

CAISO Renewables Curtailment: A Visual History

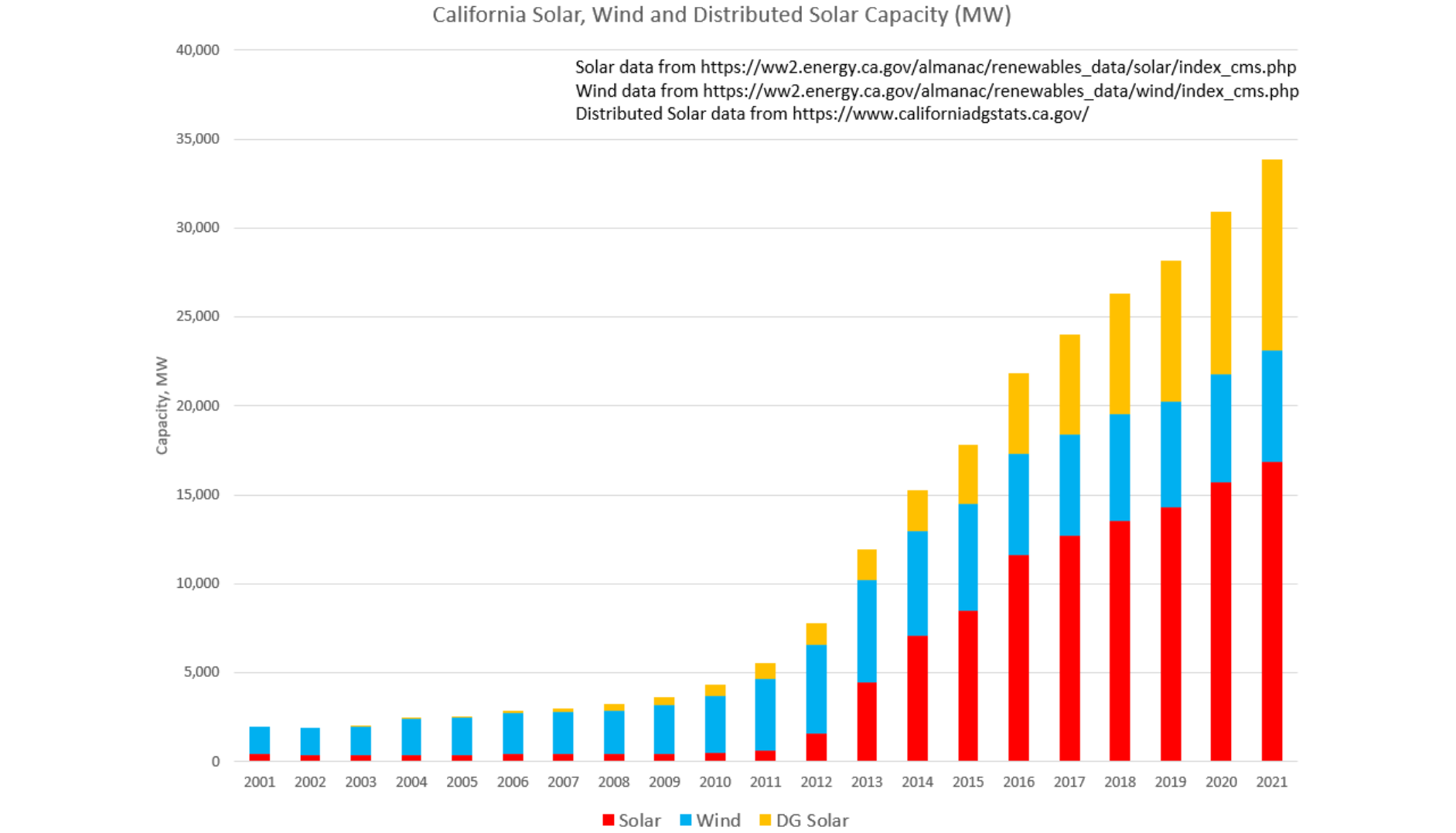
Western Power Trading Forum Roundtable

August 12, 2022

Brian Theaker, Middle River Power LLC

FUNDAMENTALS

Solar, Wind and Distributed Solar Capacity (MW)

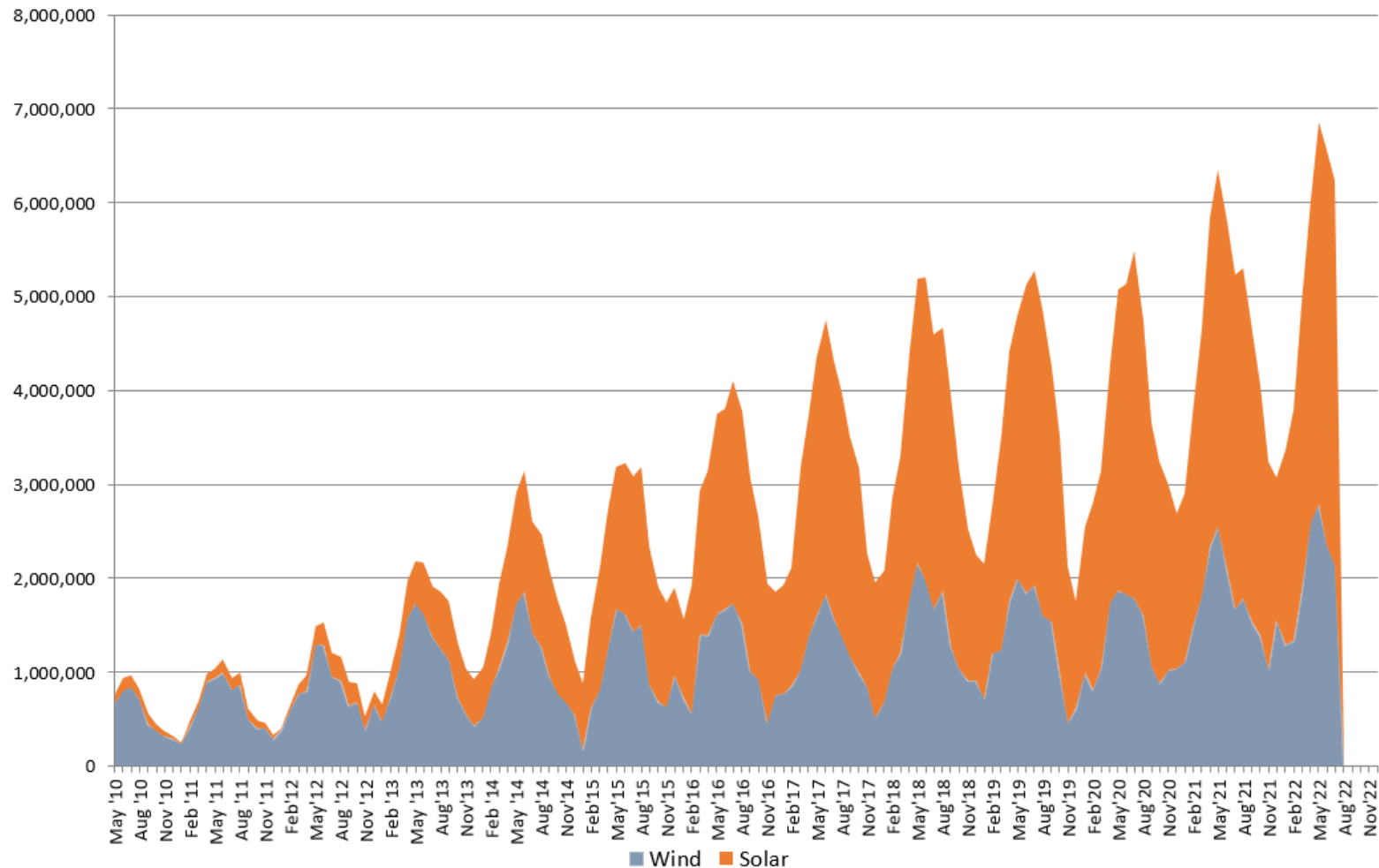


Monthly CAISO Wind and Solar Energy (MWh)

May 2010-July 2022

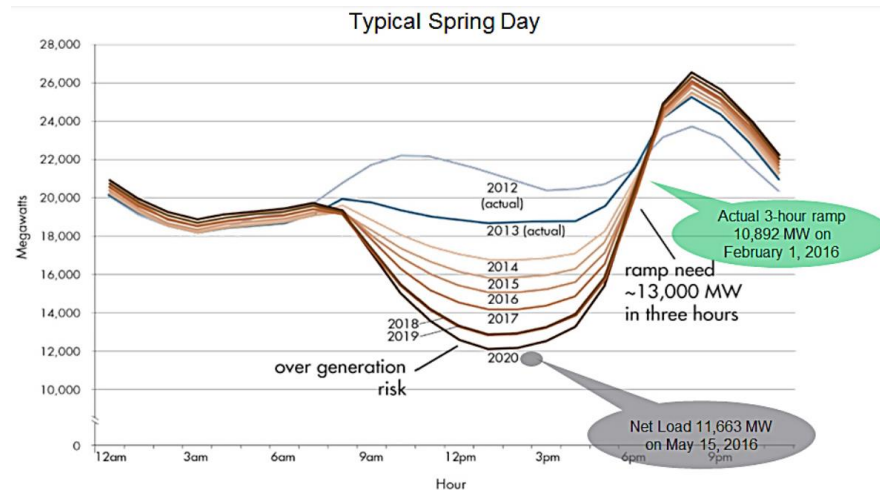


Monthly CAISO Wind and Solar Energy (MWh)

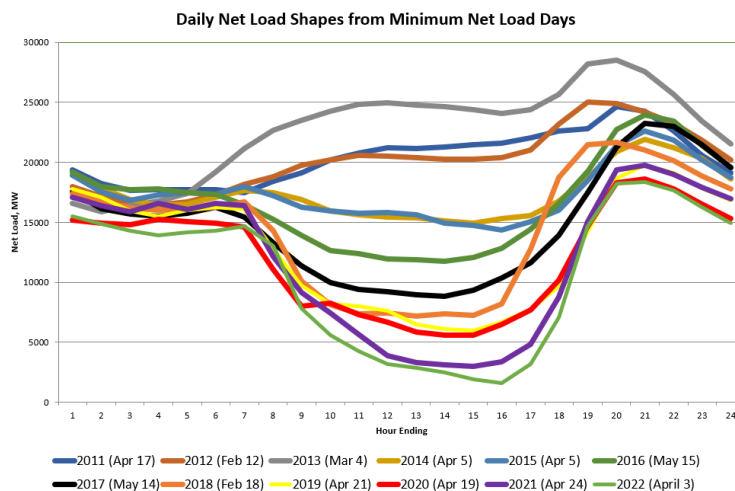


Duck (Net Load) Curves

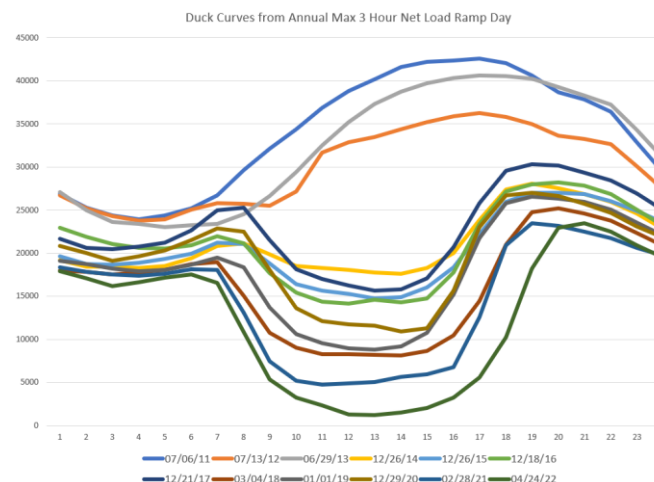
From CAISO's 2016 *"What the duck curve tells us about managing a green grid"* -
http://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf



Realized ducks
from minimum
net load days
and maximum
3-hour ramp
days



Minimum Net Load Day

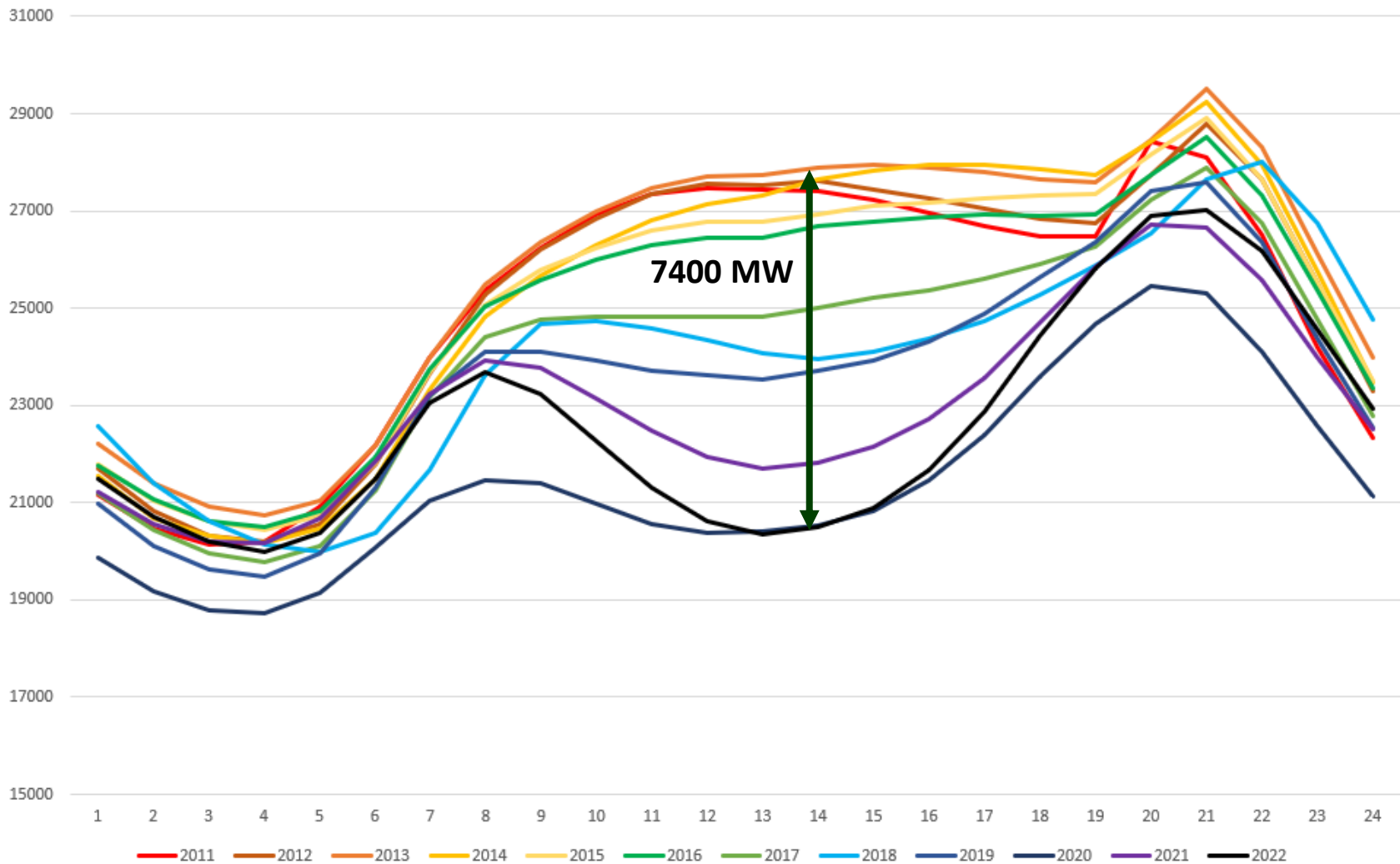


Maximum 3-Hour Net Load Ramp Day

The Growth of BTM Solar Shows In CAISO Load Curves



April Average Weekday Load Shapes 2011-2022

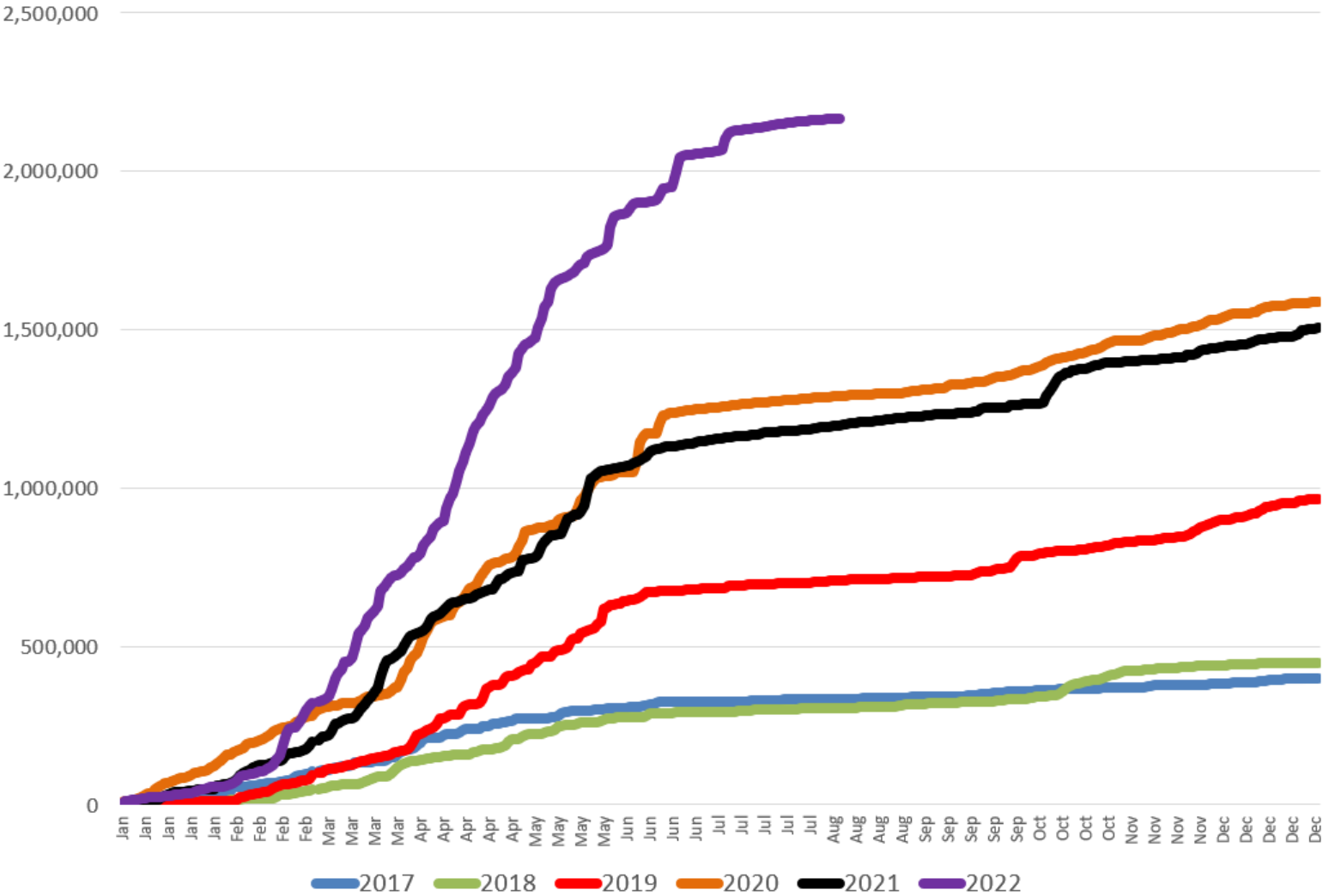


CURTAILMENT

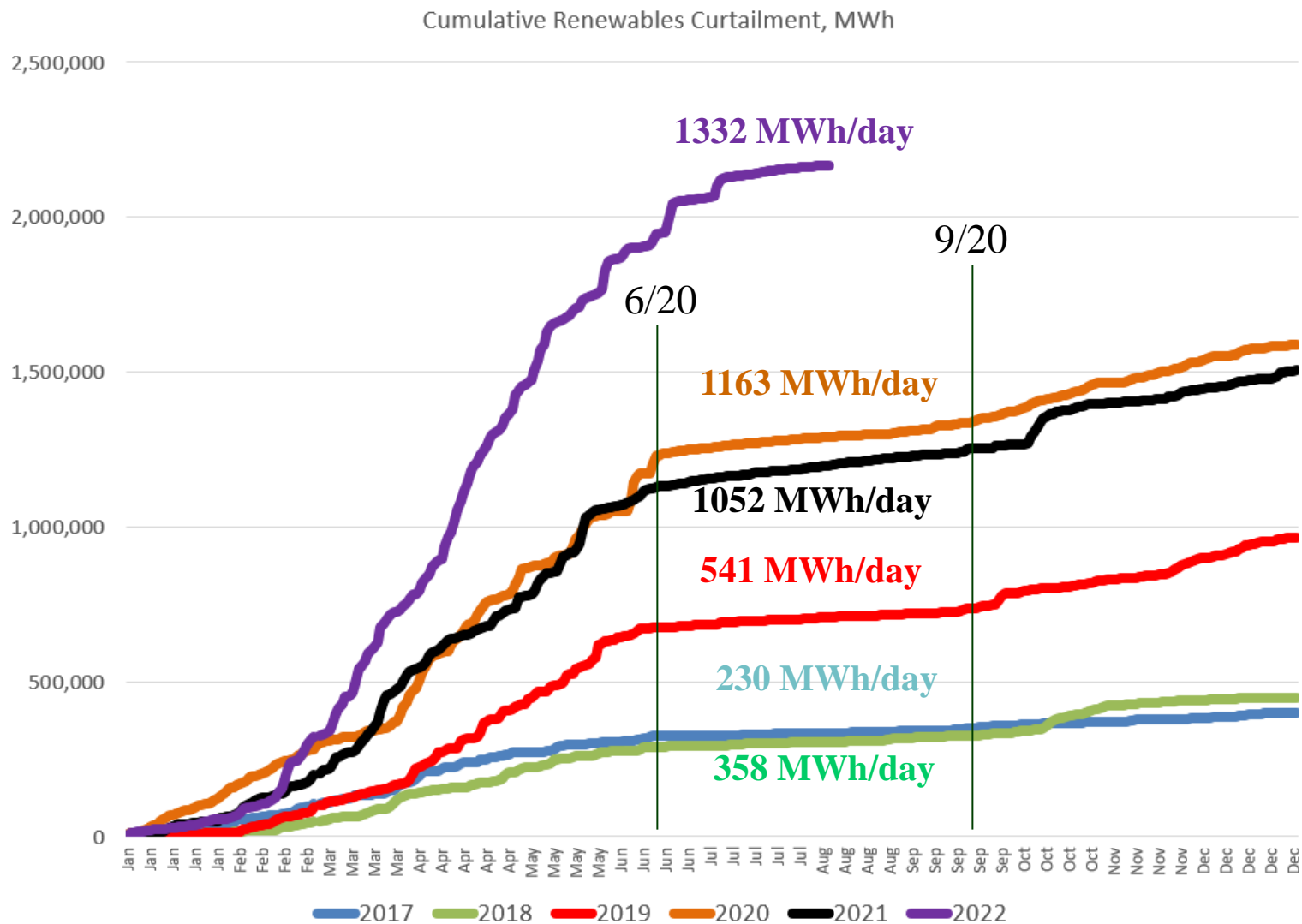
Annual Cumulative Curtailment (2022 through August 7)



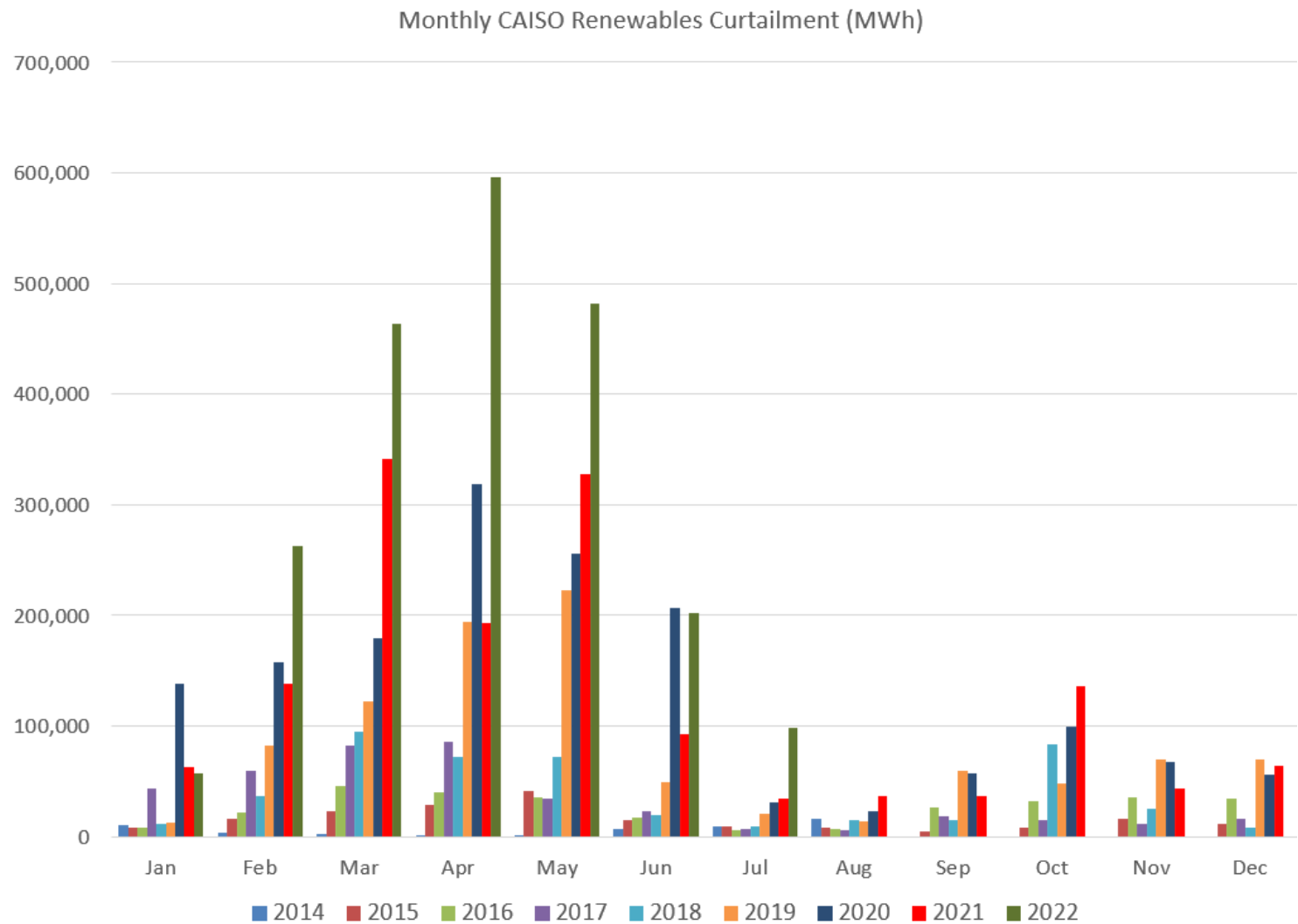
Cumulative Renewables Curtailment, MWh



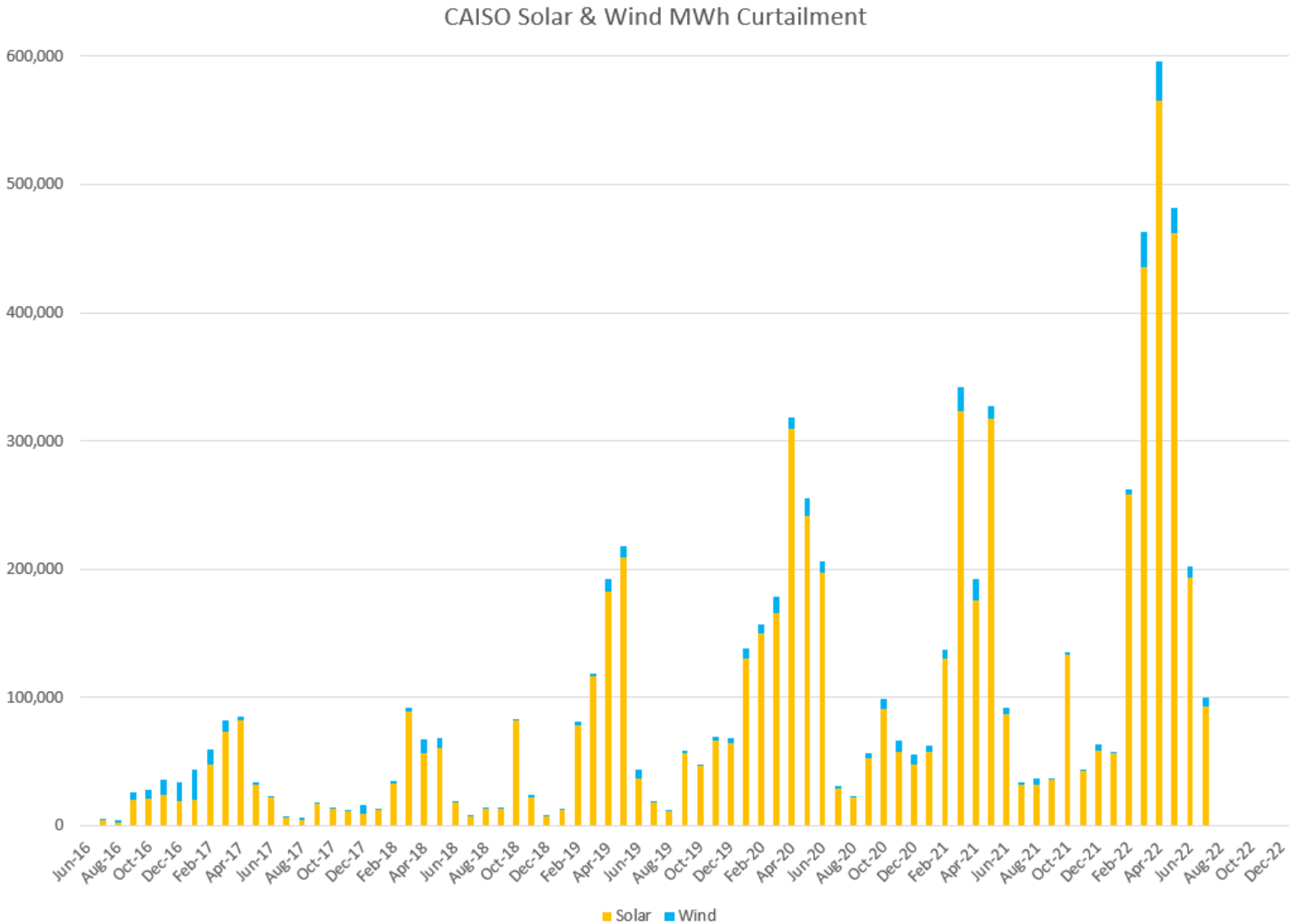
Annual Cumulative Curtailment (2022 through August 7)



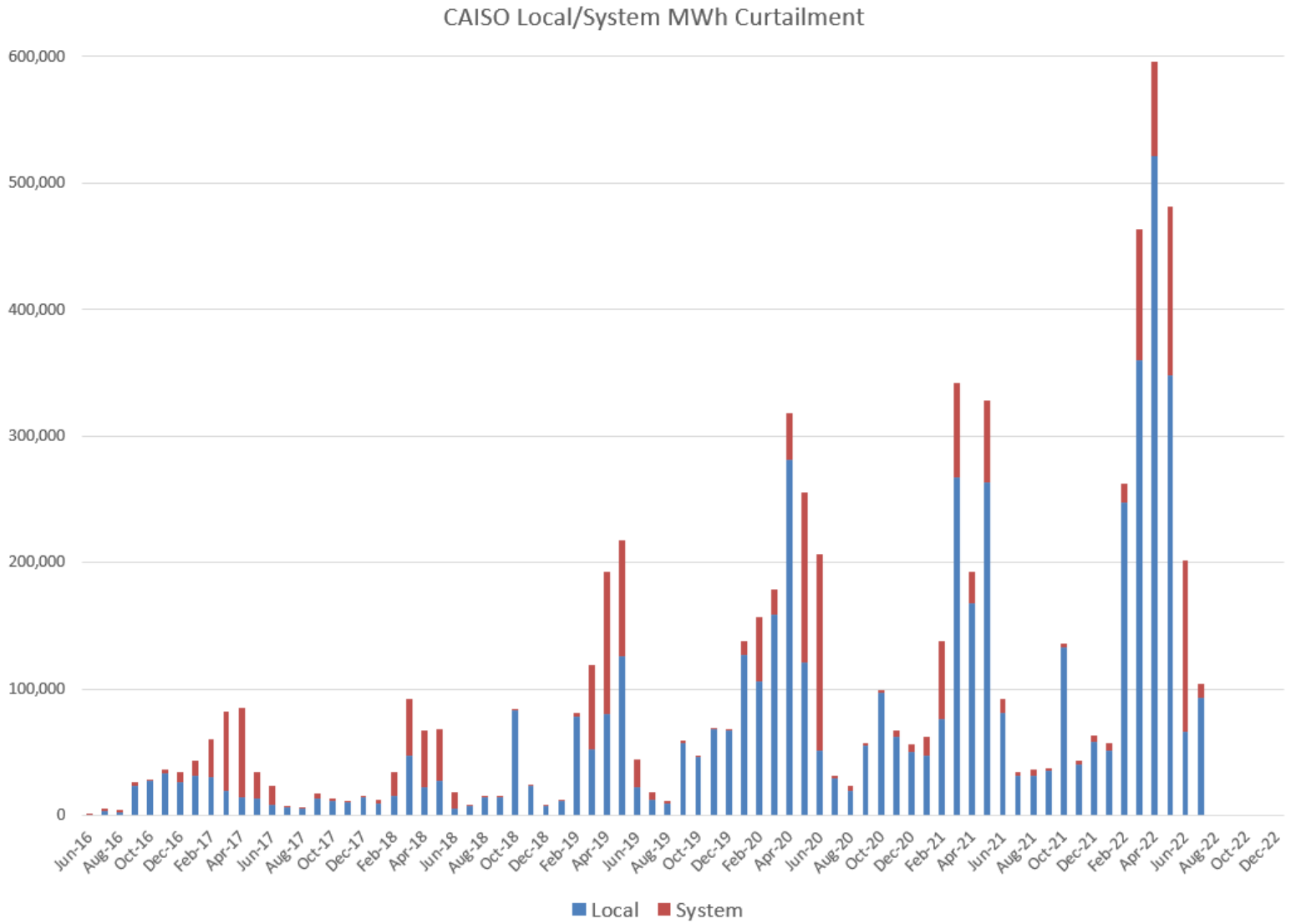
CAISO Renewables Curtailment by Month and Year



Monthly CAISO Solar and Wind Curtailment (MWh)



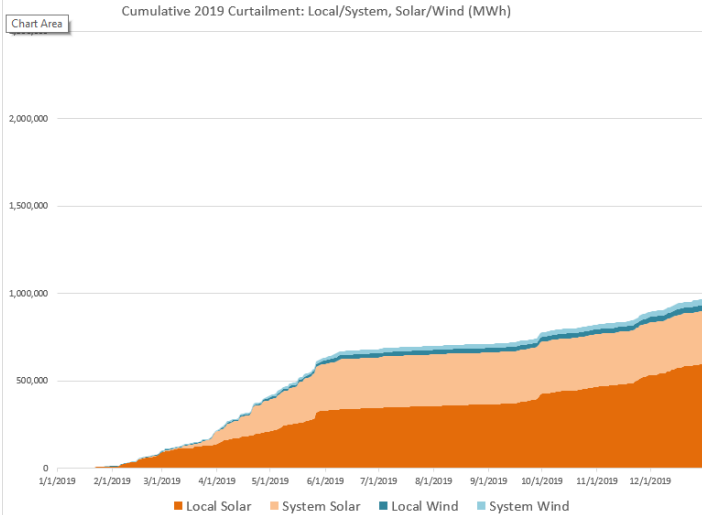
Monthly CAISO Local and System Curtailment (MWh)



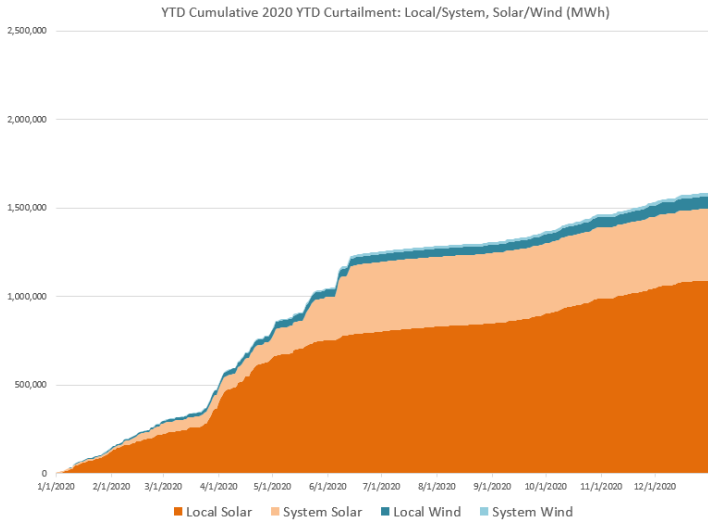
Cumulative Annual Local/System Solar/Wind



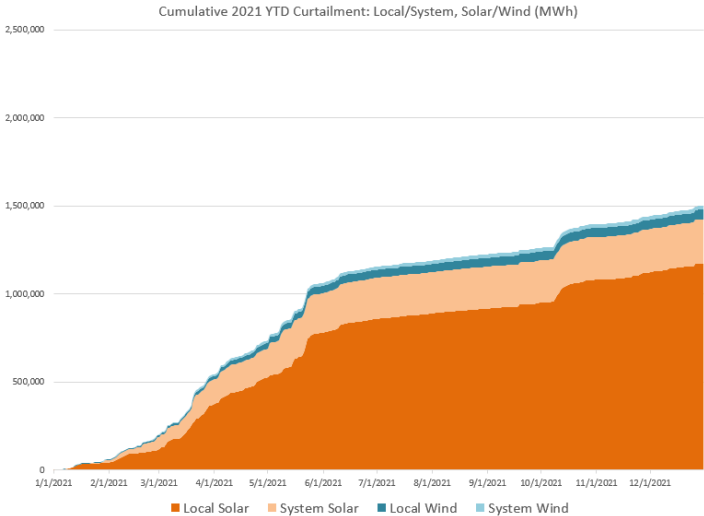
2019



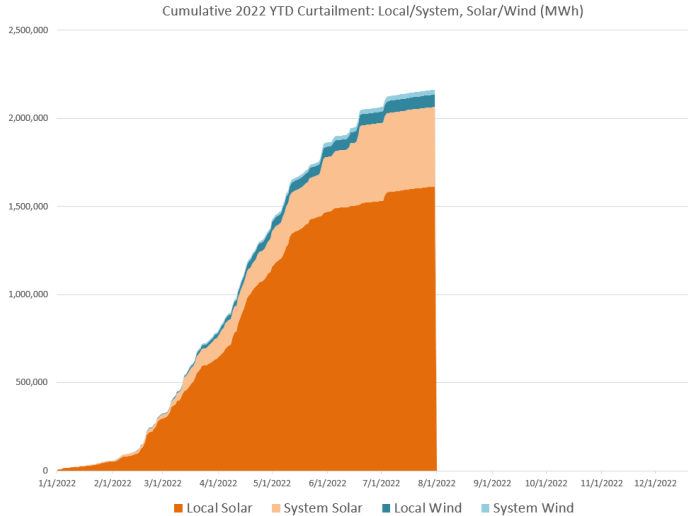
2020



2021



2022



Daily Curtailment by Year



2017



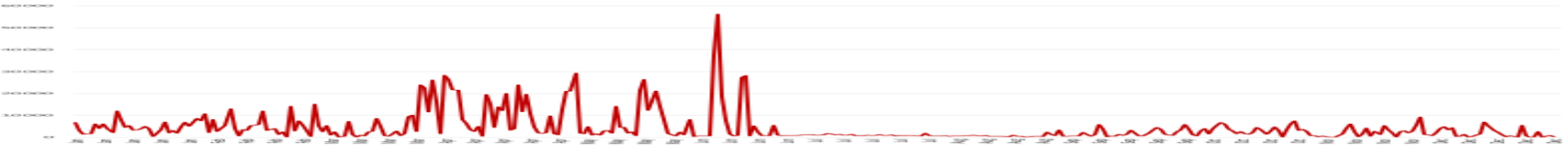
2018



2019



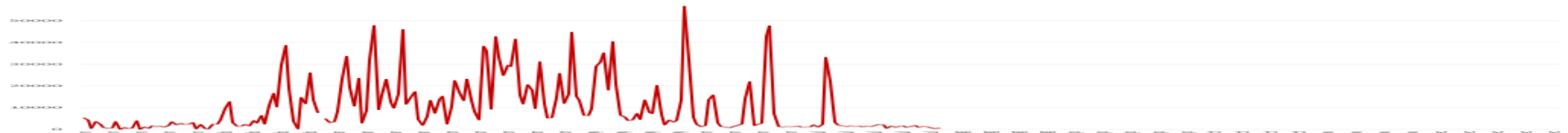
2020



2021



2022



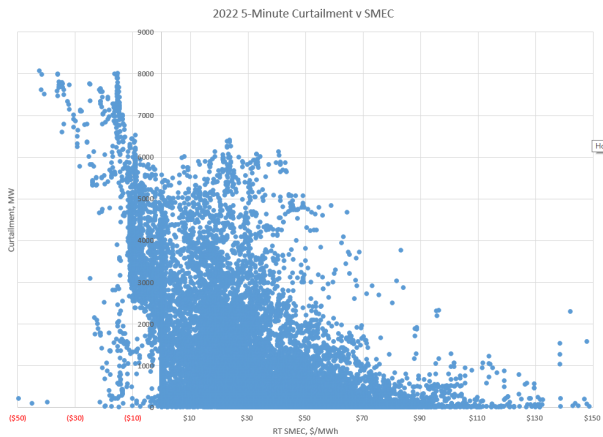
CAISO Top 20 Curtailment Days



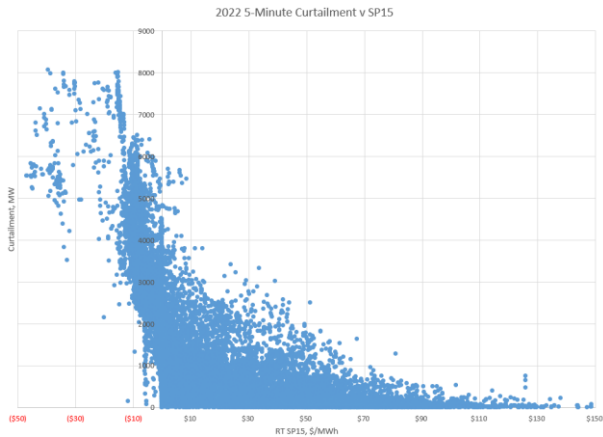
	Date	MWh	DOW
1	5/29/2022	56,674	Sun
2	6/7/2020	56,278	Sun
3	3/13/2022	47,900	Sun
4	6/19/2022	47,805	Sun
5	5/23/2021	47,540	Sun
6	3/20/2022	46,050	Sun
7	5/1/2022	44,784	Sun
8	6/18/2022	42,987	Sat
9	4/12/2022	42,779	Tue
10	4/17/2022	41,641	Sun
11	5/11/2022	40,437	Wed
12	2/20/2022	38,703	Sun
13	5/27/2019	38,355	Mon
14	4/9/2022	38,314	Sat
15	6/6/2020	37,393	Sat
16	3/21/2021	36,802	Sun
17	4/10/2022	36,074	Sun
18	5/22/2021	35,831	Sat
19	5/9/2022	35,303	Mon
20	3/6/2022	33,722	Sun

WEEKDAY	#	YEAR	#
Sunday	12	2022	14
Monday	2	2021	3
Tuesday	1	2020	2
Wednesday	1	2019	1
Thursday	-		
Friday	-		
Saturday	4		

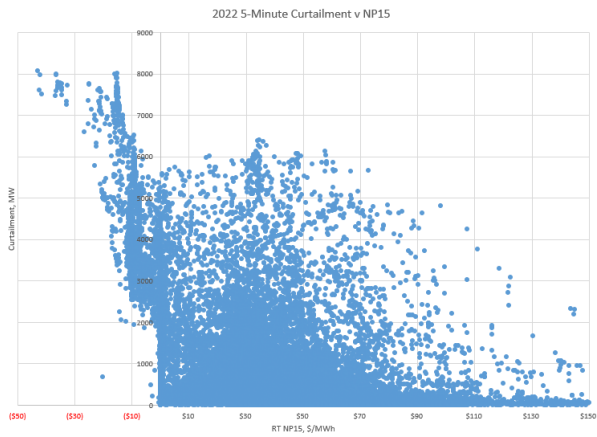
2022 Five-Minute Curtailment v SMEC, SP15 and NP15 prices



SMEC
 $R^2 = 0.24$

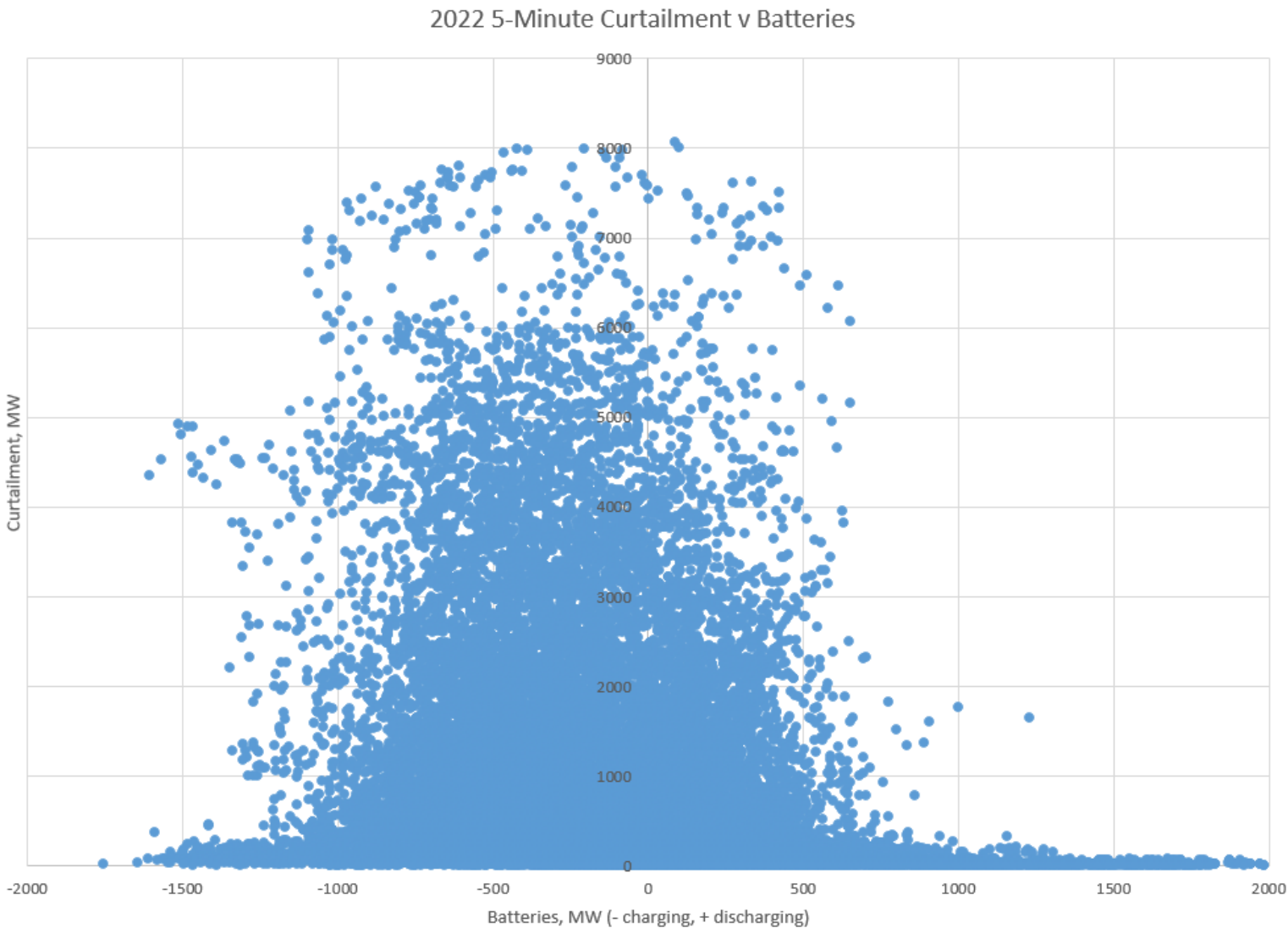


SP15
 $R^2 = 0.34$



NP15
 $R^2 = 0.15$

2022 Five-Minute Curtailment and Batteries



APPENDIX - FUNDAMENTALS

Hourly production and curtailment data came from
<http://www.caiso.com/market/Pages/ReportsBulletins/RenewablesReporting.aspx>.

5-minute production and curtailment data comes from
<http://www.caiso.com/TodaysOutlook/Pages/default.aspx>,
<http://www.caiso.com/TodaysOutlook/Pages/supply.html>, and, e.g.,
http://www.caiso.com/Documents/ProductionAndCurtailmentsData_2022.xlsx.

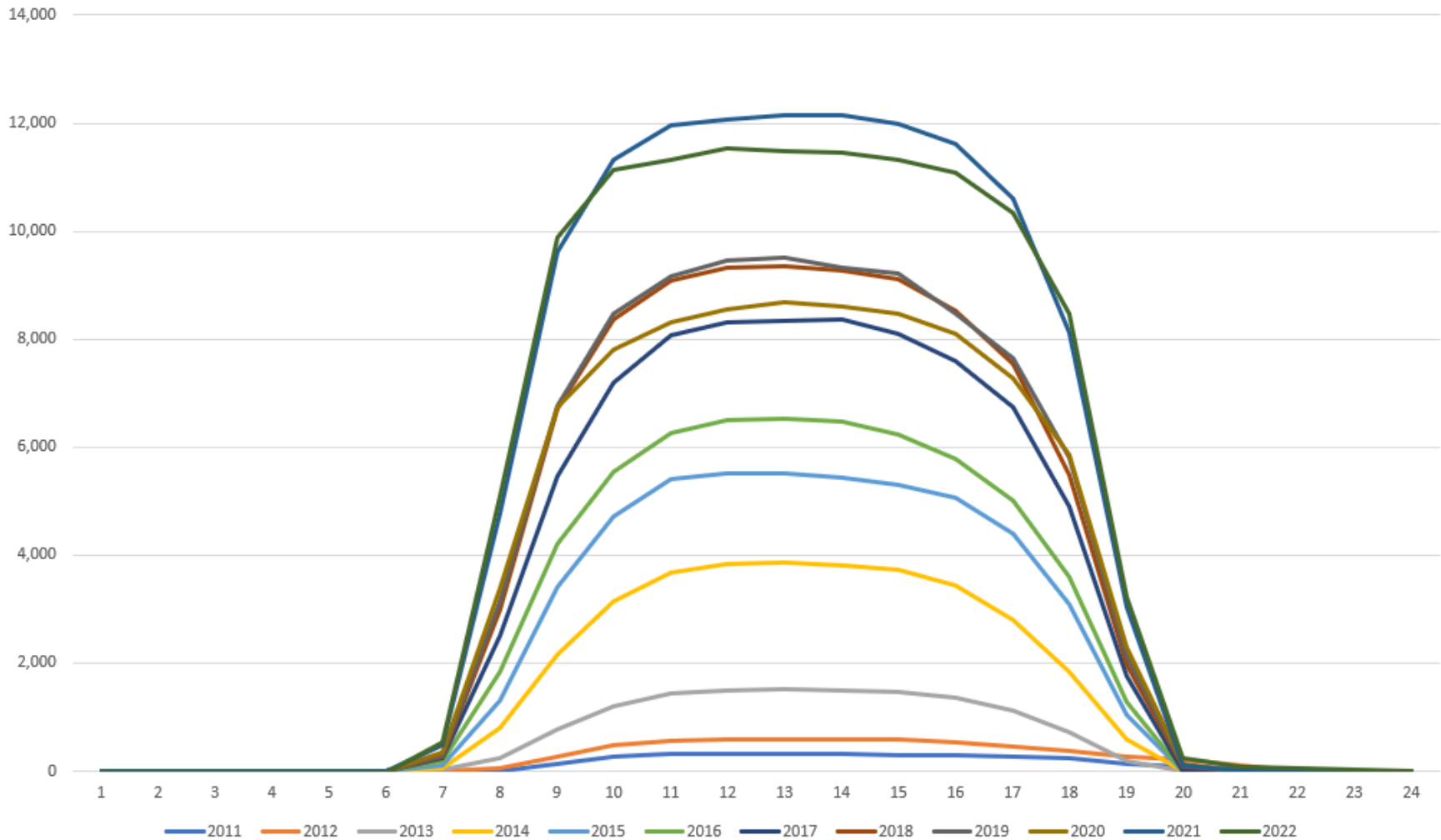
“This report is produced daily to provide a detailed accounting of the wind and solar renewable generation that was curtailed and the reasons why. This report should be read in the context of the Renewables Watch report for a more complete understanding of both renewable curtailment and generation.”

“The information contained in this report is preliminary and subject to change without notice. No inference, decision or conclusion should be made based on the information in this report or any series of these reports. All values are hourly average unless otherwise stated. Questions about this report should be directed to Short-Term Forecasting at ShortTermForecasting@caiso.com.”

April Average Weekday Solar Shapes 2011-2022



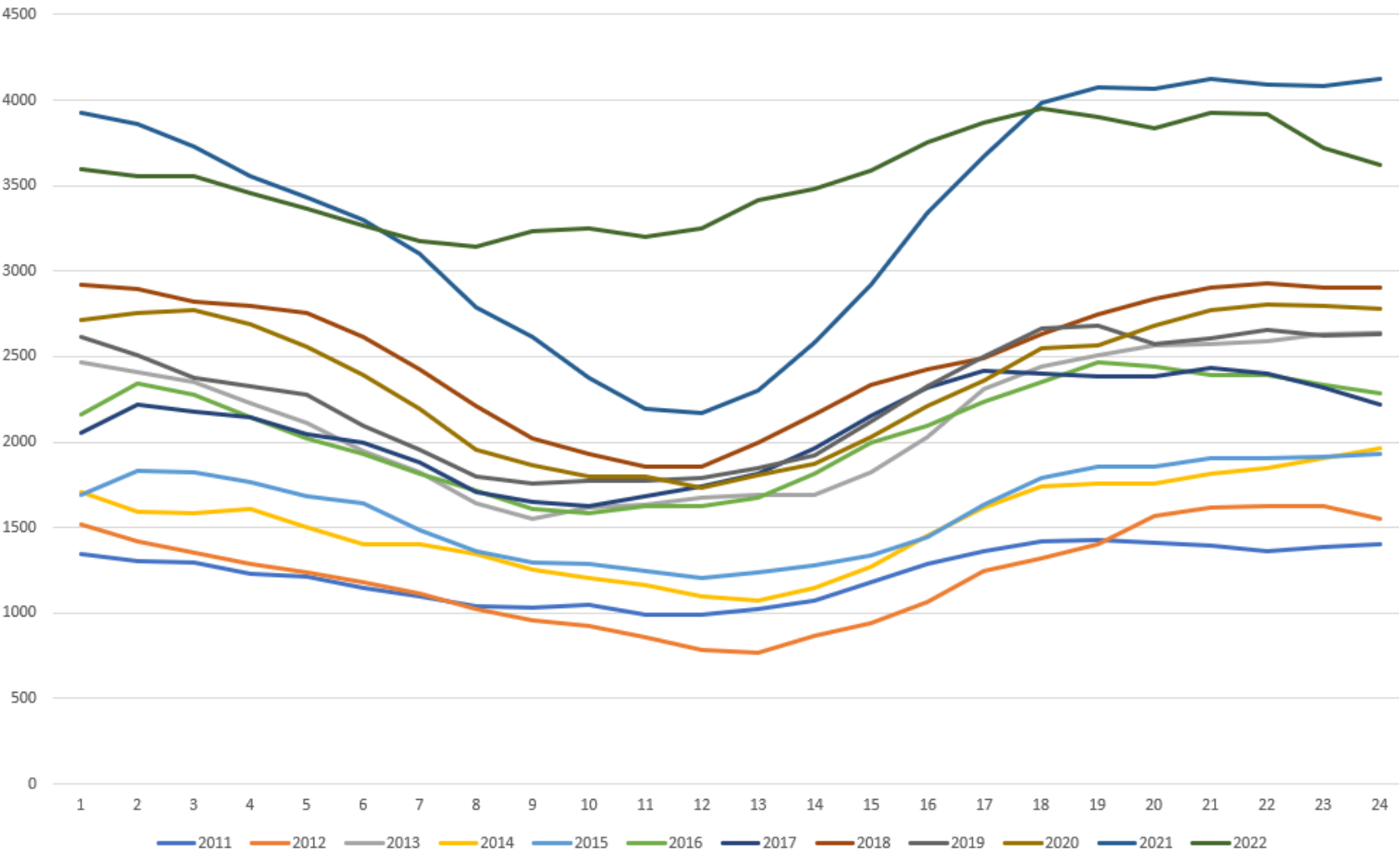
April Average Weekday Solar Shapes 2011-2022



April Average Weekday Wind Shapes 2011-2022



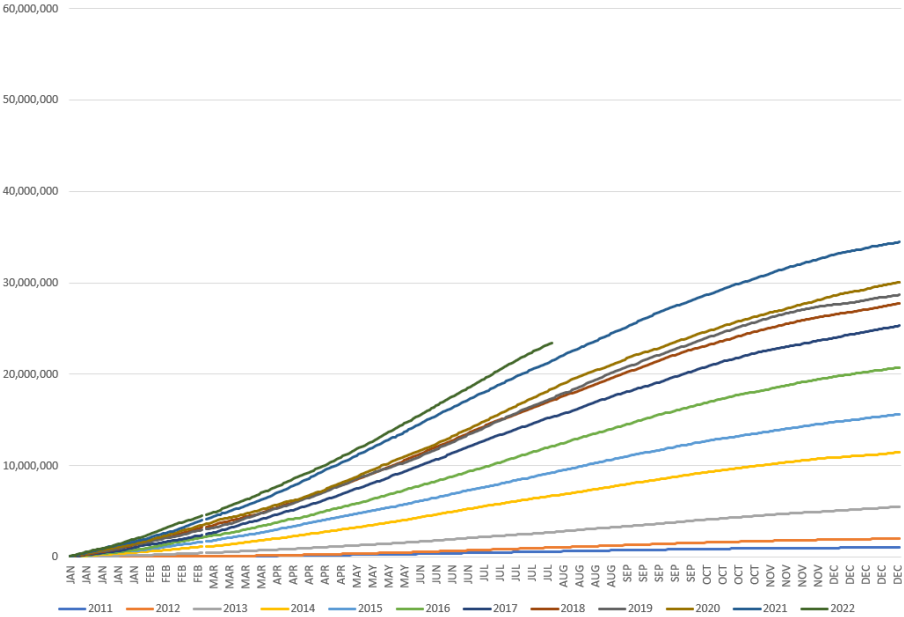
April Average Weekday Wind Shapes 2011-2022



Cumulative Annual Solar and Wind Production

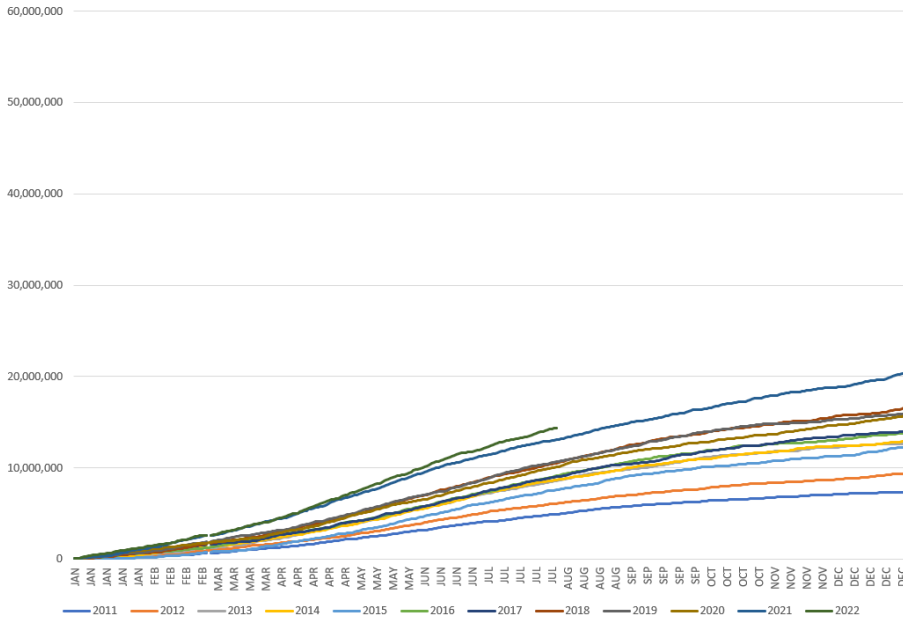


Annual Cumulative CAISO Solar 2011-2022 (MWh)



SOLAR

Annual Cumulative CAISO Wind 2011-2022 (MWh)

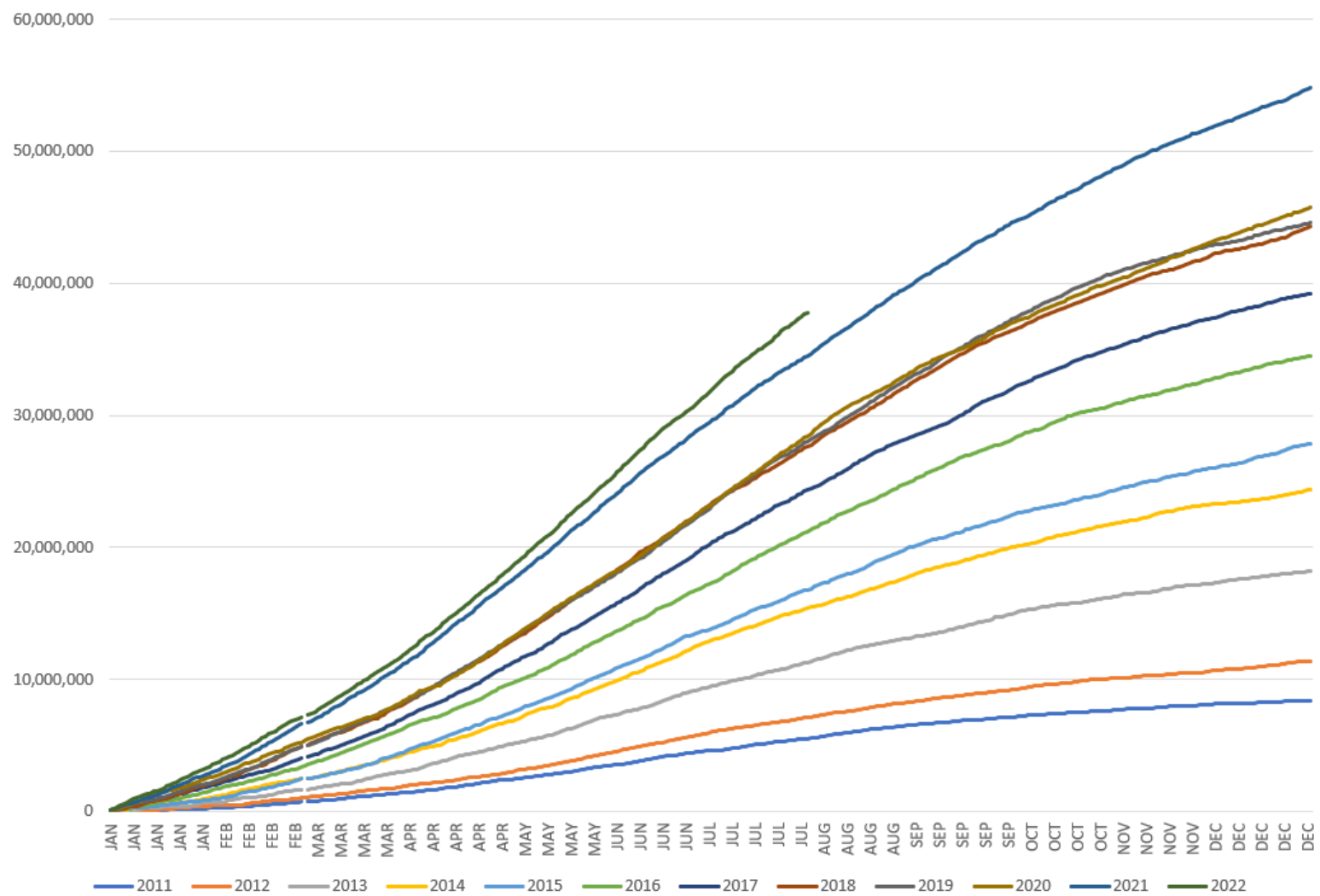


WIND

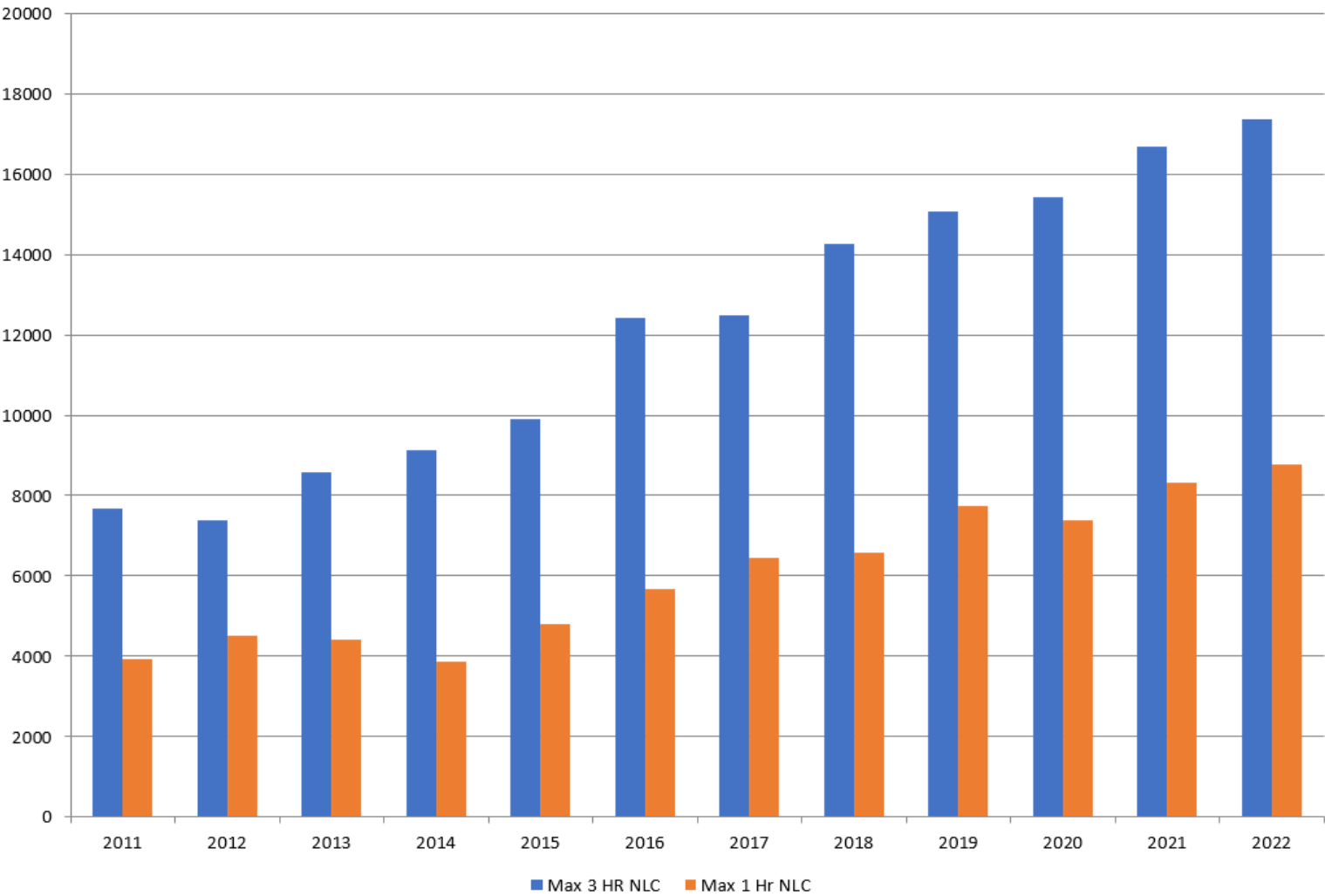
Cumulative Annual Wind and Solar Production



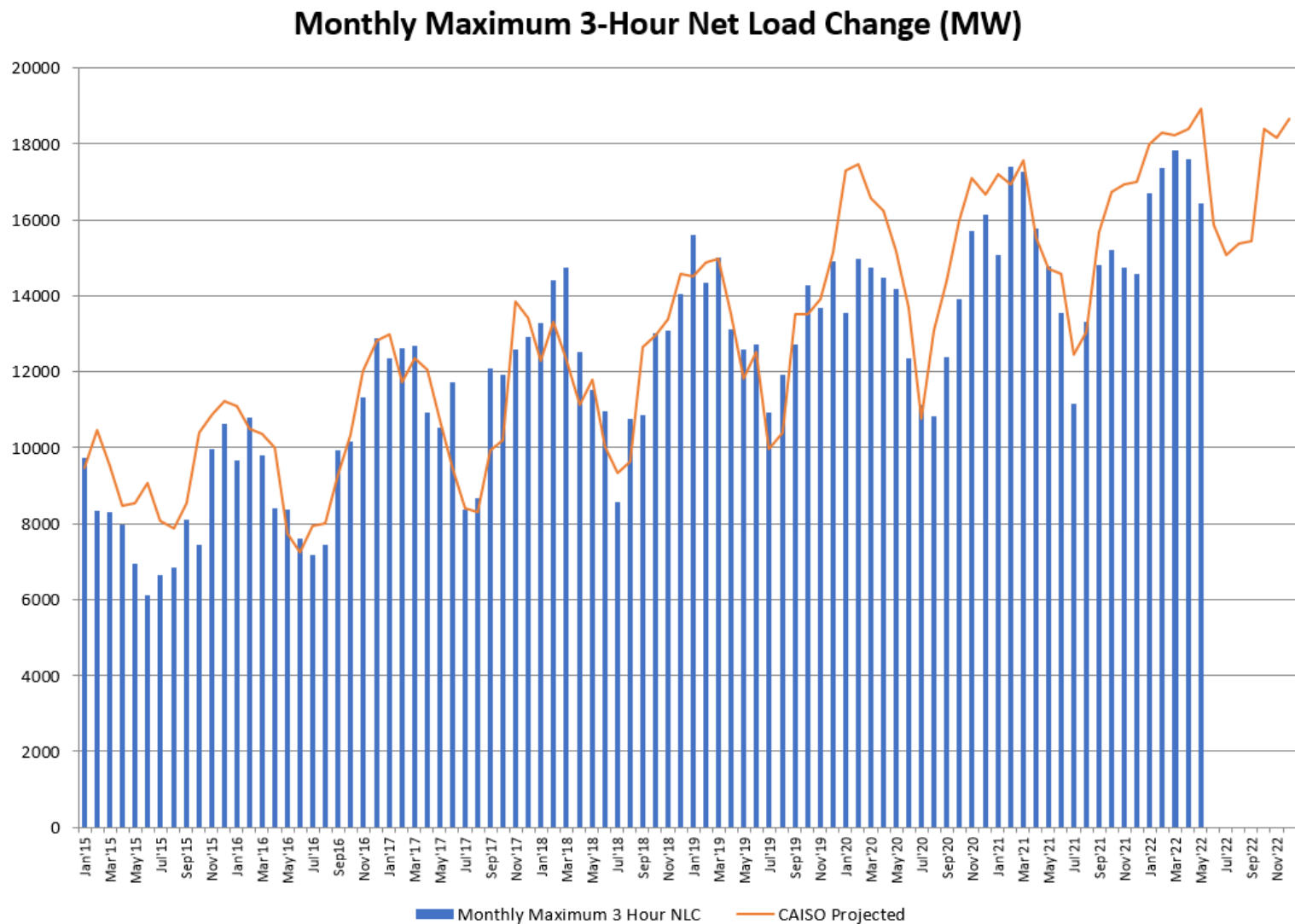
Annual Cumulative CAISO Wind and Solar 2011-2022 (MWh)



Maximum Hourly 1-Hr and 3-Hr Net Load Changes (MW)



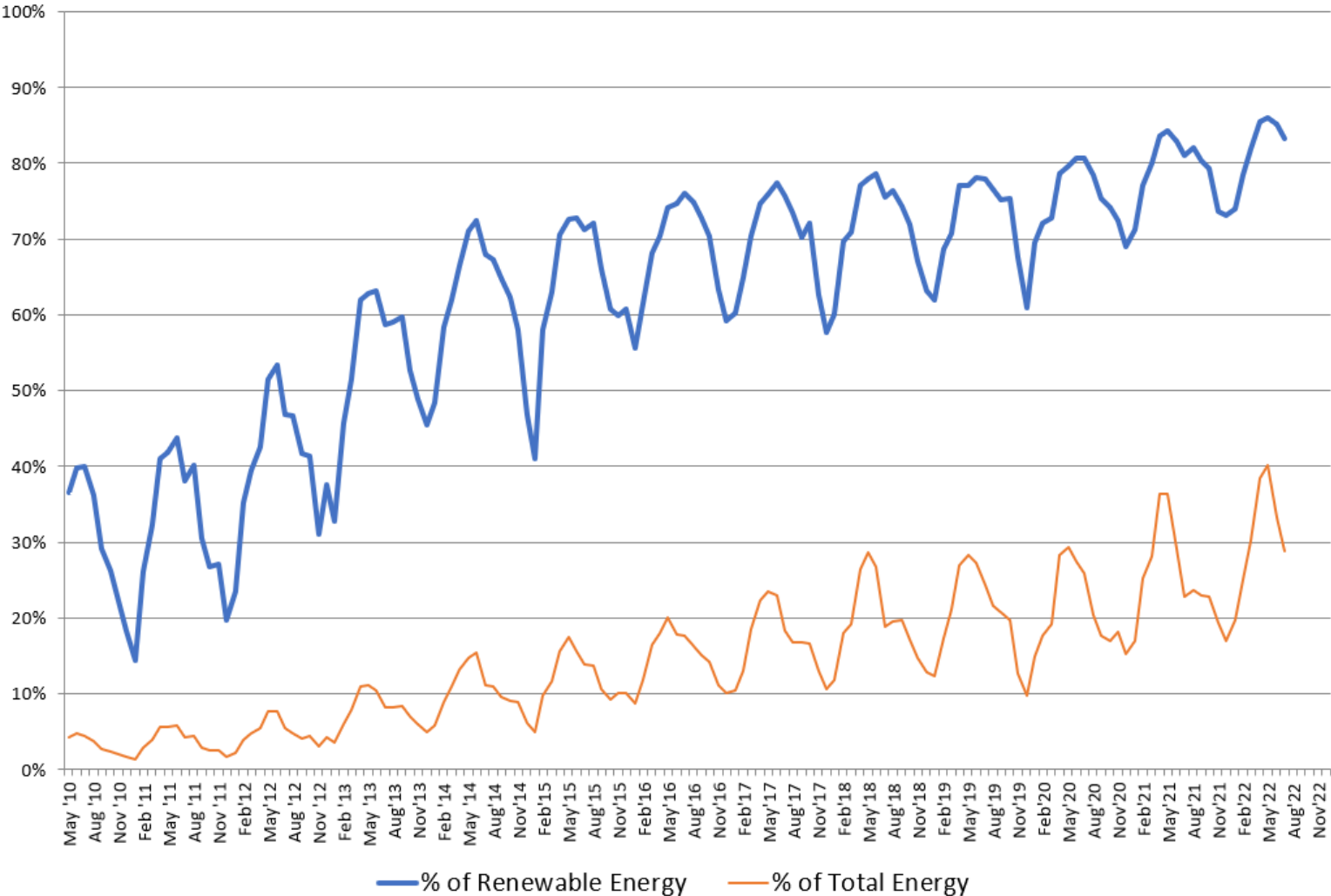
Monthly Maximum 3-Hour Net Load Ramps and CAISO 3-Hour Net Load Ramp Forecast 2015-2022



Monthly Wind and Solar as a Percent of CAISO Renewables and CAISO Total Energy



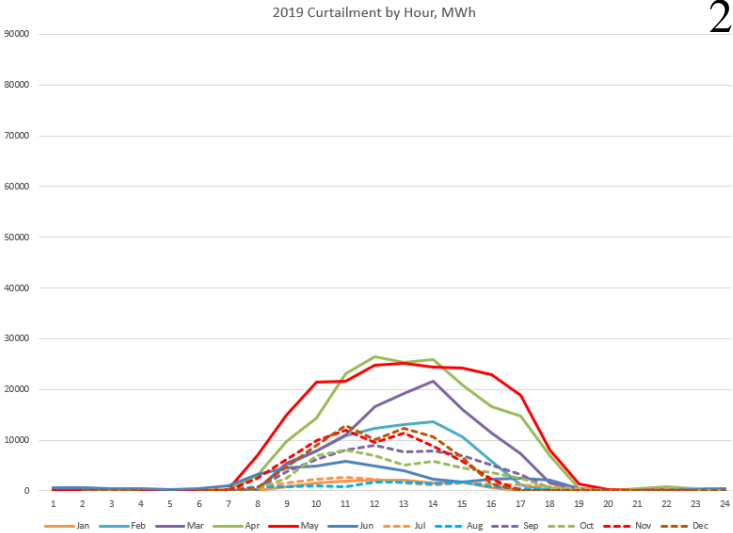
Wind and Solar % of Monthly CAISO Renewables, Total Energy



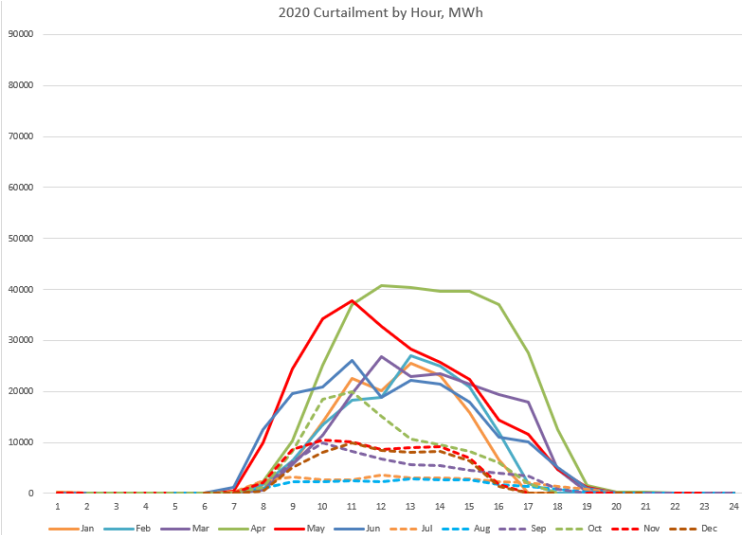
Curtailment by Month and Hour



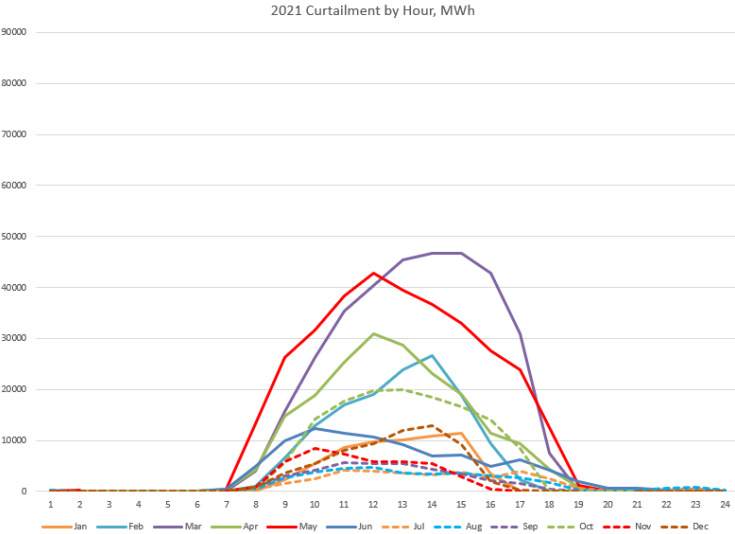
2019



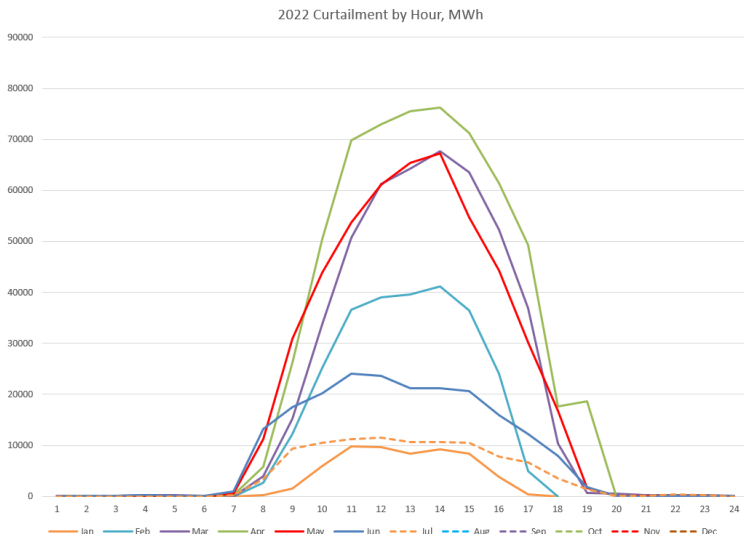
2020



2021

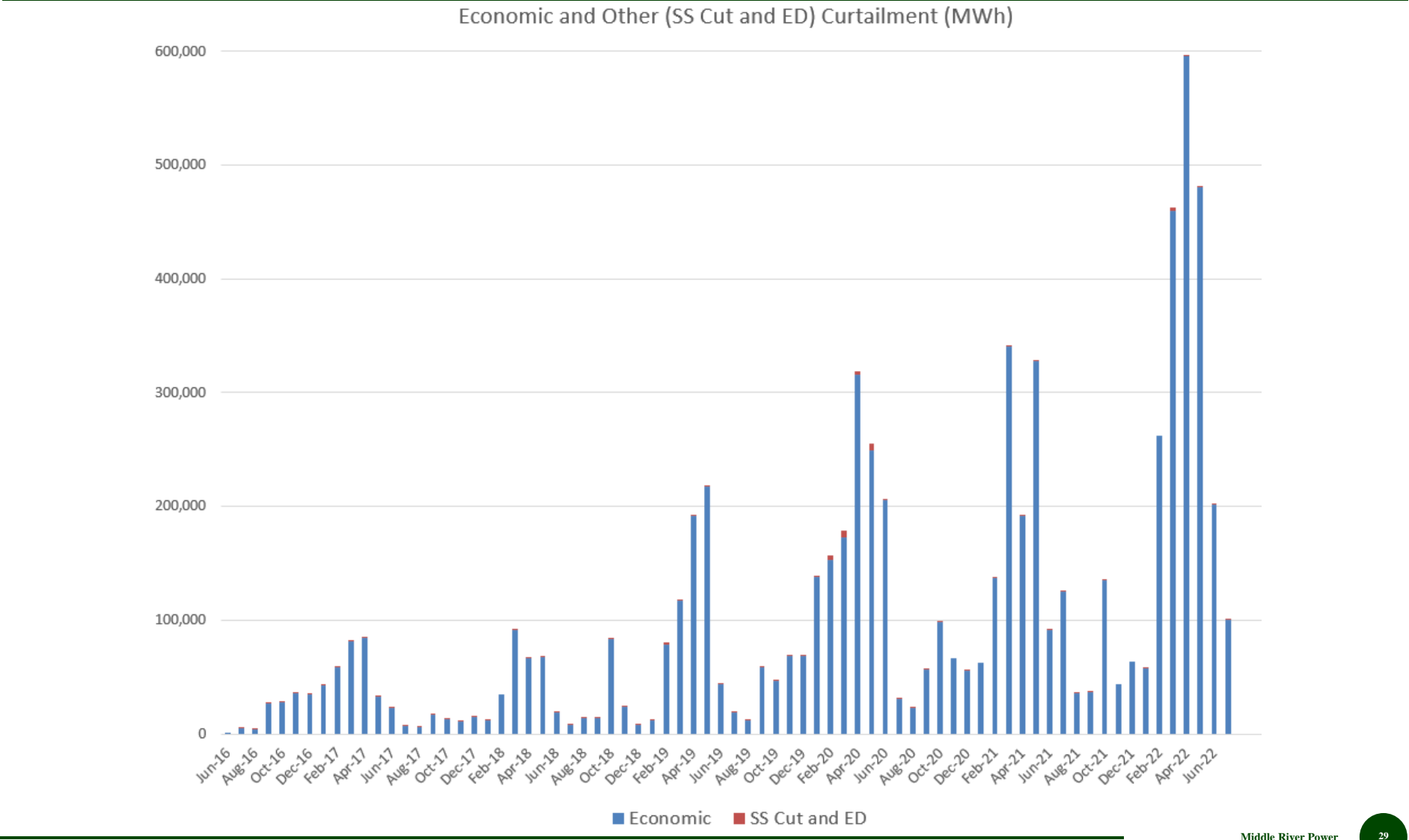


2022

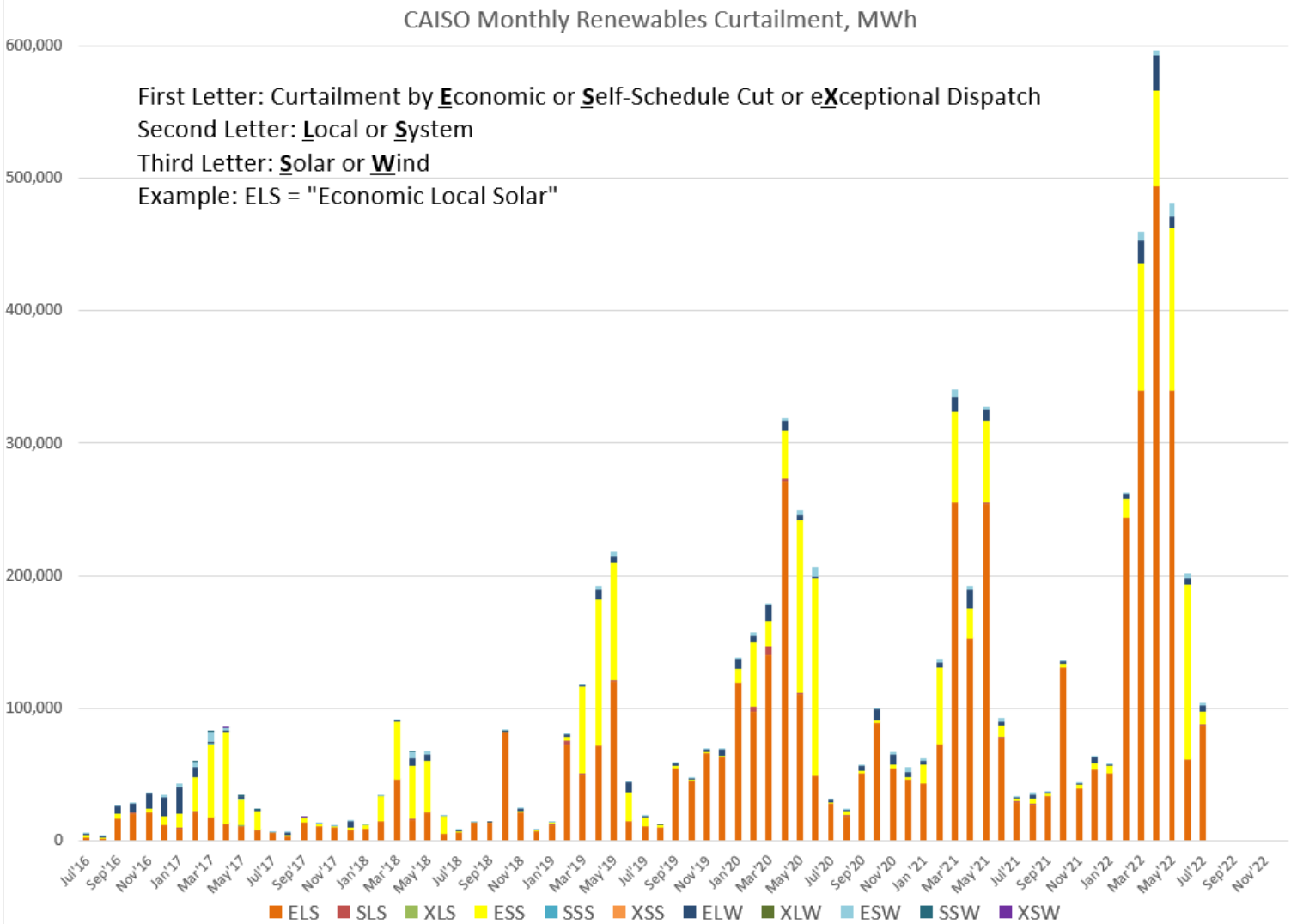


APPENDIX - CURTAILMENT

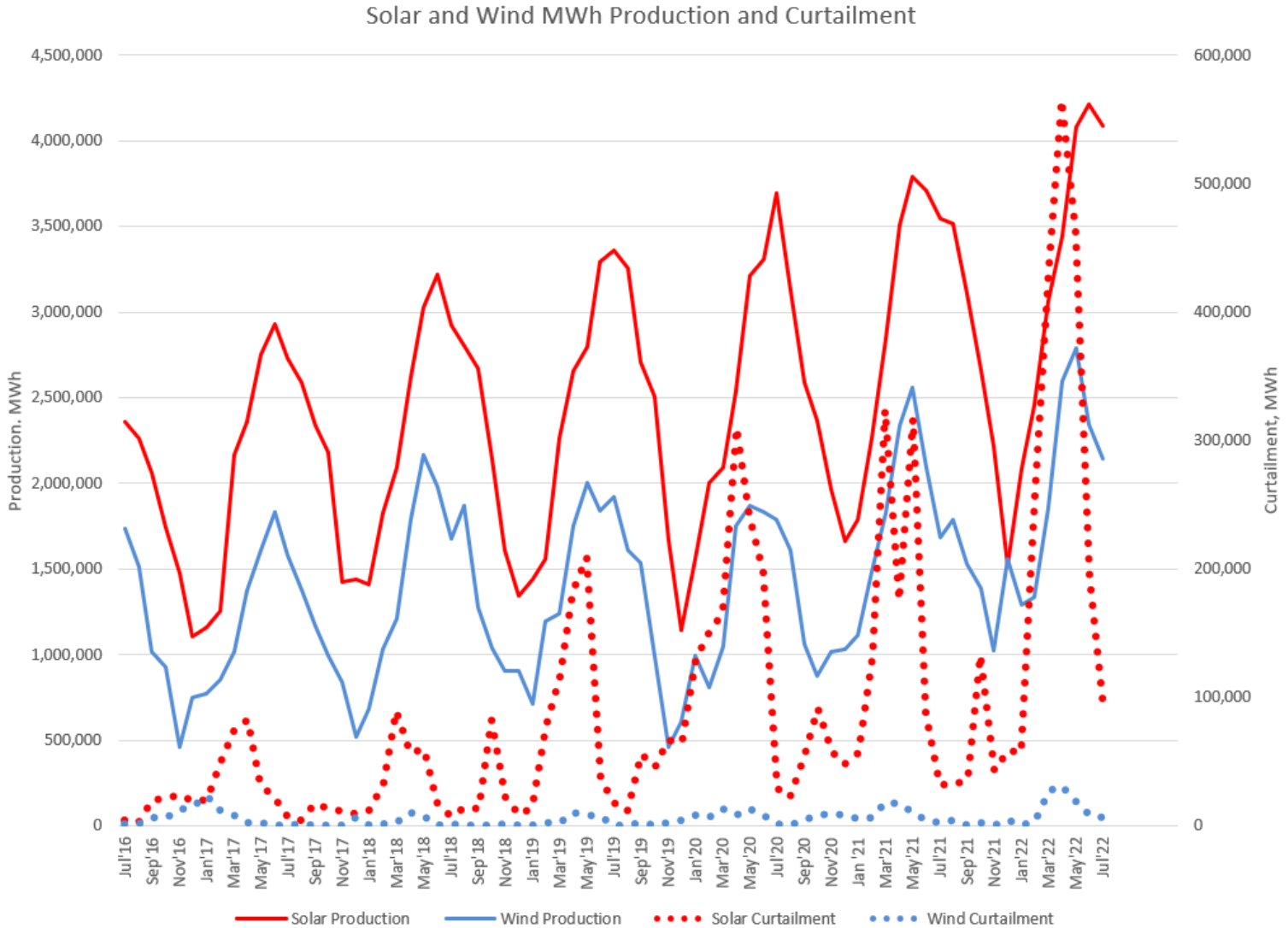
Monthly Curtailment by Type – Economic and Other (Self-Schedule Cut and Exceptional Dispatch)



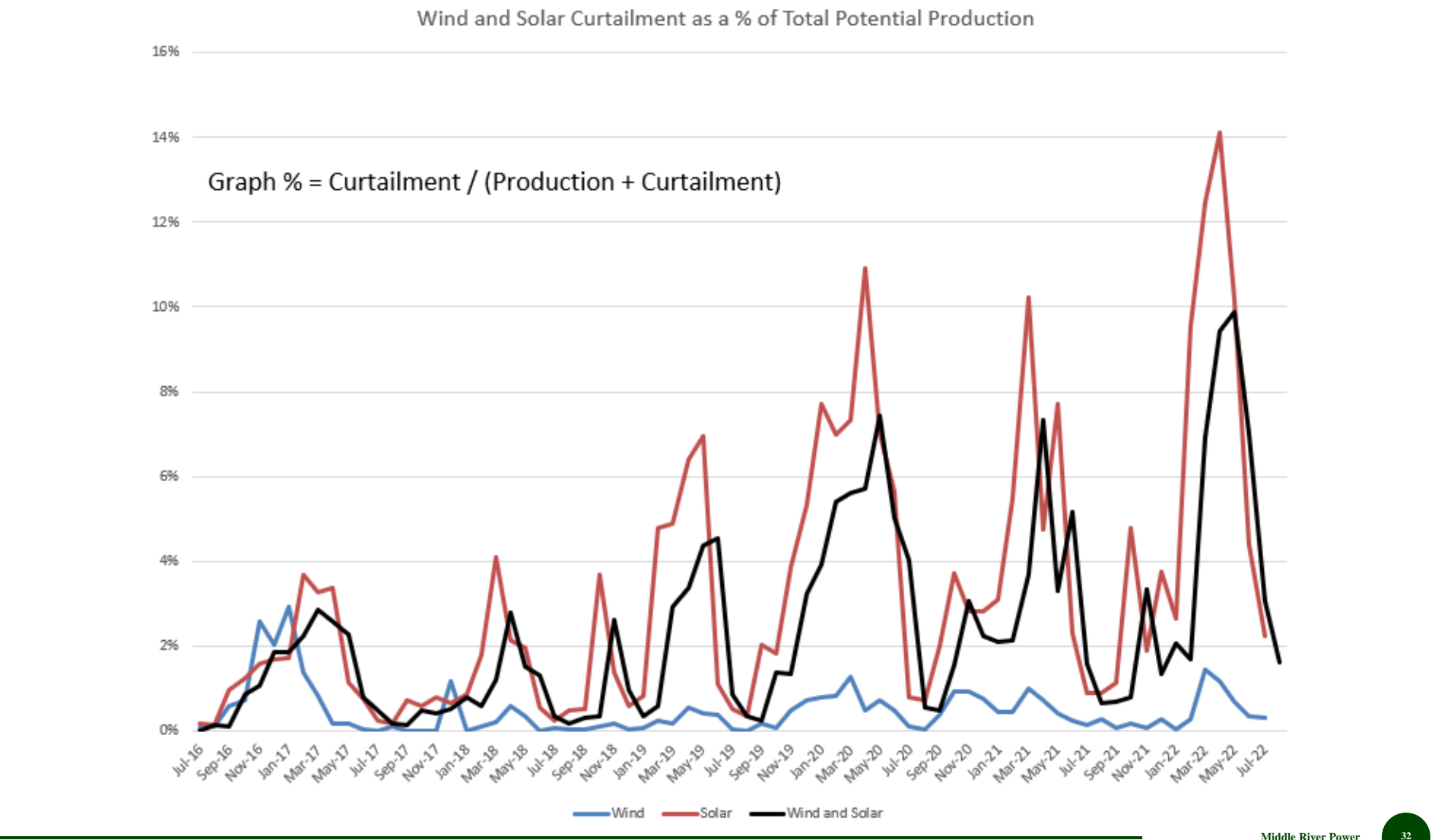
CAISO Monthly Curtailment by Type (Solar/Wind, Local/System, Economic/Self-Schedule Cut/Exceptional Dispatch)



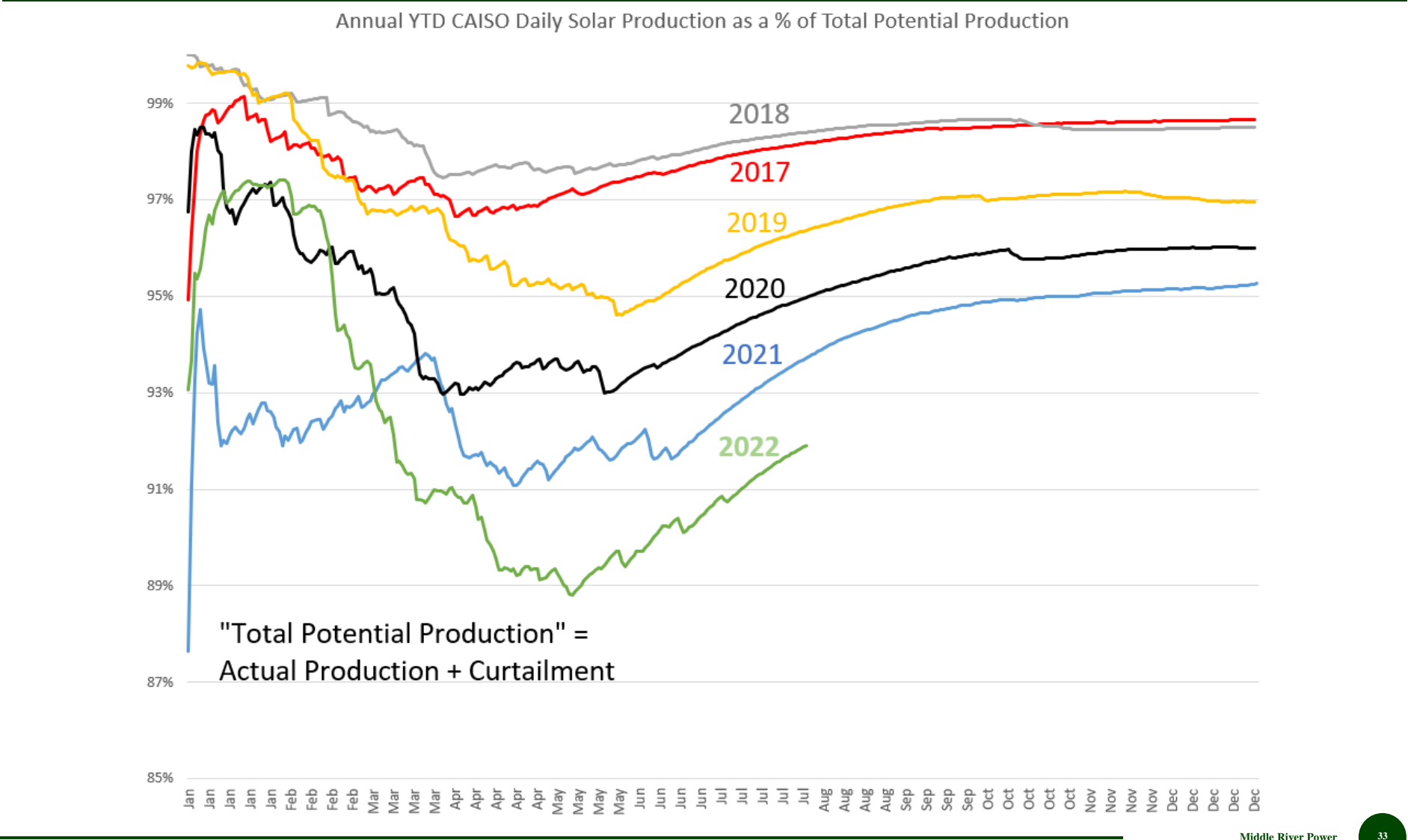
CAISO Solar and Wind Production and Curtailment (MWh)



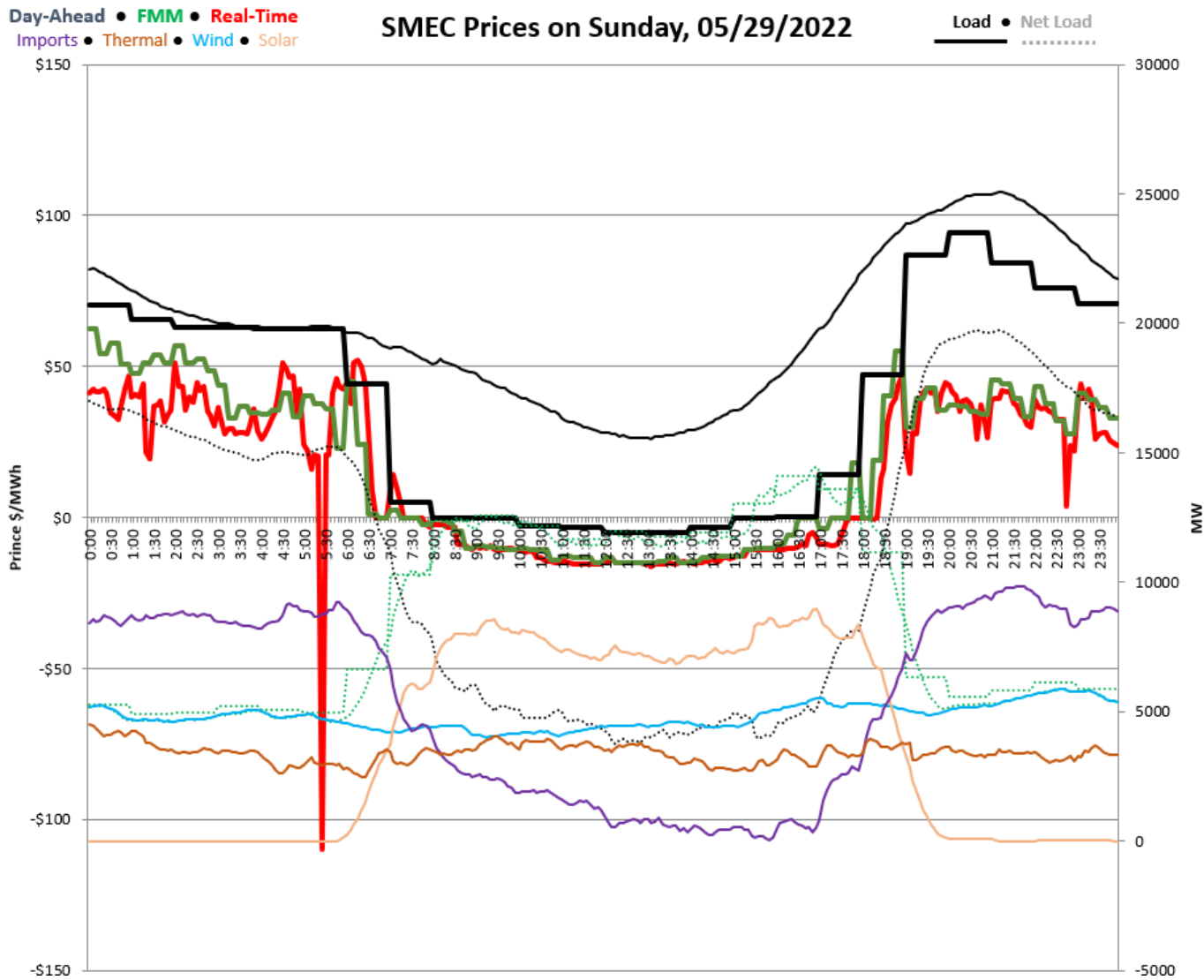
Monthly Wind and Solar Curtailment as a Percentage of Total Potential Production



Annual CAISO Cumulative Solar Production as a Percent of Total Potential Production



CAISO All-Time Curtailment Day – Sunday, May 29, 2022

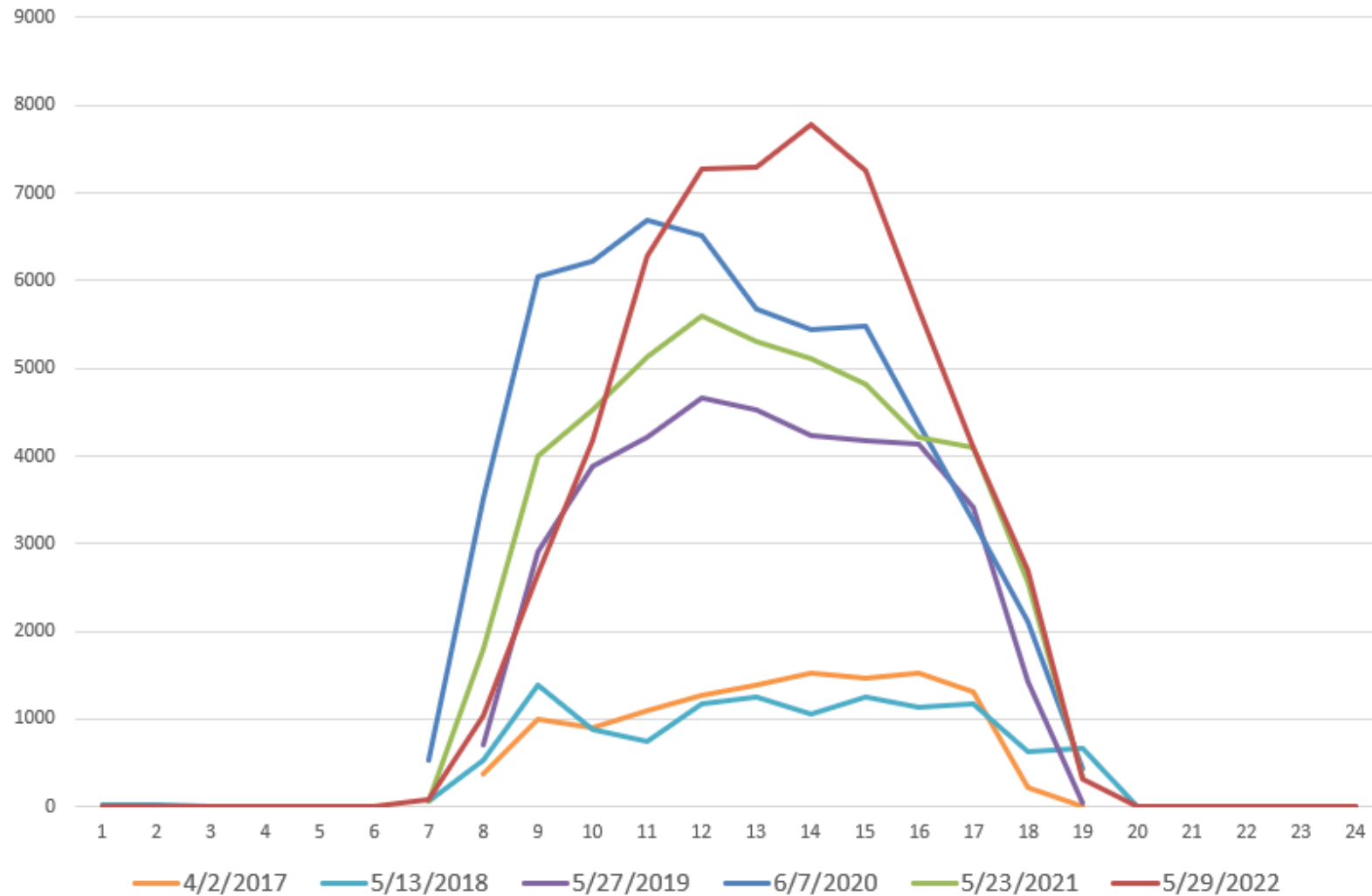


While CAISO curtailed 56,674 MWh this day, it never was a net exporter, despite having been a net exporter in 3,903 5-minute intervals from 1/1/22 to 6/30/22.

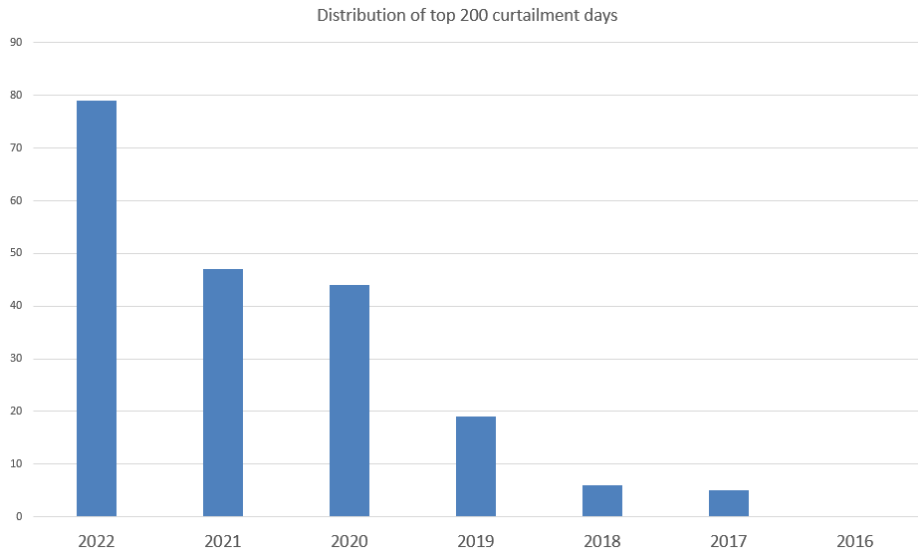
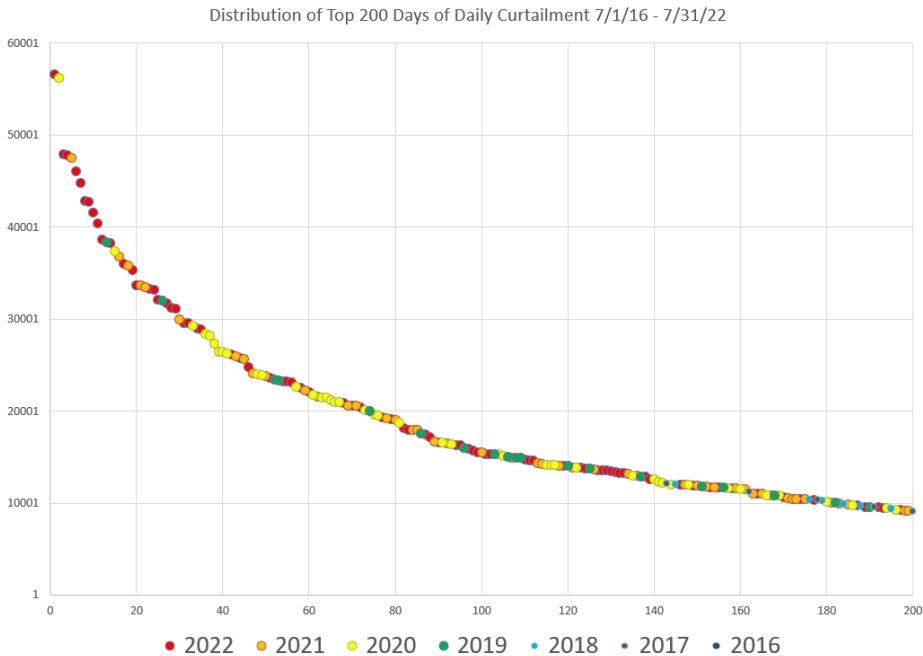
Hourly Shape of Annual Maximum Curtailment Day



Hourly Curtailment from Maximum Annual Curtailment Day



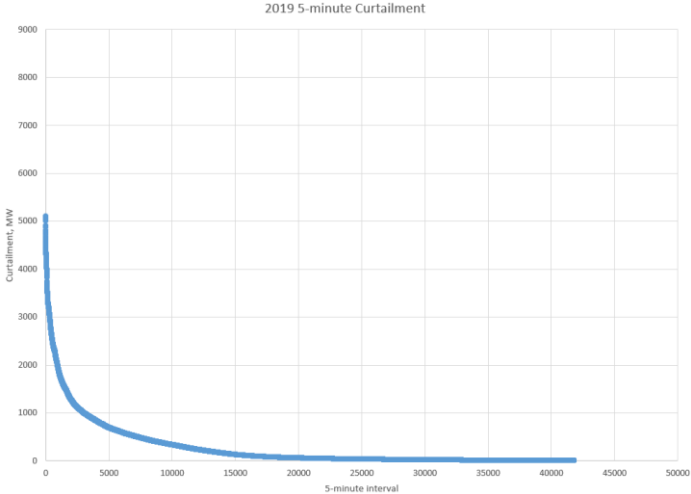
Distribution of Top 200 Curtailment Days



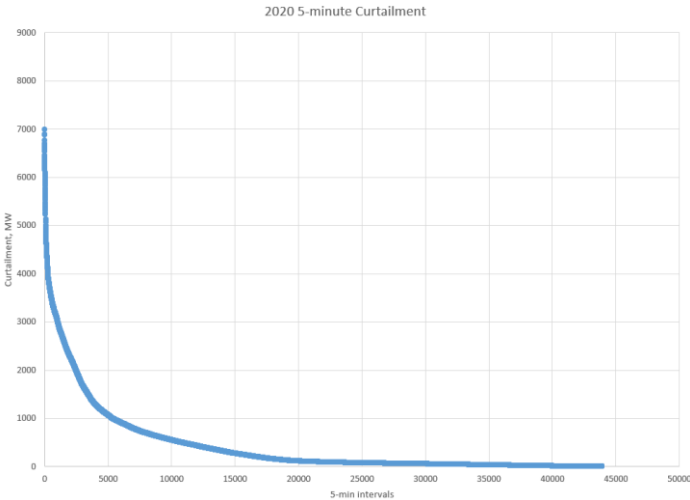
Five-Minute Curtailment (2022 through 6/30)



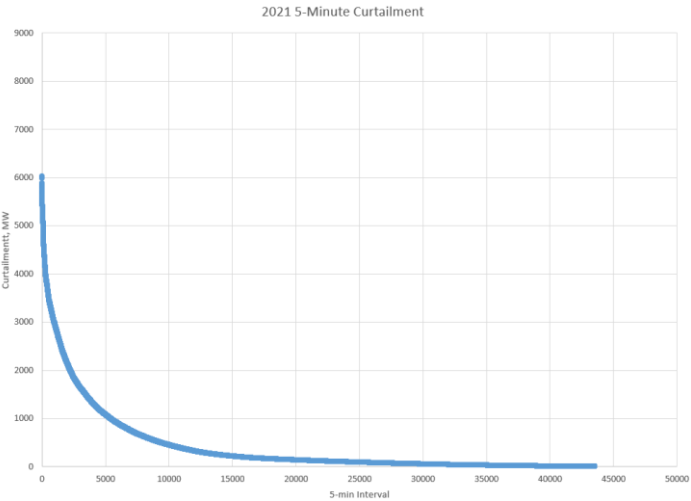
2019



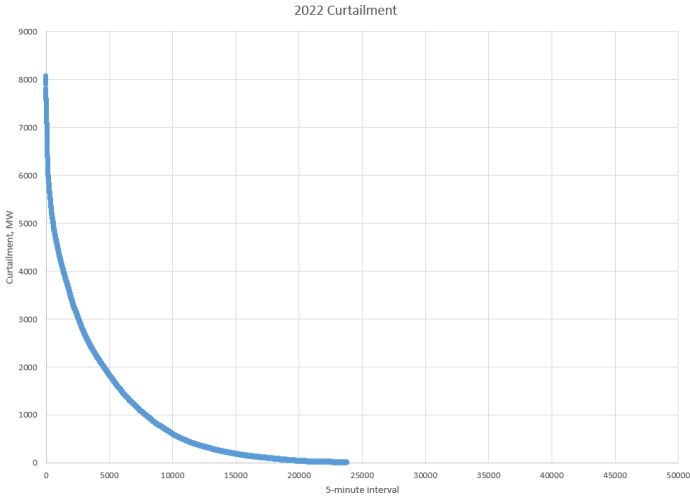
2020



2021



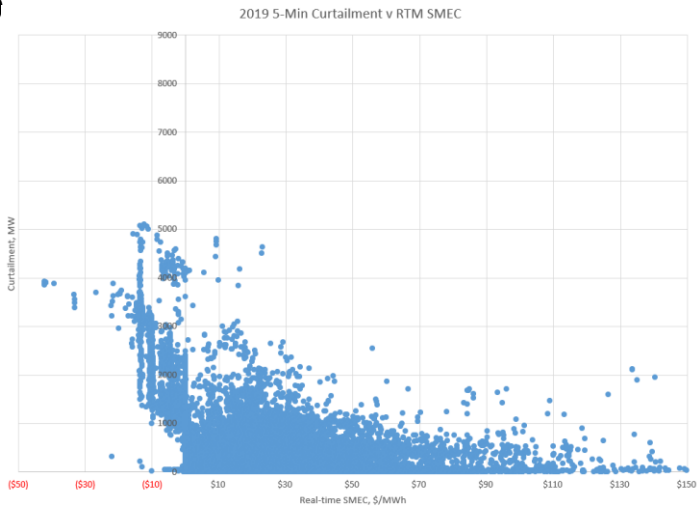
2022



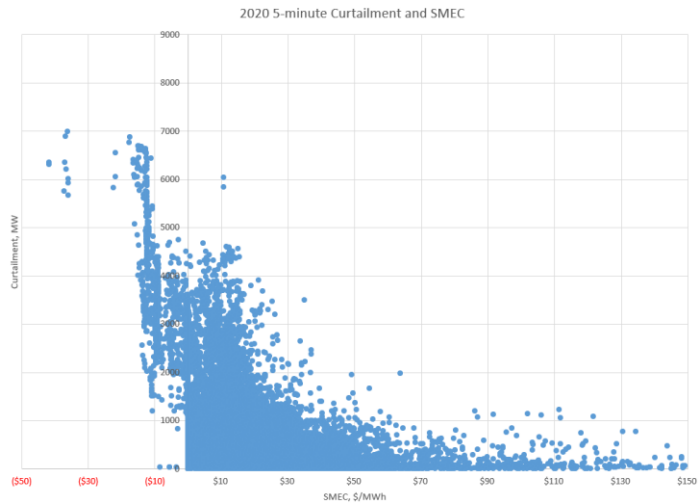
Five-Minute Curtailment and SMEC Real-Time Price



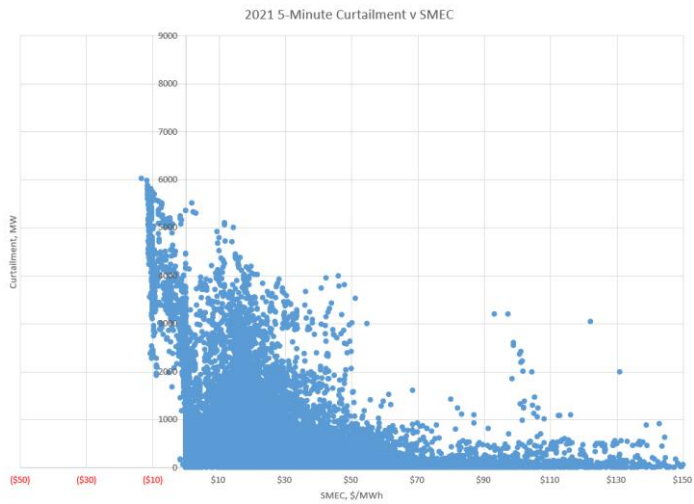
2019



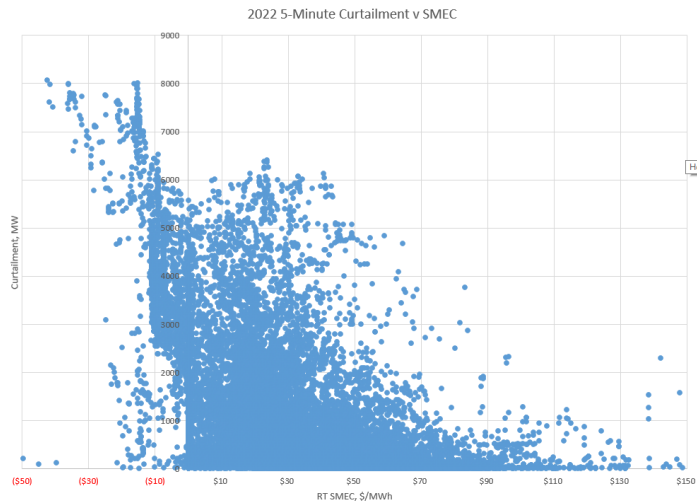
2020



2021



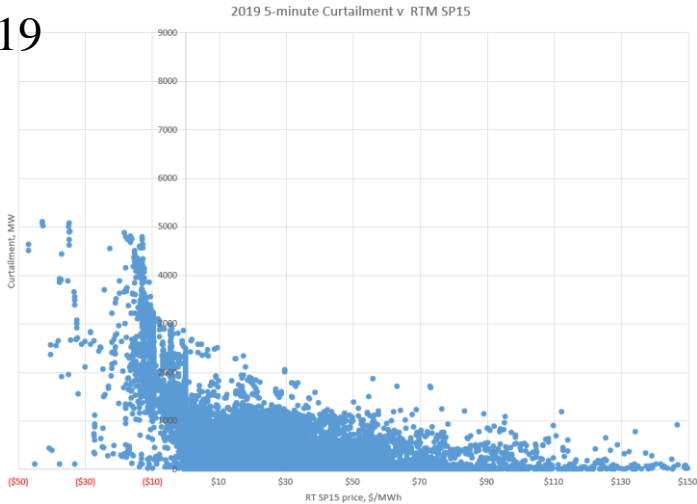
2022



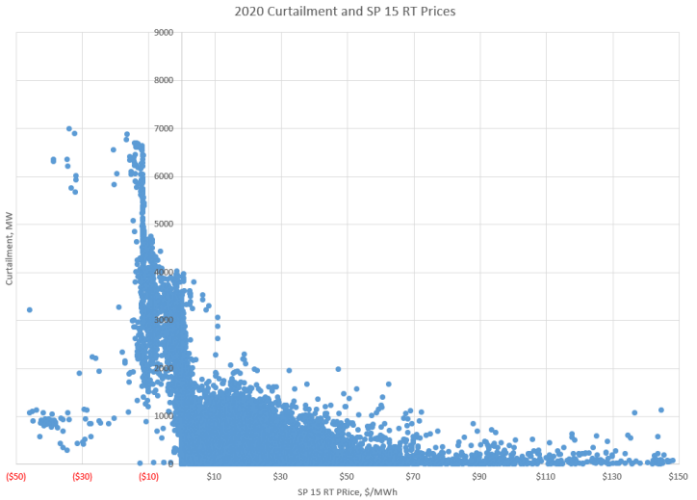
Five-Minute Curtailment and SP15 Real-Time Price



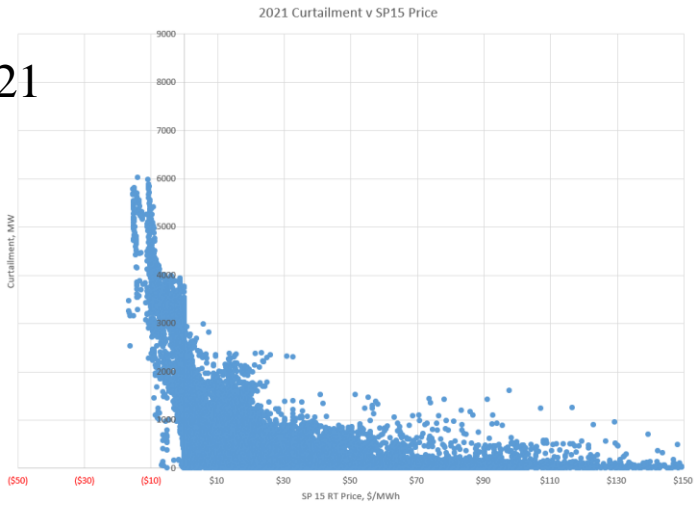
2019



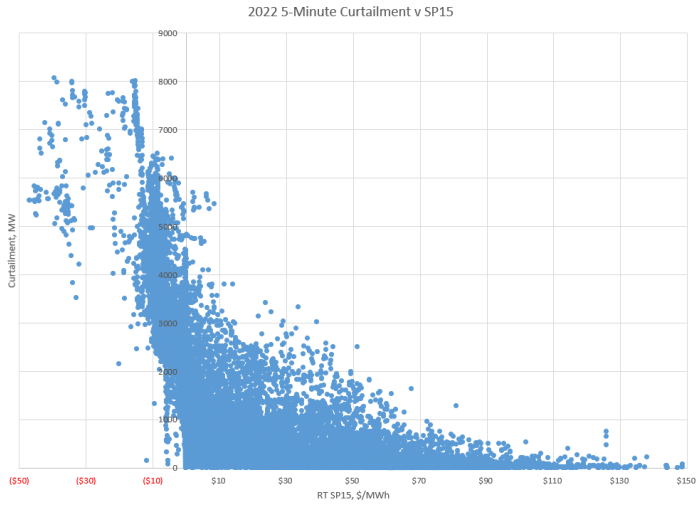
2020



2021



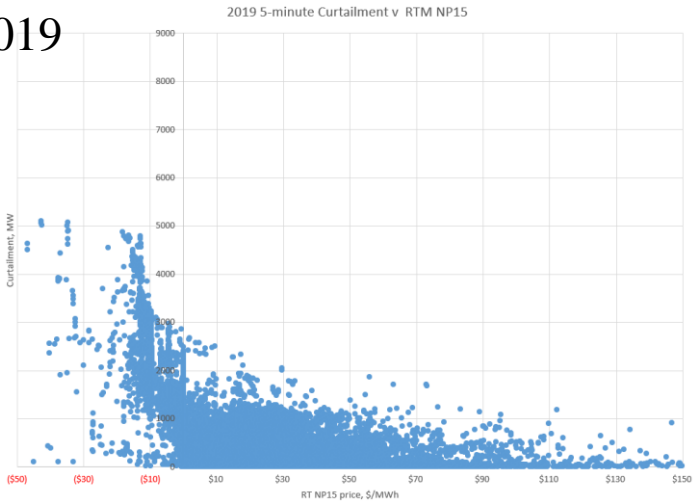
2022



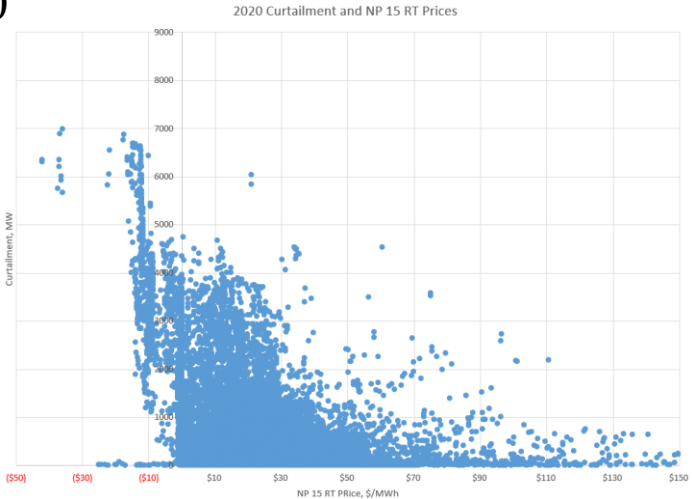
Five-Minute Curtailment and NP15 Real-Time Price



2019



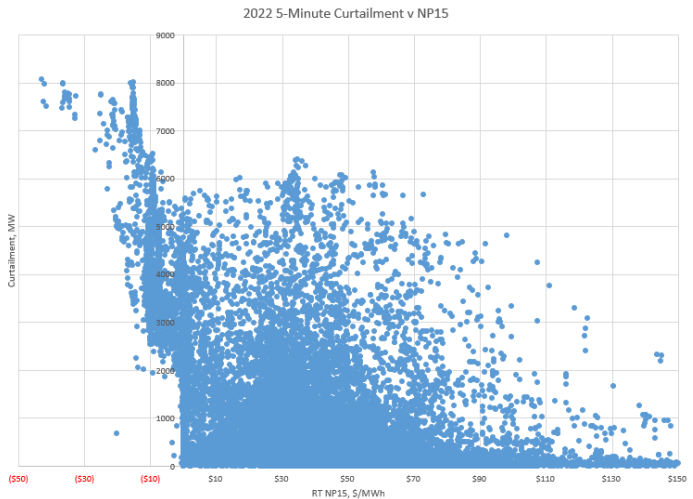
2020



2021



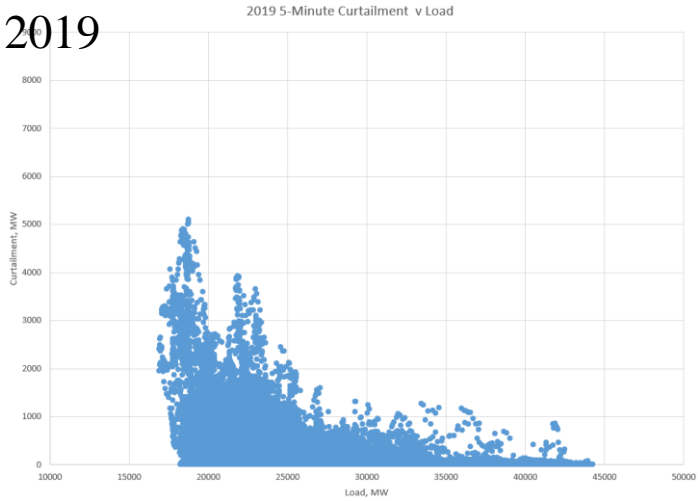
2022



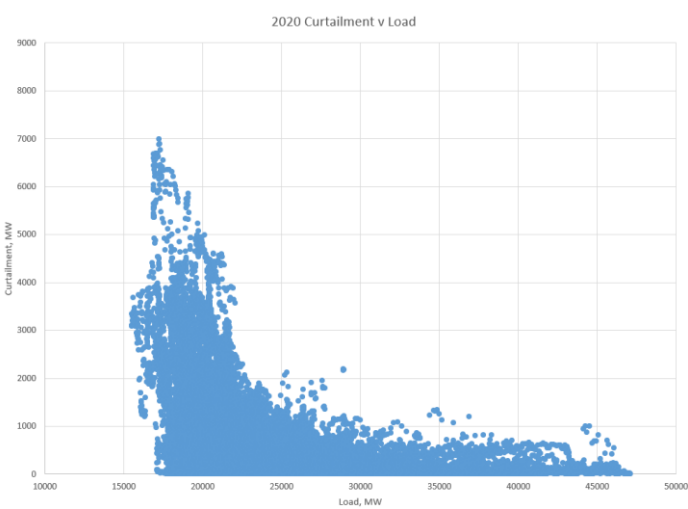
Five-Minute Curtailment and Load



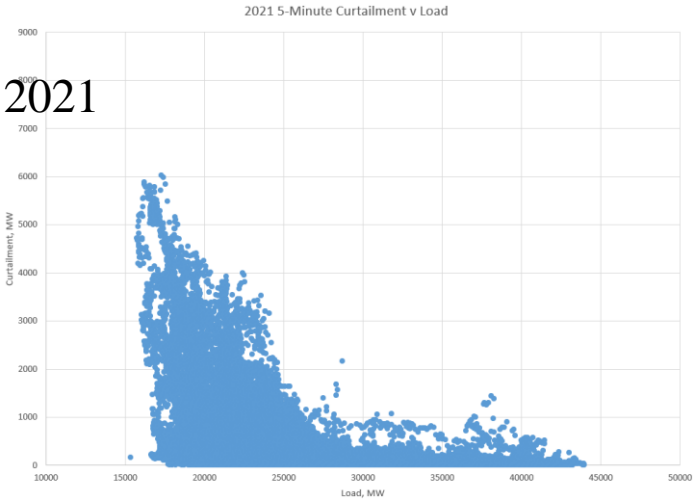
2019



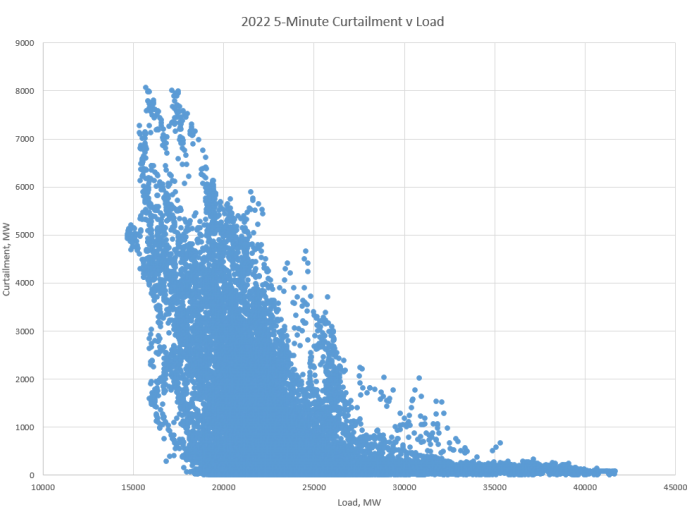
2020



2021



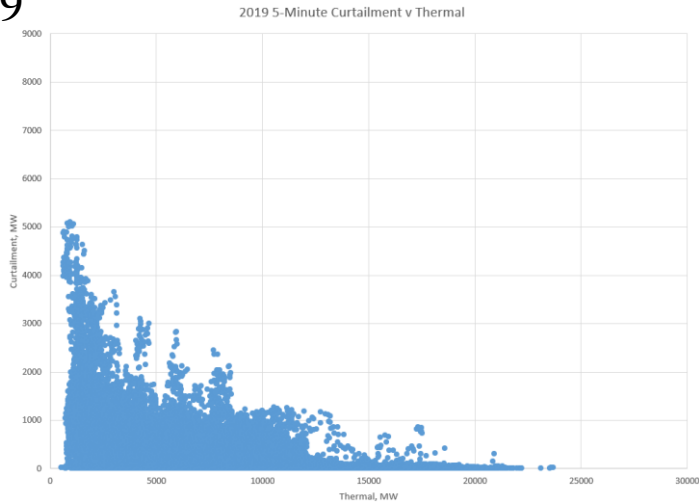
2022



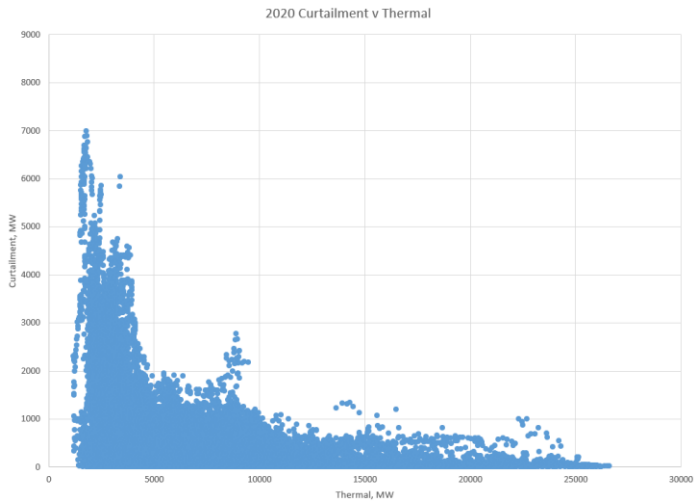
Five-Minute Curtailment and Thermal



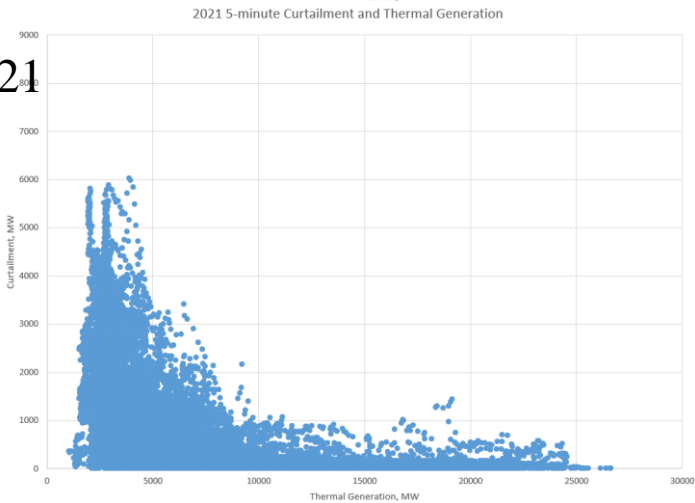
2019



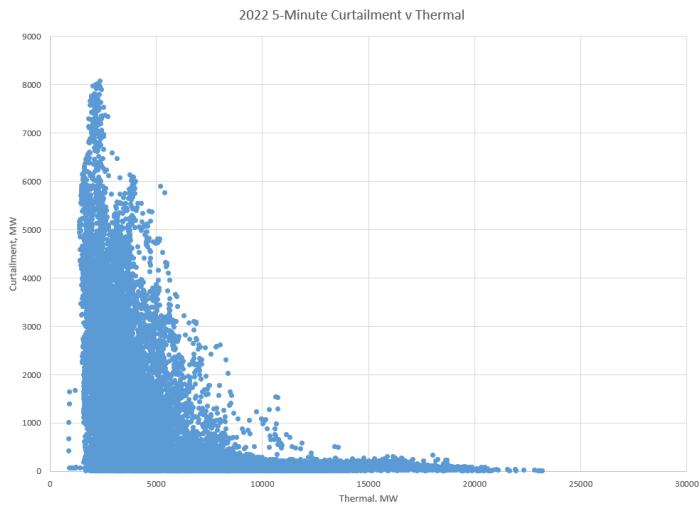
2020



2021



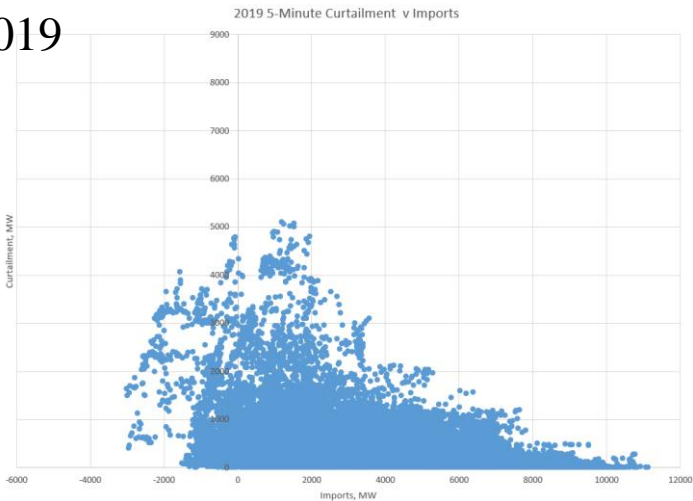
2022



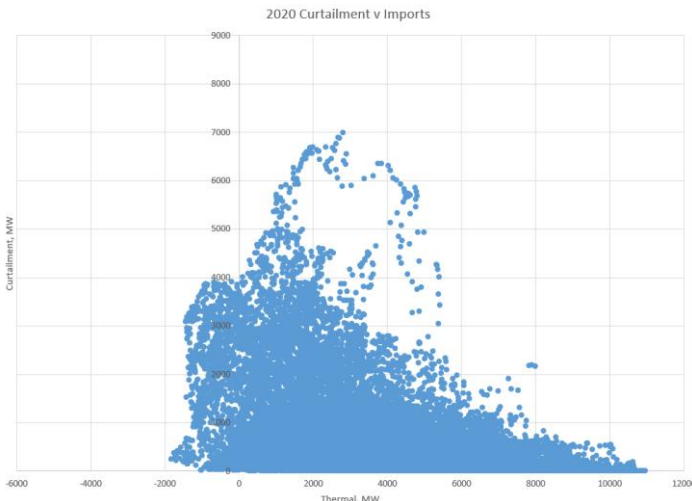
Five-Minute Curtailment and Imports



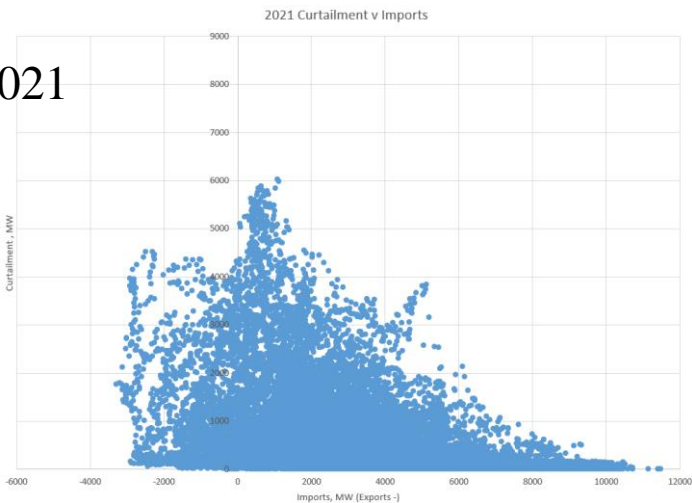
2019



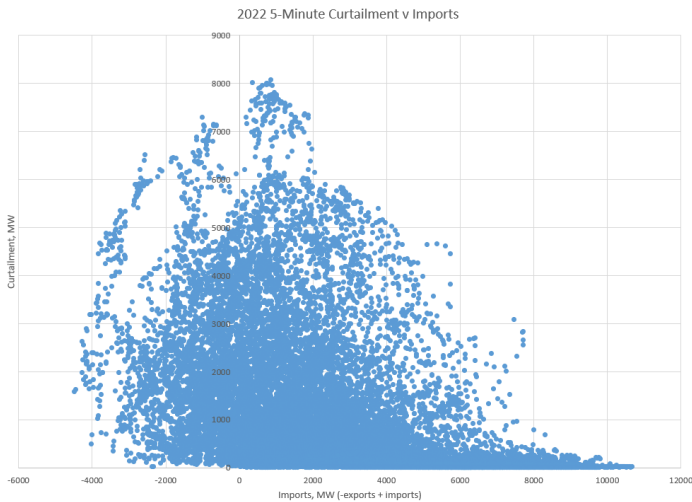
2020



2021



2022



Curtailment-Weighted Average Curtailment Prices



	NP15	SP15	SMEC
2022	\$19.96	\$1.34	\$12.60
2021	\$23.73	\$8.61	\$16.57
2020	\$12.08	\$8.46	\$11.82
2019	\$14.36	\$9.66	\$12.99

Curtailment-Weighted Average Price = $\frac{\sum (Price \times Curtailment)}{\sum (Curtailment)}$