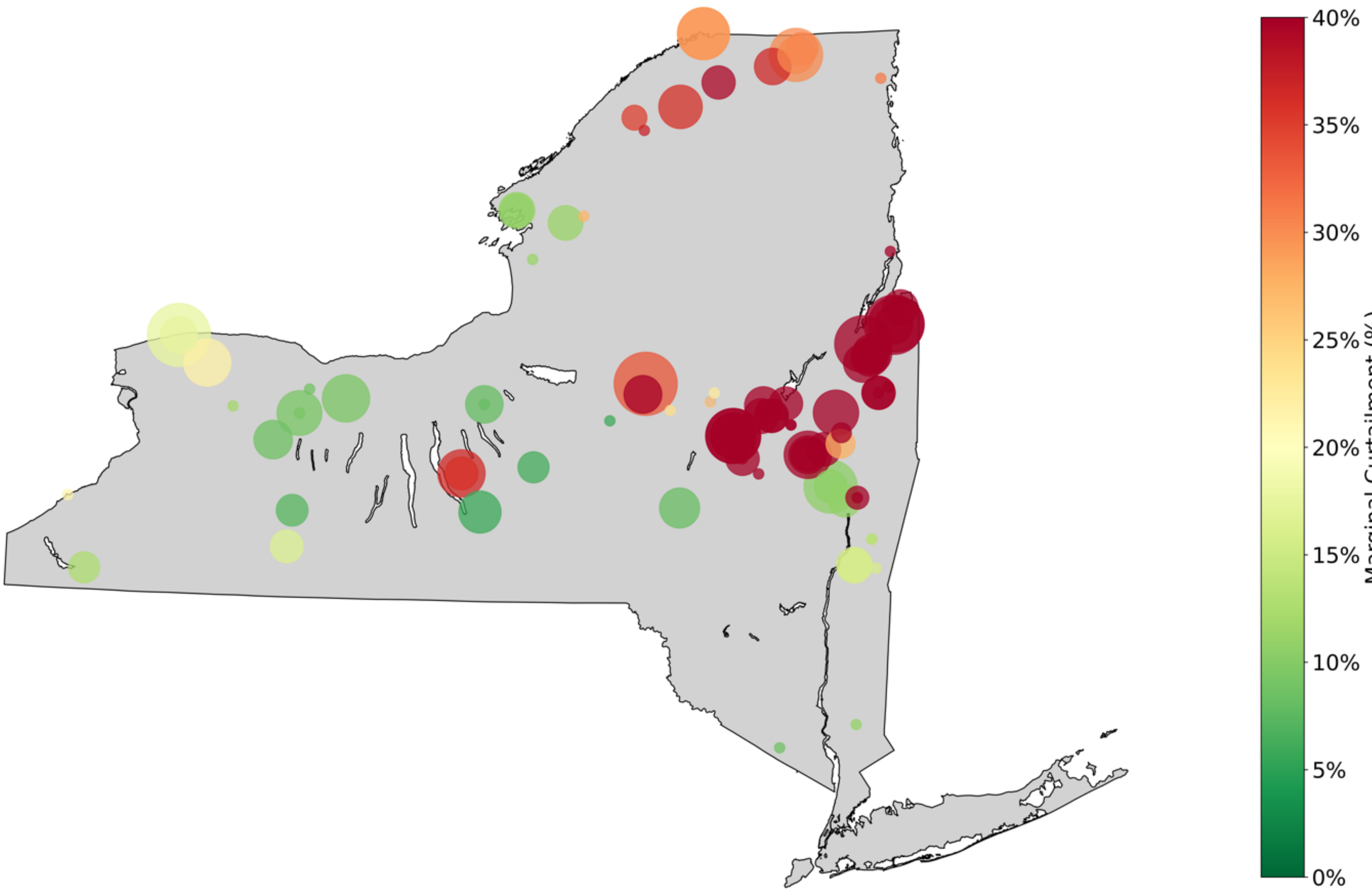


Marginal Curtailment Rate
Policy Low Case 2035 - UPV

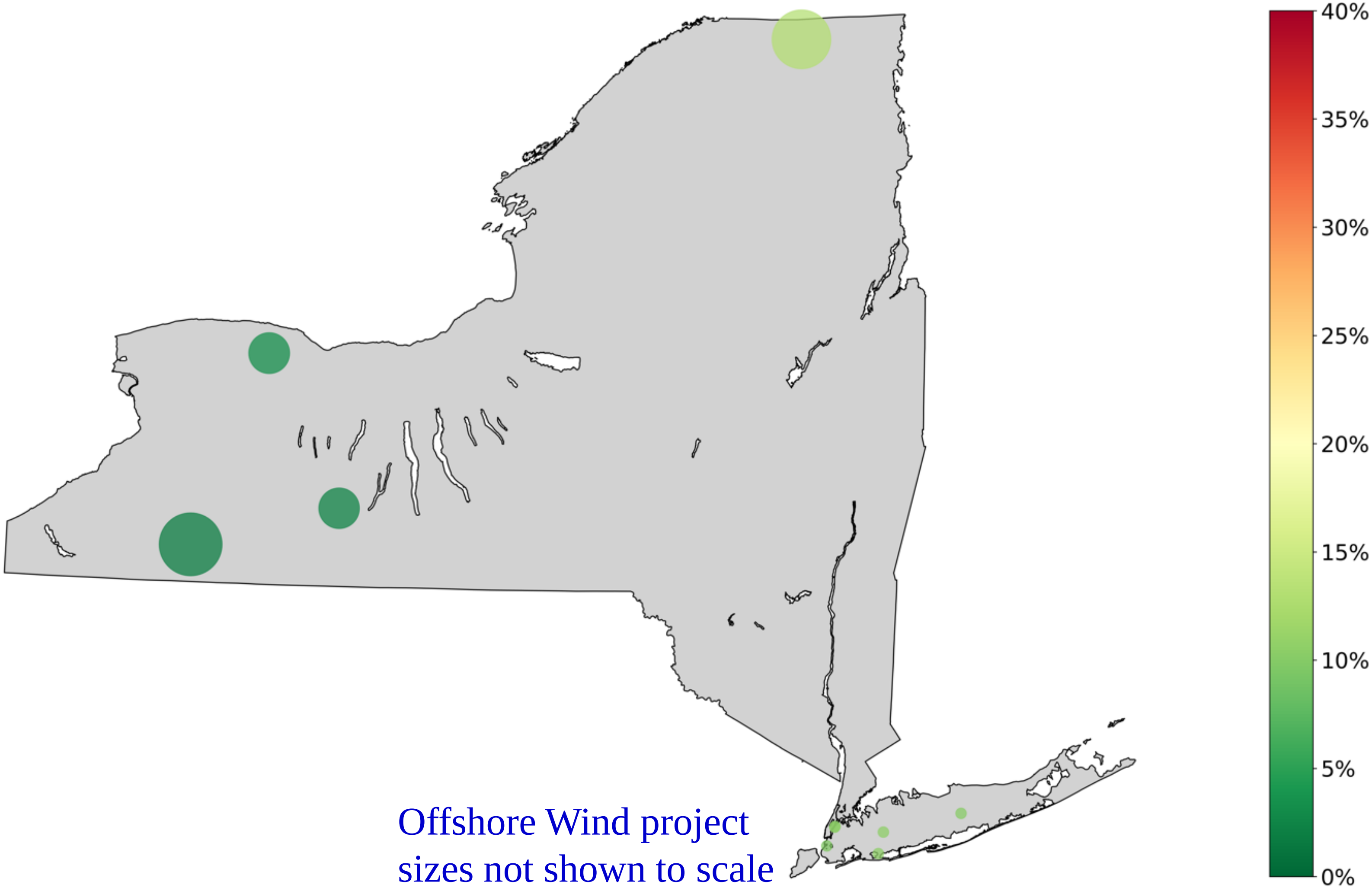


Marginal Curtailment Rate

Policy High Case 2035 - UPV

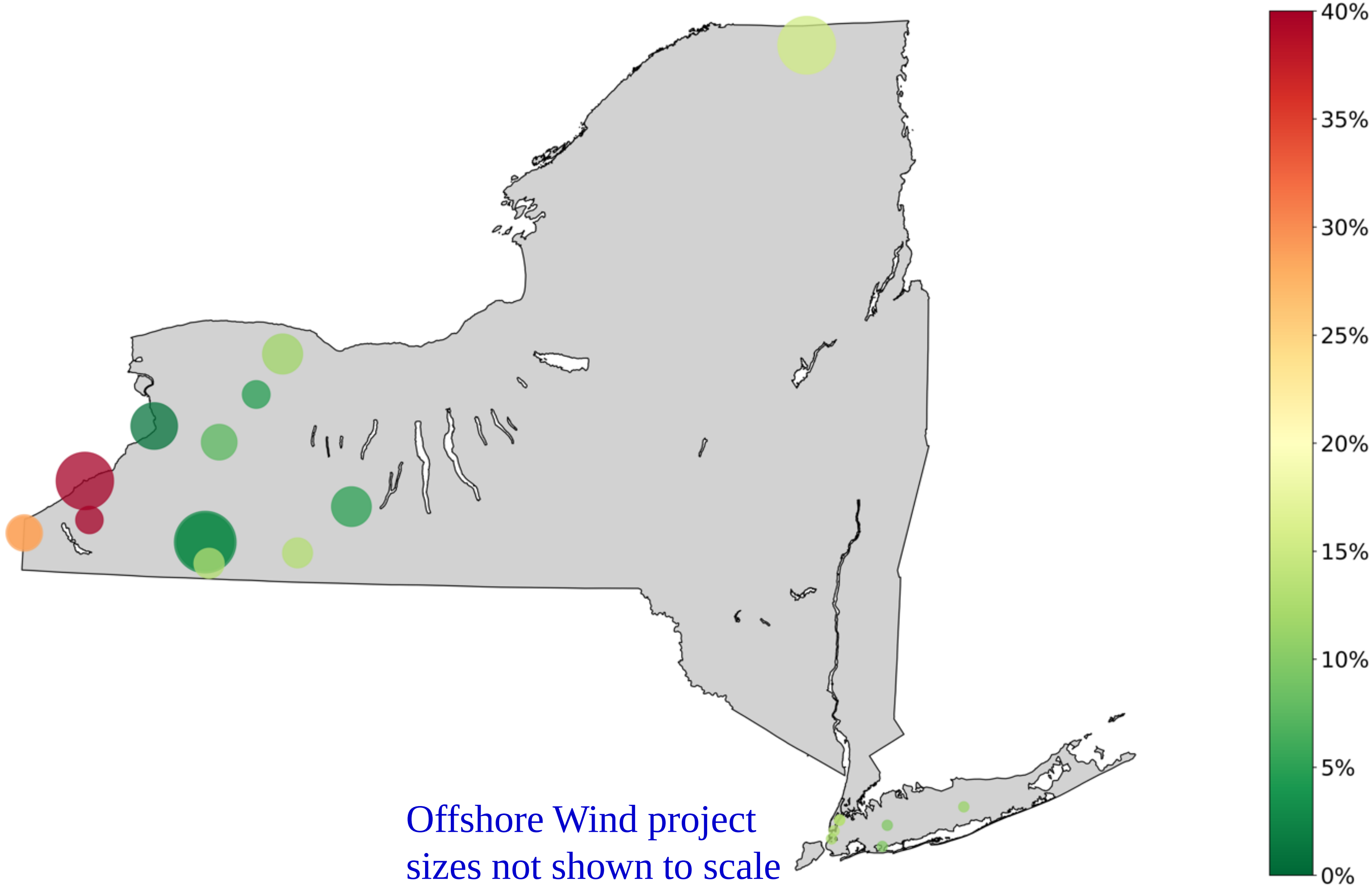


Marginal Curtailment Rate
Contract Case 2030 - Wind

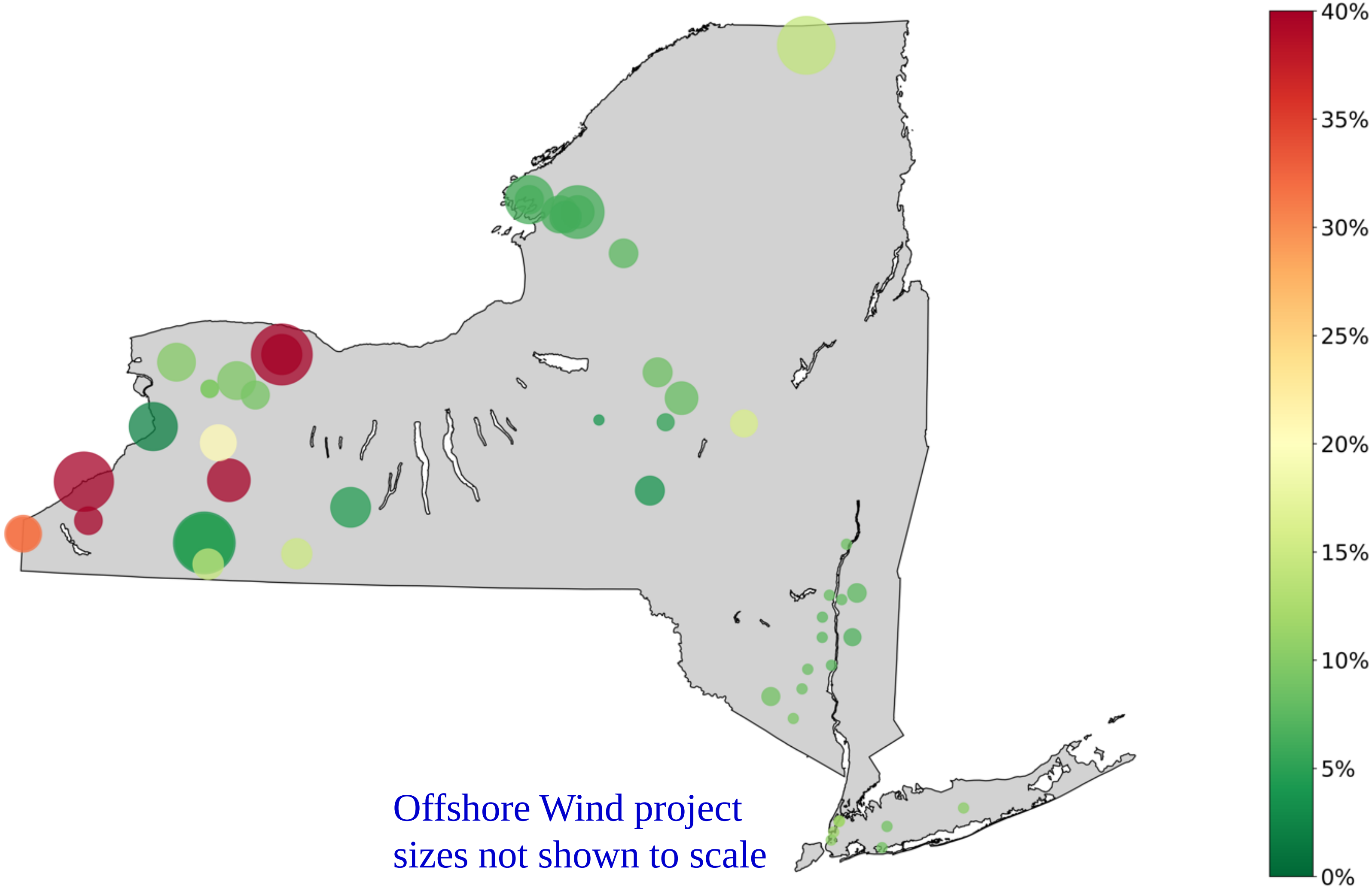


Offshore Wind project
sizes not shown to scale

Marginal Curtailment Rate
Policy Low Case 2035 - Wind



Marginal Curtailment Rate
Policy High Case 2035 - Wind



Offshore Wind project sizes not shown to scale

Renewable Deliverability Improvement (RDI)

Definition:

- Annual MWh of renewable generation that an incremental MW of battery storage capacity would prevent from being curtailed.
- Calculated using a model that optimally charges/discharges battery based on LBMP.
- RDI is the number of hour pairs where a 1 MW battery charges during LBMP of $0 or negative and discharges during hours with positive LBMP.

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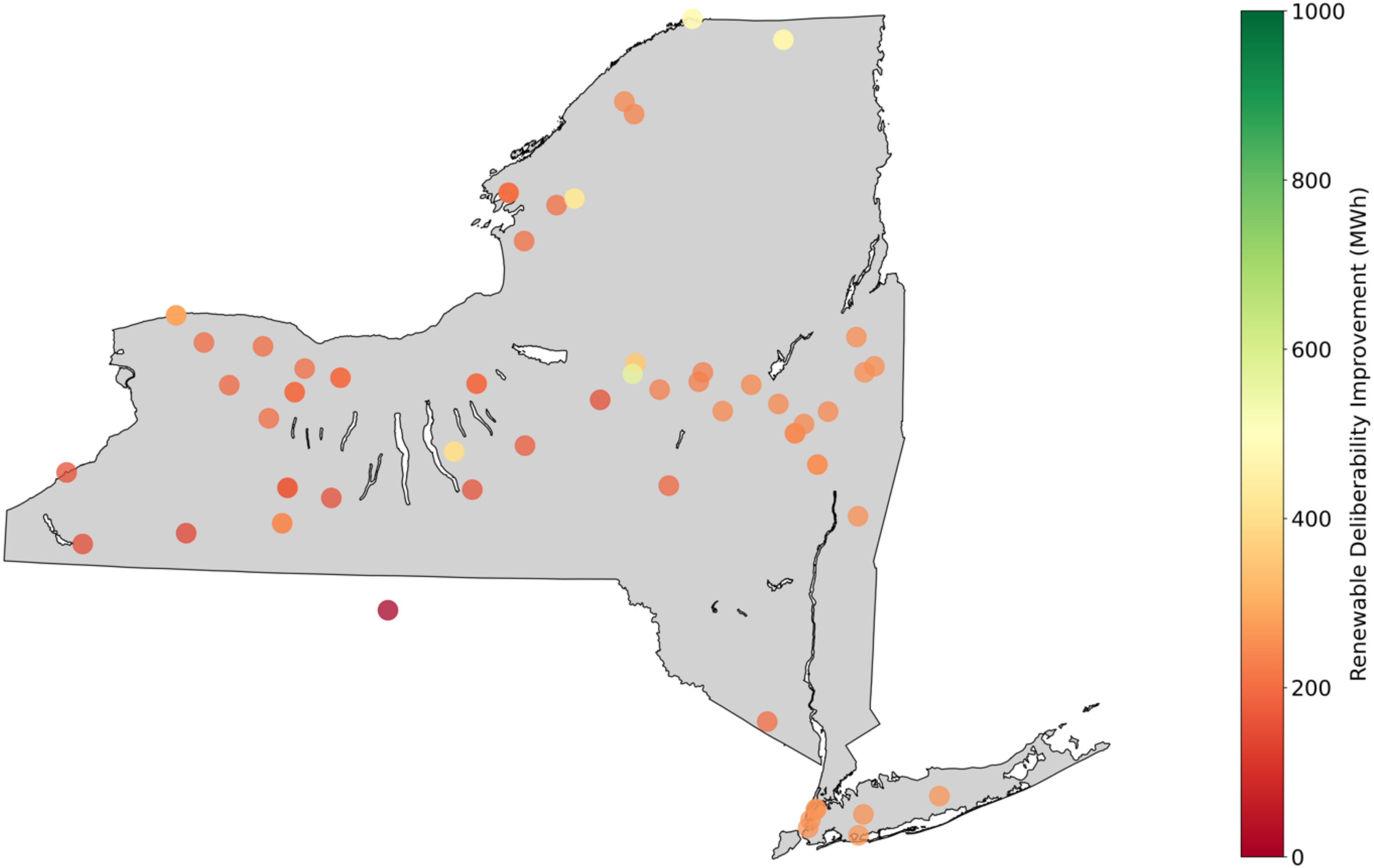
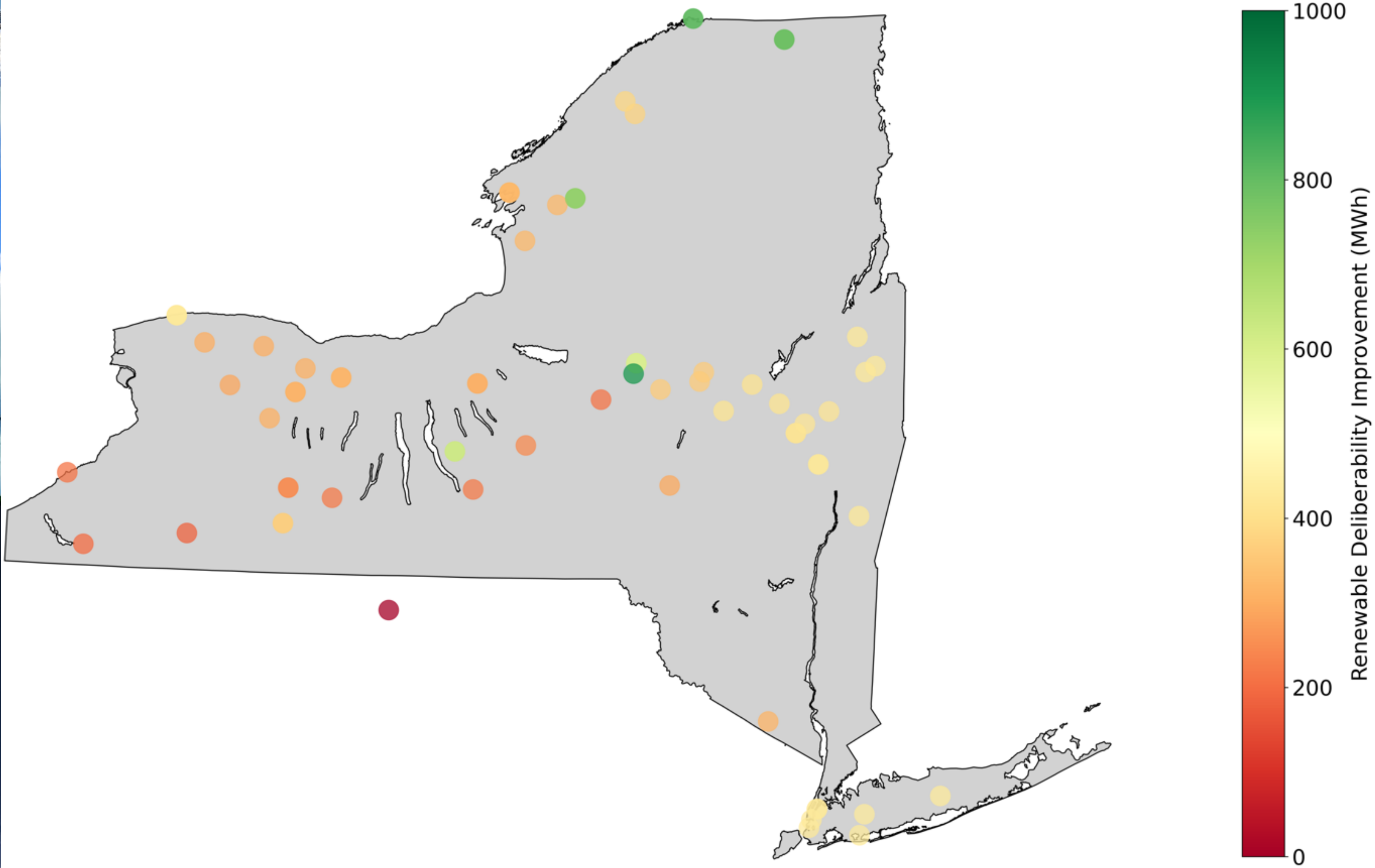
Renewable Deliverability Improvement (RDI) Overview

- The following slides show RDI results for each case at all locations with renewable or storage projects in the Outlook study. Conclusions:
  - ✓ RDI is relatively low in most cases/locations.
    - For reference, a 4-hour battery that charges to reduce curtailment for a full 4-hour cycle each day would have RDI of 1,460 MWh.
    - The 4-hour RDI was <400 MWh at most locations across cases.
    - RDI values were very high in Zone F in Policy High case due to high marginal curtailment of overbuilt solar capacity
  - ✓ Much of the curtailment from the previous Outlook study has been reduced by planned transmission → Reduces impact of additional storage on the amount of deliverable clean energy.
  - ✓ Storage projects have higher RDI values in locations with higher marginal solar/wind curtailment rates
  - ✓ The Policy cases include 3 GW of storage per state law – our results suggest that the last unit has low RDI

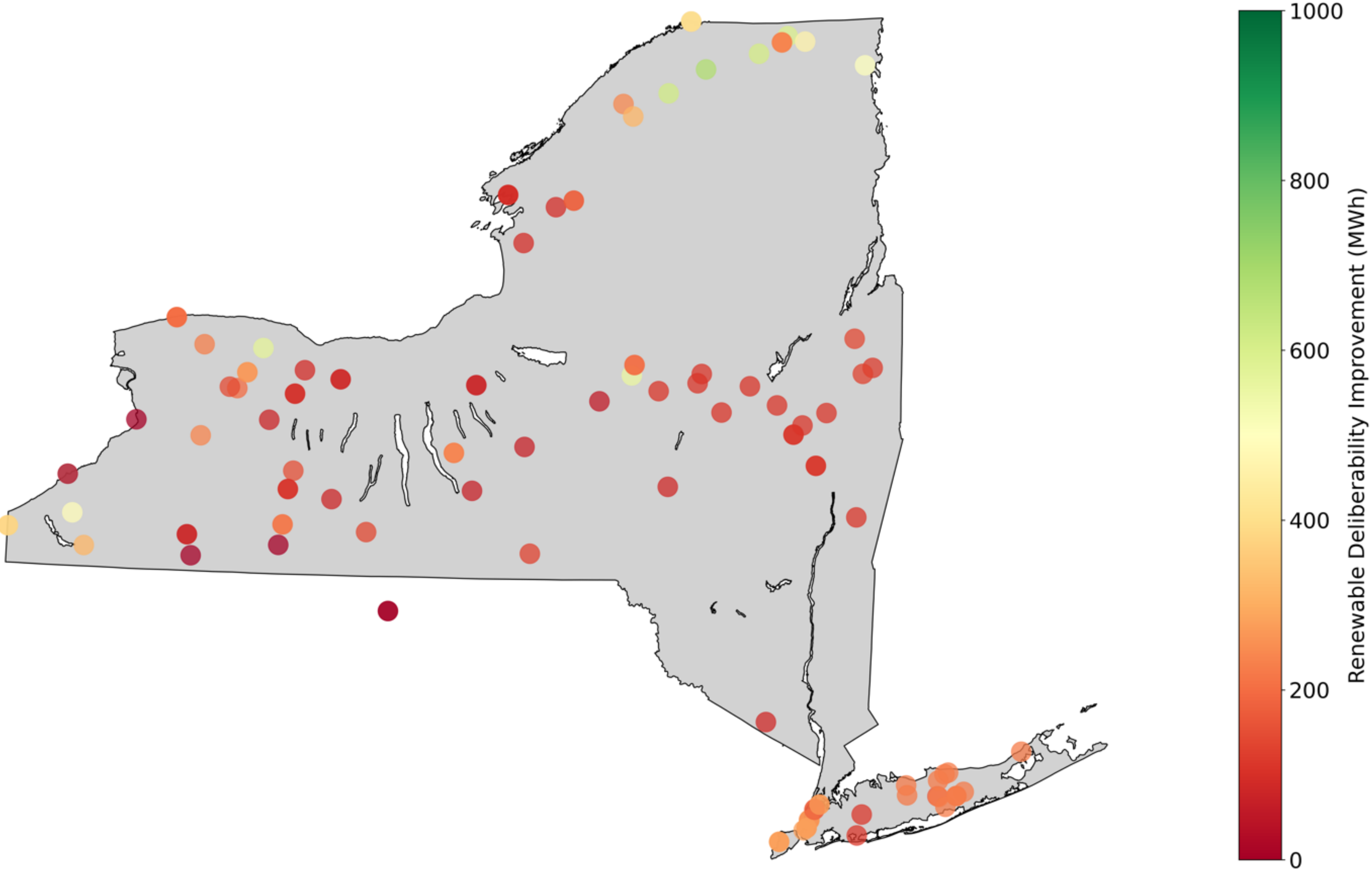
Renewable Deliverability Improvement (RDI)
Contract Case 2030 – 4 Hour Battery



Renewable Deliverability Improvement (RDI)
Contract Case 2030 – 8 Hour Battery



Renewable Deliverability Improvement (RDI)
Policy Low Case 2035 – 4 Hour Battery



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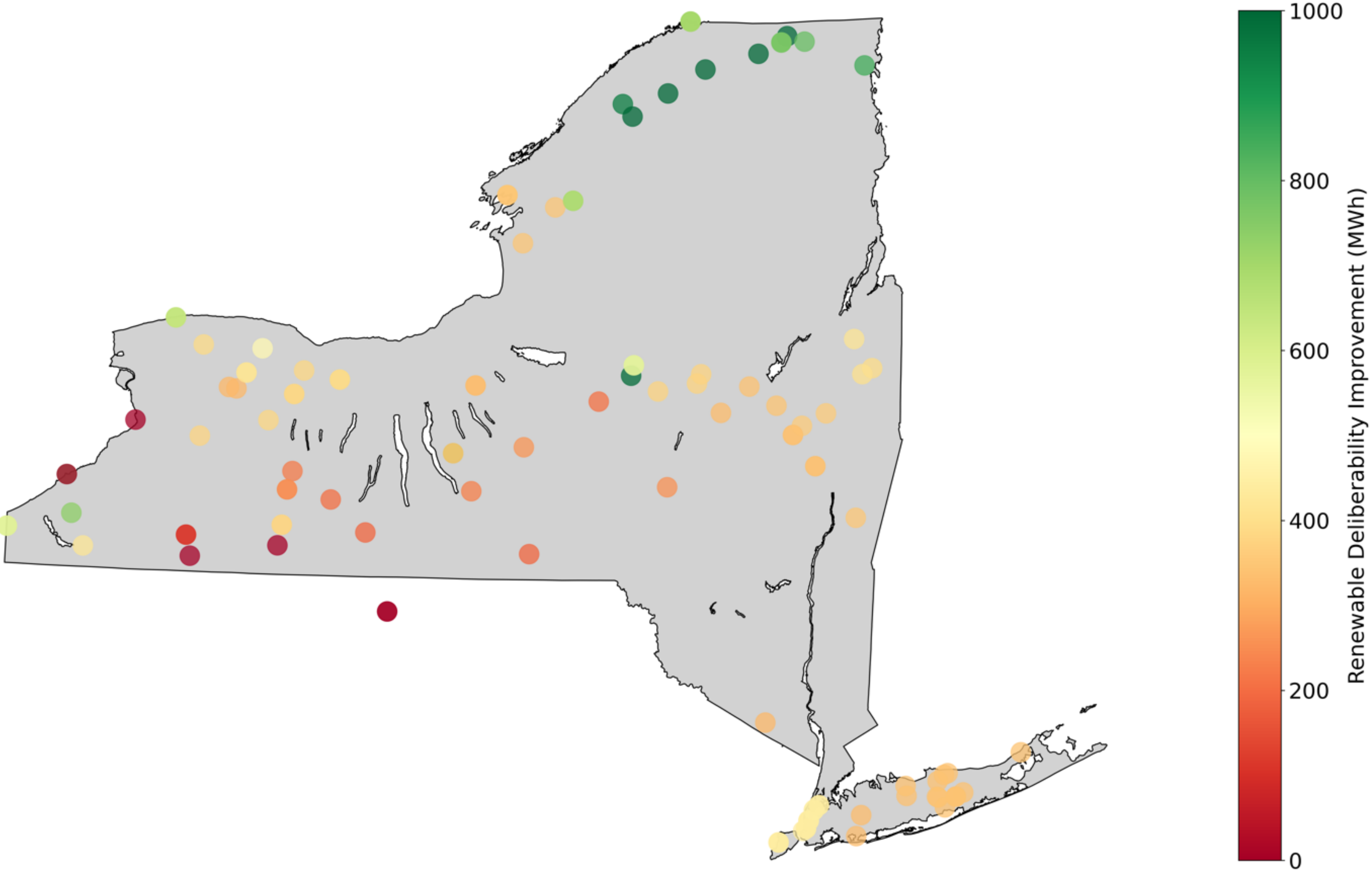
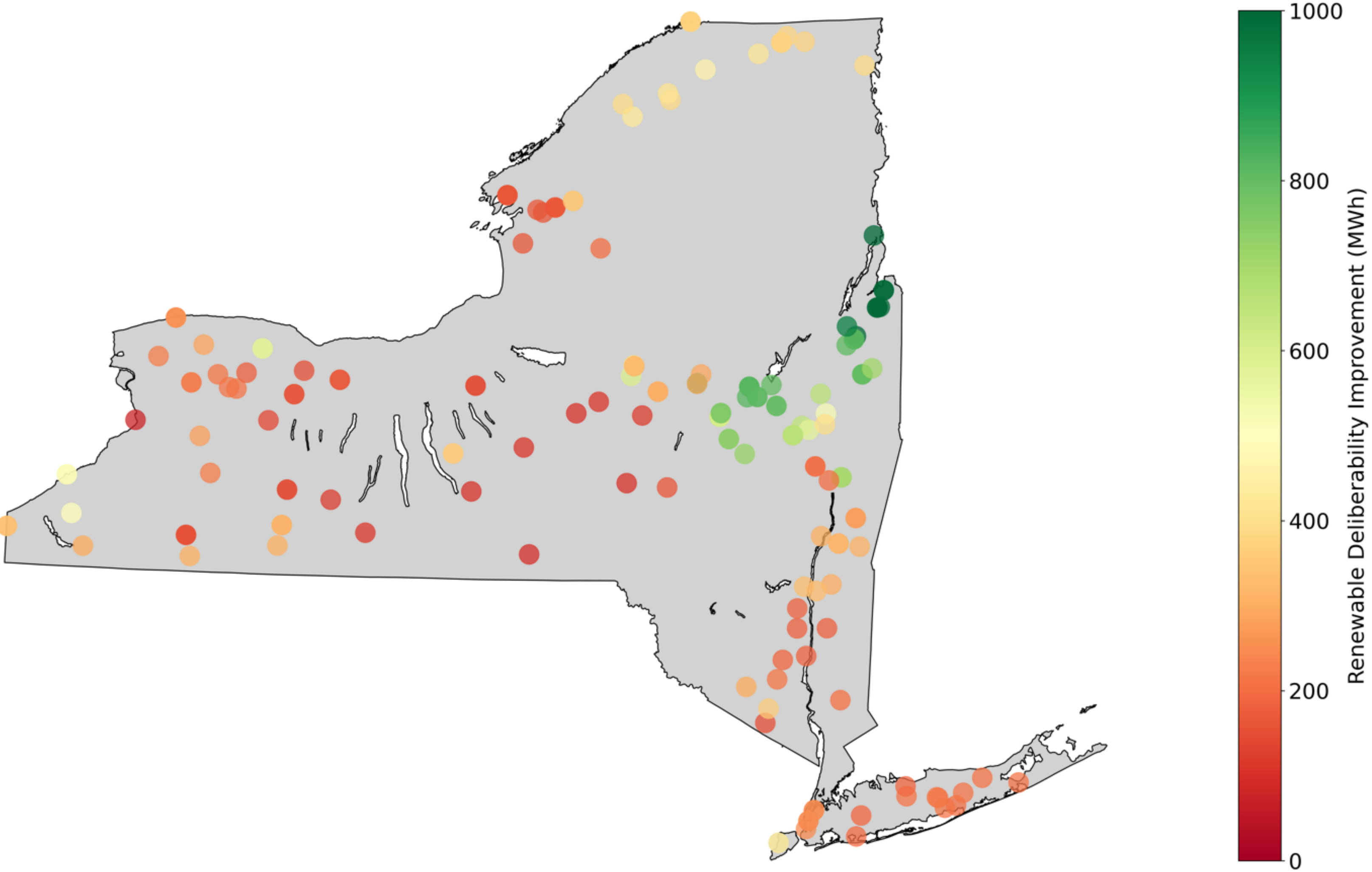
Renewable Deliverability Improvement (RDI)
Policy Low Case 2035 – 8 Hour Battery



Renewable Deliverability Improvement (RDI)
Policy High Case 2035 – 4 Hour Battery



Renewable Deliverability Improvement (RDI)
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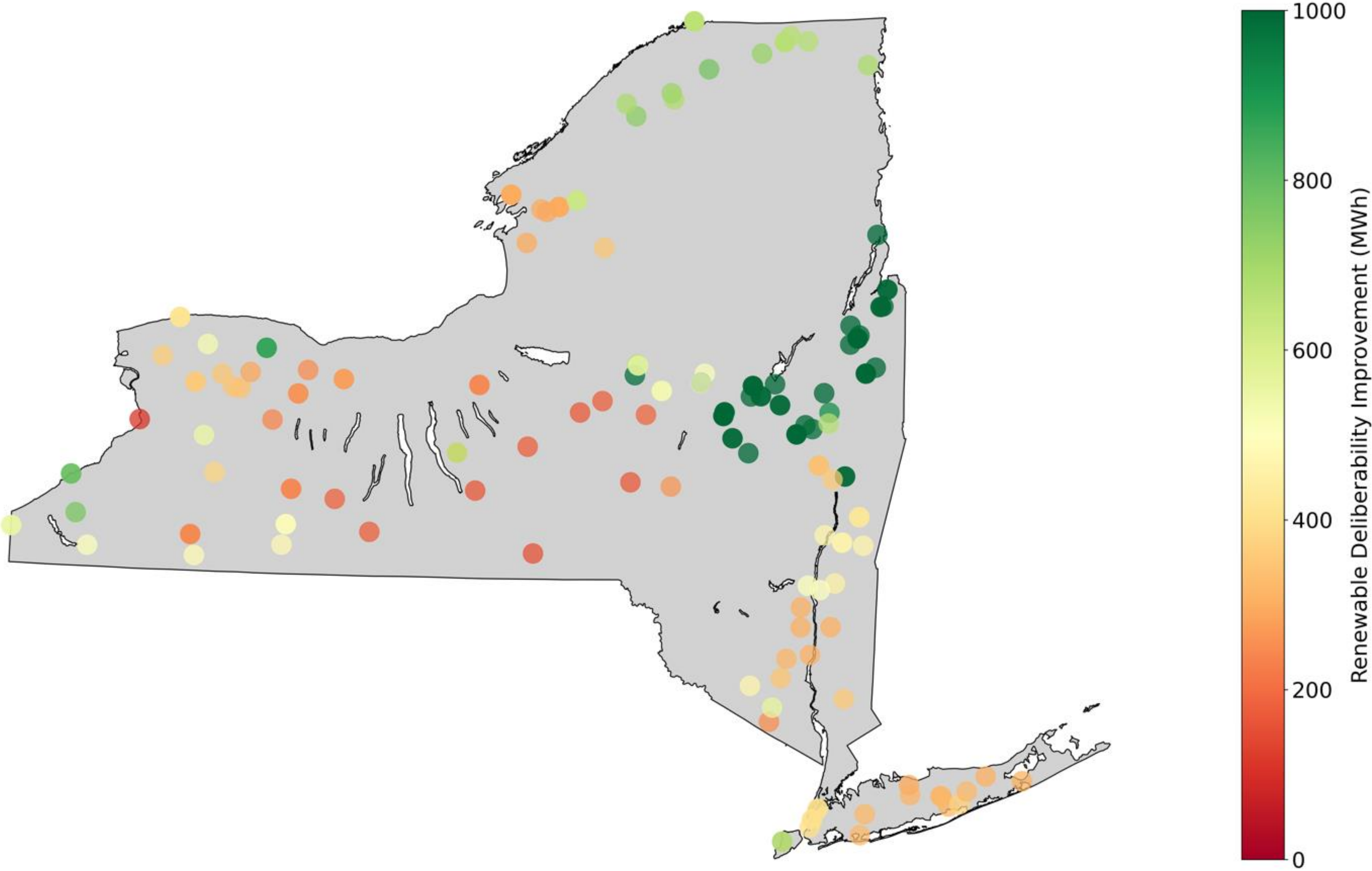


Technology and Nodal Discounts

Technology Discount Definition:

- Difference between (1) simple average zonal LBMP and (2) average zonal LBMP weighted by potential generation profile of resource.

Nodal Discount Definition:

- Difference between (1) simple average zonal LBMP and (2) average nodal LBMP weighted by potential generation profile of resource.

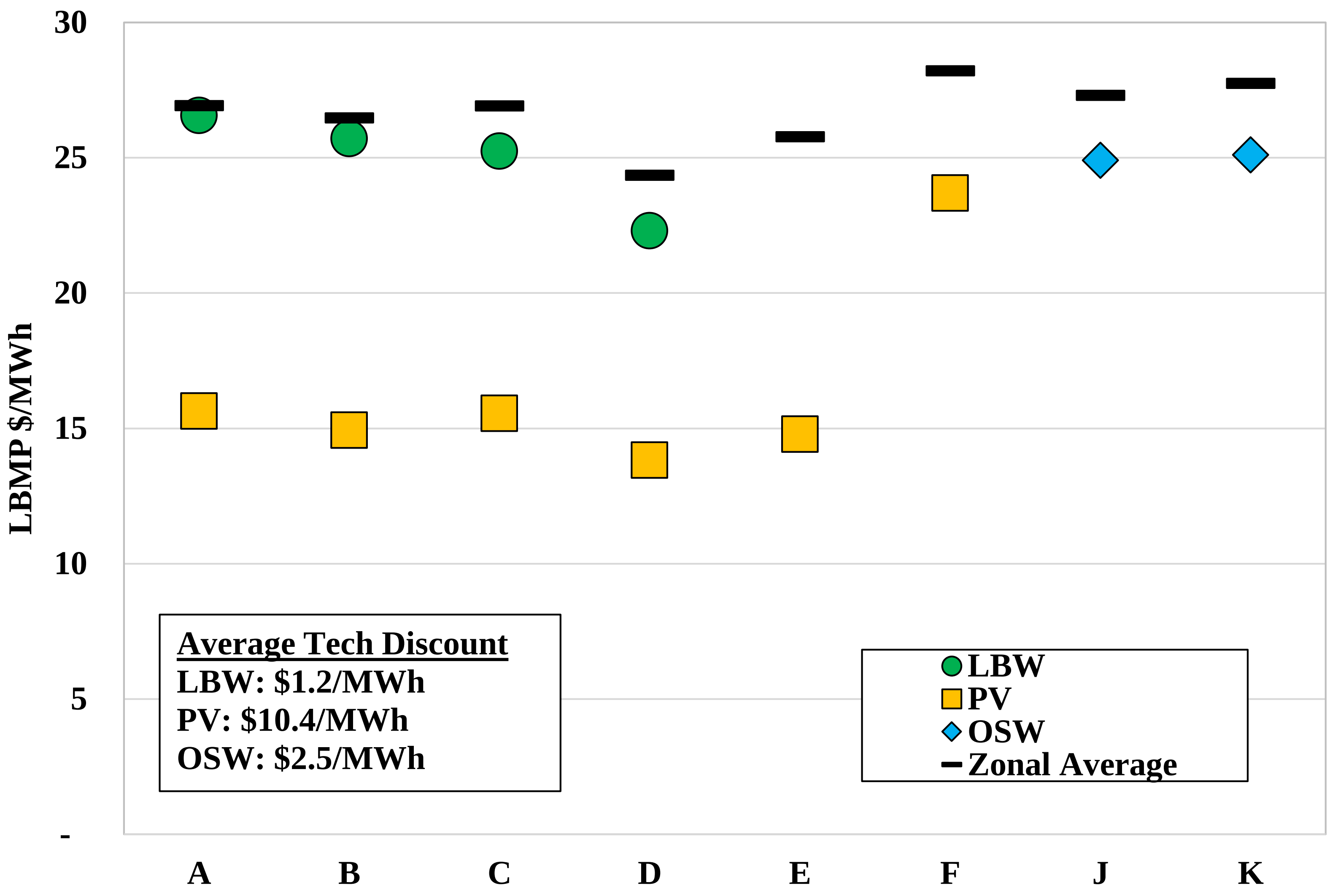
Technology and nodal discounts indicate amount by which total revenues of resource (including REC payments) will fall short of Index REC Strike Price.

- Index REC payments are linked to simple average zonal LBMP

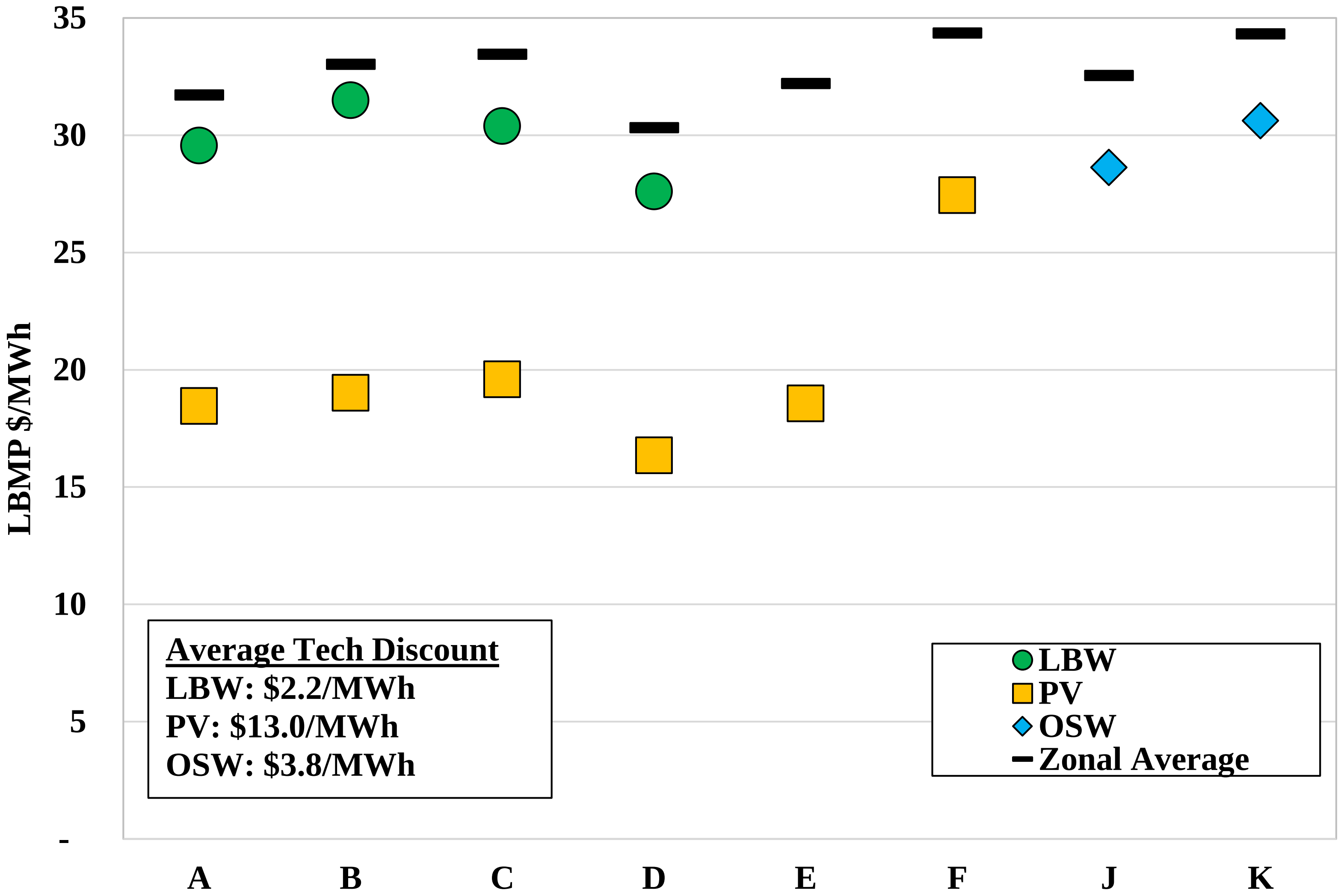
Technology and Nodal Discounts Overview

- The following slides show Technology and Nodal Discount results for each case. Conclusions:
  - ✓ Solar in zones west of Central East had large technology discounts, indicating heavy saturation of solar in this area causing depressed prices
    - In High Policy case, solar projects in Zone F also had very high discounts due to overbuilt capacity
    - Solar projects face risk of earning total revenues (including RECs) materially below Index REC strike prices
  - ✓ Land-based and offshore wind generally had small technology discounts due to low correlation with solar output
  - ✓ Nodal discounts were generally much smaller than zonal discounts due to planned transmission. There were large nodal discounts at some locations with overbuilt capacity.

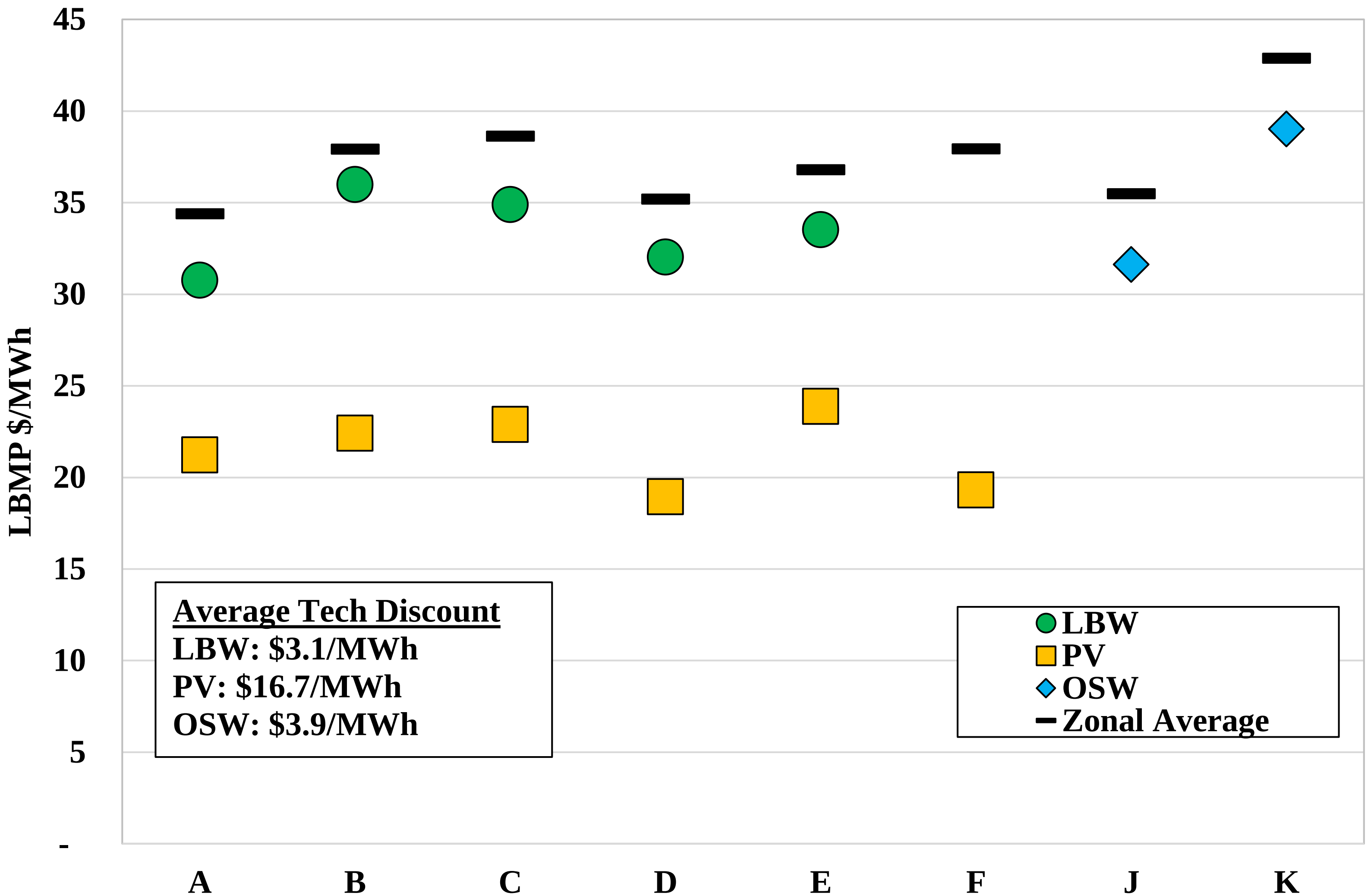
Technology Discounts
Contract Case 2030



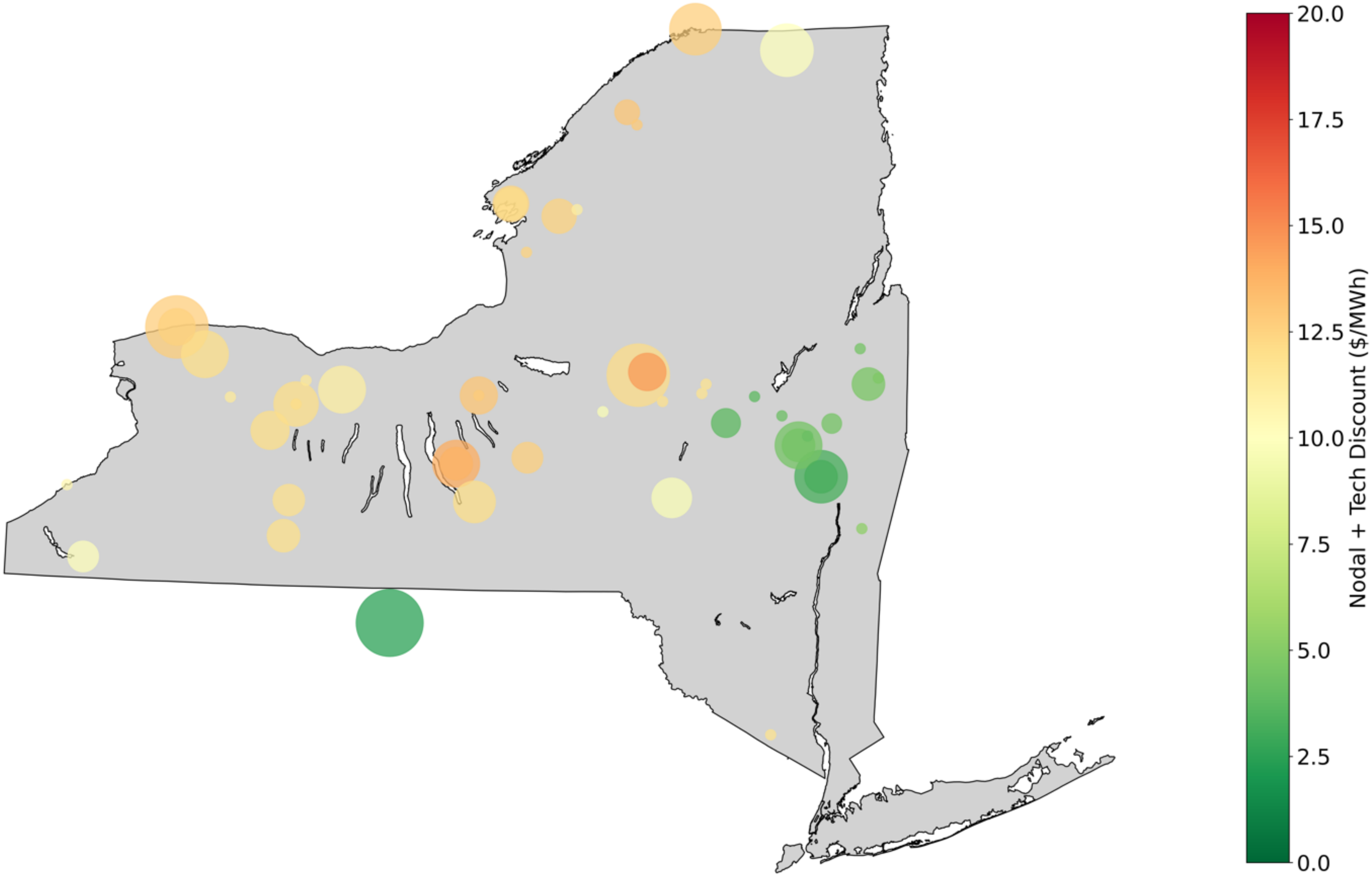
Technology Discounts
Policy Low Case 2035



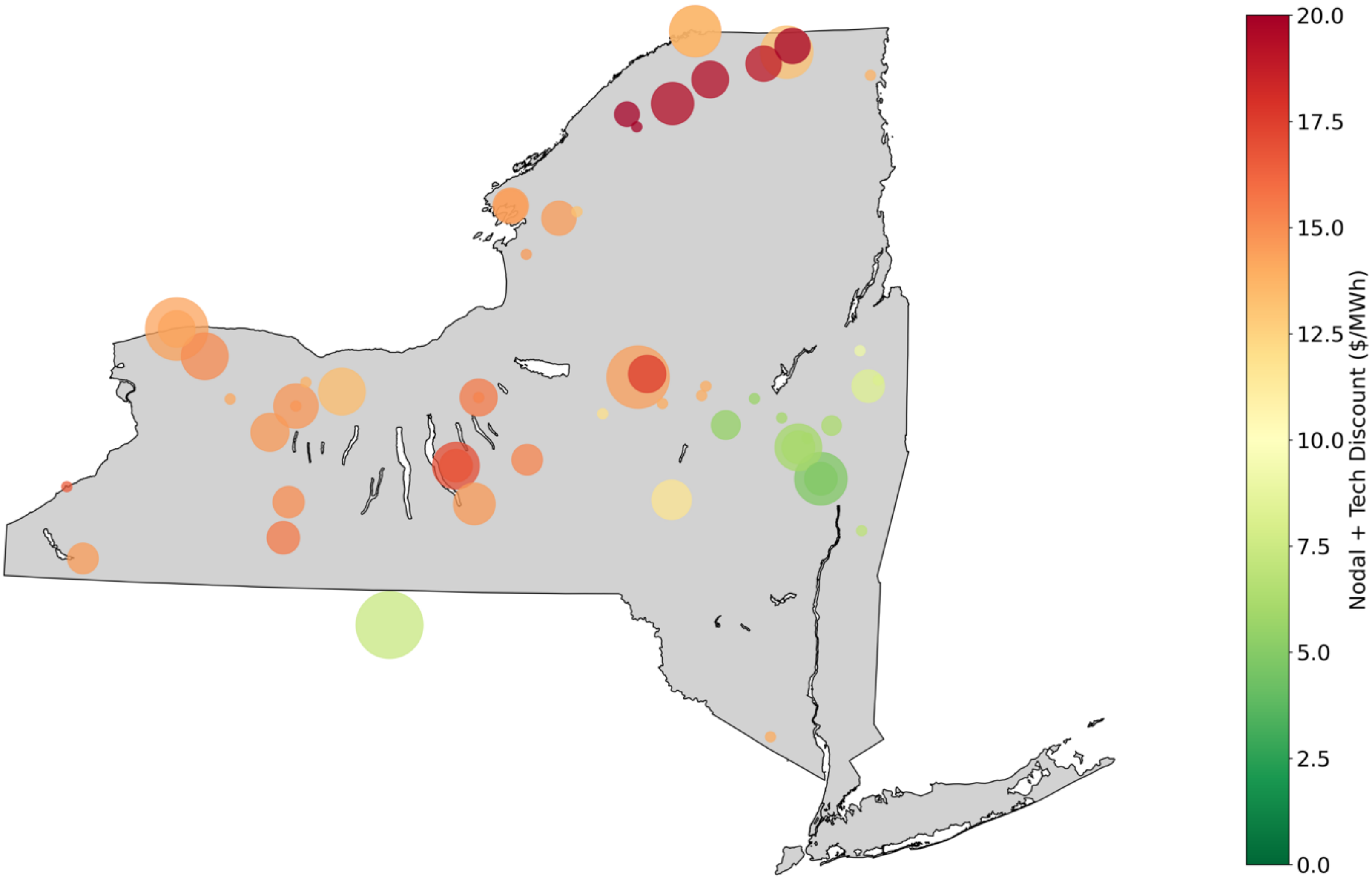
Technology Discounts
Policy High Case 2035



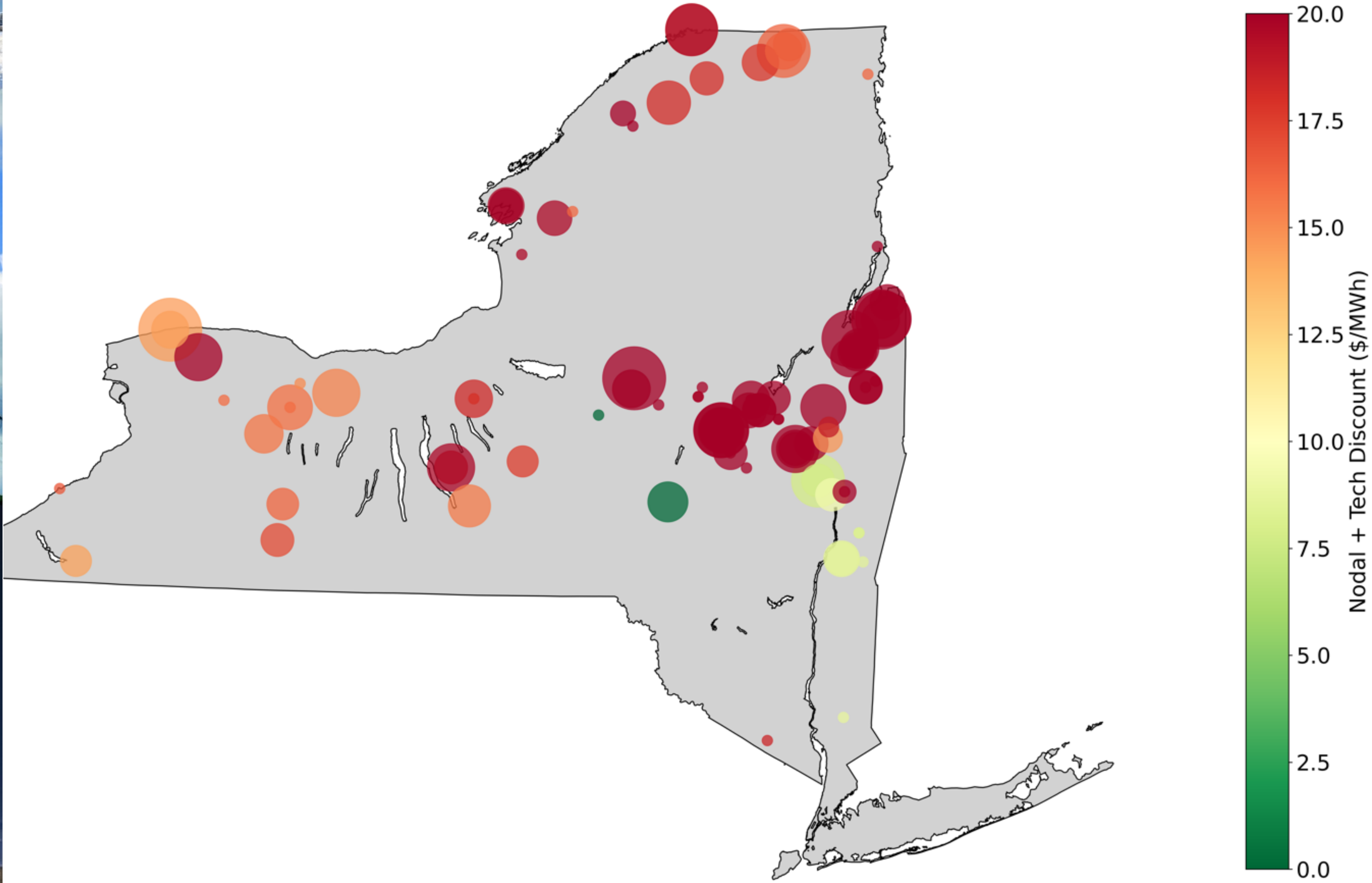
Technology + Nodal Discounts
Contract Case 2030 - UPV



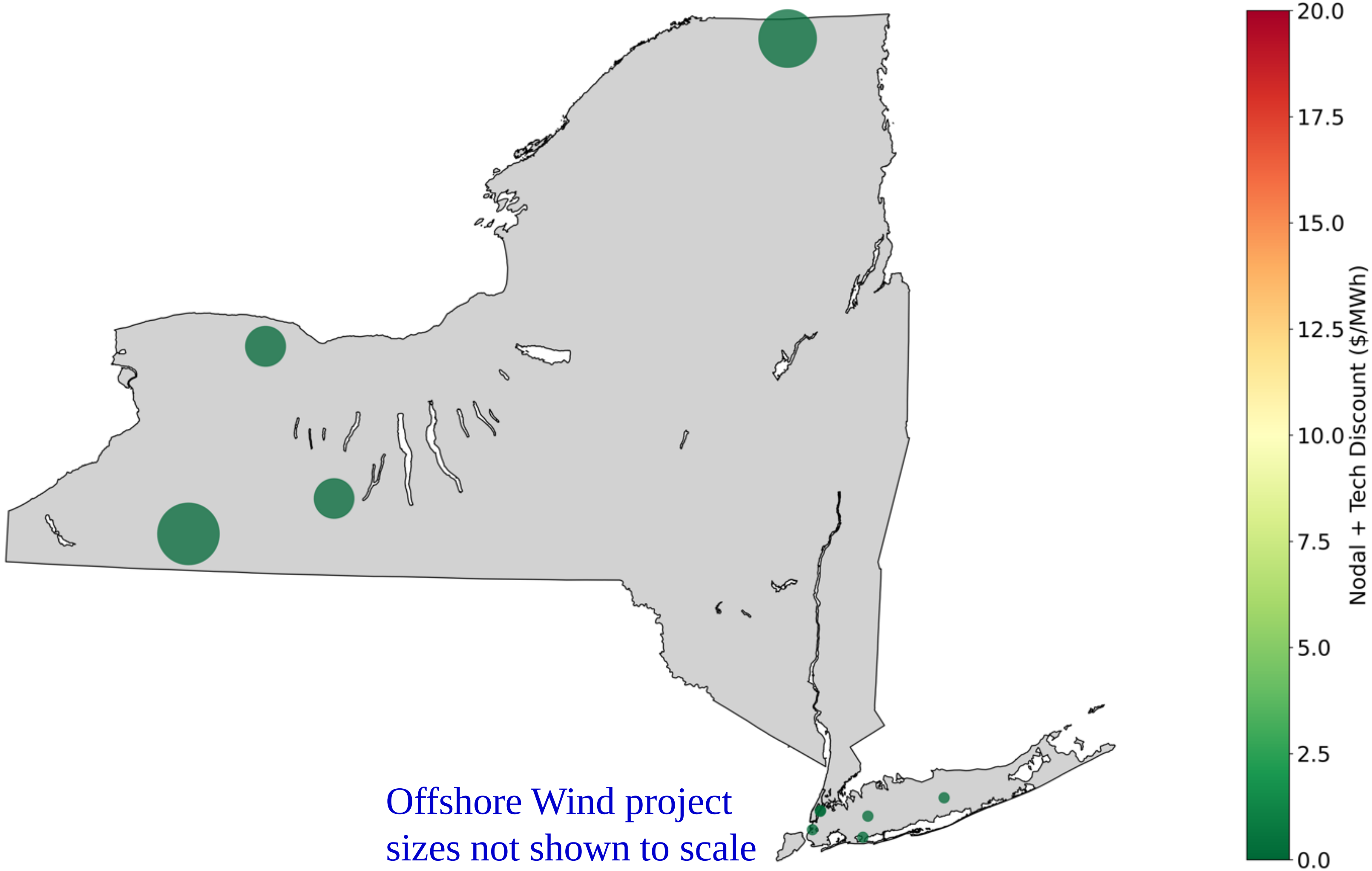
Technology + Nodal Discounts
Policy Low Case 2035 - UPV



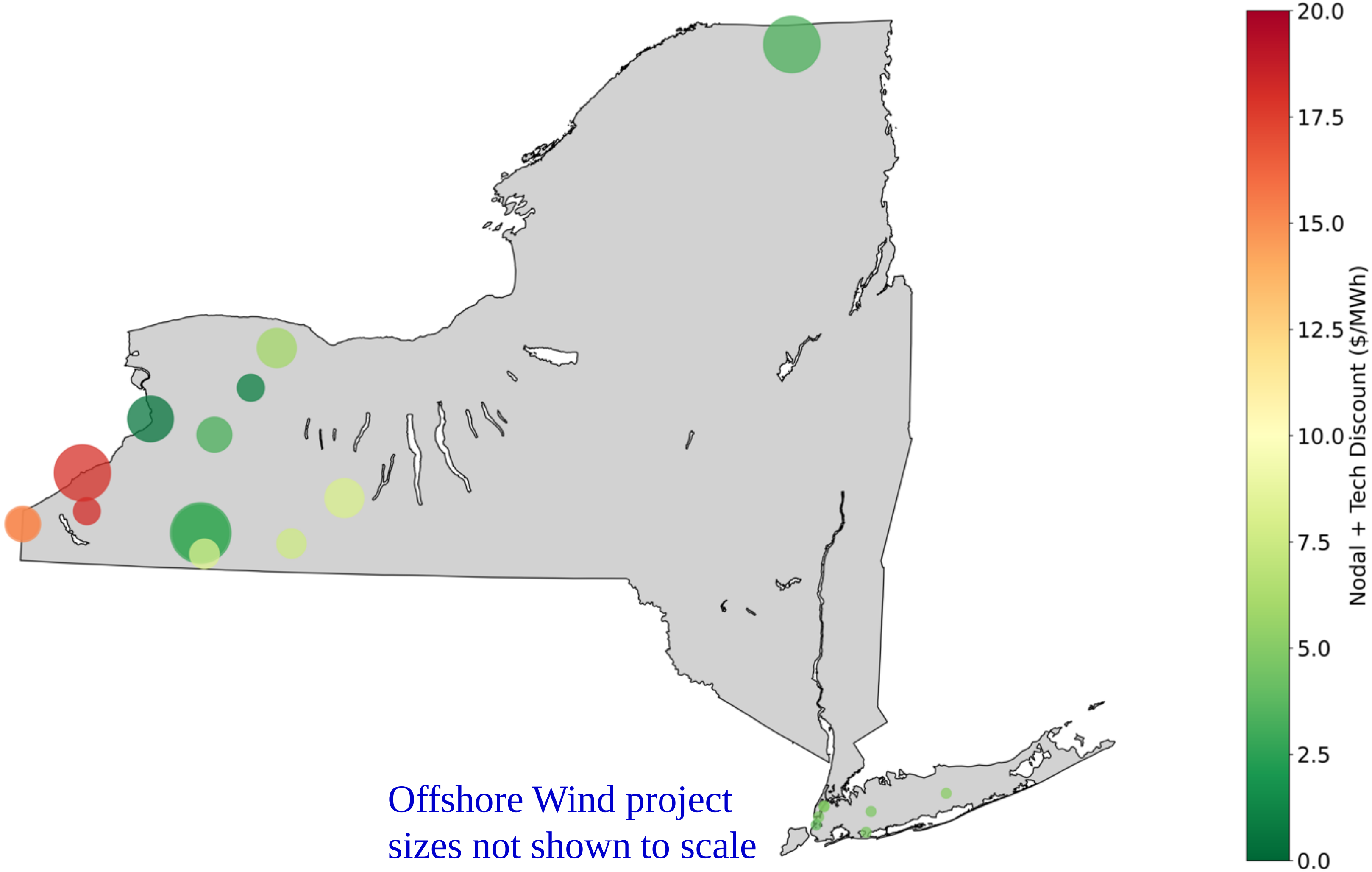
Technology + Nodal Discounts
Policy High Case 2035 - UPV



Technology + Nodal Discounts
Contract Case 2030 - Wind

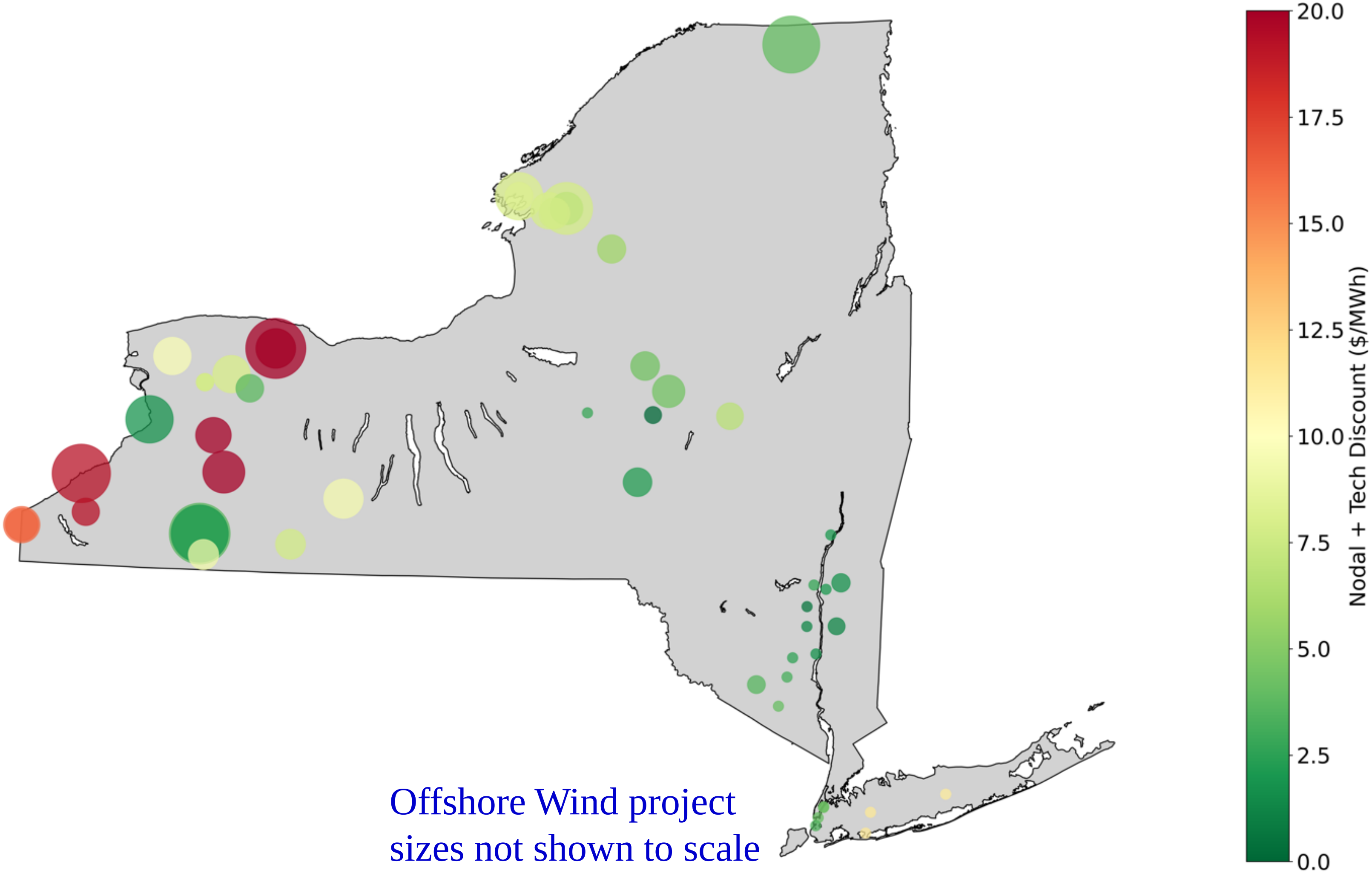


Technology + Nodal Discounts
Policy Low Case 2035 - Wind



Offshore Wind project
sizes not shown to scale

Technology + Nodal Discounts
Policy High Case 2035 - LBW



Offshore Wind project sizes not shown to scale

Implied Net REC Cost

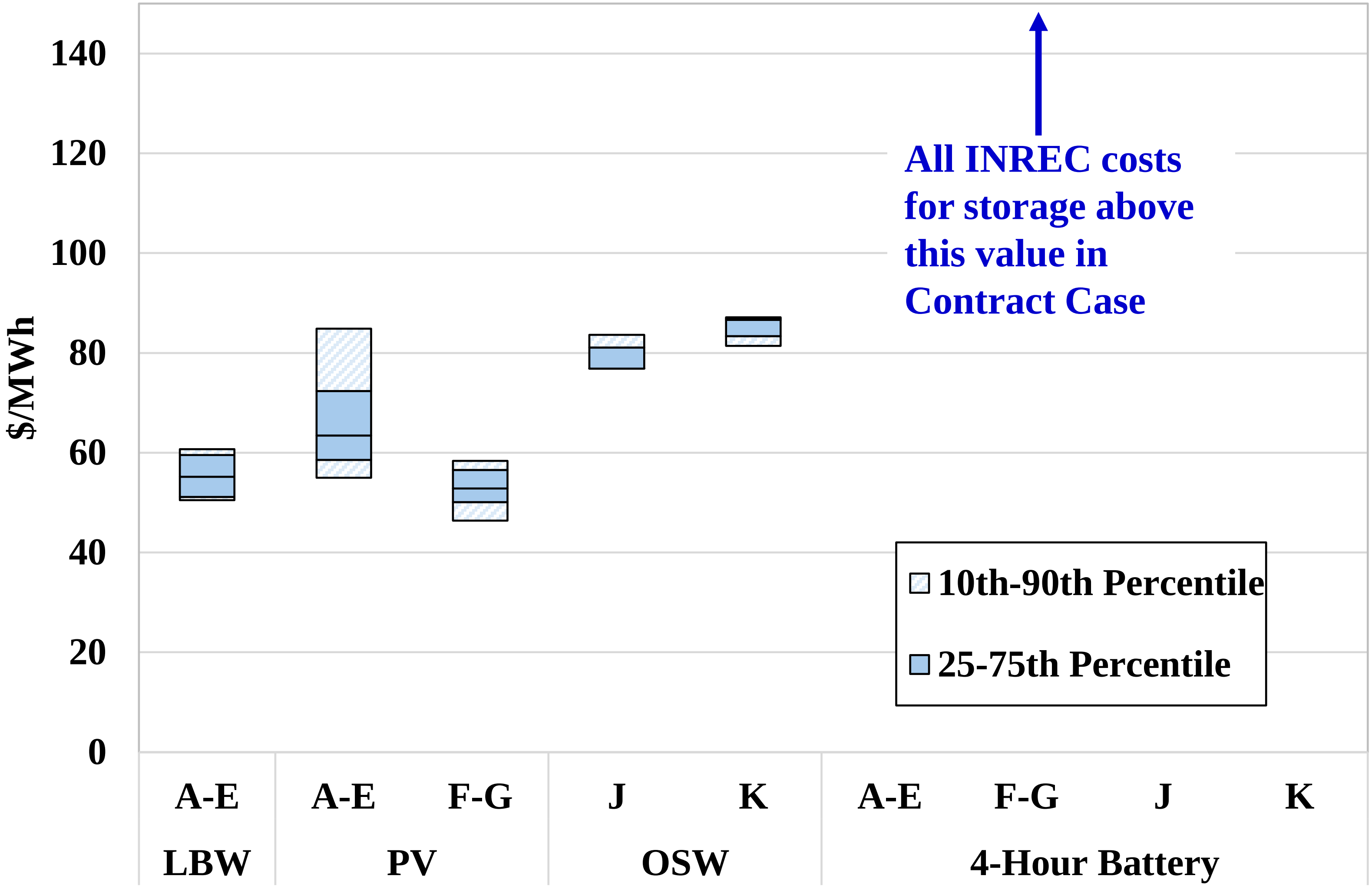
Definition:

- The net cost of incremental renewable energy deliveries from an investment in generation, storage, or transmission.
- Calculated as the resource’s levelized Cost of New Entry (CONE), less energy and capacity revenues, divided by the incremental renewable energy it provides:
  - ✓ For wind and solar, incremental renewable energy is the annual potential generation of an additional MW adjusted down by its Marginal Curtailment Rate
  - ✓ For energy storage, incremental renewable energy is the Renewable Deliverability Improvement (RDI) of an additional MW (e.g., the annual MWh of renewable generation it would save from being curtailed)

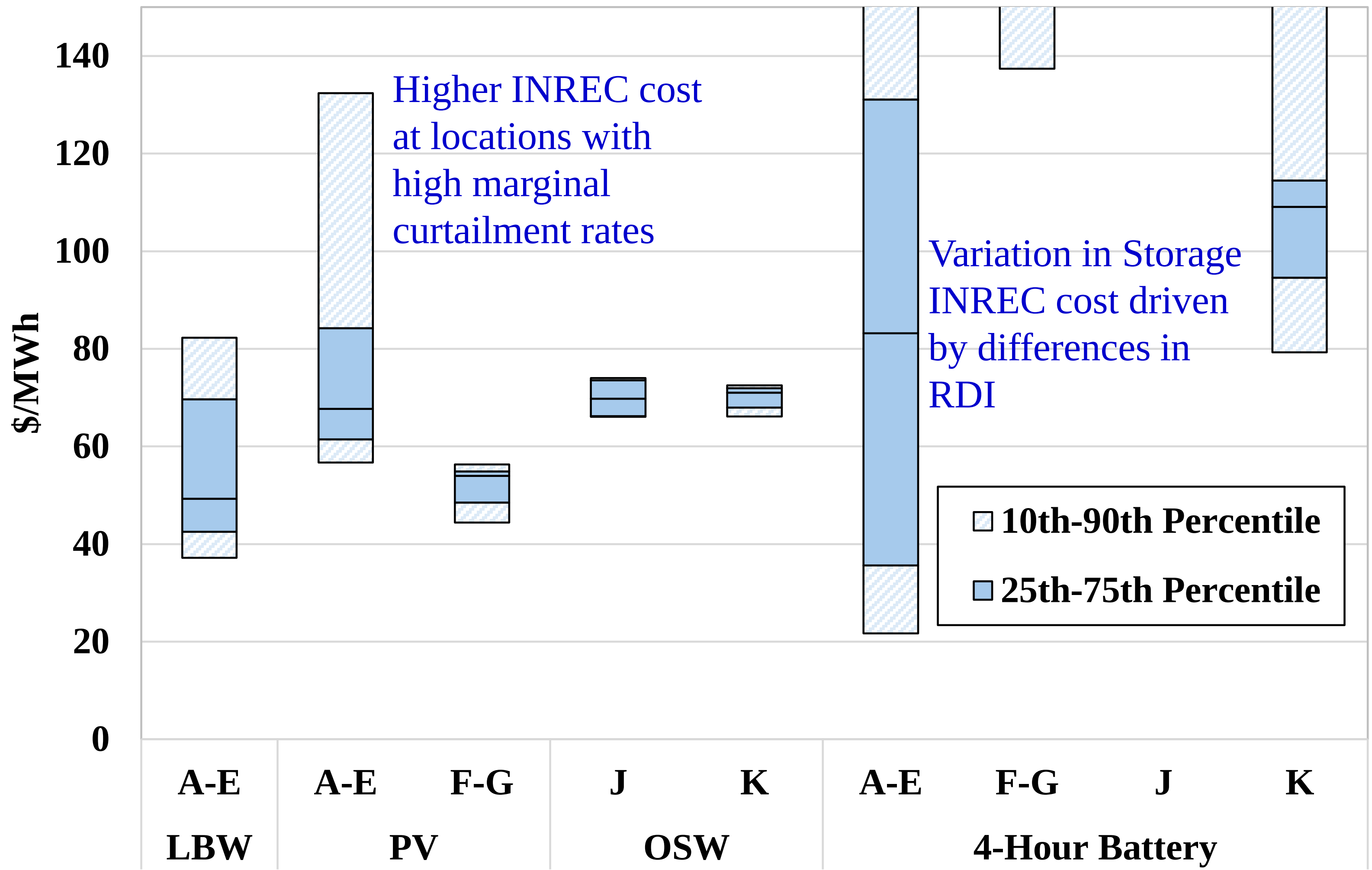
Implied Net REC Cost

- The following slides present Implied Net REC Cost results for each case. Conclusions:
  - ✓ INREC costs of renewable technologies are generally higher than today's market conditions due to rising marginal curtailment rates and downward pressure on energy prices from renewable buildout.
  - ✓ Storage INRECs are much higher than other technologies in the Contract Case (2030). This is due to (1) low capacity prices set by the going-forward cost of existing units in the Contract Case, and (2) low RDI values for storage.
    - Planned transmission and lack of need for new capacity resources in this timeframe make storage a comparatively costly way to improve deliverable clean energy.
  - ✓ Storage INRECs are competitive with or lower than renewable technologies at some locations in the Policy Cases due to higher capacity revenues (due to the need to build DEFRs in these cases) and higher RDIs at some locations.

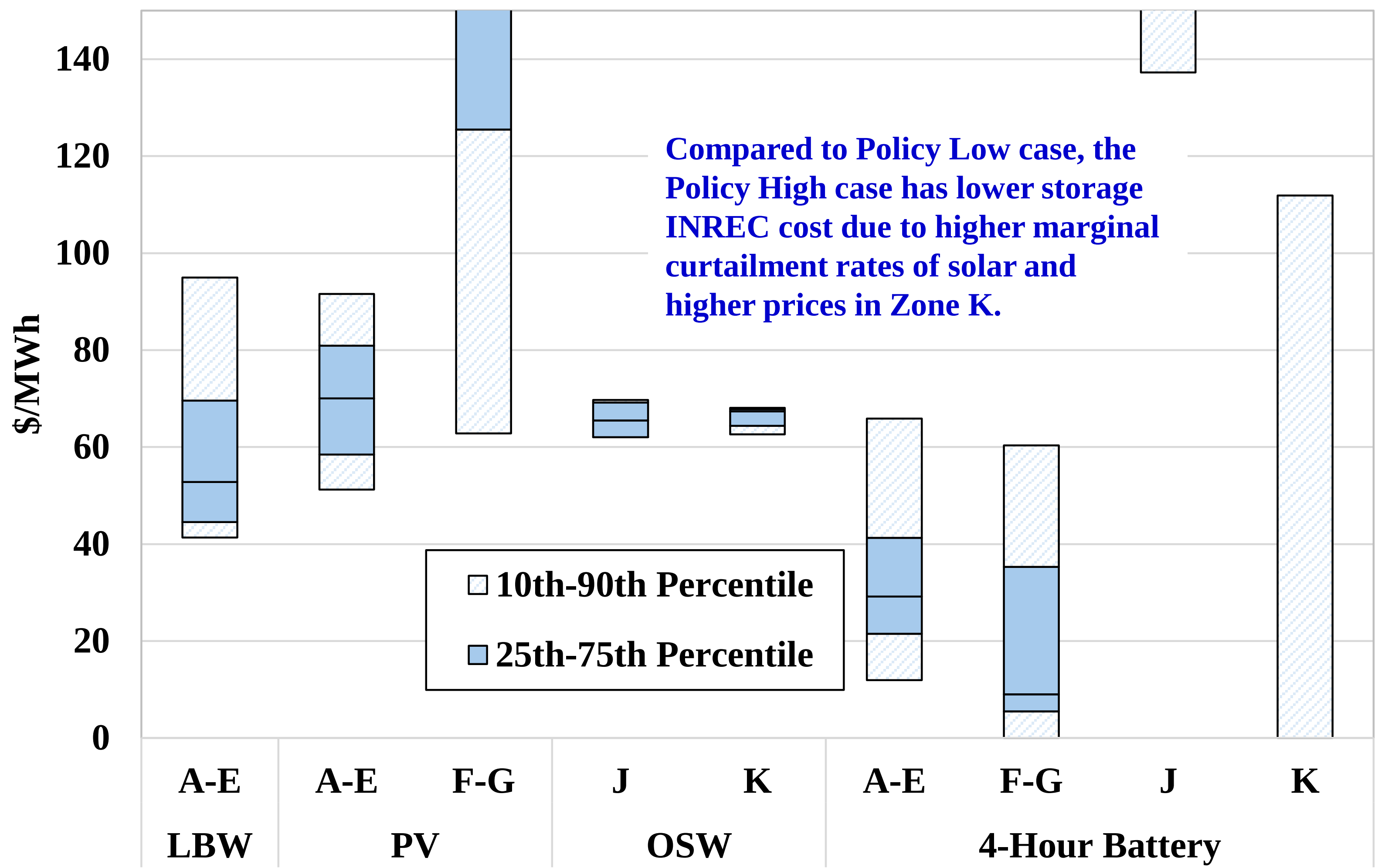
Implied Net REC Cost
Contract Case 2030



Implied Net REC Cost
Policy Low Case 2035



Implied Net REC Cost
Policy High Case 2035



Recommendations for Future Outlook Studies

- *P23-1:* Model realistic local capacity requirements driven by changes in the resource mix and transmission network;
- *P24-1:* Represent drivers of winter risk including fuel unavailability in capacity expansion model;
- *P22-1:* Model procurement of ancillary services in production cost models, considering how future needs will be driven by resource mix changes;
- *P22-2:* Perform an ‘optimized’ production cost model sensitivity case in which renewable capacity in locations with high marginal rates of curtailment is relocated to locations with lower marginal rates of curtailment;
- *P22-3:* Improve the siting and dispatch pattern of storage investments in MAPS to more realistically minimize renewable curtailment based on market incentives; and
- *P19-6:* Consider transmission outages and day-ahead net load forecast error when estimating production costs and curtailment.

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Methodology Details for MMU Review of 2023-2042 Outlook

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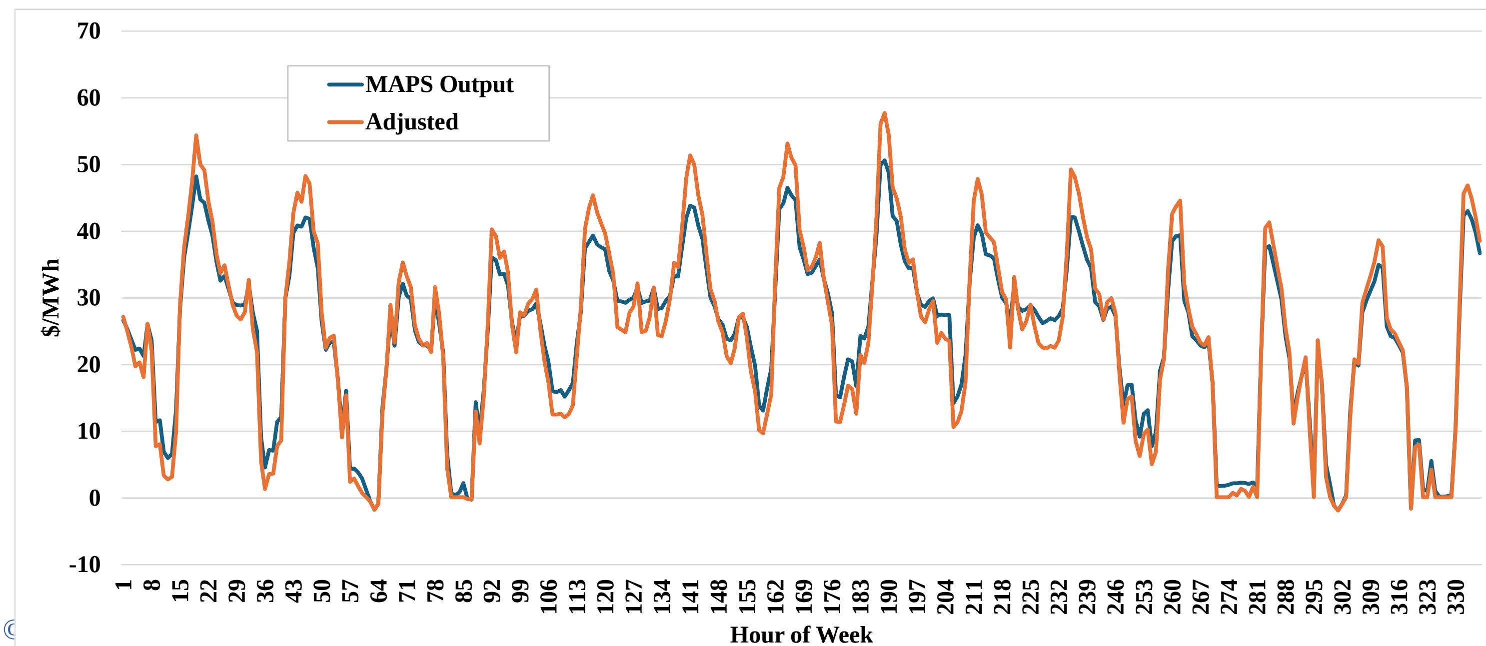
Methodology Details – MAPS LBMP Adjustment

- LBMPs produced by GE-MAPS generally have less intra-day volatility than observed market LBMPs
- We apply hourly adjustment factors to the MAPS LBMPs calculated by comparing intraday price variation in the Benchmark Case to historic data from the same year
- Example week:



Methodology Details – Implied Net REC Calculations

- The implied NET REC cost is calculated as follows:

$$\frac{CONE(\$) - E\&AS\ Revenues(\$) - Capacty\ Revenues(\$)}{Incremental\ Deliverable\ Clean\ Energy\ (MWh)}$$

- For renewables, the Incremental Deliverable Clean Energy is the resource's annual potential output multiplied by (1 – Marginal Curtailment Rate)
- For battery storage, the Incremental Deliverable Clean Energy is equal to the Renewable Deliverability Improvement (RDI)
- CONE values are calculated based on cost data from the NYSERDA Supply Curve Analysis. Financial parameters are used from the Supply Curve Analysis, with Cost of Equity adjusted upward to account for market risk.
  - ✓ CONE values reduced to account for effects of ITC/PTC for all renewables and storage
- Capacity prices are assumed to be set by existing unit going-forward costs in 2030 and by DEFR CONE in 2035

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