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ASSESSING THE ROLE OF LOW-COST, LONG-DURATION ENERGY STORAGE

VS.

HIGH-EFFICIENCY, SHORT-DURATION TECHNOLOGIES

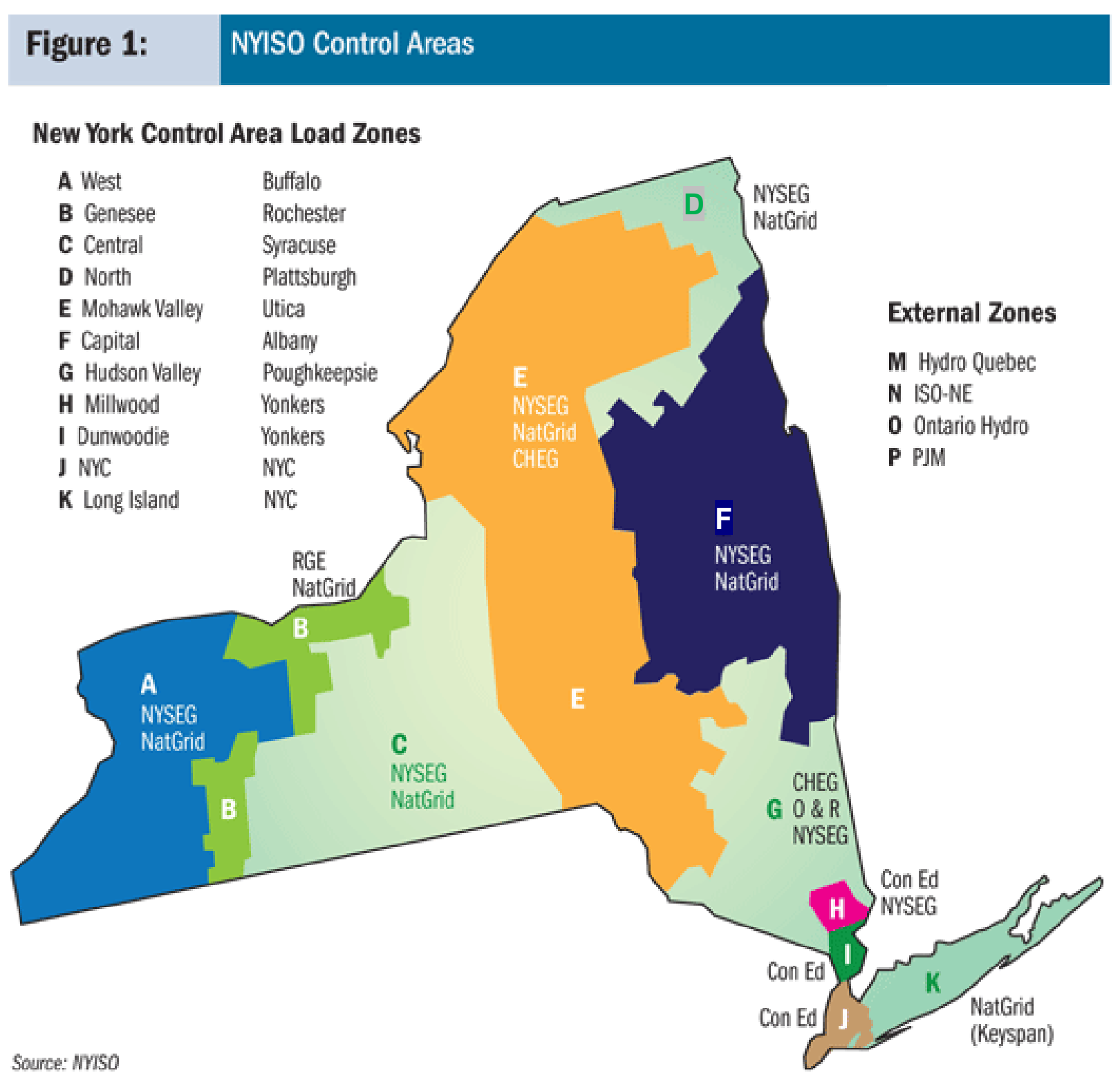
IN THE CONTEXT OF NEW YORK STATE'S CLEAN ENERGY GOALS

1. Introduction and Background

This study compares short duration energy storage, characterized by a high round-trip efficiency but higher marginal cost of energy capacity and long duration storage, characterized by a relatively lower round-trip efficiency and significantly lower marginal cost of energy capacity and attempts to answer the following questions:

a. What is the optimal portfolio of energy storage to economically reduce curtailment of variable renewable energy?

b. How much energy storage can be deployed cost effectively to solve this problem?



Source: NYISO

Figure 1. Zonal map of The New York Control Area

A model was constructed of the New York Control Area's (NYCA) eleven load zones.

The model solves to reduce curtailment of renewables by deploying a mixed energy storage portfolio in each of the eleven zones.

Renewables are deployed according to New York's 2025 targets.

The storage portfolios comprise two technologies:

- Lithium-ion – 85% RTE, $181 / kWh marginal cost of installed energy capacity
- Cryogenic Energy Storage – 60% RTE, $50 / kWh marginal cost of installed energy capacity

2. Modeling approach

A linear program is used to model the NYCA.

Establishing a baseline

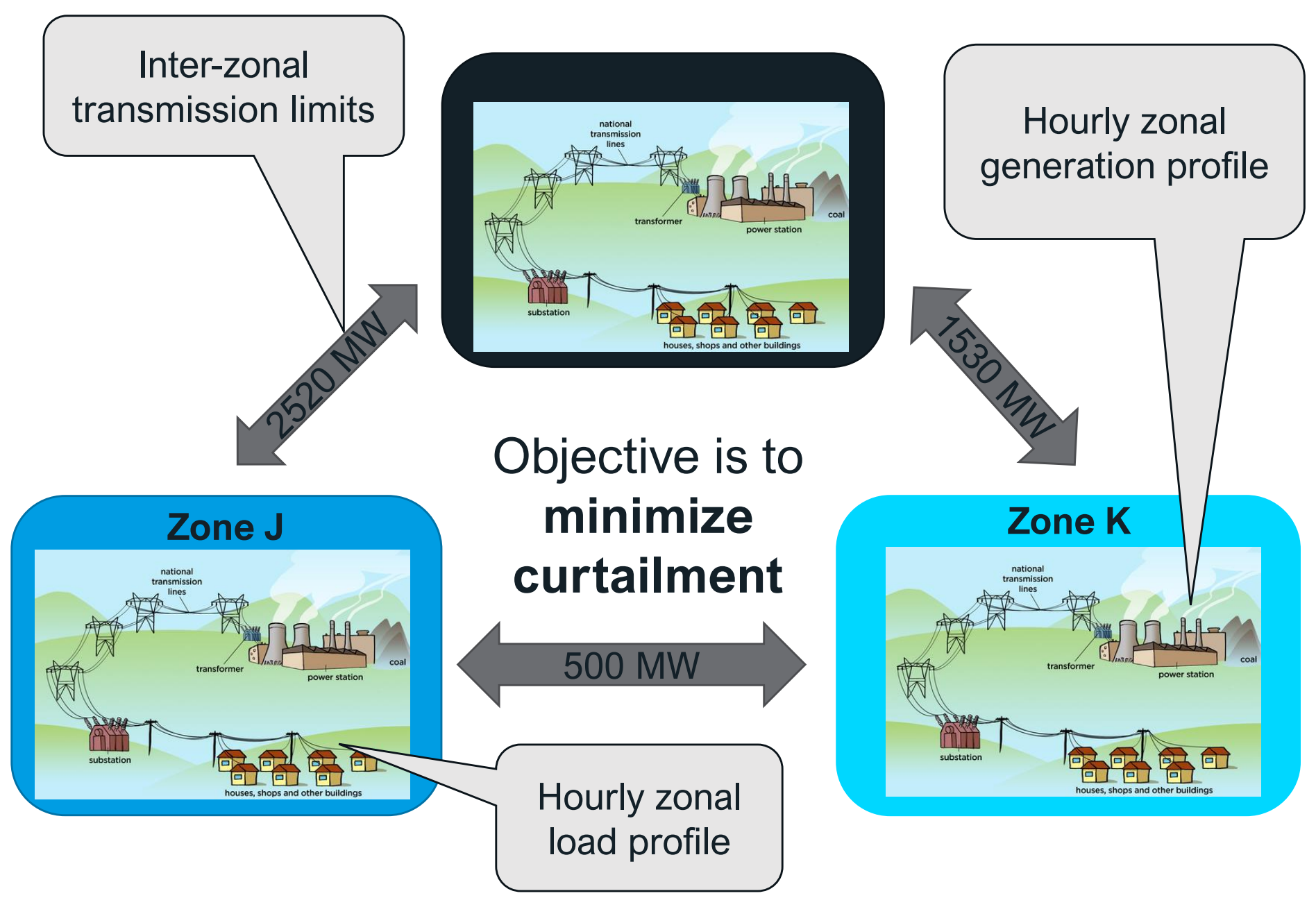
A baseline is established using no storage and based on 2025 renewable forecasts from public sources (NYISO and state procurements).

Real wind and solar profiles are generated based on the locations and capacities in *Table 1*.

Load profiles and frequently dispatched generators (i.e. nuclear, combined-cycle) are forecasted accordingly.

Zone	Wind (MW)		PV (MW)	
	Onshore	Offshore	Utility	Distributed
A	1,401	0	214	440
B	396	0	48	332
C	1,660	0	288	775
D	1,002	0	430	63
E	1,310	0	389	454
F	120	0	1,150	662
G	0	0	264	1,196
H	0	0	0	84
I	0	0	0	139
J	0	816	0	710
K	0	880	378	1,151

Table 1. Zonal breakdown of 2025 renewable capacities used in this analysis



Objective is to **minimize curtailment**

Figure 2. Linear program construct

Without storage **14 TWh** of renewable energy is curtailed either for lack of load or due to inter-zonal transmission constraints.

Introducing storage

The model is now constrained to reduce curtailment with respect to the baseline by deploying storage in each of the eleven zones. For a target curtailment reduction, the model solves to optimize for the lowest cost storage portfolio. A metric is defined to measure cost: the Levelized Cost of Curtailment Avoided (LCOCA) – defined in *Equation 1*, where the numerator is the lifetime cost of the storage portfolio minus any ancillary storage revenues and the denominator is the quantity of energy 'liberated' from curtailment by the storage.

$$LCOCA_s = \frac{\sum_{t=1}^{T}\left(I_t + O_t + R_t\right)(1+r)^{-t}}{\sum_{t=1}^{T} E(1+r)^{-t}}$$

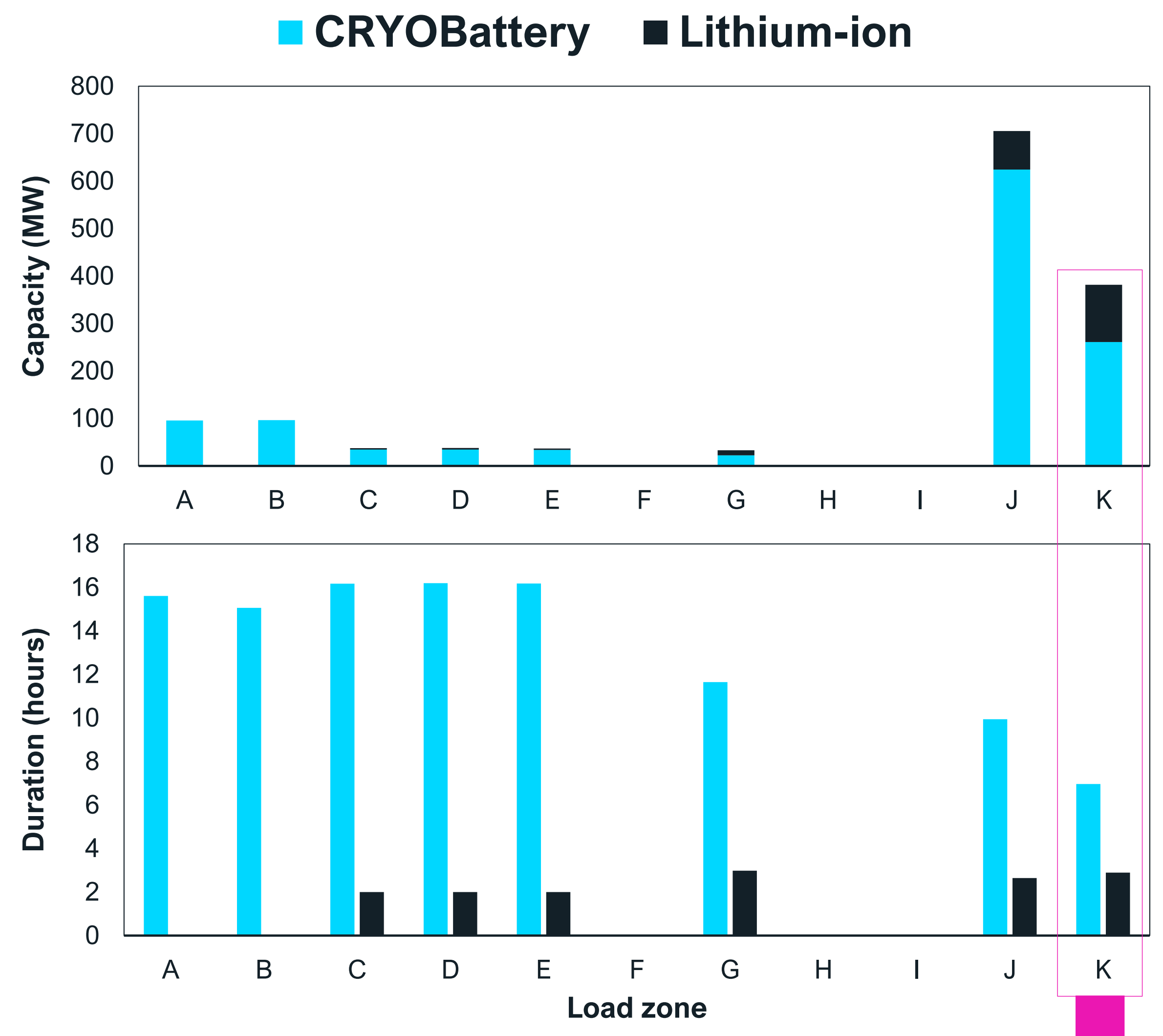
Equation 1. The levelized cost of curtailment avoidance, where s is a model solution enabling the delivery of E MWh of otherwise curtailed energy per period, T requiring an investment, I and periodic operating costs, O and R can be a periodic non-energy revenue.

The model minimizes the LCOCA by optimizing the following variables:

- Technology mix
- Aggregate MW capacity per technology
- Aggregate MWh energy per technology
- Hourly aggregate dispatch of each technology over one year (8760 hours)

3. Results

Curtailment reduction with 1.5 GW of storage on the grid



New York State targets 1.5 GW of storage by 2025.

The model predicts that applied to the problem of curtailment, 1 TWh of curtailment can be avoided.

Figure 3 shows storage deployments by zone.

Figure 3. Zonal breakdown of optimal storage technologies by capacity and duration that can avoid 1 TWh of curtailment

A closer look at Zone K in Figure 4

Focus on Zone K (Long Island)

To shift otherwise curtailed energy to the large daily peaks, at least 6 hours of duration discharge is optimal. At the same time, the short-duration technology is effective at shifting energy to the smaller peaks and helping with the larger peaks when necessary.

Despite a lower round-trip efficiency, long duration technology allows large peaks to be serviced cost-effectively. The low marginal energy cost is clearly advantageous.

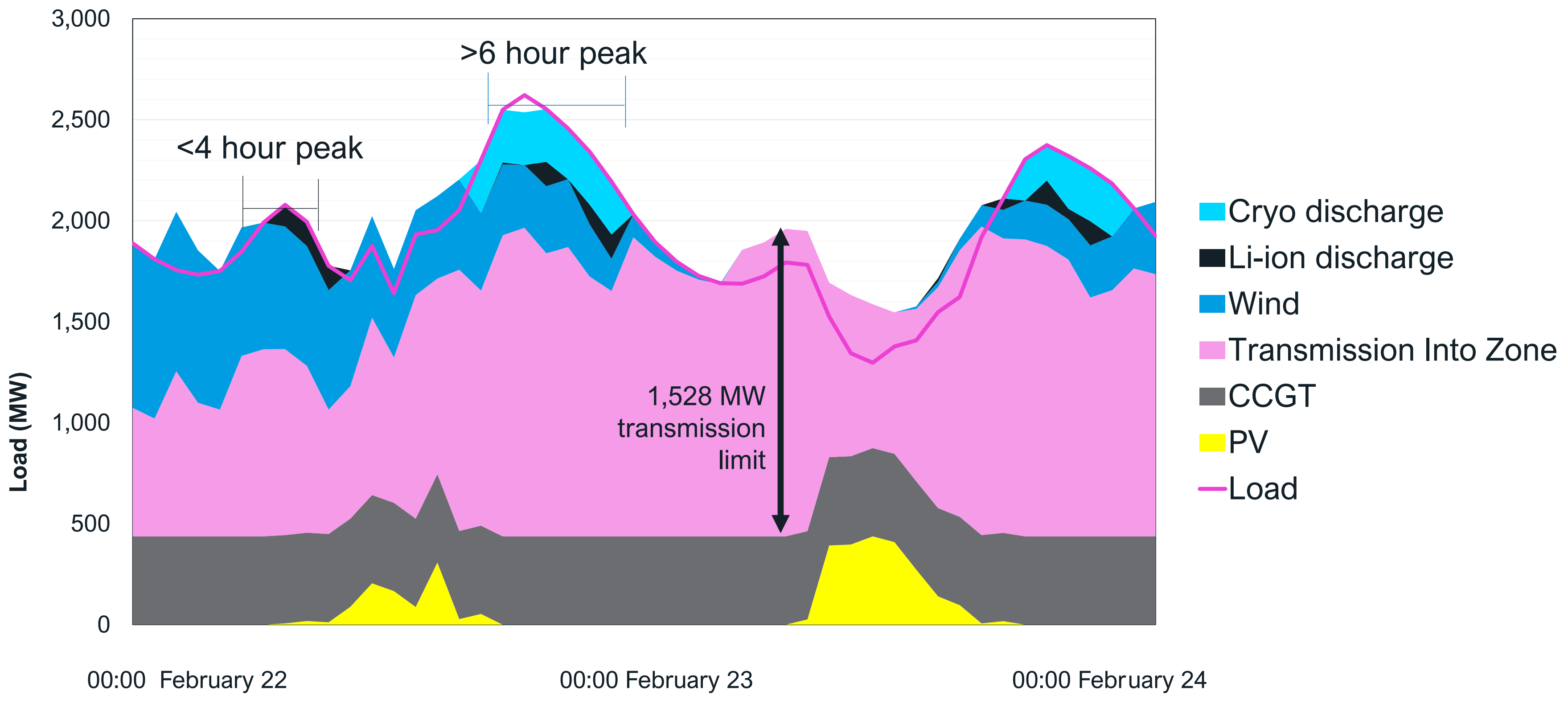
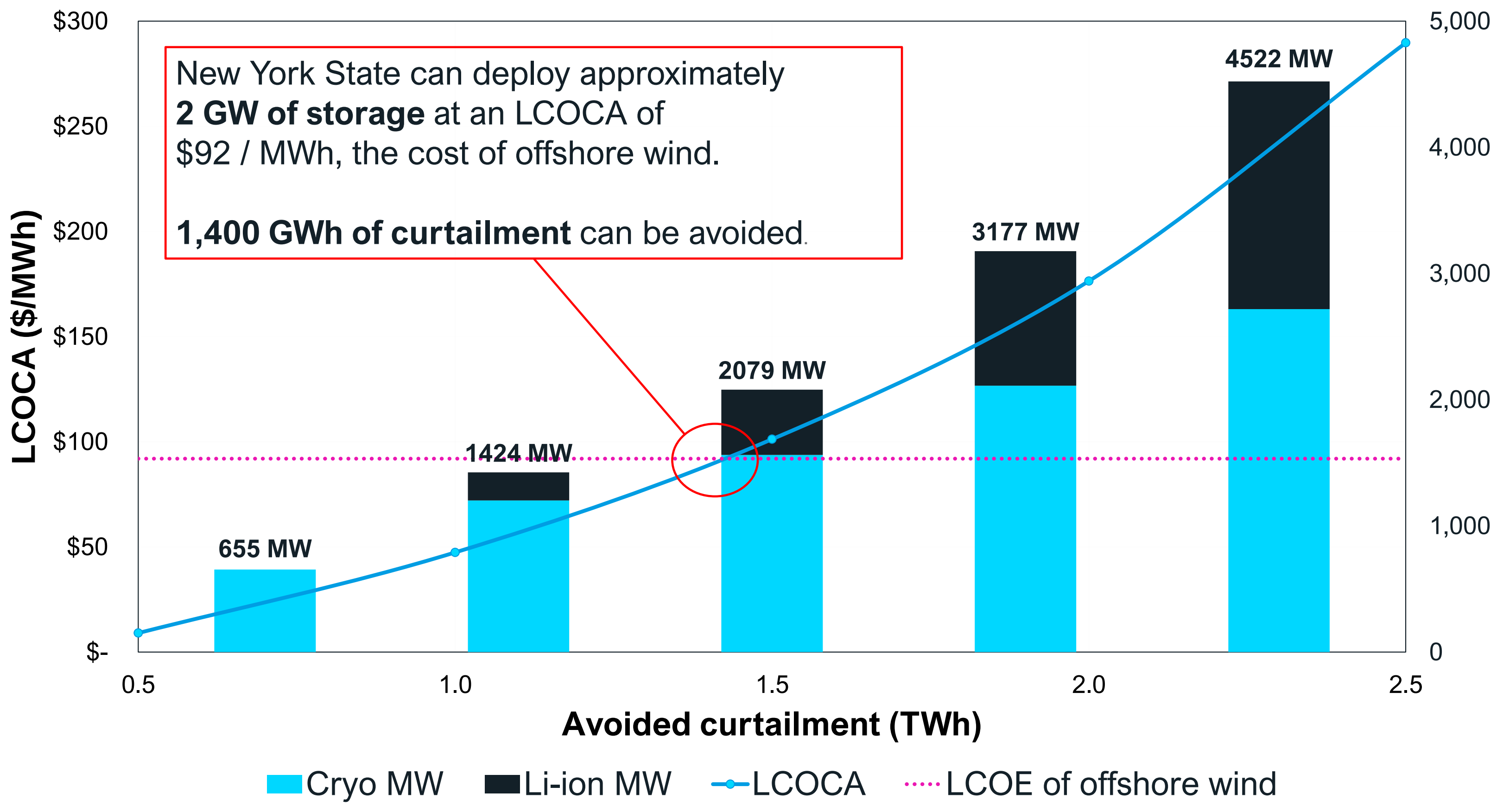


Figure 4. A 48-hour snapshot of the hourly generation mix for the solution of Zone K (Long Island) based on 1 TWh of avoided curtailment.

How much can be curtailed cost-effectively with storage?

The Levelized Cost of Energy for additional generation can be used as a benchmark for cost-effective storage deployments. The LCOCA, including offsets from additional revenue for capacity rights and ancillary services, is shown in *Figure 5,* and compared to the EIA forecast for the Levelized Cost of Energy for offshore wind 2025 ($92 / MWh). The model predicts that up to **2 GW of dispatchable storage** can be deployed to avoid 1.4 TWh of curtailment annually for the same cost.



New York State can deploy approximately **2 GW of storage** at an LCOCA of $92 / MWh, the cost of offshore wind.

1,400 GWh of curtailment can be avoided.

Figure 5. Optimal grid-wide storage capacity and corresponding levelized cost of curtailment avoidance for various sensitivities on the constrained curtailment avoided.

4. Conclusion

The study indicates that the most cost effective portfolio for reducing curtailment is dominated by long-duration, low-cost storage, with a supplement of higher-efficiency, higher cost storage. Accounting for additional systemic benefits of storage – for example sub-hourly balancing, reliability in constrained grid locations and intra-zonal transmission constraints - will likely predict larger storage portfolios.