



California ISO

Overview of Battery Storage Experience CAISO

Operations Policy and Analytics

Darren Lamb – Operations Policy Manager
September 2023

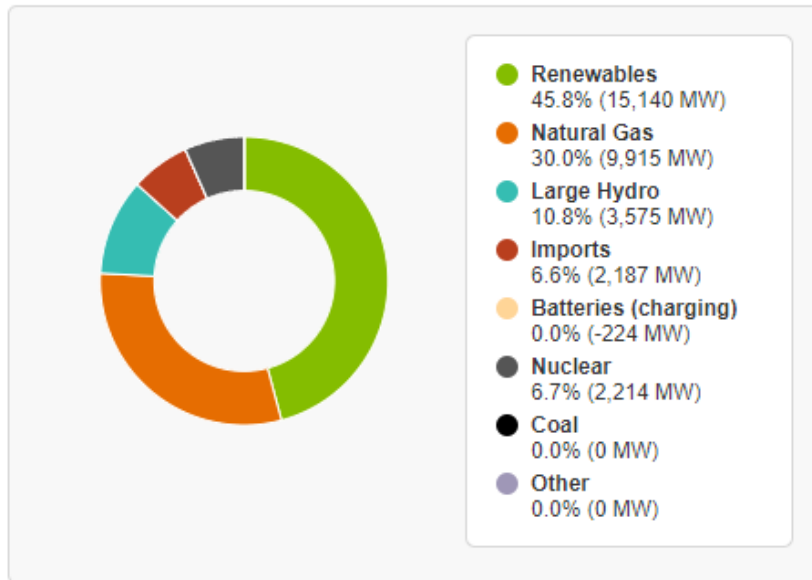
California Environmental Goals Are Driving the Development of New Battery Storage Facilities

- California has a goal to generate electricity in a 100% Greenhouse Gas (GHG) free by 2045
 - Energy will come from renewables
 - Storage is required to save energy for consumption when generation is less than loads
- The California market peaks at ~50 GW in the summer
 - 6,000 MW of storage is already integrated into the market
 - Nearly all is lithium-ion and 4-hour duration
 - CPUC anticipates more than 10 GW of storage before summer 2024
 - CPUC anticipates more than 1 GW of long-duration storage by 2026

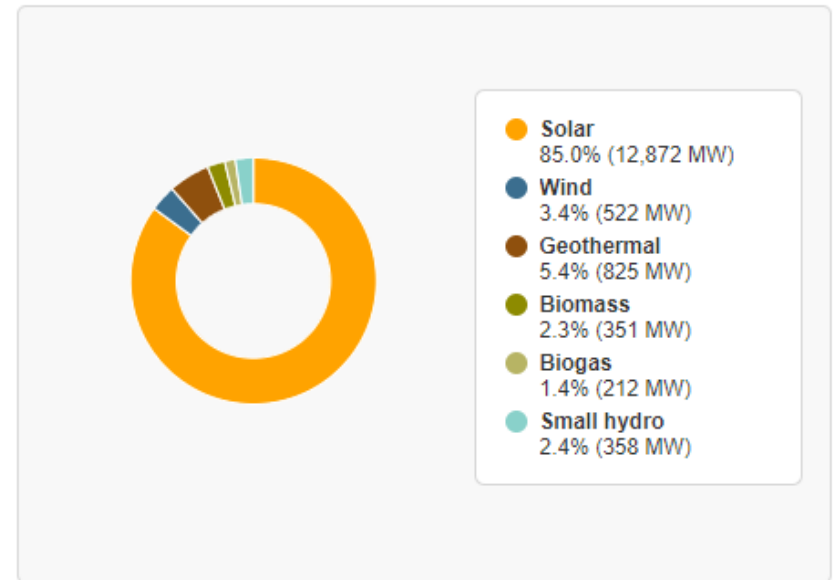
Current State of CAISO Generation

9/5/2023 @ 17:15

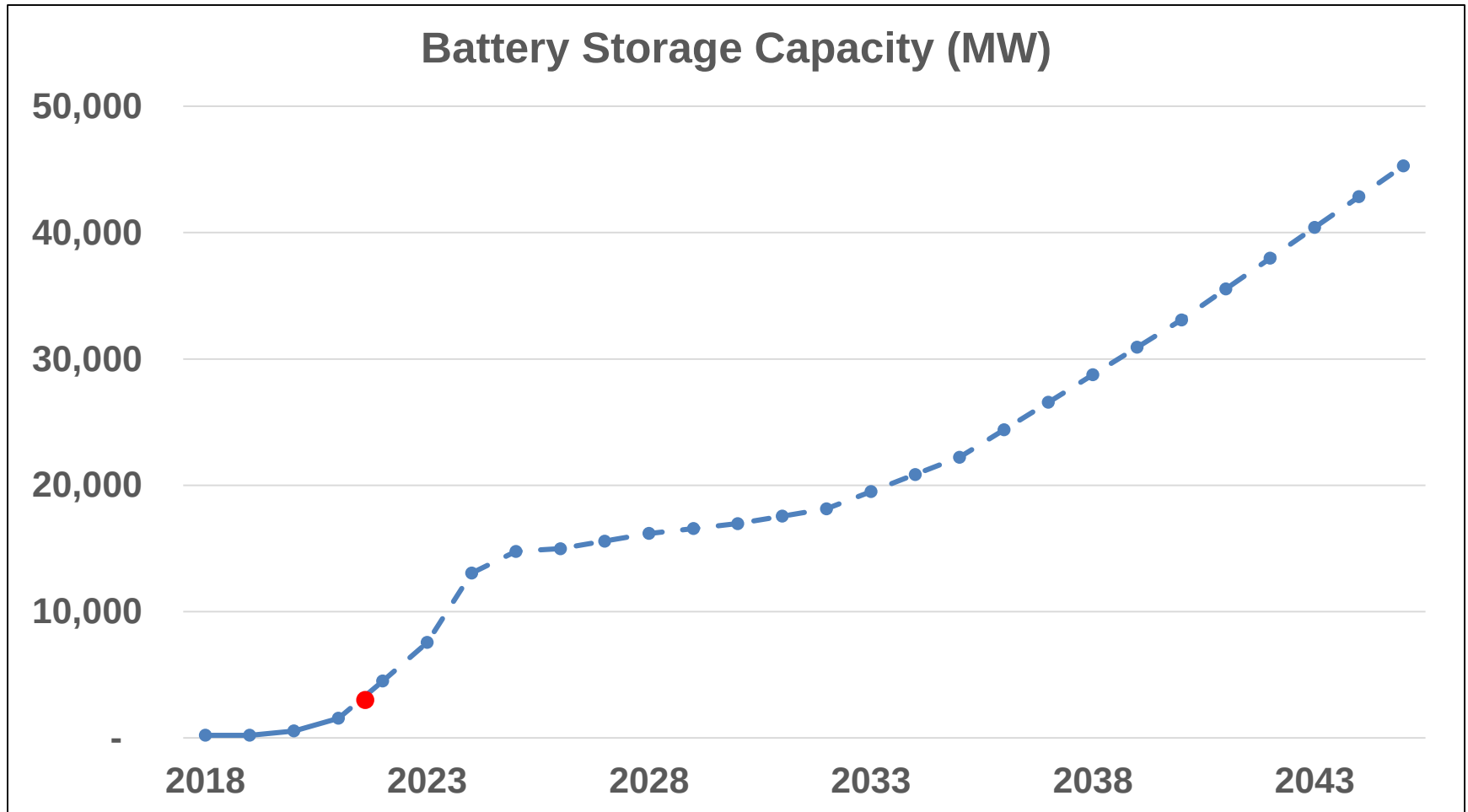
Current supply



Current renewables



The CAISO Expects a Massive Buildout of Battery Storage to Meet California's 2045 GHG Reduction Targets

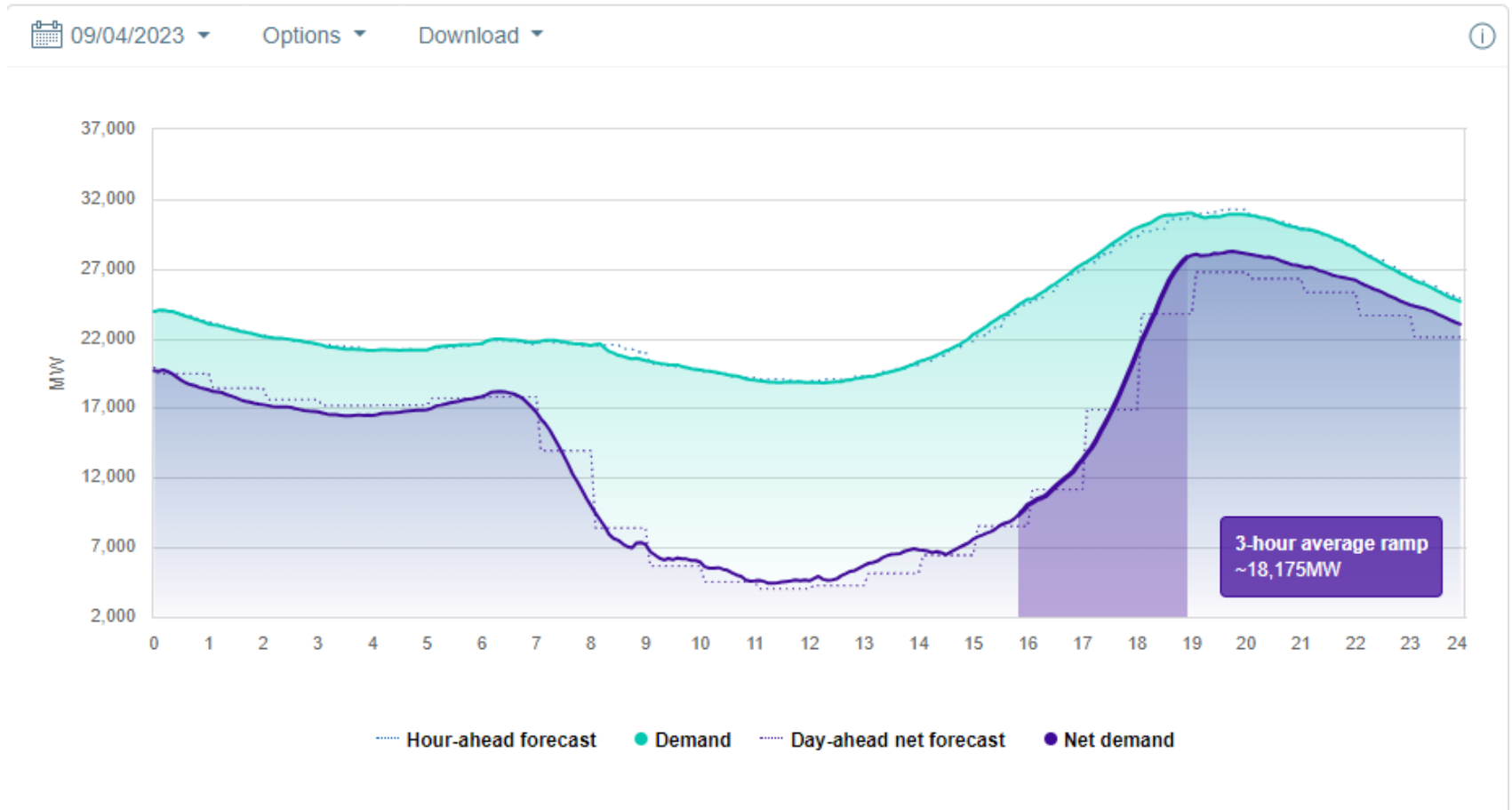


Battery Storage is Critical In Meeting Grid Challenges

- Meeting Net Load Capacity
- Cushioning Excess Supply During Solar Hours
- Addressing Ramping Needs During Solar Ramps
- Fast Ramping Regulating Units
- Providing Frequency Response

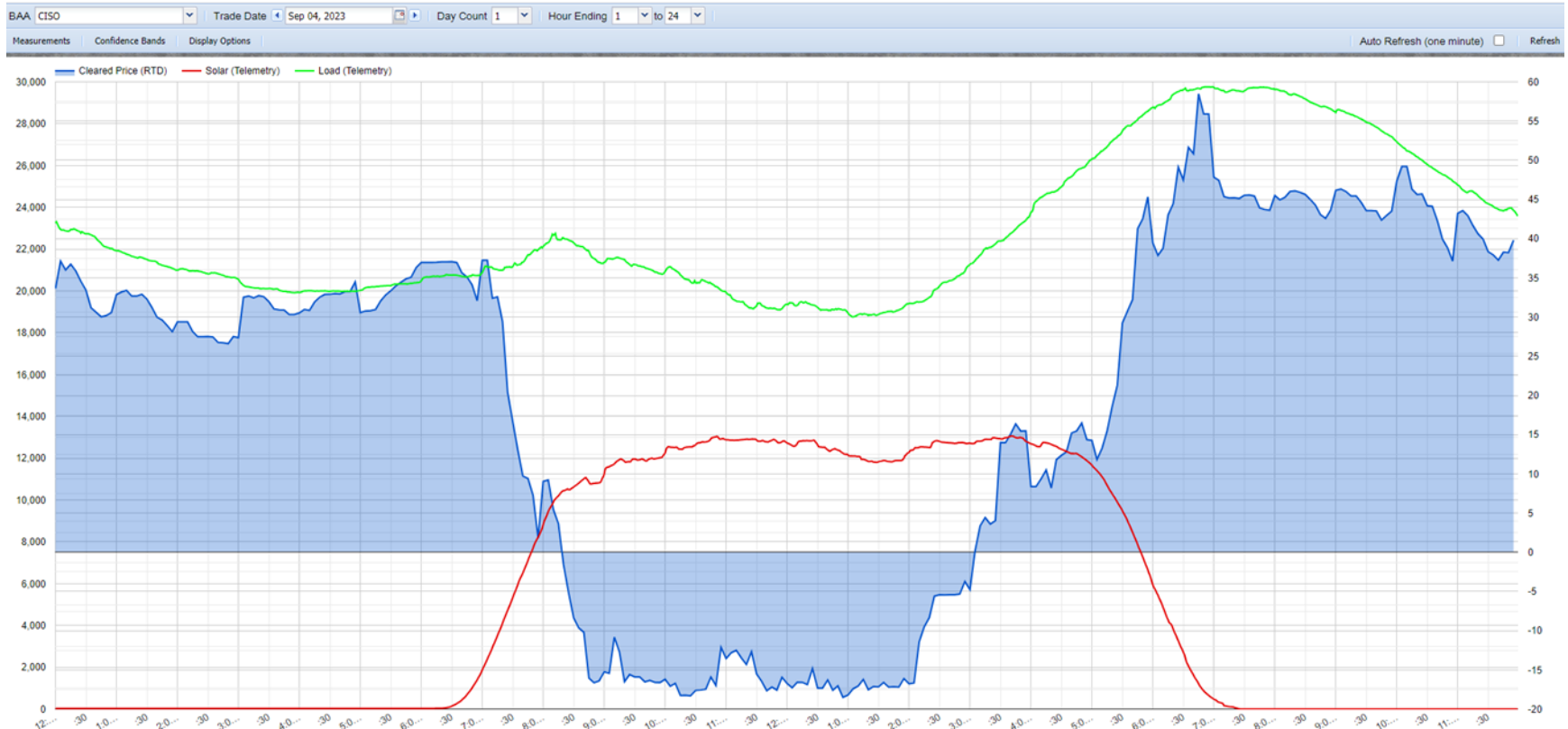
System Demand Versus Net Demand

September 4, 2023



Real Time Market Prices vs Solar Output vs Load

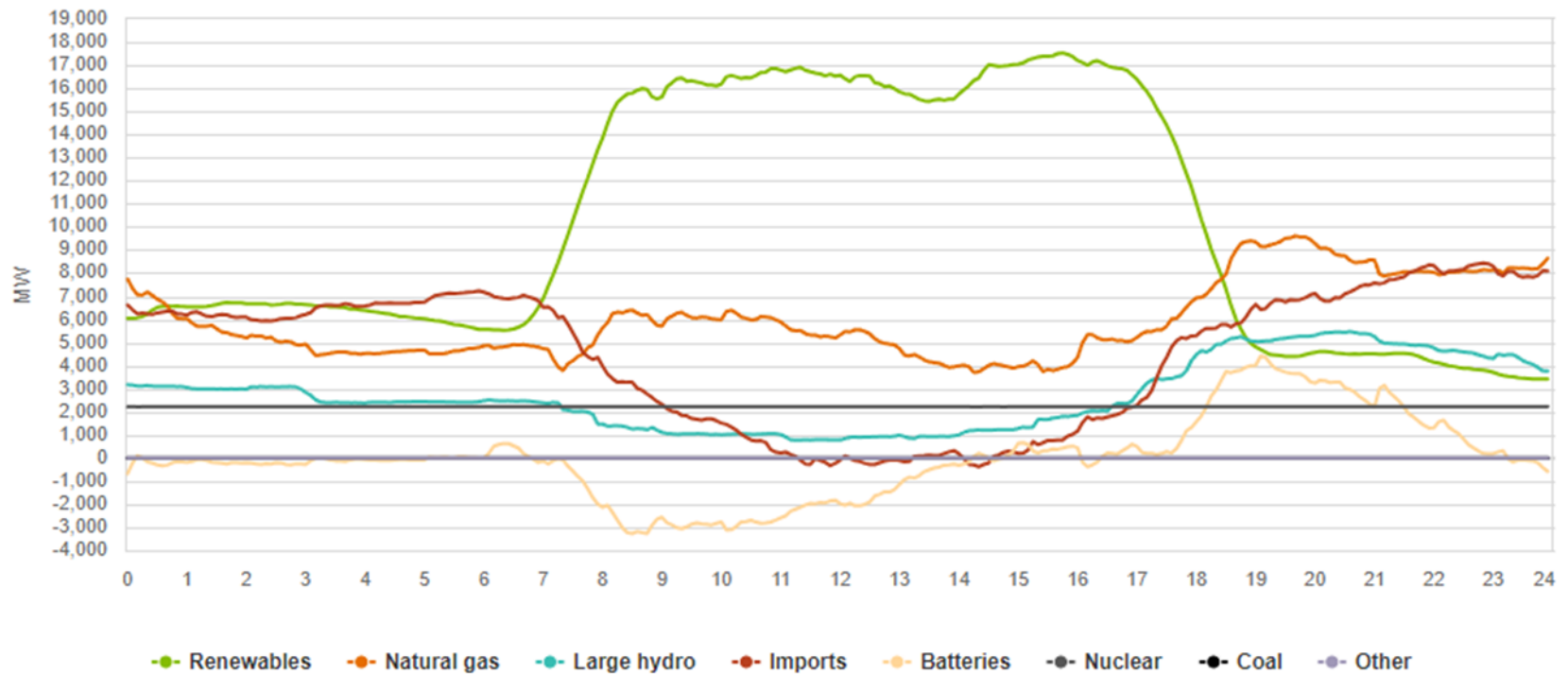
September 4, 2023



Energy in MW Broken Down by Resource

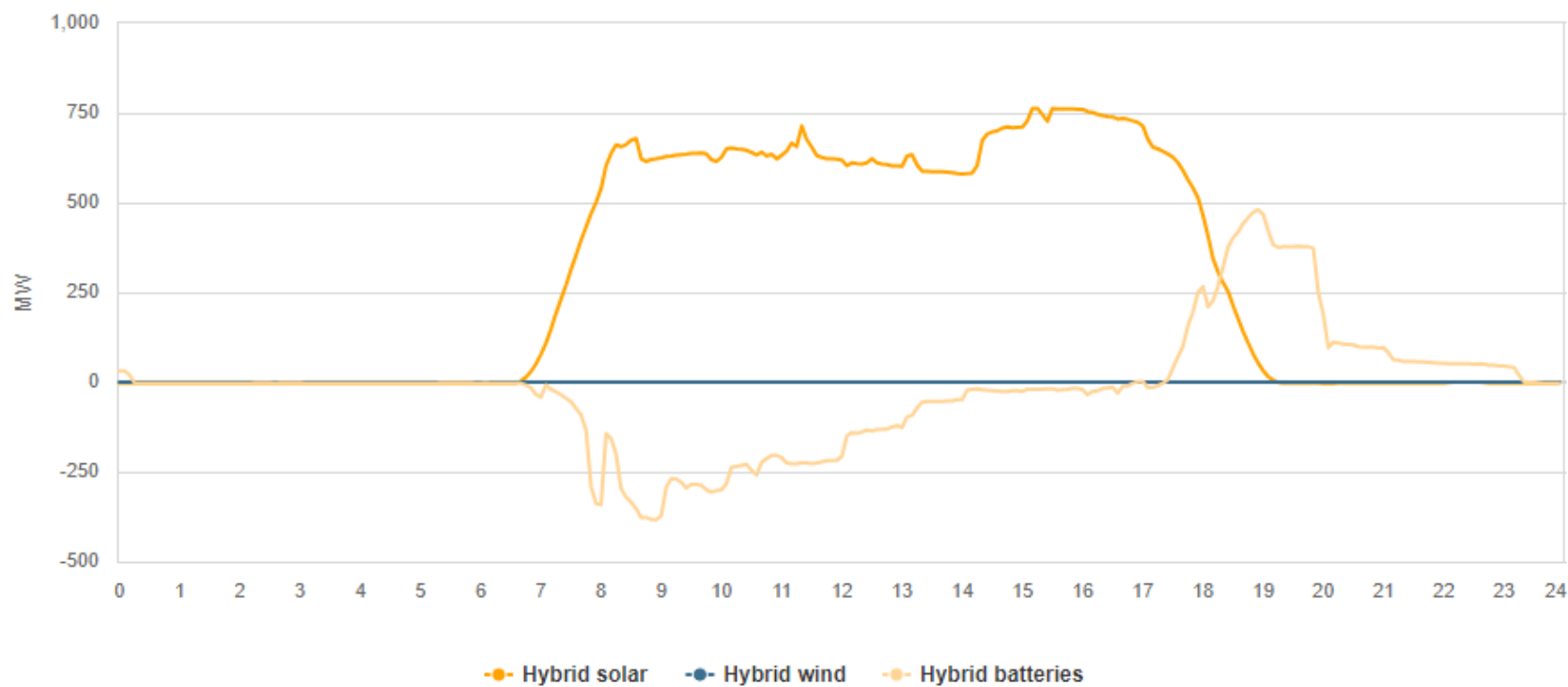
September 4, 2023

09/04/2023 ▾ Options ▾ Download ▾



Hybrid Resources – 9/4/2023

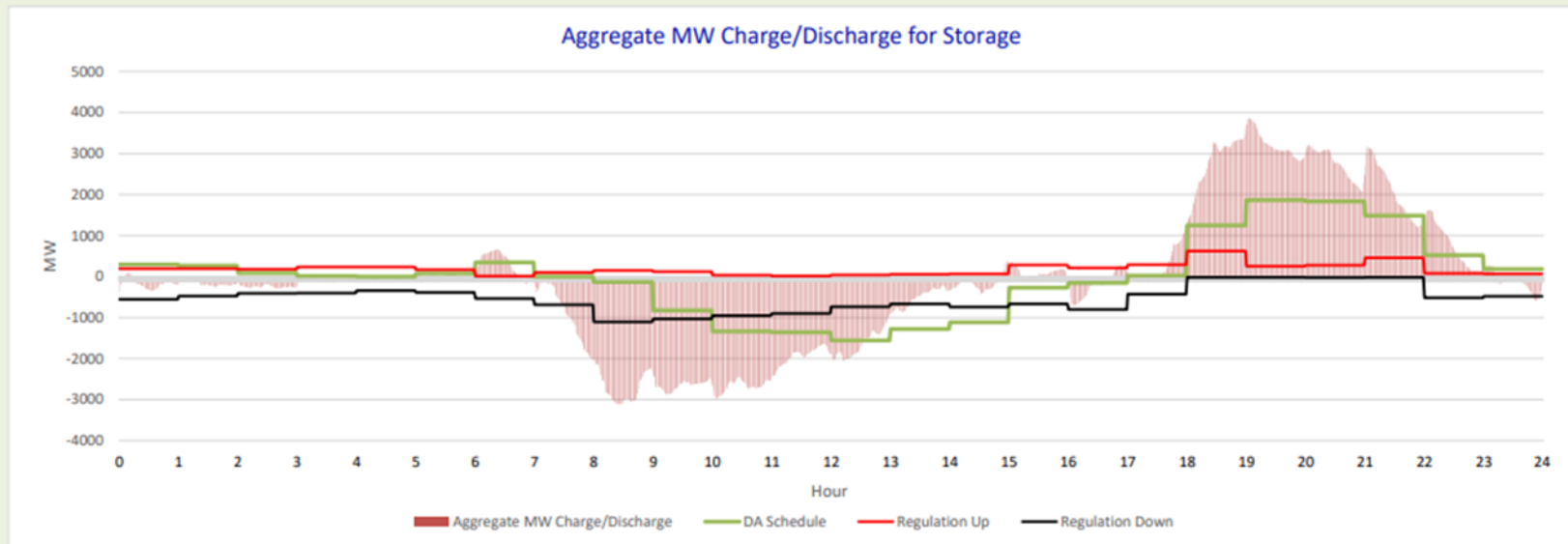
09/04/2023 ▾ Options ▾ Download ▾



Battery Storage Critical for Net Peak Load, Ramping Challenges, and Regulation Needs

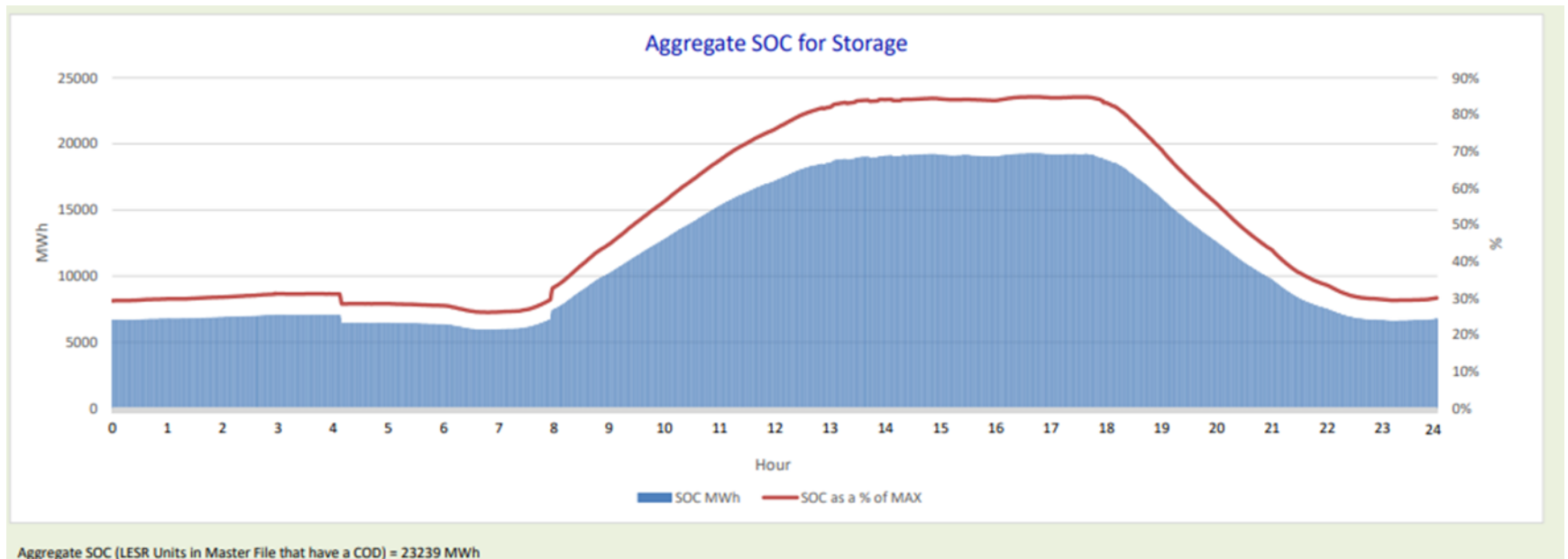
Daily Metric for Storage Resources

September 4, 2023



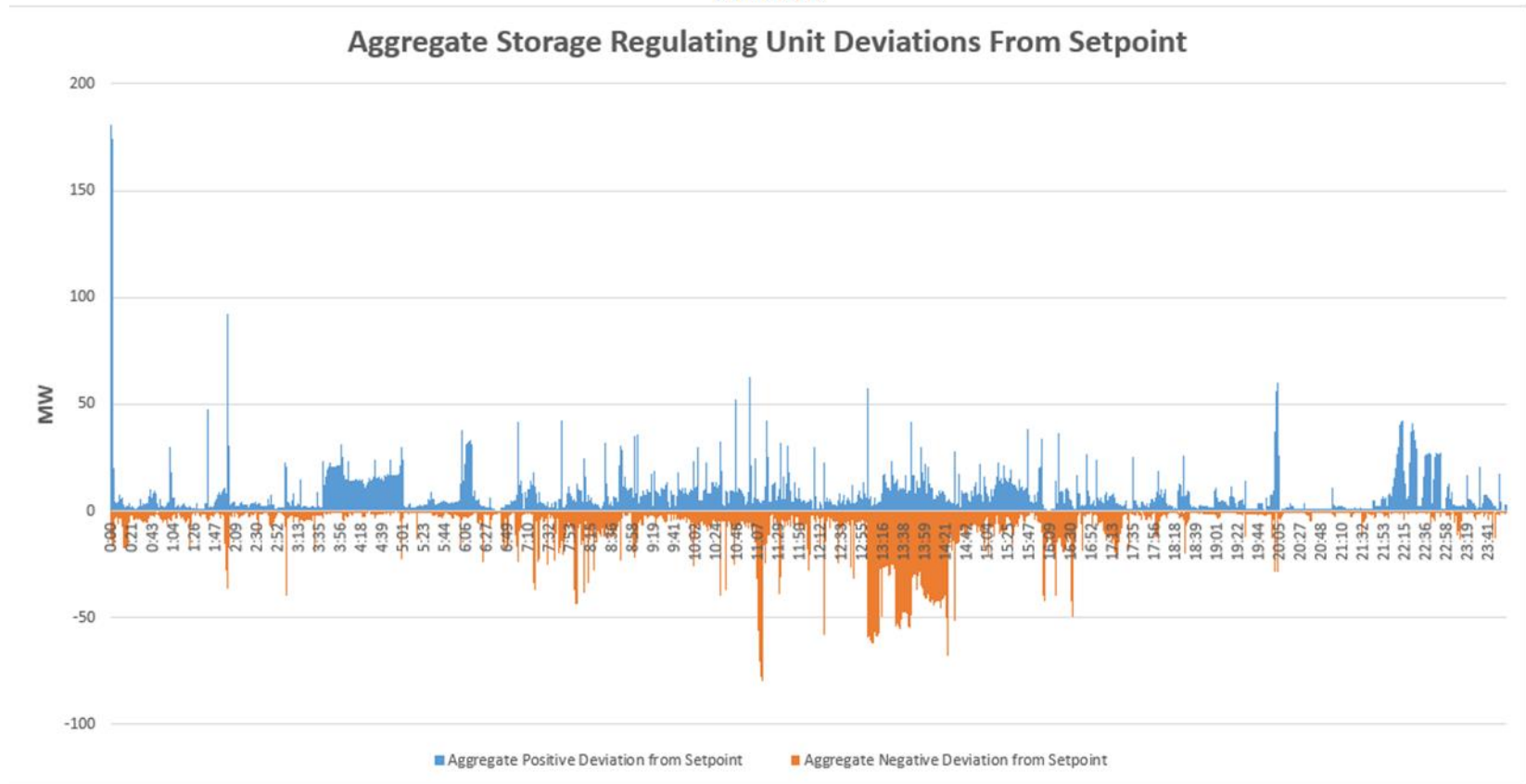
Aggregate MW Installed Capacity (LESR Units in Master File that have a COD) = 6030 MW

Aggregate Battery Storage State of Charge September 4, 2023



Macro View of Battery Storage Unit Performance Under Regulation

9/4/2023



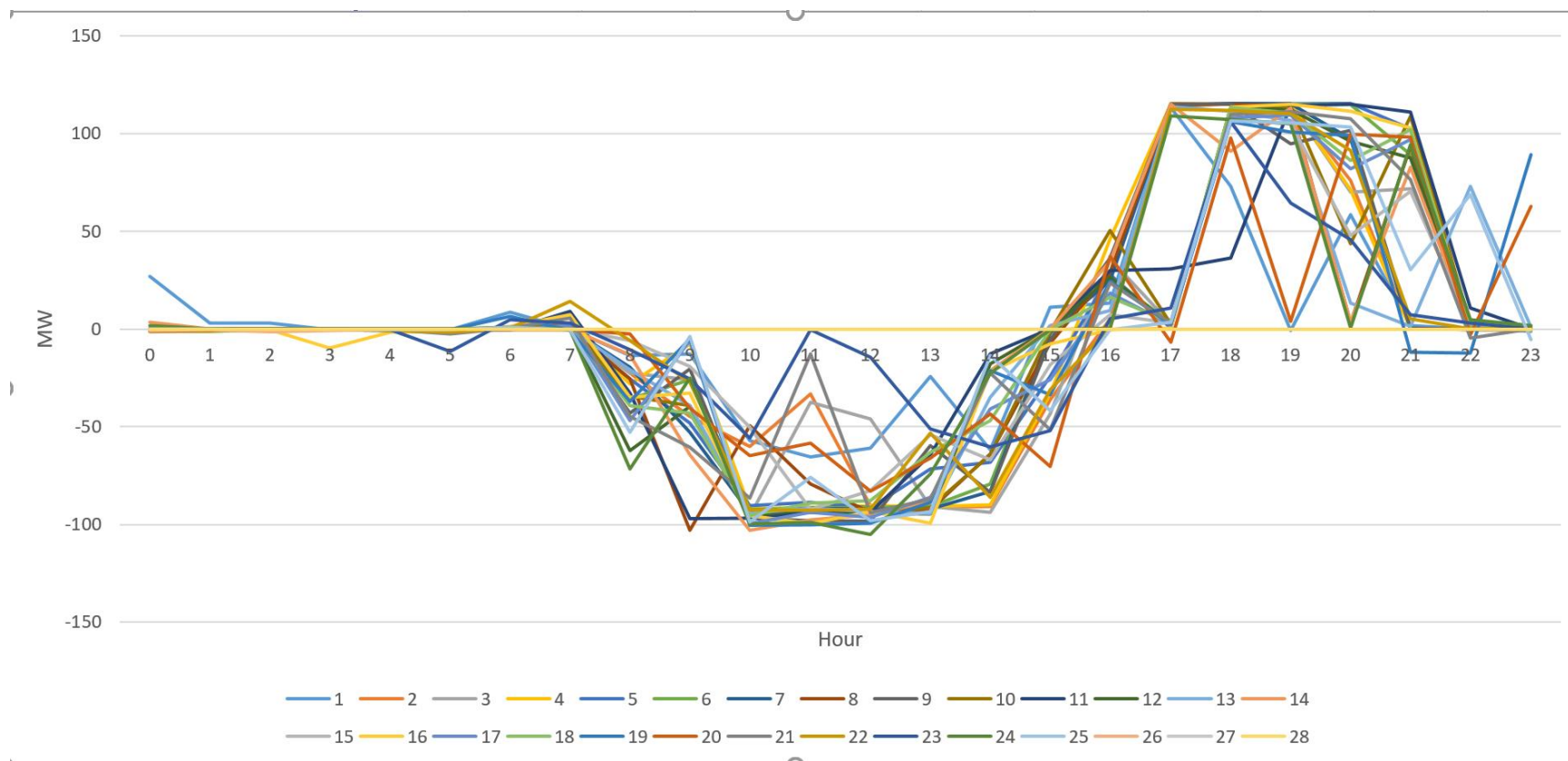
Investment Tax Credit (ITC)

Over the course of the year, the battery storage must be charged at least 75% of the time by a renewable source rather than from the grid in order to be eligible for ITC. “75% cliff rule”.

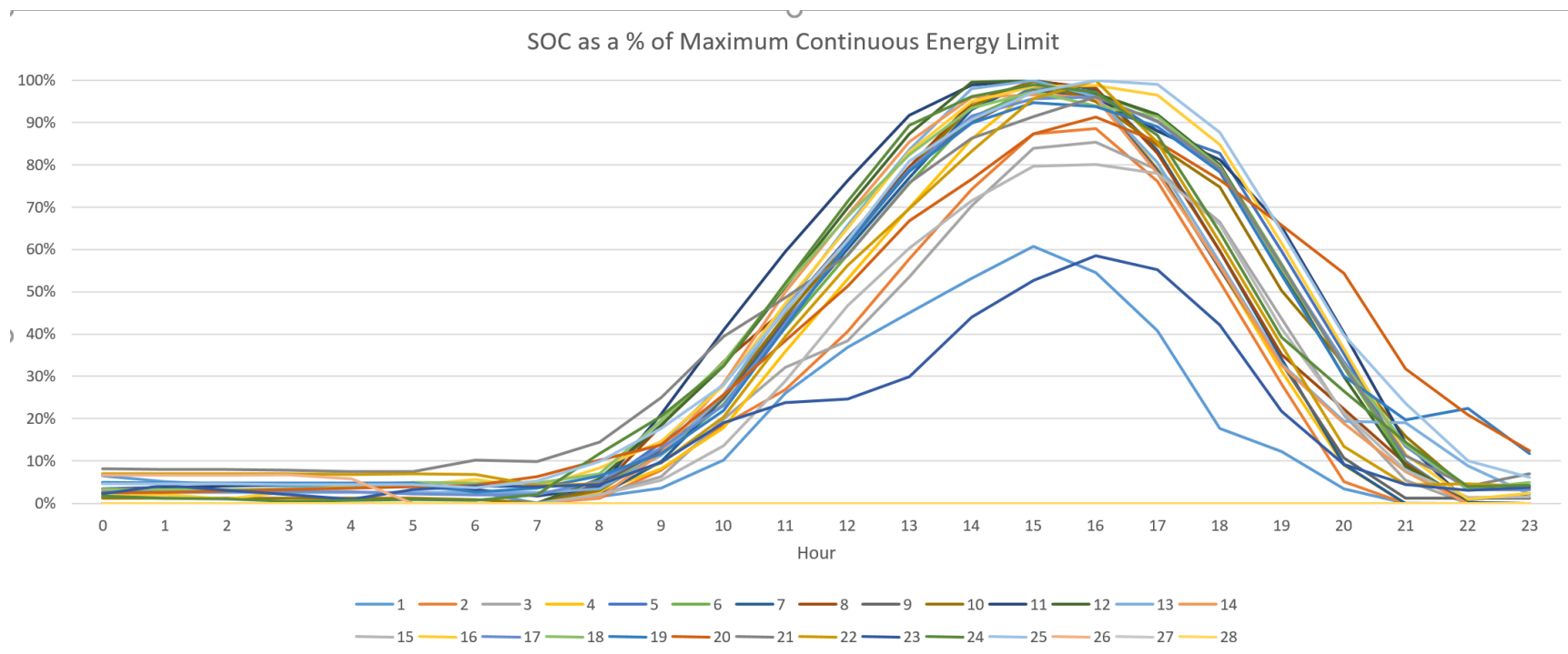
For Co-Located Battery Storage Units Primarily Being Charged by Solar Units:

- Will SOC be impacted on cloudy days?
- Will SOC be impacted by solar unit being curtailed?
- How will the Co-Located average hourly SOC compare to Storage units charging from the grid?

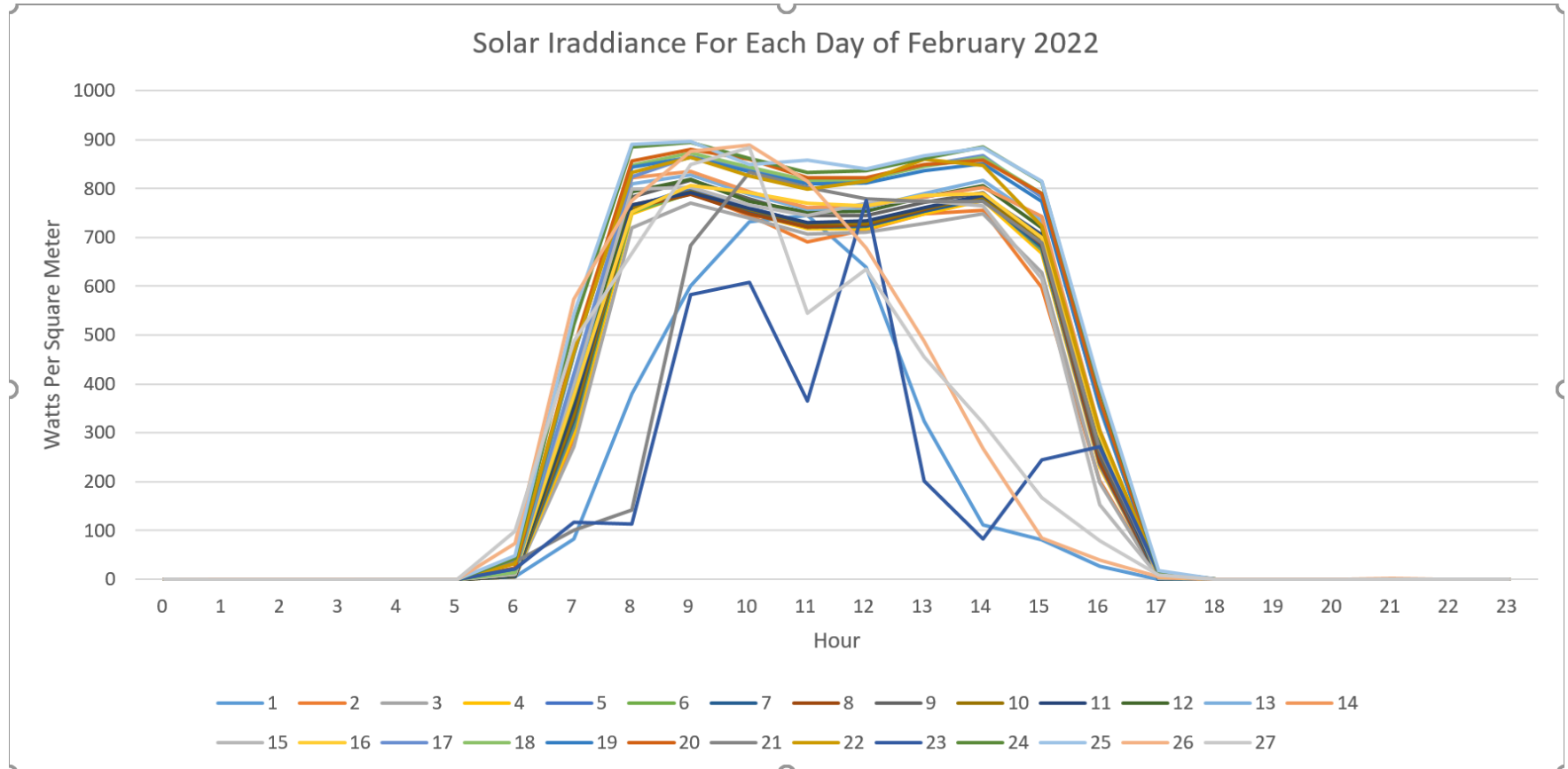
One Identifier of ITC Impacted Units: Charging Mainly During Solar Hours – Unit X (February 2022)



Unit X SOC as % of Max For the Month of February



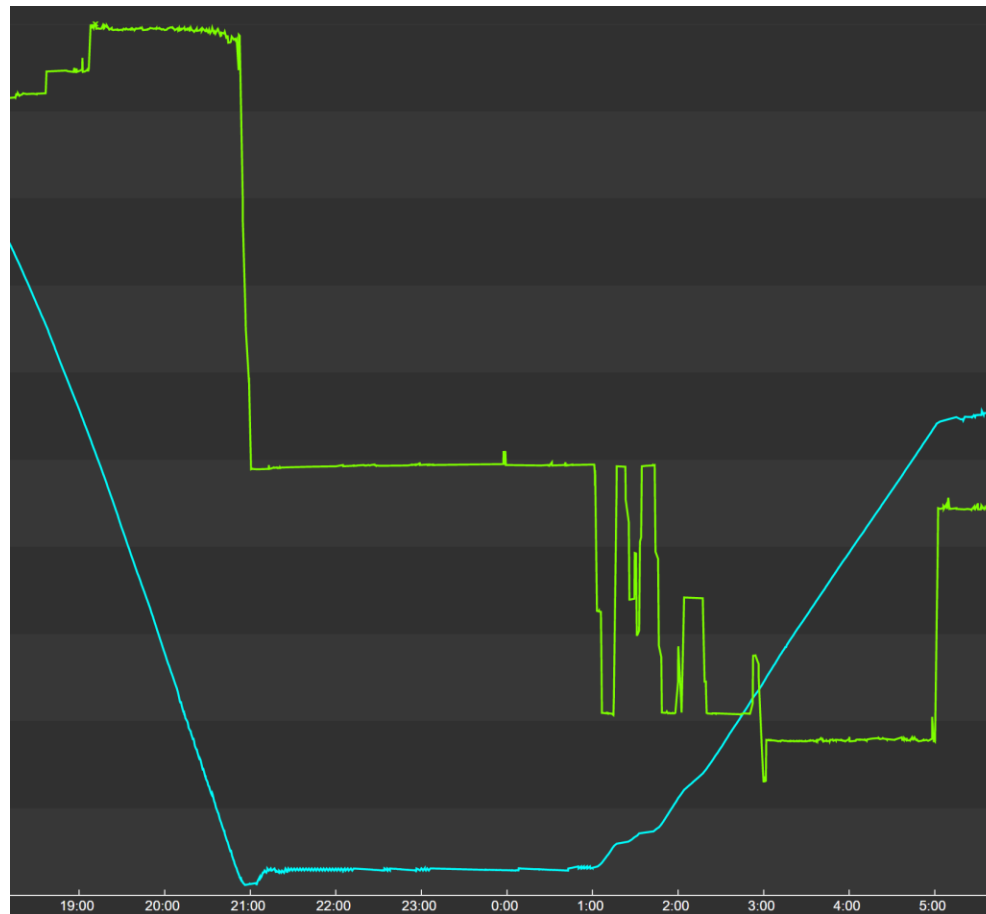
Distinguishing Cloudy vs Clear Days for February 2022 for Unit X



Hourly SOC as % of Max For Select Co Located Units (February 2022)

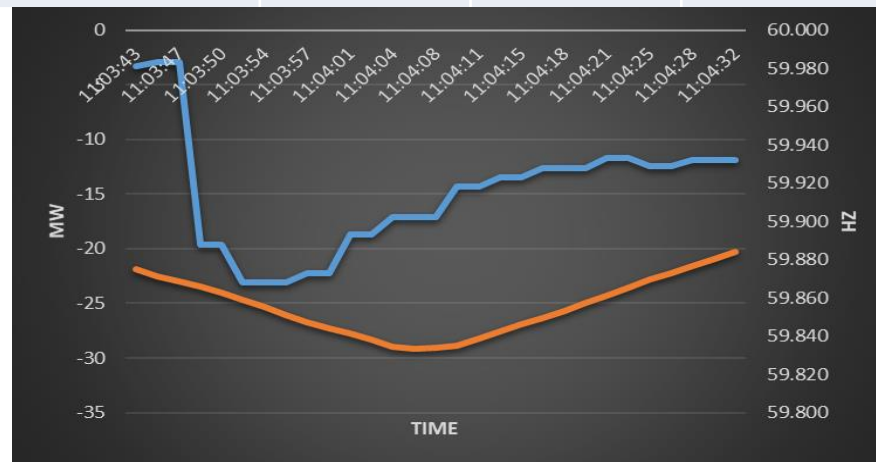
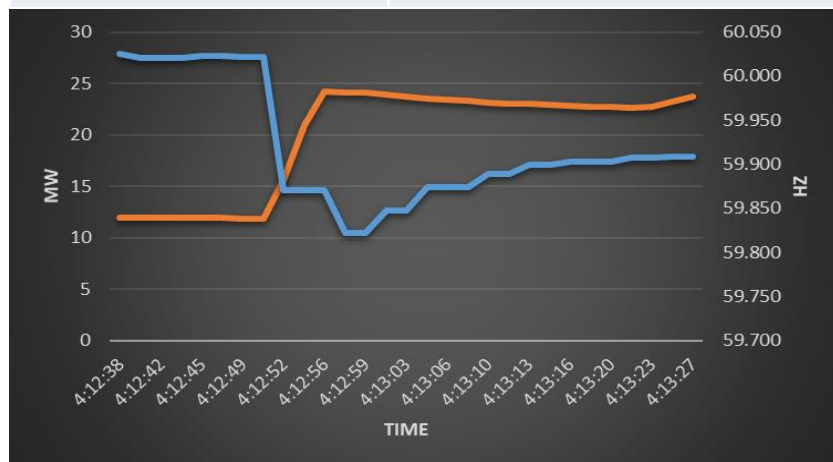
Hour	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Co-located Average	Control (All Storage Units)
0	3%	3%	25%	2%	2%	18%	40%	1%	2%	11%	19%
1	3%	2%	24%	2%	2%	16%	37%	1%	2%	10%	20%
2	3%	2%	23%	2%	2%	15%	35%	1%	2%	10%	21%
3	3%	2%	21%	2%	2%	15%	33%	1%	2%	9%	23%
4	2%	2%	20%	2%	2%	14%	32%	2%	2%	9%	24%
5	2%	2%	18%	2%	2%	11%	31%	5%	2%	8%	24%
6	2%	2%	13%	2%	1%	7%	22%	5%	2%	6%	21%
7	2%	2%	12%	2%	1%	4%	15%	4%	2%	5%	17%
8	3%	5%	16%	5%	3%	5%	16%	13%	5%	8%	20%
9		16%	24%	12%	12%	10%	27%	29%	12%	18%	28%
10		31%	35%	24%	24%	19%	40%	45%	23%	30%	38%
11	26%	47%	48%	40%	37%	30%	55%	60%	38%	42%	50%
12	44%	62%	60%	56%	49%	41%	68%	70%	52%	56%	62%
13	62%	76%	71%	71%	62%	54%	77%	75%	66%	68%	73%
14	78%	87%	79%	78%	74%	66%	83%	75%	77%	77%	80%
15	83%	92%	82%	79%	80%	74%	86%	80%	82%	82%	84%
16	83%	90%	81%	79%	81%	78%	86%	79%	82%	82%	84%
17	72%	79%	74%	74%	72%	75%	77%	68%	74%	74%	76%
18	51%	60%	63%	58%	59%	65%	70%	50%	60%	60%	64%
19	30%	41%	49%	38%	42%	53%	66%	32%	40%	43%	49%
20	10%	22%	39%	22%	27%	41%	60%	19%	22%	29%	36%
21	3%	8%	34%	10%	13%	31%	54%	10%	9%	19%	27%
22	3%	4%	30%	5%	5%	25%	49%	3%	3%	14%	22%
23	3%	3%	28%	4%	2%	22%	45%	2%	3%	12%	20%

Ramping Concerns - Rapid Decline Once SOC is Depleted



Frequency Response

Date and Time	Cause of Frequency Event	Freq. Before (Hz)	Freq. After (Hz)	Delta (Hz)
02/06/2021 04:12:44	Line relay causing 1700 MW of generation to trip	60:029	59.899	0.1297
12/06/2021 11:03	Loss of 1325 MW of generation	59.983	59.865	0.118



Orange Storage Unit Output
Blue Frequency

Questions?