



California ISO

Storage Workshop: Storage Resources Providing Ancillary Service

Energy Storage Enhancements Initiative
September 12, 2022

Agenda

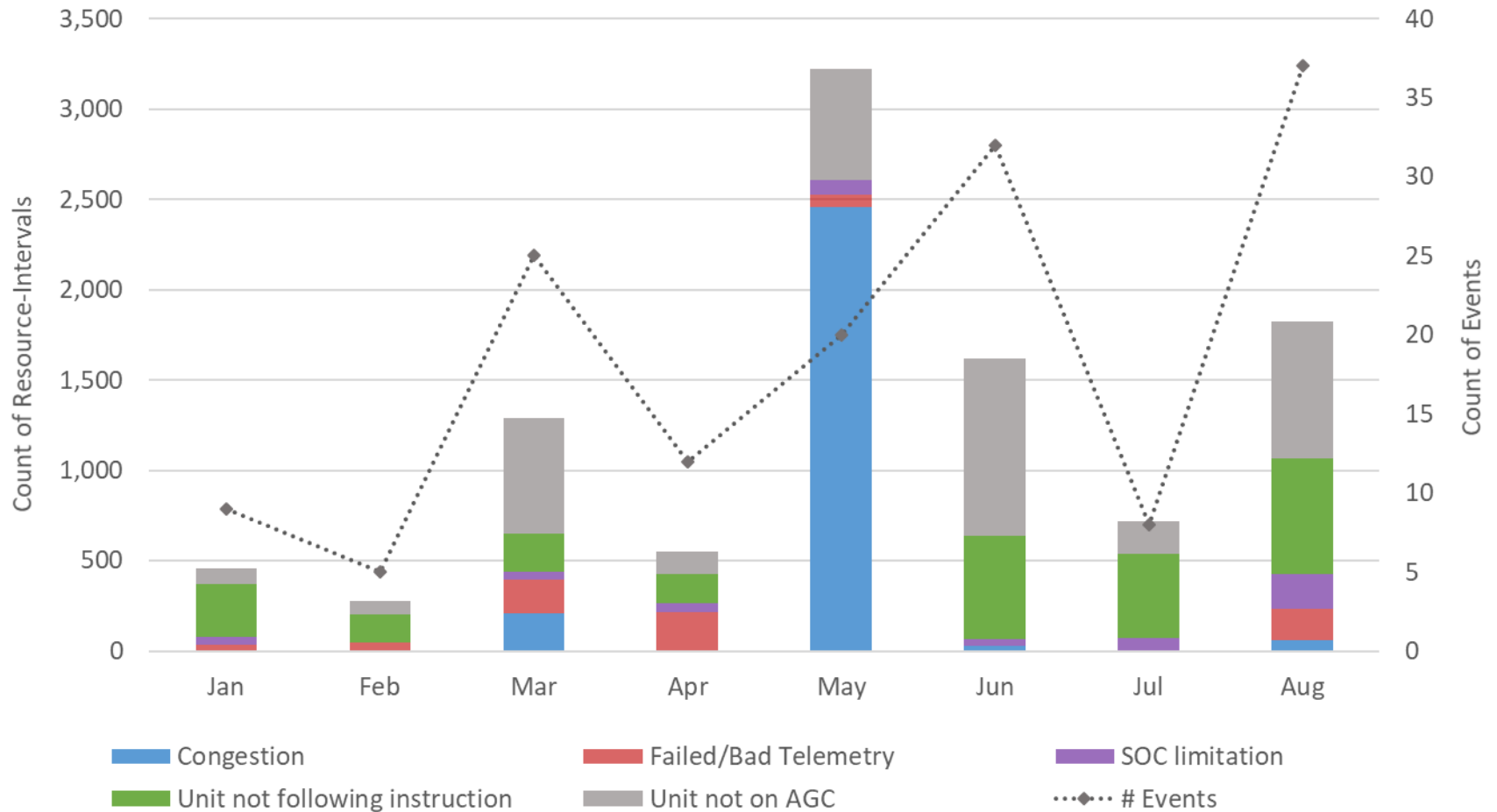
Time	Item	Speaker
9:00-9:10	Introductions	Brenda Corona
9:10-9:45	Data: Storage Providing AS	Guillermo Bautista Alderete
9:45-10:00	Potential Solutions for Storage Providing AS	Gabe Murtaugh
10:00-10:40	Stakeholder Presentation	Alva Svoboda (PG&E)
10:40-11:55	Roundtable Discussion	
11:55-12:00	Next Steps	Brenda Corona

STORAGE PROVIDING ANCILLARY SERVICE

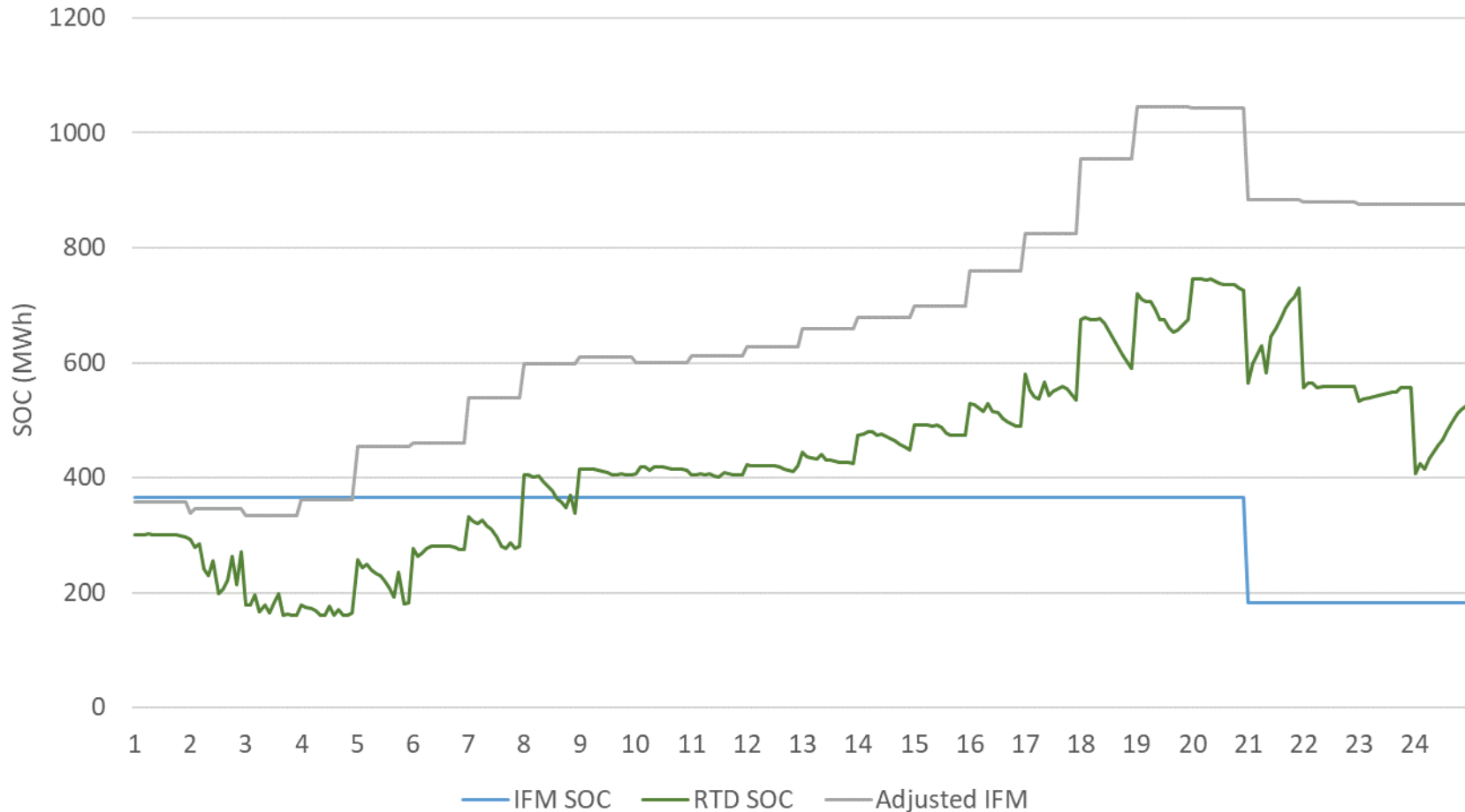
The ISO identified two potential areas of concern for storage resources providing ancillary services

1. The modeled state of charge could better match reality, specifically when storage provides regulation
 - Today the formula that governs state of charge does not account for changes related to use of regulation
 - When storage provides regulation up, state of charge will decrease
 - When storage provides regulation down, state of charge will increase
2. If a resource has a depleted state of charge, it cannot provide ancillary services
 - Some storage resources become completely depleted while providing ancillary services
 - The ISO may have no ability to access capability from these resources

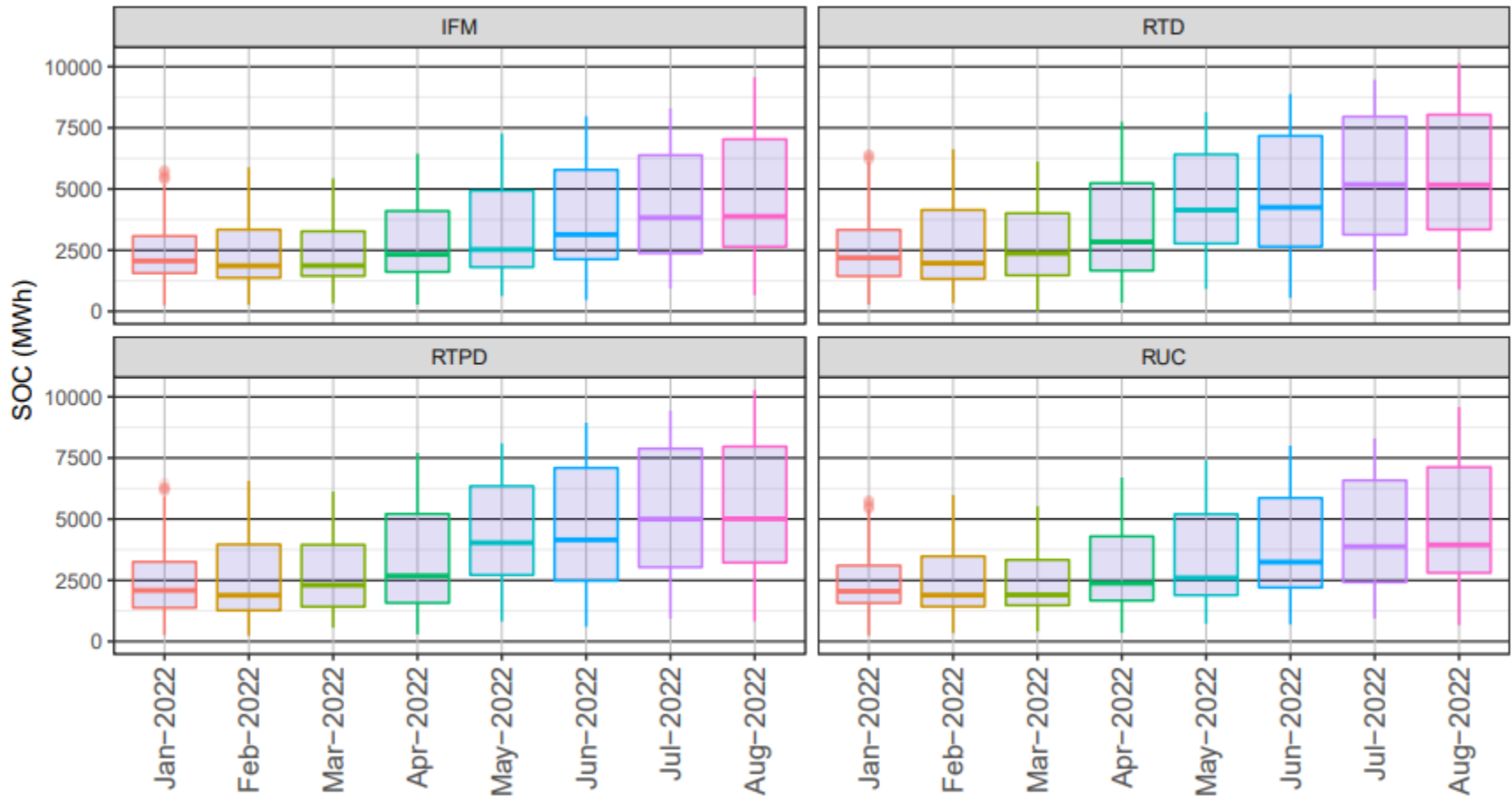
Multiple drivers for not getting regulation from storage resources



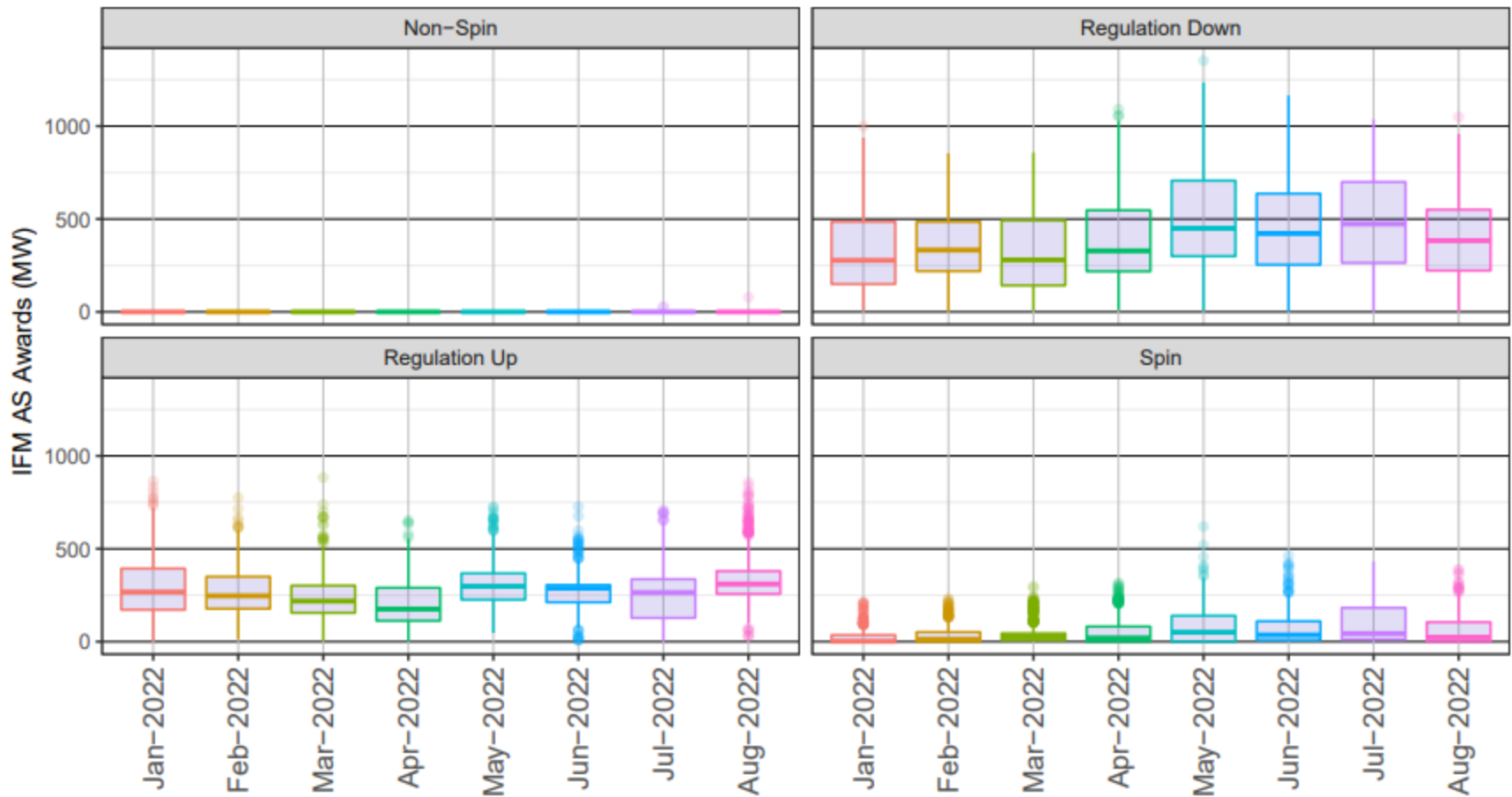
The real-time SOC can be fairly different to the reference used in day-ahead to clear AS awards



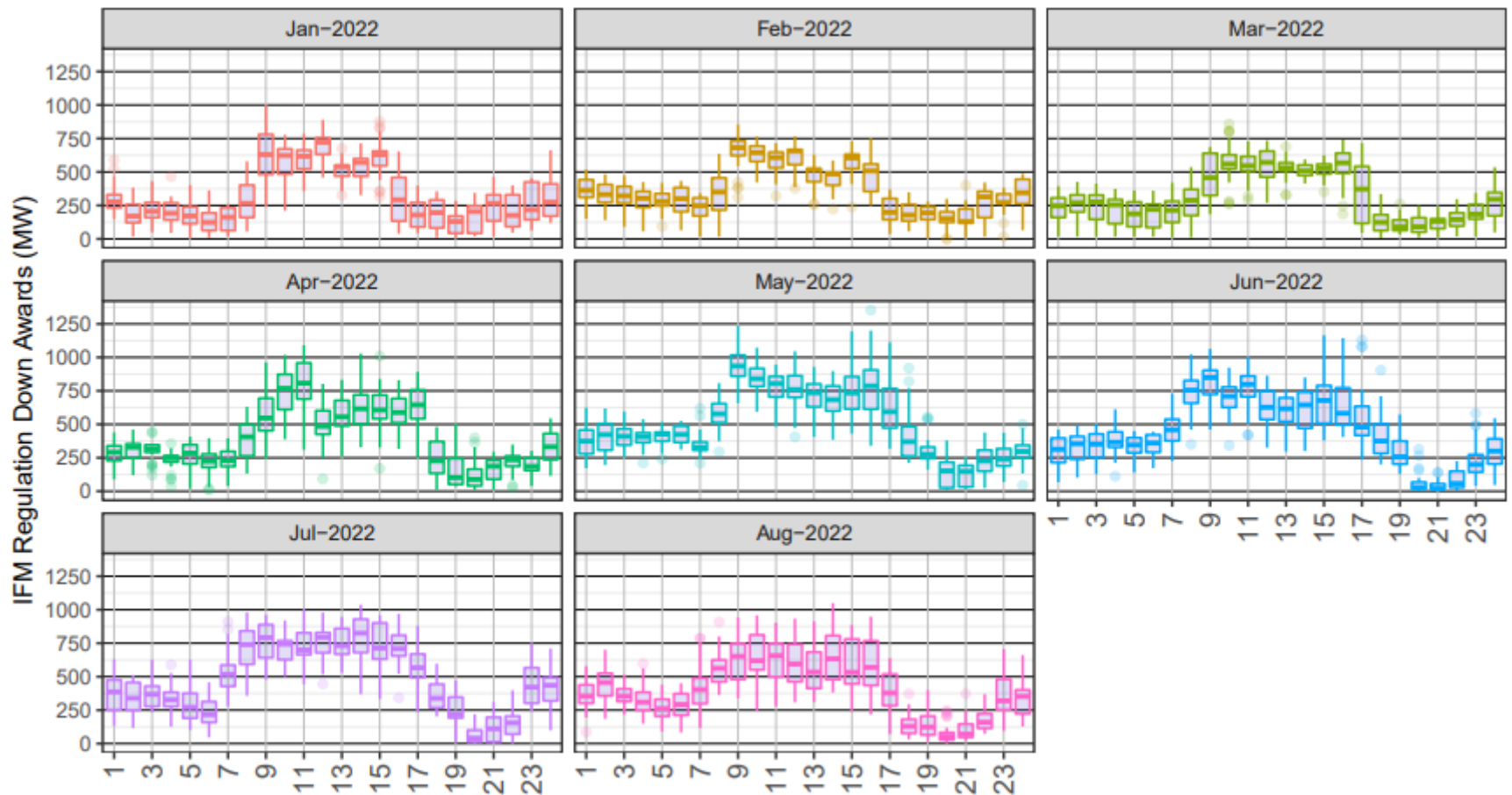
AS procurement from storage resources keeps growing



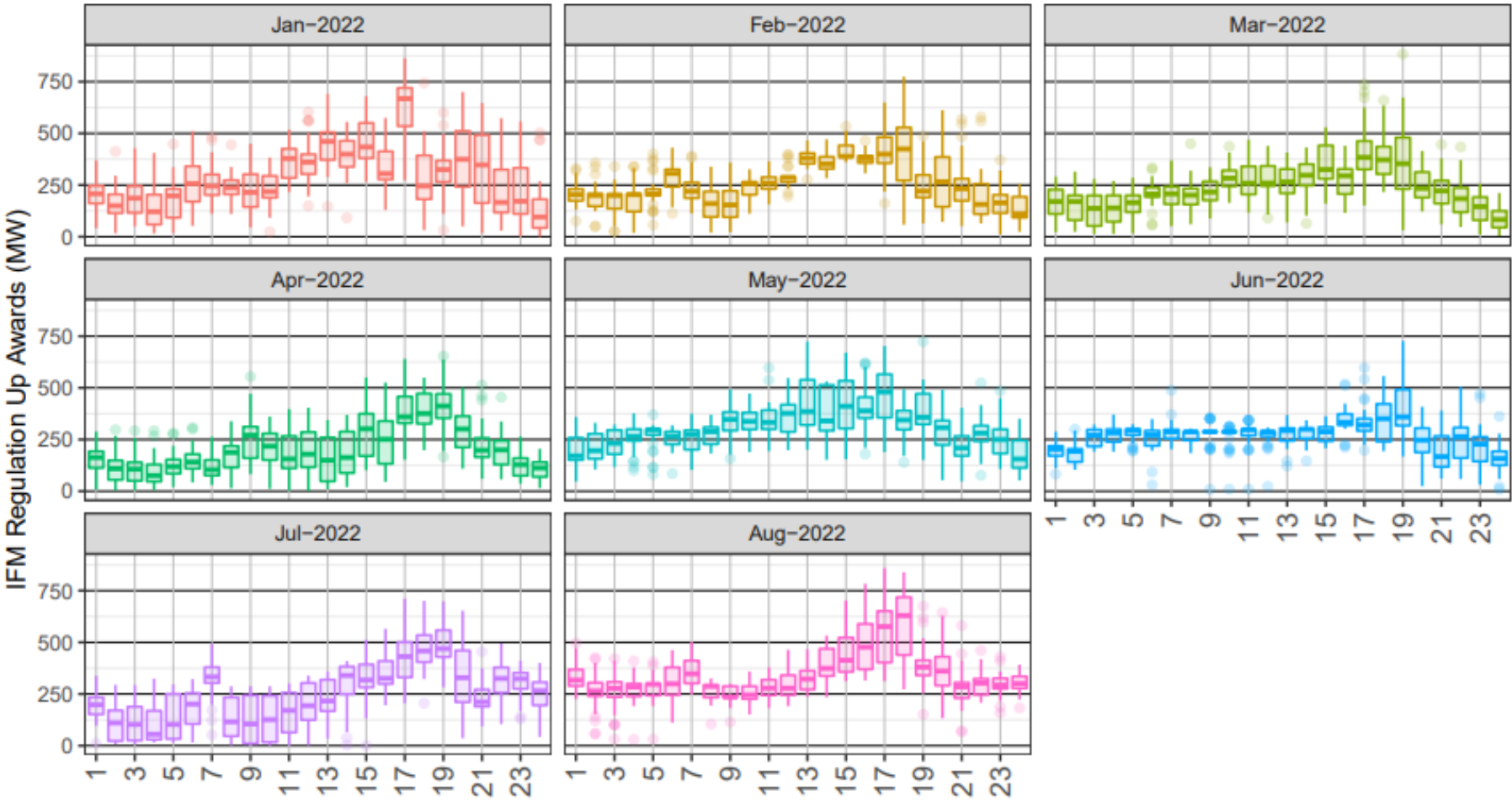
Storage resources have a significant share of the regulation market



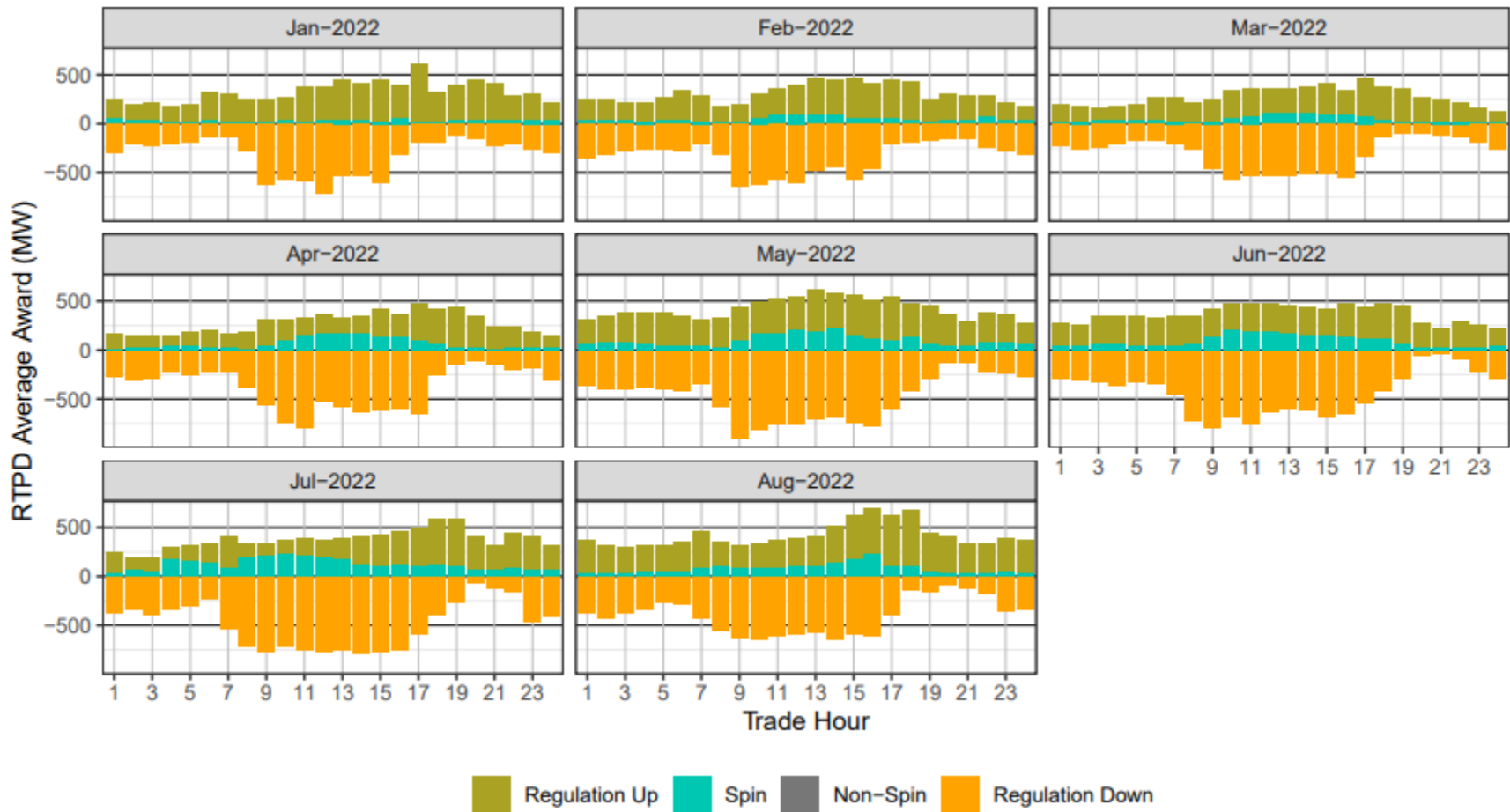
Regulation down awards follows a well define hourly trend



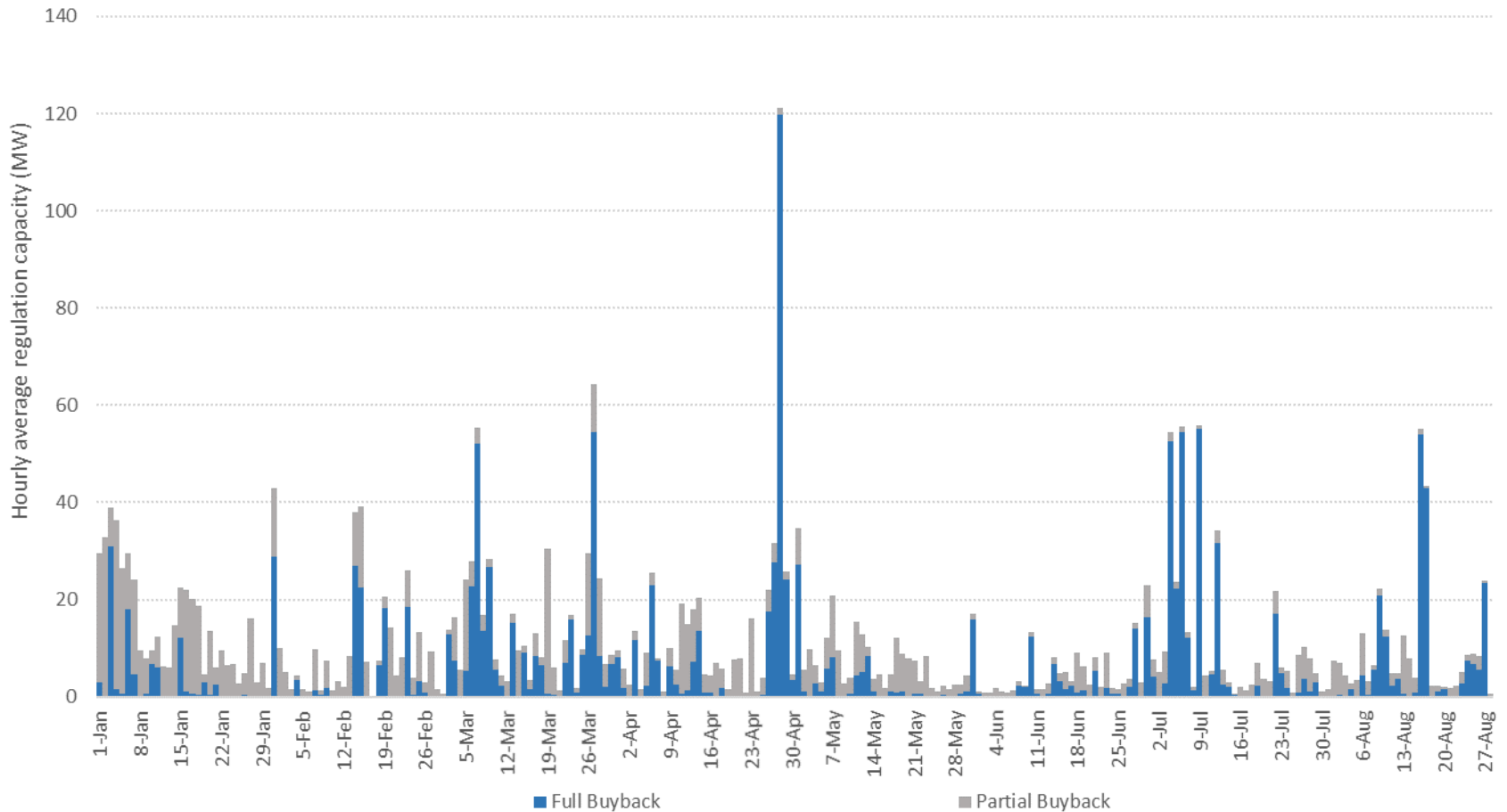
Regulation up awards tend to increase to meet requirements during peak hours through the day-ahead market



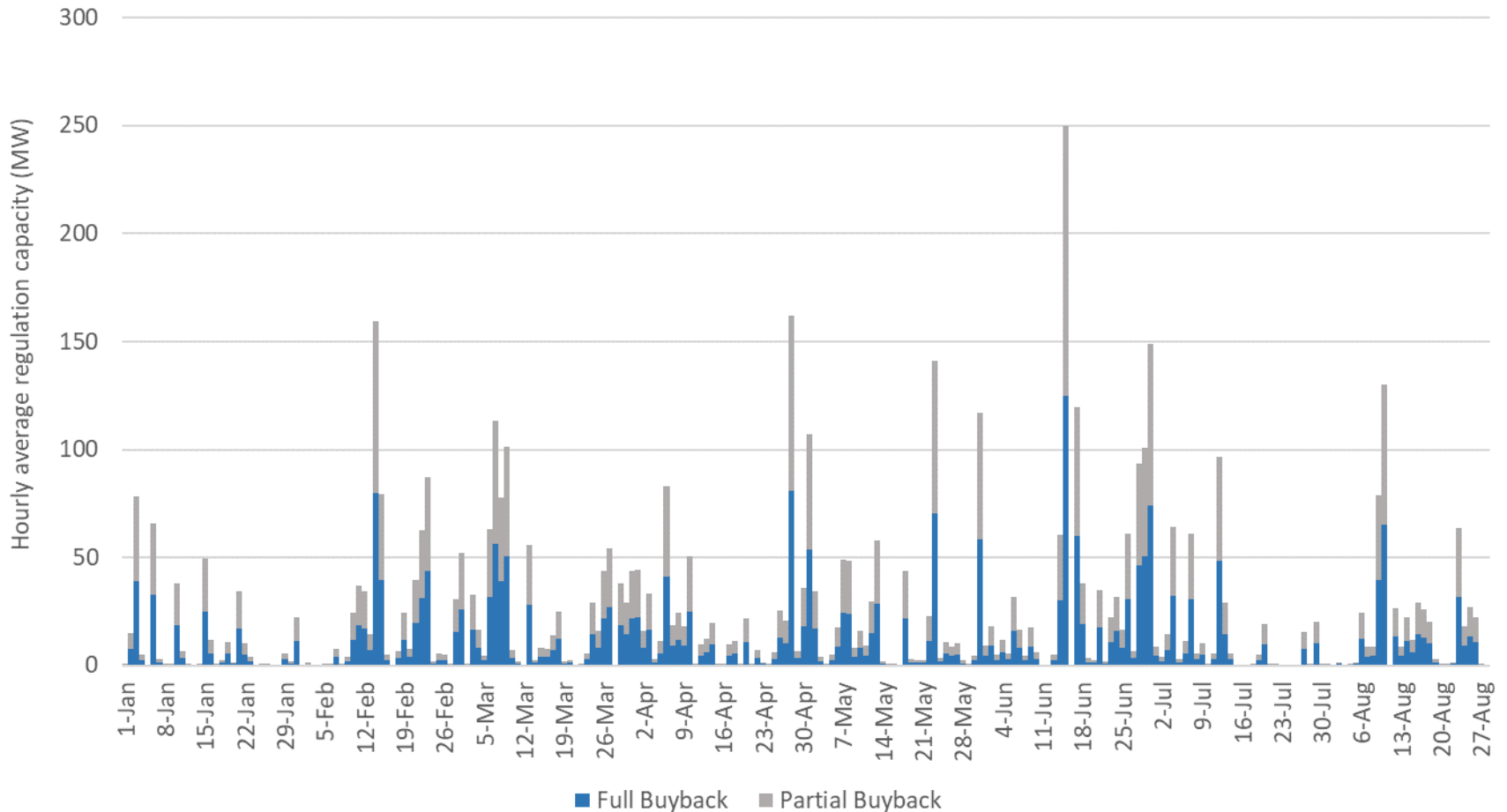
On average, storage resources provide more capacity towards regulation down through the day-ahead market



Regulation up awards from day-ahead are bought back in real-time



Regulation down awards are bought back in real-time due to changing conditions or concerns about inability to follow regulation instructions



Full regulation buyback is persistent over time and across multiple resources

Regulation Up

Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Res 1	0.6	6.5	16.7	9.3	18.8	8.4	40.1	
Res 2	2.7	0.7	4.7	19.9	4.0	1.7	1.3	18.4
Res 3	0.1	0.1	0.7	9.9	0.6	1.9	15.5	0.6
Res 4		0.5	1.3	8.7		6.5	15.1	9.3
Res 5		0.5	4.4	8.4	0.1	1.8		7.6
Res 6	1.3	3.3	49.3	6.9		8.7		1.5
Res 7	0.0	0.5	1.2	9.1	1.3	2.8	0.1	7.7
Res 8	0.1		16.1	5.5	0.2	1.0	0.7	6.5
Res 9	8.9	2.7	4.0	0.8	3.5			5.6
Res 10		1.1	5.0	0.1	2.4	1.4		0.9
Res 11	4.5	16.9	8.9		2.5		1.5	5.0
Res 12							9.5	11.6
Res 13			8.0	3.1	3.2	0.4	0.3	
Res 14	8.3	0.6		2.1	66.7	3.7	5.5	10.7
Res 15		1.6	4.1		0.1		1.7	0.2
Res 16	2.3	0.5	0.1	0.6	0.0	0.2	0.0	0.3
Res 17				14.9	0.1		1.5	1.1
Res 18	6.3			0.1	1.9	0.3	3.5	1.9
Res 19		15.8	16.5			6.7		11.4
Res 20		0.2		0.1		12.2		1.8
Res 21		0.0	30.1		1.1		1.6	
Res 22	0.1	2.0				11.6		7.6
Res 23			19.7	6.2	0.5		1.8	
Res 24	0.3	0.6		0.3	1.3	0.6	0.9	
Res 25	0.2		0.1		0.5	0.7	0.7	0.7
Other	0.7	2.1	0.5	1.8	1.6	1.4	0.3	2.2

Regulation Down

Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Res 1	1.8	6.1	13.4	8.0	22.4	10.1	35.8	
Res 2	0.3	0.9	4.0	12.2	0.4	7.0	10.7	11.3
Res 3	2.7	2.2	3.7	23.0	5.0	2.1	2.1	25.6
Res 4	0.3	0.3	6.3	12.1	1.2	6.6	3.6	9.8
Res 5	0.2	0.8	4.3	12.7	2.1	5.3	2.2	10.1
Res 6	2.2	7.0	4.6	0.2	2.6	5.7	0.3	1.6
Res 7	9.1	2.2	2.7	7.8	63.3	3.8	4.3	10.8
Res 8		10.9	4.2	6.4	5.1	11.6	0.0	11.7
Res 9	4.4	7.1	4.1	0.7	7.1	8.5	5.0	6.8
Res 10		0.0	24.9	2.2	11.4	6.5	2.8	1.6
Res 11		11.3	60.1	11.8	0.3	9.2	1.7	
Res 12	2.3	1.1	0.5	2.2	1.4	2.3	1.3	1.0
Res 13	1.8		26.0	11.9	3.9	0.6	2.4	3.7
Res 14	0.1	9.0				11.3	0.1	0.4
Res 15	0.0		23.9	2.1	6.9		1.3	1.6
Res 16		3.6	4.5		0.5	0.1	2.9	0.5
Res 17						19.9	0.1	1.7
Res 18	2.0	1.4	1.3	6.6	2.9	4.3	11.5	
Res 19		5.3	7.0	1.7	11.0	0.7	0.8	6.7
Res 20	0.7	0.6	4.1	0.5	5.5	6.6	0.0	6.1
Res 21							7.5	10.4
Res 22	16.3		0.7		6.2			1.9
Res 23			10.4	3.2	1.8	2.9	0.3	3.8
Res 24				1.3	0.3	14.2		5.8
Res 25		2.2	1.5	0.6	0.9	4.4	4.6	3.1
Other	0.8	0.5	0.6	1.4	0.9	1.1	0.7	1.0

The values in the matrices are percentage of the intervals with day-ahead awards bought back in real-time

Buy back of regulation down is concentrated in midday hours

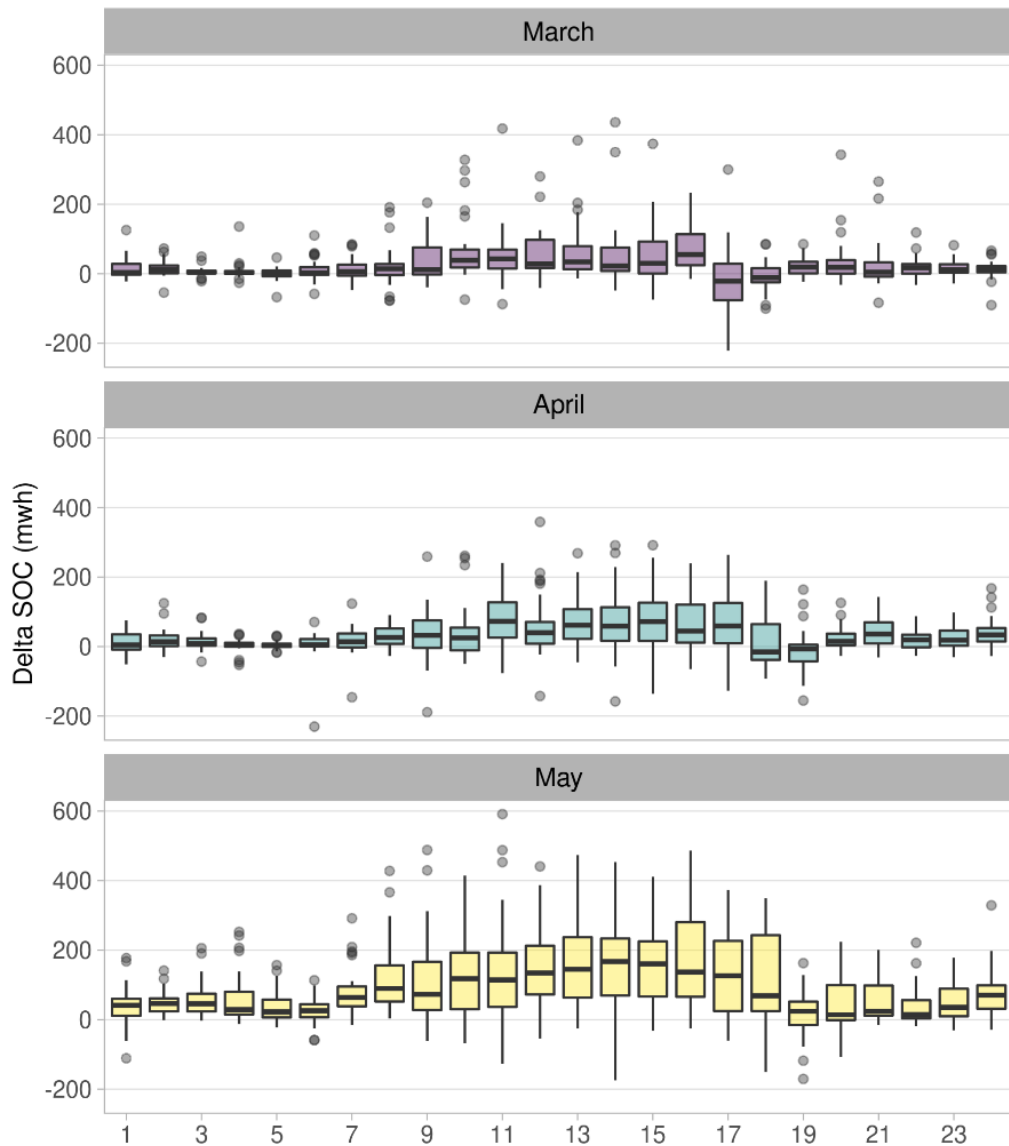
Resource	Hour																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Res 1	6.8	7.4	9.5	6.5	10.5	9.8	8.3	10.6	8.0	7.6	7.9	14.0	12.1	15.6	11.4	12.2	12.7	14.8	16.0				10.8	14.5
Res 2	4.8	5.0	3.0	3.9	5.8	4.6	5.9	5.2	4.3	4.5	3.5	6.9	5.4	5.6	4.6	6.2	6.9	4.6	5.4	6.0	6.1	4.8	5.6	8.7
Res 3	3.4	3.8	4.9	4.5	4.7	5.1	4.9	7.6	7.9	6.1	7.4	8.6	9.4	7.4	7.3	7.8	13.4	3.8		1.5	13.1	15.8	9.5	5.6
Res 4	4.5	3.3	2.8	6.3	5.3	5.4	5.0	5.0	3.6	4.7	6.4	4.5	3.8	2.5	2.8	4.7	7.0	6.1	7.1	8.6	6.3	2.2	3.2	7.6
Res 5	3.6	3.9	1.8	4.2	4.9	4.0	4.0	4.6	4.3	4.4	4.6	4.3	2.3	4.7	2.7	5.0	6.0	5.8	6.2	7.7	5.9	2.2	3.6	7.2
Res 6	2.5	2.8	5.3	9.7	8.5	6.6	3.5	2.0	1.7	2.0	2.1	0.5	1.2	2.4	3.1	4.0	4.4	2.6	0.8	8.0	6.1	3.7	4.0	2.9
Res 7		2.0	1.8	1.8	1.5			4.0	8.3	6.0	6.7	6.9	8.6	7.7	8.4	8.3	13.7							
Res 8								3.0	3.0	5.7	5.4	6.9	8.7	9.4	8.3	7.7	5.3	4.8	6.0					
Res 9								6.3	4.4	3.9	3.8	4.6	4.6	5.9	6.9	7.6	10.1	5.9						
Res 10								57.1	5.1	5.4	5.2	5.8	5.3	4.2	4.8	8.1	8.0	9.1						
Res 11								3.0	7.6	7.3	7.5	5.5	7.3	9.1	9.0	6.7	2.7							
Res 12	4.2	9.3					5.2	1.2	8.3	17.8	14.9	13.0	18.8	10.4	8.7	10.4	10.7	2.2		57.1				
Res 13	0.2			0.1		0.1	0.1	1.4	1.0	2.2	3.3	3.4	2.9	3.9	5.0	3.8	2.1							2.1
Res 14									4.9	5.4	4.8	4.2	10.2	9.3	7.8	8.8	9.5	2.3						
Res 15	2.0	2.7	3.6	4.2	2.1	3.1	7.2	2.8	4.4	3.7	4.0	3.2	3.1	2.6	3.7	4.1	1.8	5.0		7.7		5.7	2.8	4.6
Res 16									2.5	3.2	3.8	4.4	3.7	3.1	3.9	5.2	4.8	5.6						
Res 17	2.7	0.9	0.8	0.7	0.8	1.3		2.3	1.6	1.2	1.6	1.3	1.0	1.5	2.2	1.7								
Res 18	4.3	7.7	6.6	8.2		18.2	6.6	5.4	9.9	5.2	5.9	4.0	5.9	1.8	4.1	2.9	3.8	3.7	13.8		36.4	50	8.0	10.9
Res 19				4.9	4.6		1.5	3.1	0.2	2.7	2.3	2.7	5.0	4.7	8.7	5.4	6.3	4.6						
Res 20	3.5	1.5	2.9	2.8					2.0	2.4	3.8	2.6	3.4	4.5	4.0	6.3	1.1							
Res 21	11.7	13.0	12.5	14.3	18.8	13.7	10.5	13.2		5.6	5.0	5.1	12.3	9.5	14.6	12.2	7.4	4.5					7.0	10.5
Res 22	1.7	2.3	1.8	0.8	0.6	1.5	1.1	2.1	2.8	2.2	4.7	2.6	1.4	3.4	2.9	1.6		2.0	1.9			2.9	3.4	2.8
Res 23		4.3						1.0	1.1	3.1	2.8	5.2	3.8	3.3	2.5	2.8	3.1	6.9	6.1			5.0	6.7	4.7
Res 24	2.0	2.2	1.9	3.1	4.0	5.1	2.8	6.3	2.8	4.8	5.4	5.9	4.4	3.2	3.4	3.3	5.4	6.3						17.6
Res 25								3.5	5.5	3.3	3.1	3.5	2.2	2.0	2.1	2.1								
Other	1.0	0.5	0.6	0.7	0.4	0.4	0.8	0.8	0.6	0.9	1.2	1.0	1.0	1.1	1.4	1.3	1.3	1.2	0.3	0.1	0.0	0.1		0.7

Buyback of AS awards may happen due to a variety of reasons

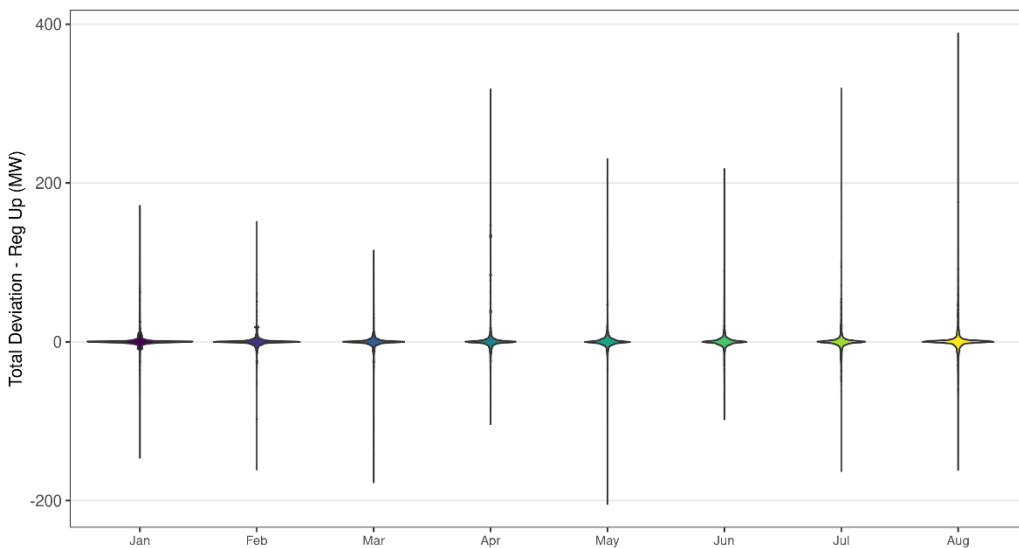
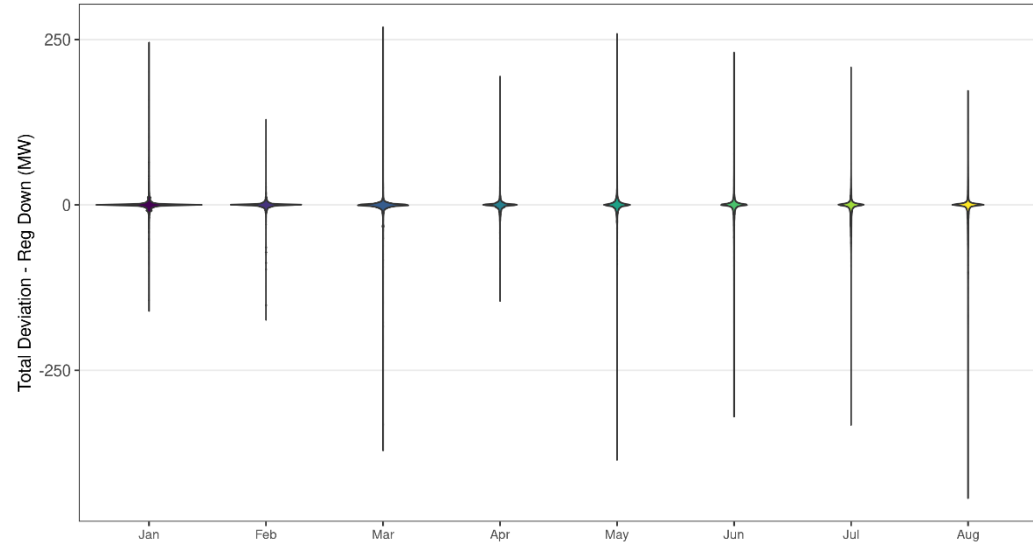
- Operators' action once there is an issue with deployment of regulation
 - Undeliverable due to congestion
 - Resources deviating
 - Issues with bad telemetry
- Market optimization buyback based on changing conditions
 - Resources' derates in real-time
 - Reaching its min/max SOC

The projected day-ahead SOC is a reference for day-ahead awards

Actual SOC in real-time is influenced by energy use to support regulation deployment



Deviation to provide regulation jeopardizes the reliable operation of the system



Deviation to provide regulation is persistent across hours

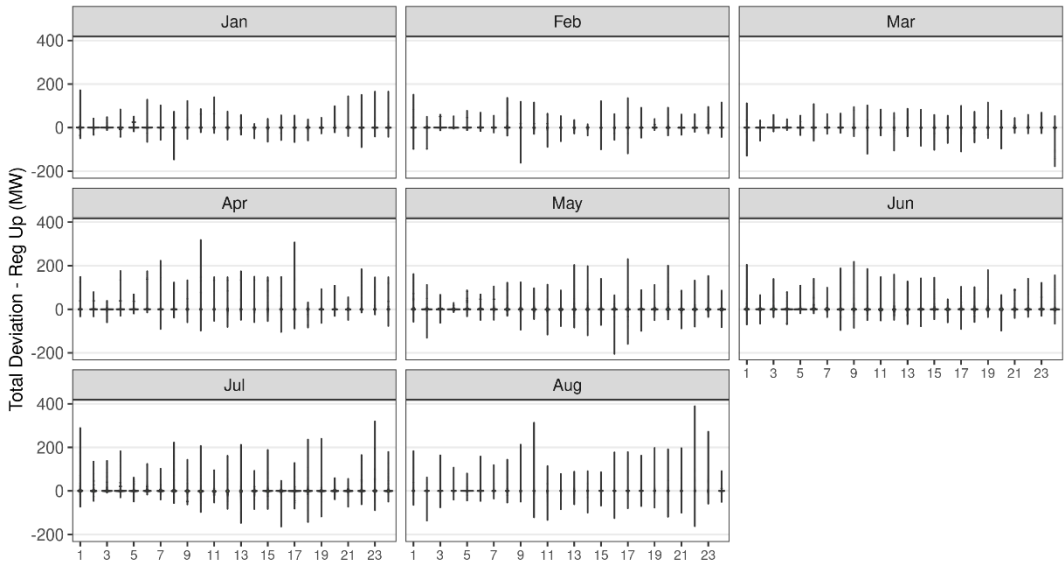
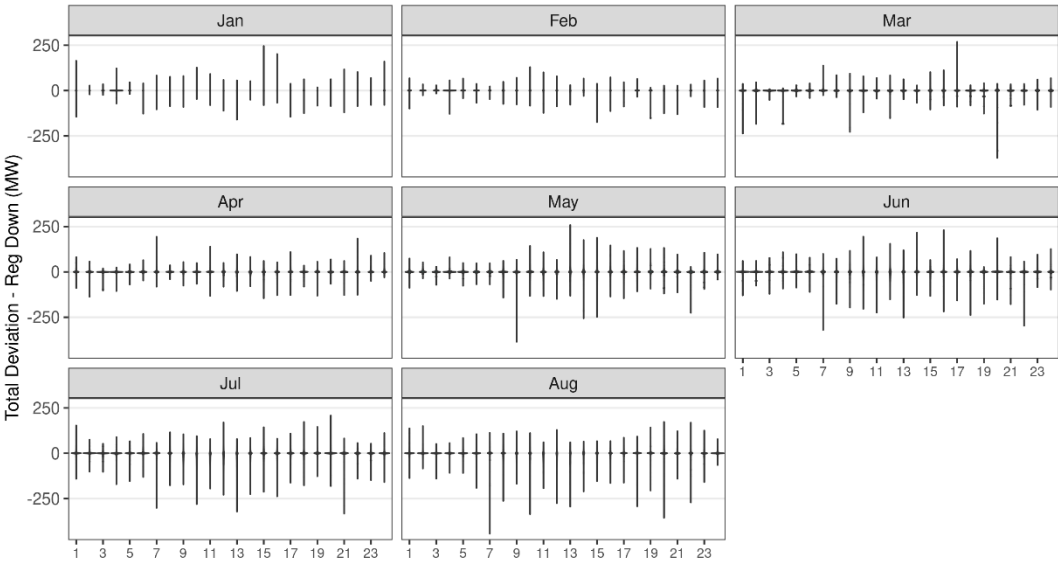
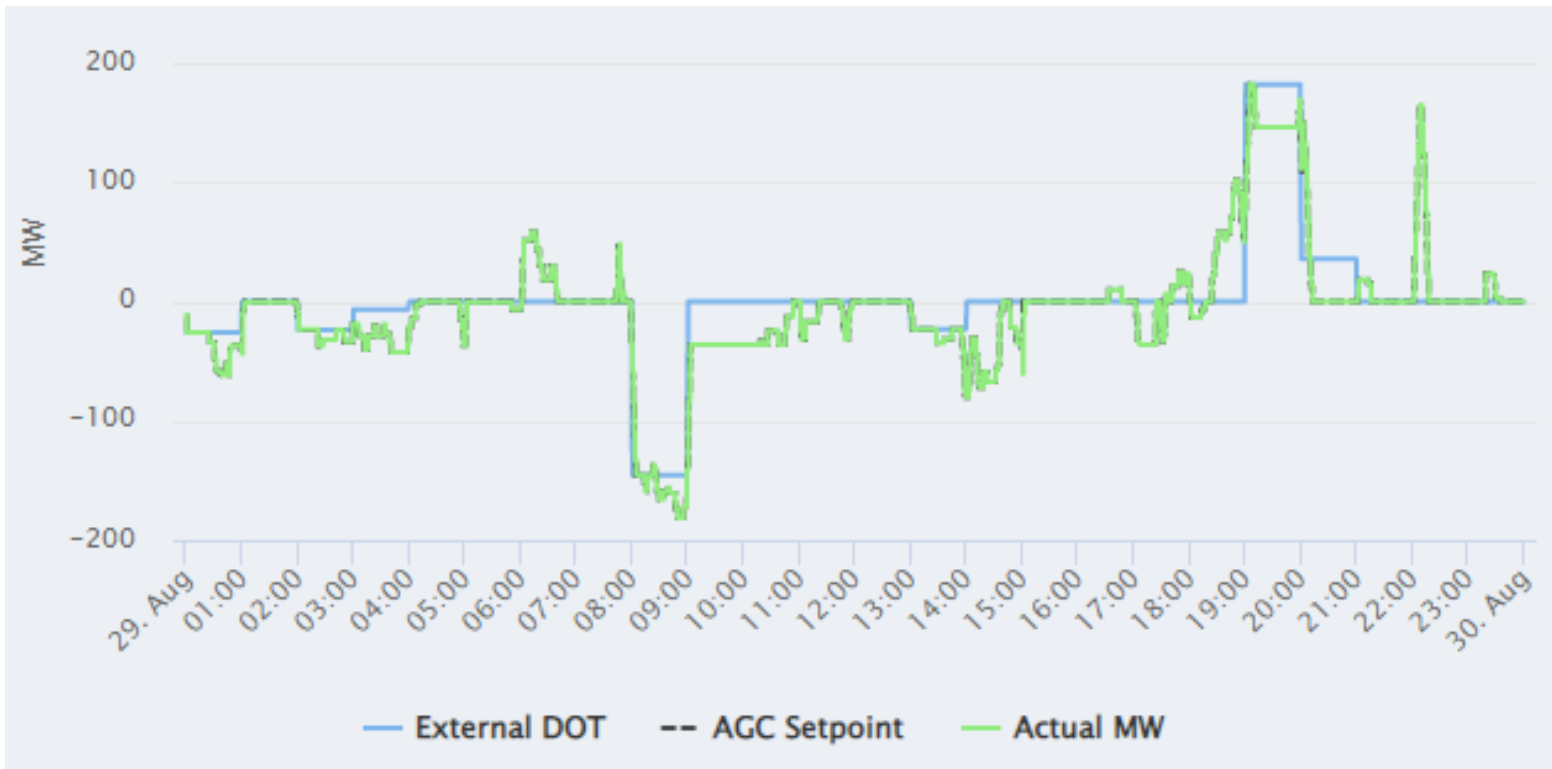
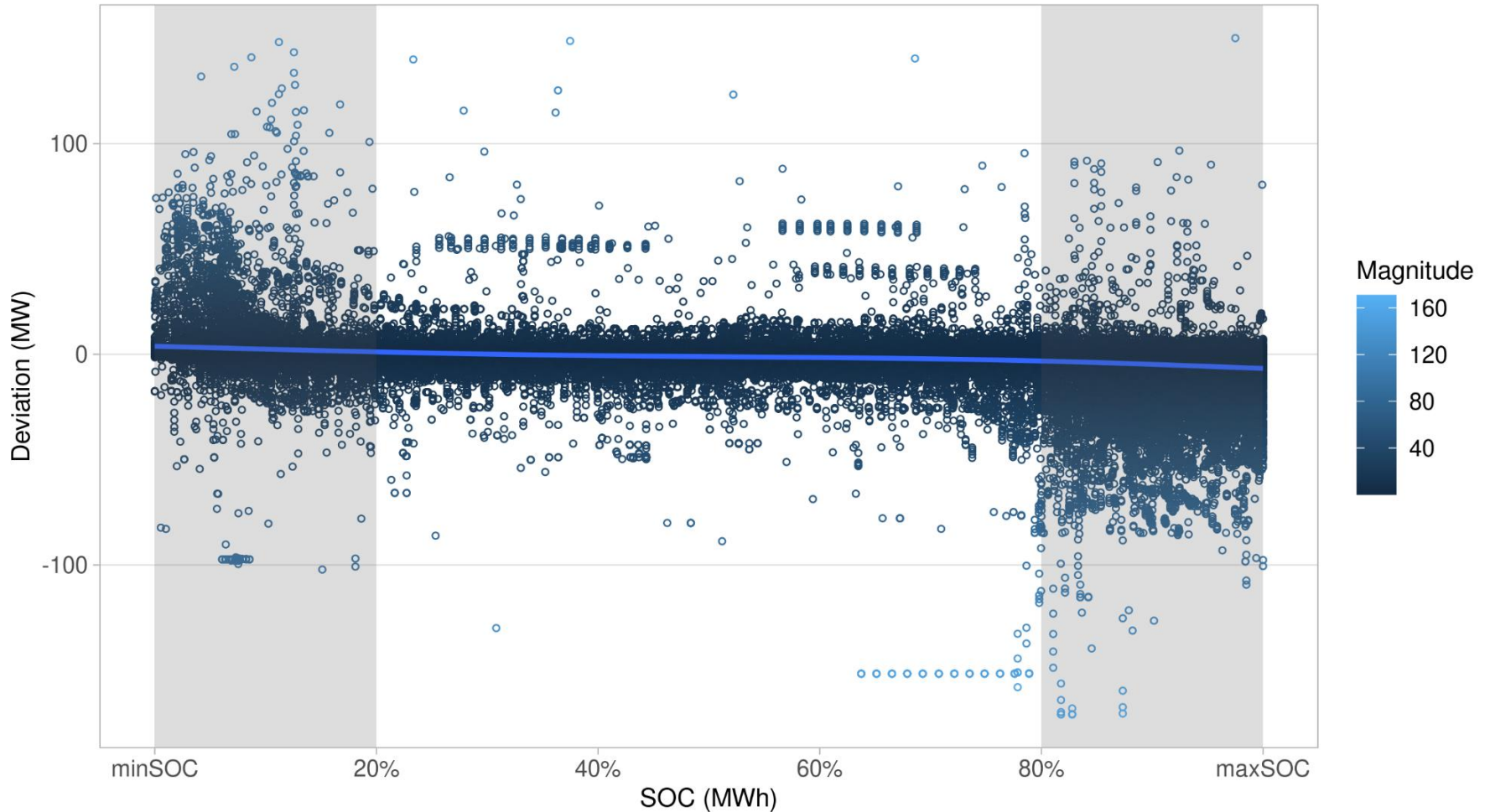


Illustration of how well a resource can follow the regulation signal

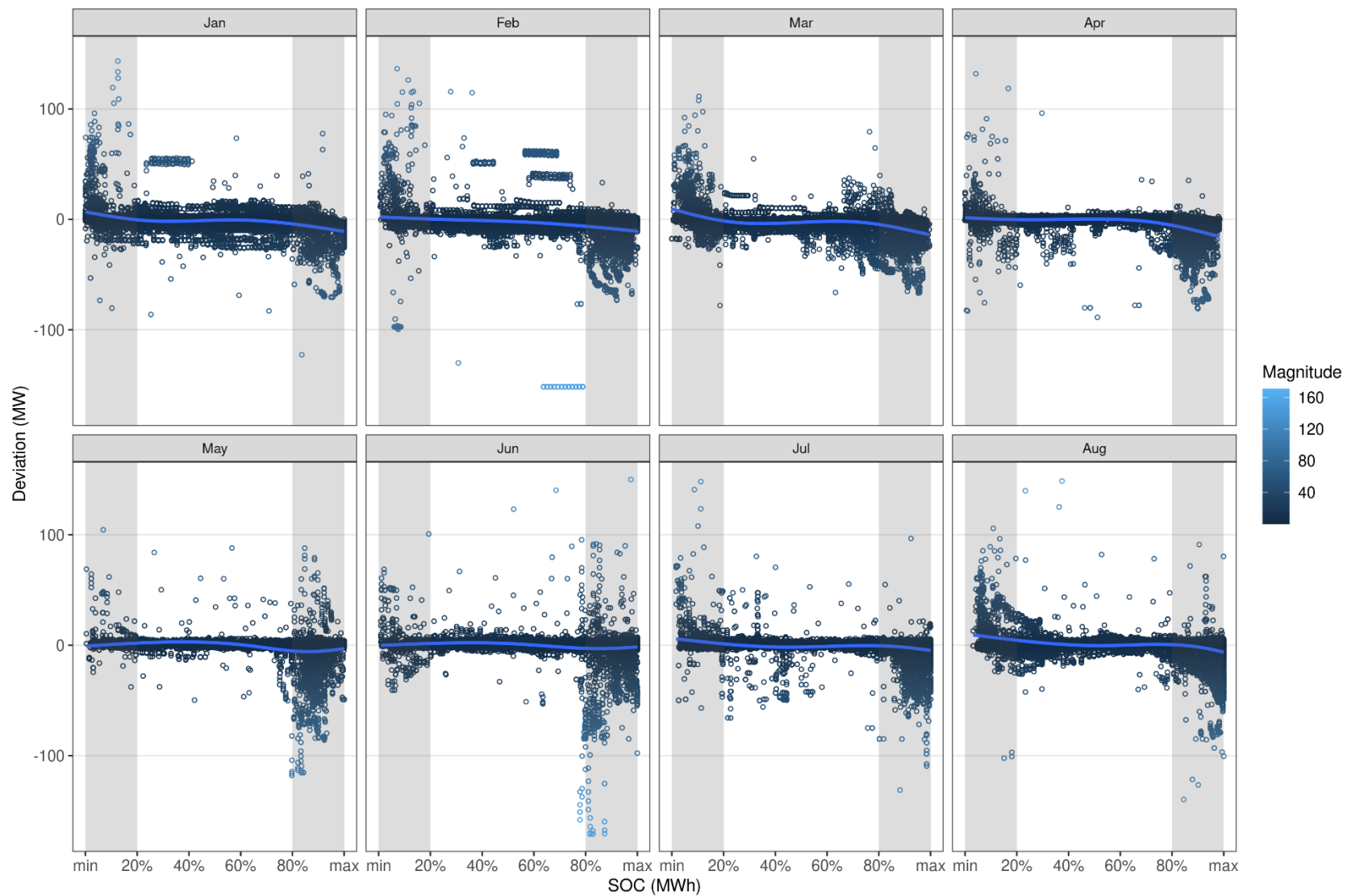


Resource has regulation –up and down- for all hours of the day so resource is set on AGC and be able to follow the set points

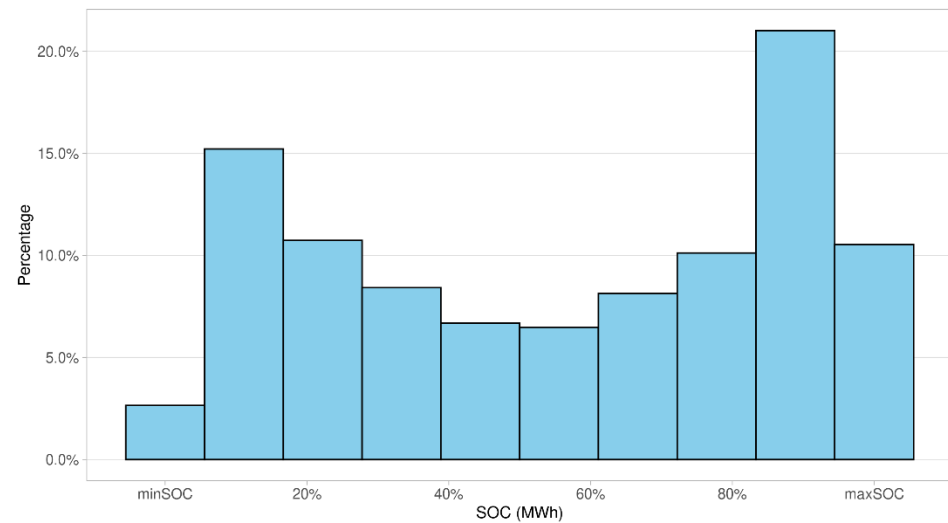
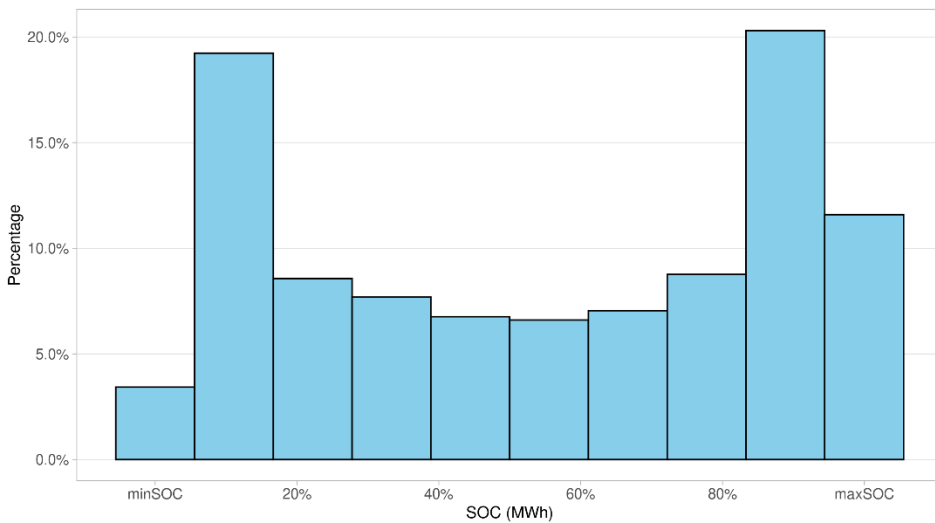
Resource-specific trends exhibit certain level of deviations at the ends of the SOC range



Deviations tend to be persistent over time



Distribution of deviations exhibits higher frequencies at the ends of the SOC range



POTENTIAL SOLUTIONS FOR STORAGE PROVIDING AS

The ISO proposes policy to help ensure storage resource availability while providing ancillary service

1. Update the state of charge equation so that it reflects regulation awards
 - Make the estimated state of charge more accurate
 - Use a formula that includes different hourly multipliers
 2. Require bids alongside ancillary service awards
 - Ensure that storage resources can always provide ancillary service
 - This rule will apply in the day-ahead and real-time markets
 - The ISO may consider tailoring requirements to specific hours
- ISO proposes both tools, because they provide different functions, which will help address independent concerns

1. Update the state of charge formula

- Today the formula that governs state of charge is:

$$SOC_{i,t} = SOC_{i,t-1} - \left(P_{i,t}^{(+)} + \eta_i P_{i,t}^{(-)} \right)$$

- The ISO proposes to update the formula as follows:

$$SOC_{i,t} = SOC_{i,t-1} - \left(P_{i,t}^{(+)} + \eta_i P_{i,t}^{(-)} + \mu_1 RU_{i,t} - \mu_2 \eta_i RD_{i,t} \right)$$

$SOC_{i,t}$	State of charge for resource i at time t
$P_{i,t}^0$	Dis/Charge (+/-) instruction for resource i at time t
η_i	Round trip efficiency for resource i
$RU_{i,t}$	Regulation up awarded to resource i at time t
$RD_{i,t}$	Regulation down awarded to resource i at time t
μ	Multiplier

- The value of the multipliers will change each hour

Preliminary analysis shows potential differences in multipliers across hours

Hour	Reg Up	Reg Down
1	6%	12%
2	2%	10%
3	2%	13%
4	7%	18%
5	6%	11%
6	8%	13%
7	12%	24%
8	6%	22%
9	3%	13%
10	8%	13%
11	4%	13%
12	6%	18%
13	7%	20%
14	11%	21%
15	8%	21%
16	9%	21%
17	16%	25%
18	16%	35%
19	12%	21%
20	7%	35%
21	6%	37%
22	8%	23%
23	3%	26%
24	5%	25%

2. Require energy bids alongside ancillary service awards

- Operators noted storage resources can run out of SOC, resulting in an inability to provide ancillary services
 - Storage schedules with ancillary services may become infeasible
- ISO proposes that upward/downward ancillary services awards have accompanying energy bids
 - Storage resources are required to have energy bids in the opposite direction of ancillary service awards, at **50%** of the award
 - Bids would be required in the real-time market, not in the day-ahead market
 - Requirement will limit the amount of ancillary services storage could qualify for
- This proposal may help reduce the amount of ancillary service buybacks in the real-time market

Example: A ± 12 MW storage 48 MWh resource

- In the day-ahead market the resource could be awarded:
 - Up to 12 MW of regulation up,
 - Up to 12 MW of regulation down,
 - Up to 8 MW of Regulation up and 8 MW of regulation down, or
 - Another combination still allowing energy bids in the real-time market
 - There would be no new bidding requirement in the day-ahead market
- In the real-time market:
 - If awarded 12 MW of regulation up, the requirement would be to bid at least 6 MW of energy in the charging (negative) range
 - If awarded 12 MW of regulation down, the requirement would be to bid at least 6 MW of energy in the discharging (positive) range
 - If awarded 8 MW of regulation up and 8 MW of regulation down, the requirement would be to bid the remaining 4 MW of discharging and charging range as energy
- This rule makes no requirements on energy that will or will not clear in the market

STAKEHOLDER PRESENTATIONS

ROUNDTABLE DISCUSSION

Stakeholders expressed concern about the bidding requirements being overly burdensome

- Could there be relaxations during certain hours when the storage resources are likely to lose less state of charge?
 - I.e. hour ending 2, there is only typically a 2% impact on state of charge for regulation up awards and a 10% impact on state of charge for regulation down awards
- Could there be additional checks that would preclude the need to bid in the real-time market?
 - If a resource is fully charged going into a specific hour with a regulation up award could that resource be relieved of the obligation to bid charging capability?

NEXT STEPS

Next Steps

- The ISO will discuss the Energy Storage Enhancement policy at the Market Surveillance meeting on **Monday, September 19, 2022**
 - The Market Surveillance Committee will provide an opinion for the policy, when it goes to the Board of Governors
 - All related information for the Energy Storage Enhancements initiative is available at:
<https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-enhancements>



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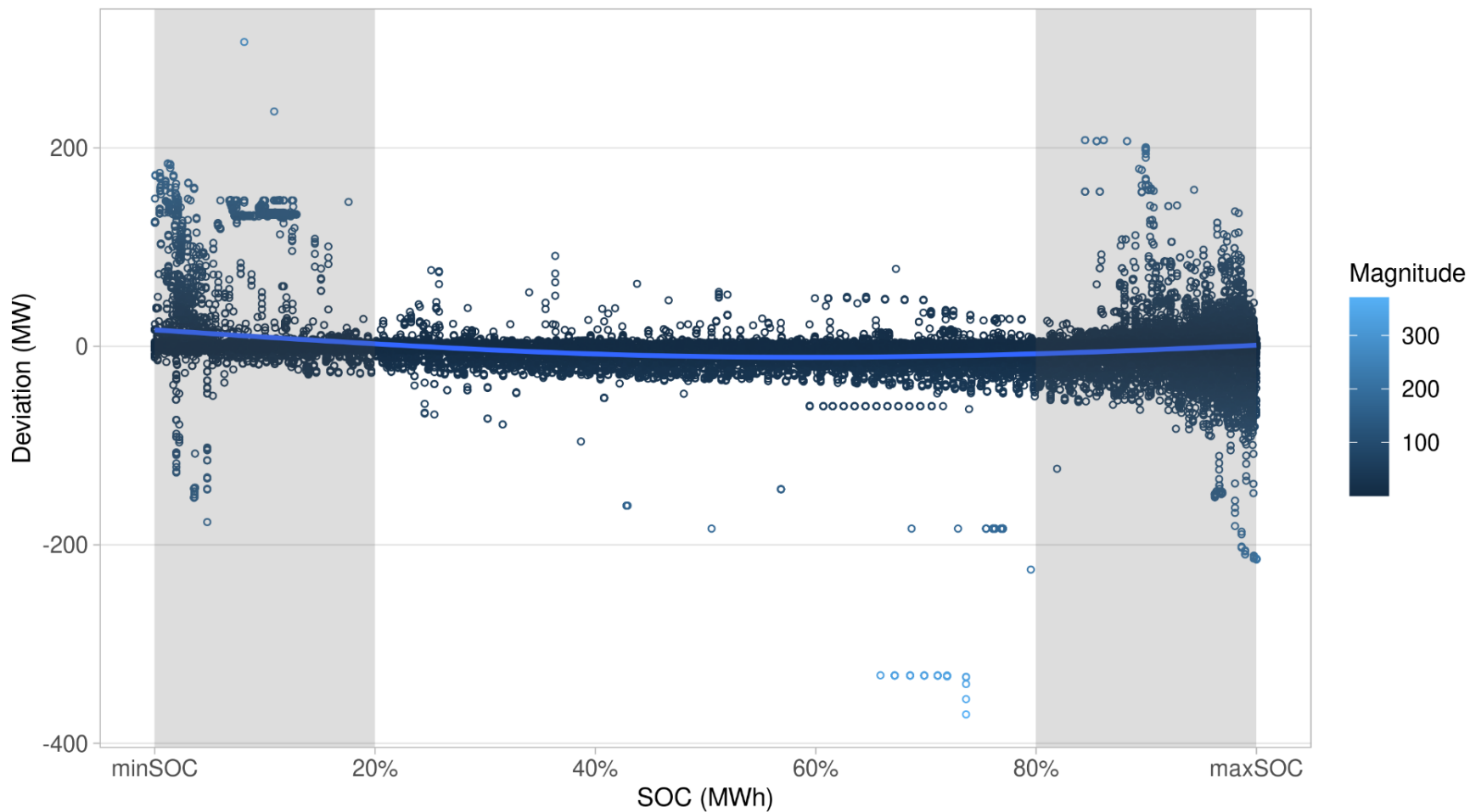
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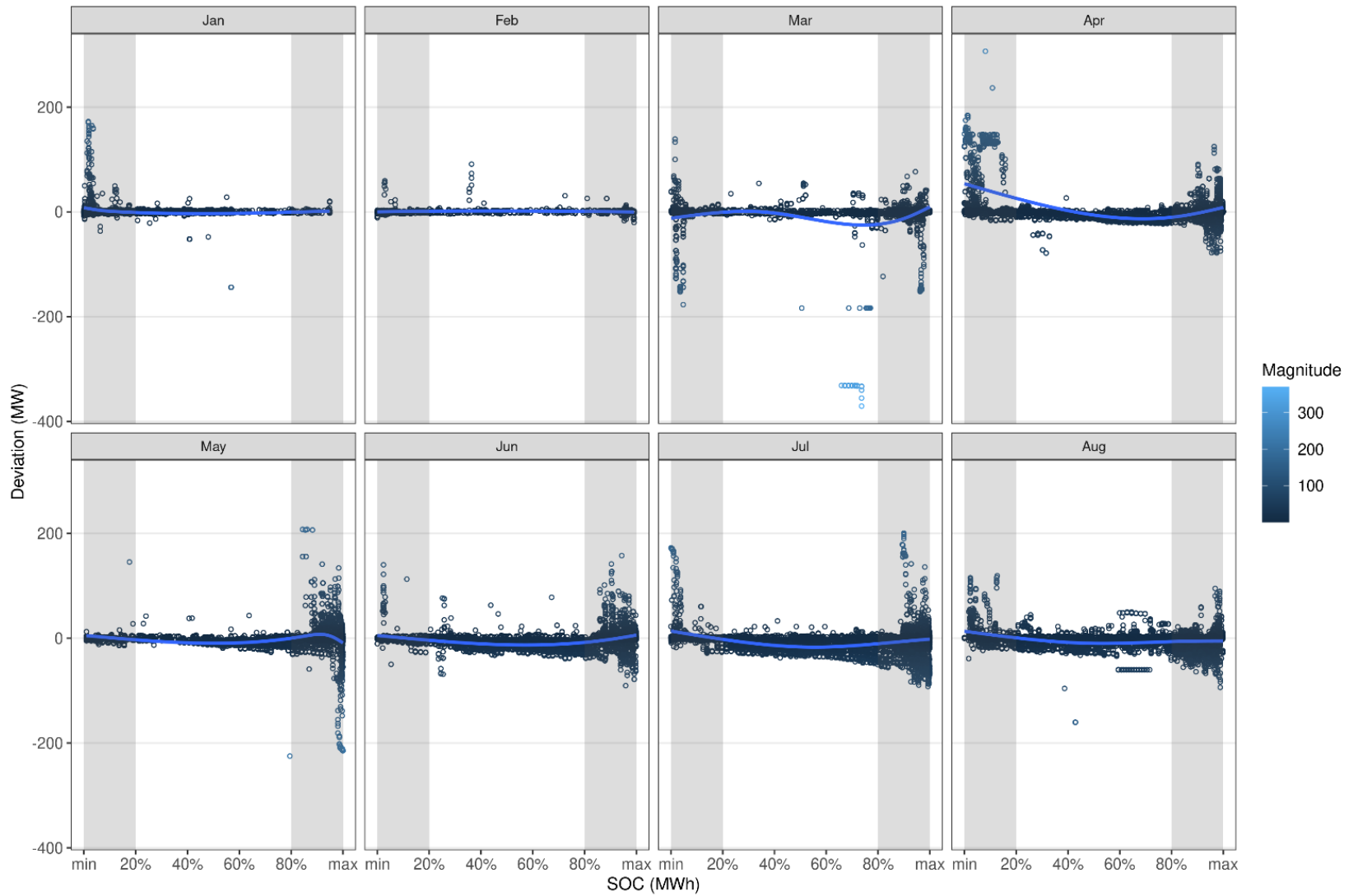
Appendix

Deviation metrics for top five resources based on data sample from January 1 through August 31, 2022

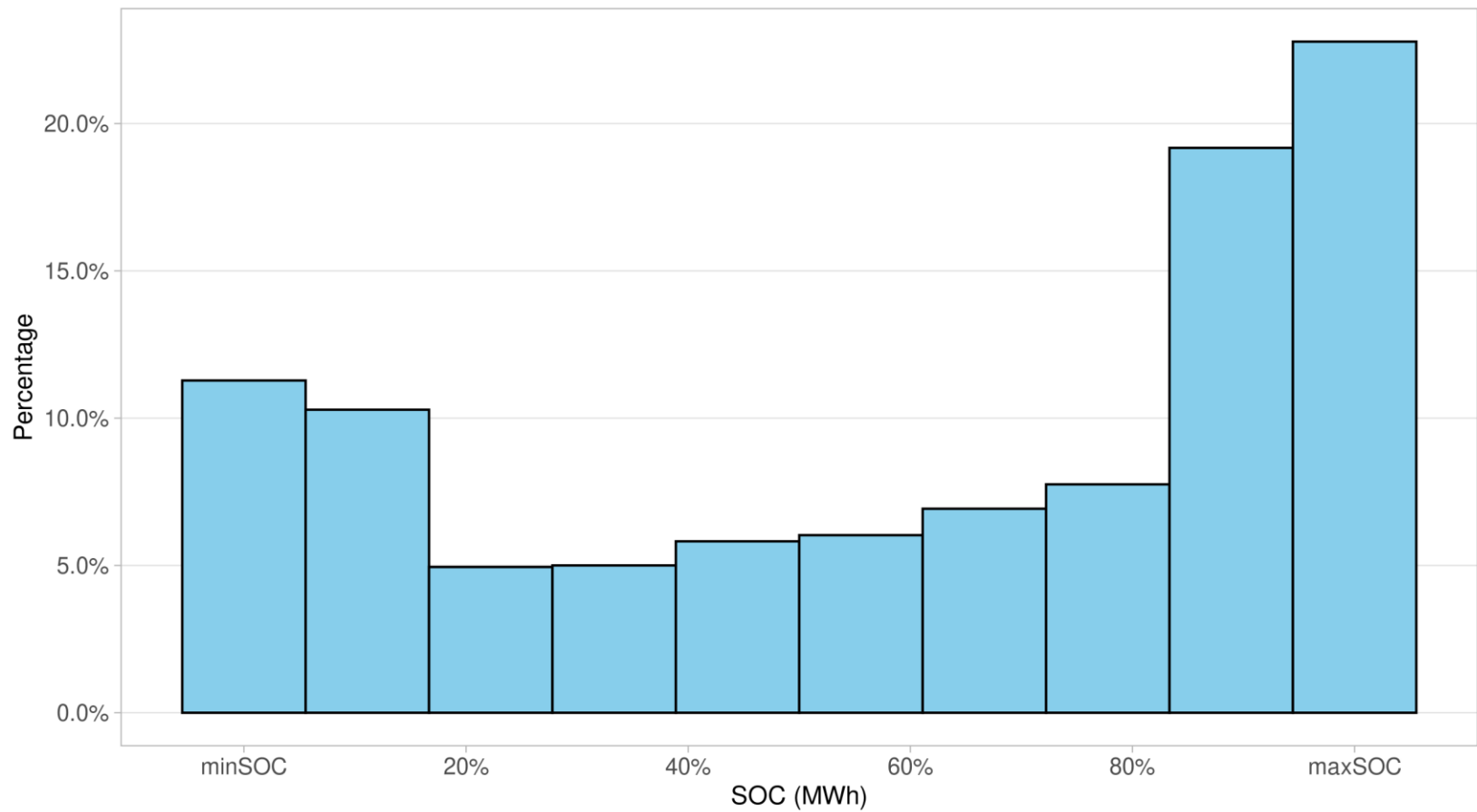
Resource 2



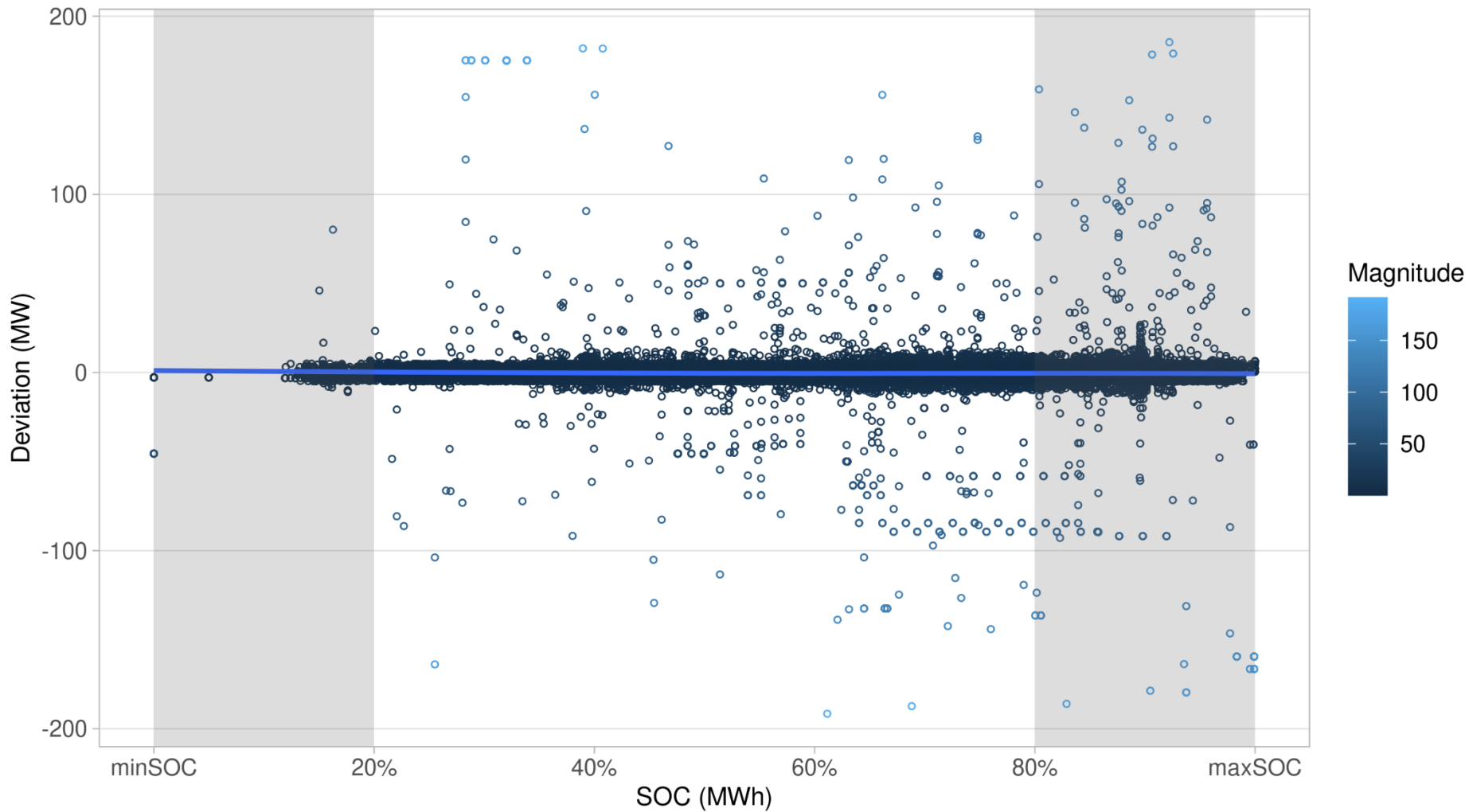
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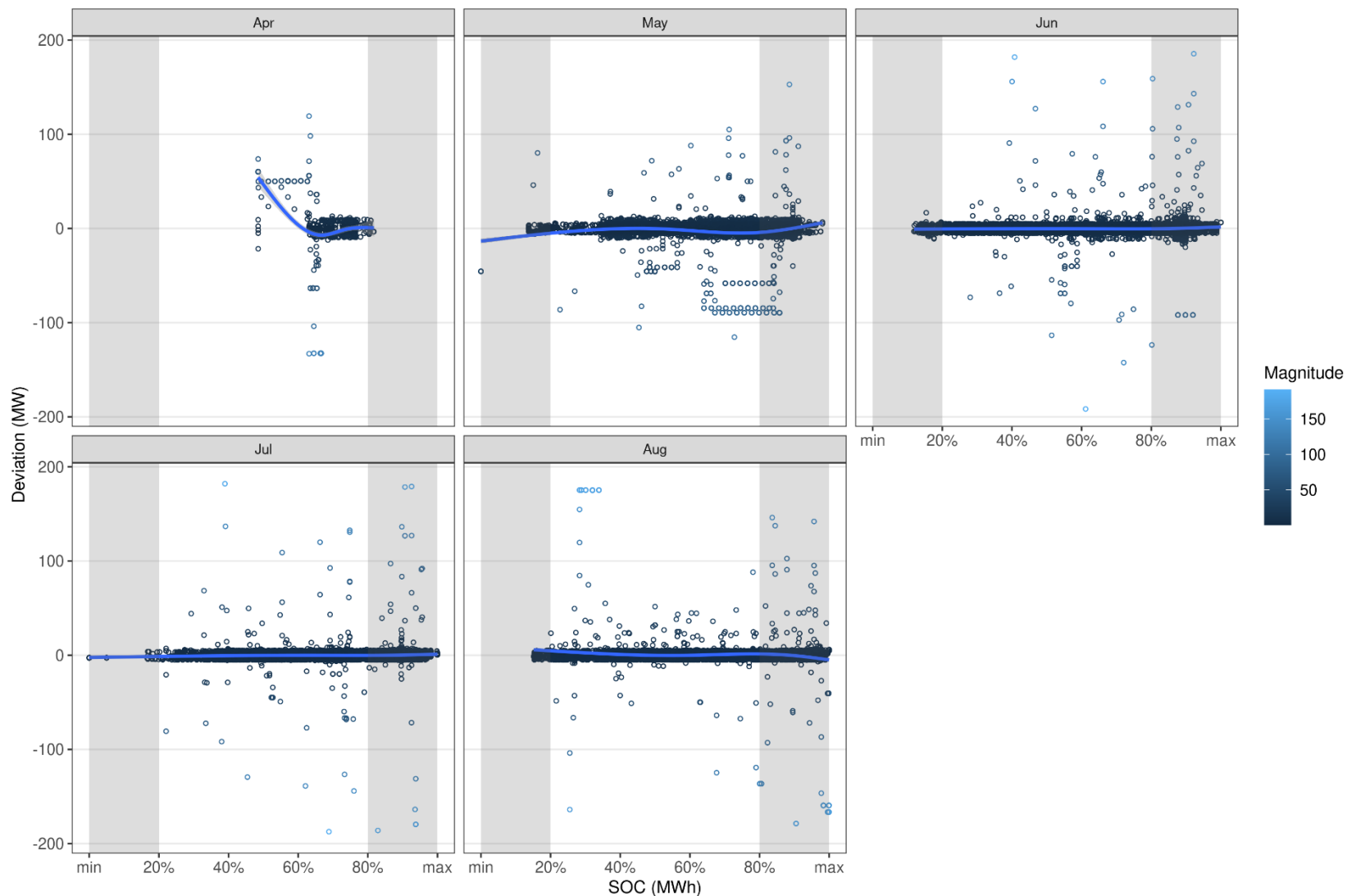
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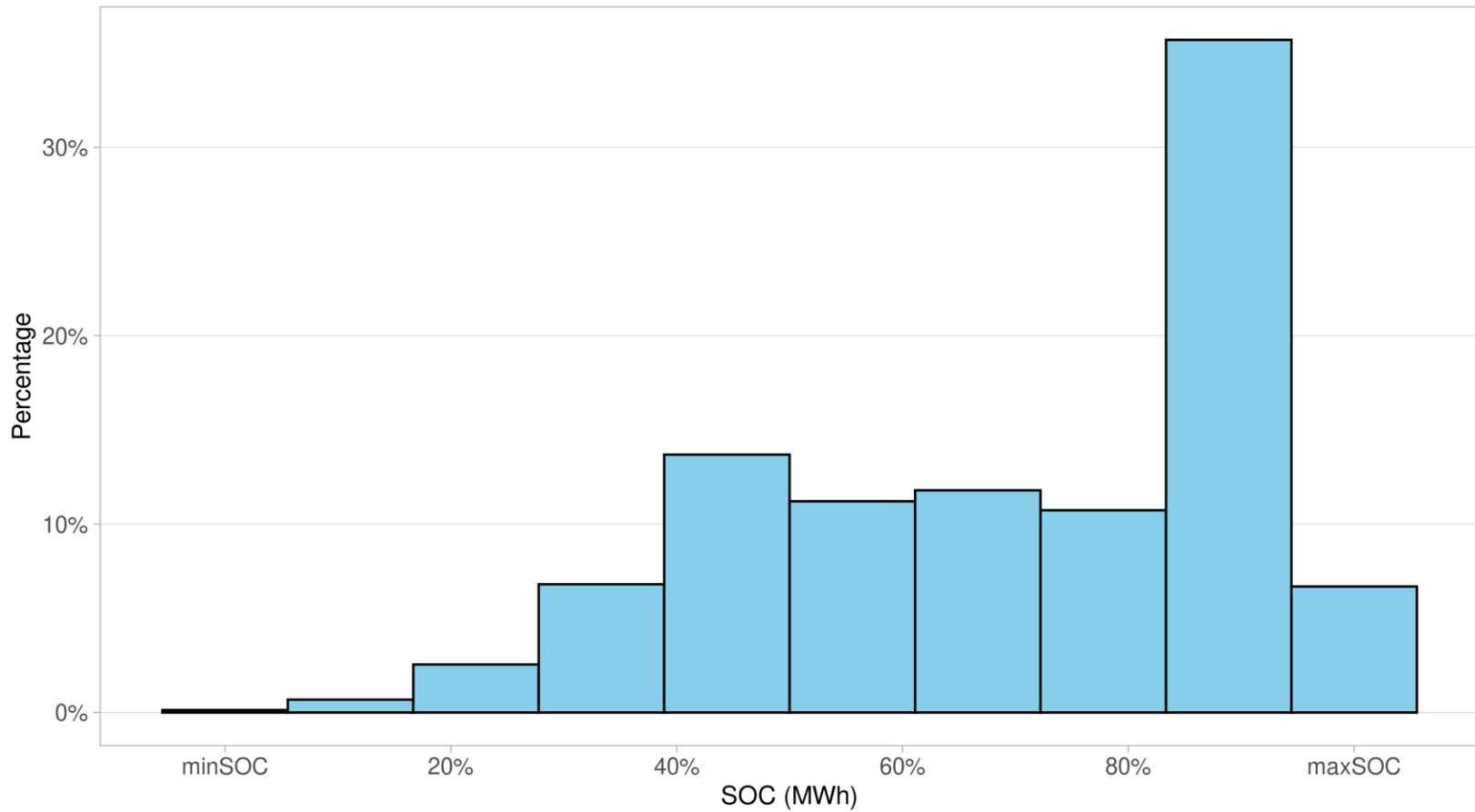
Resource 3



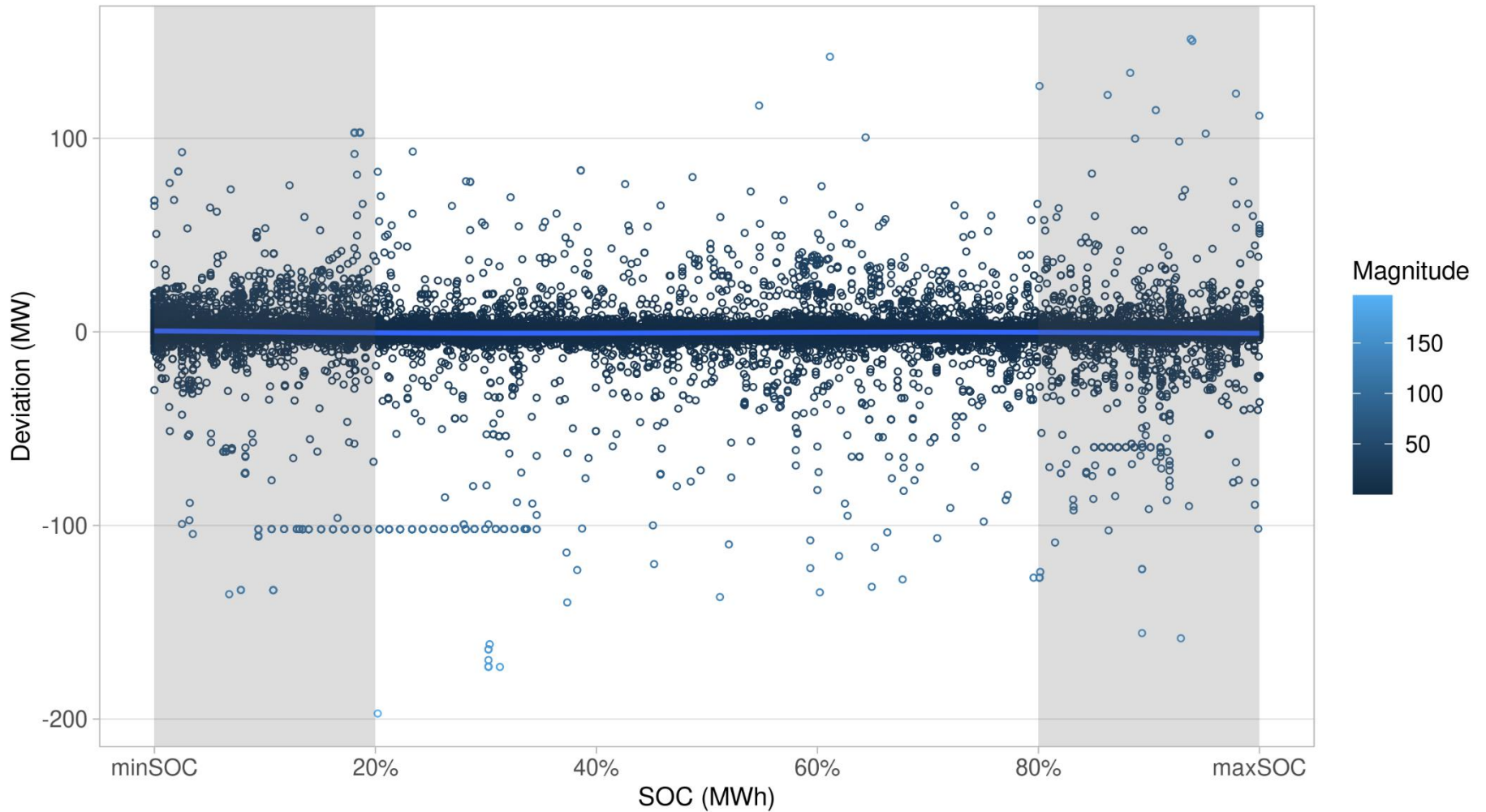
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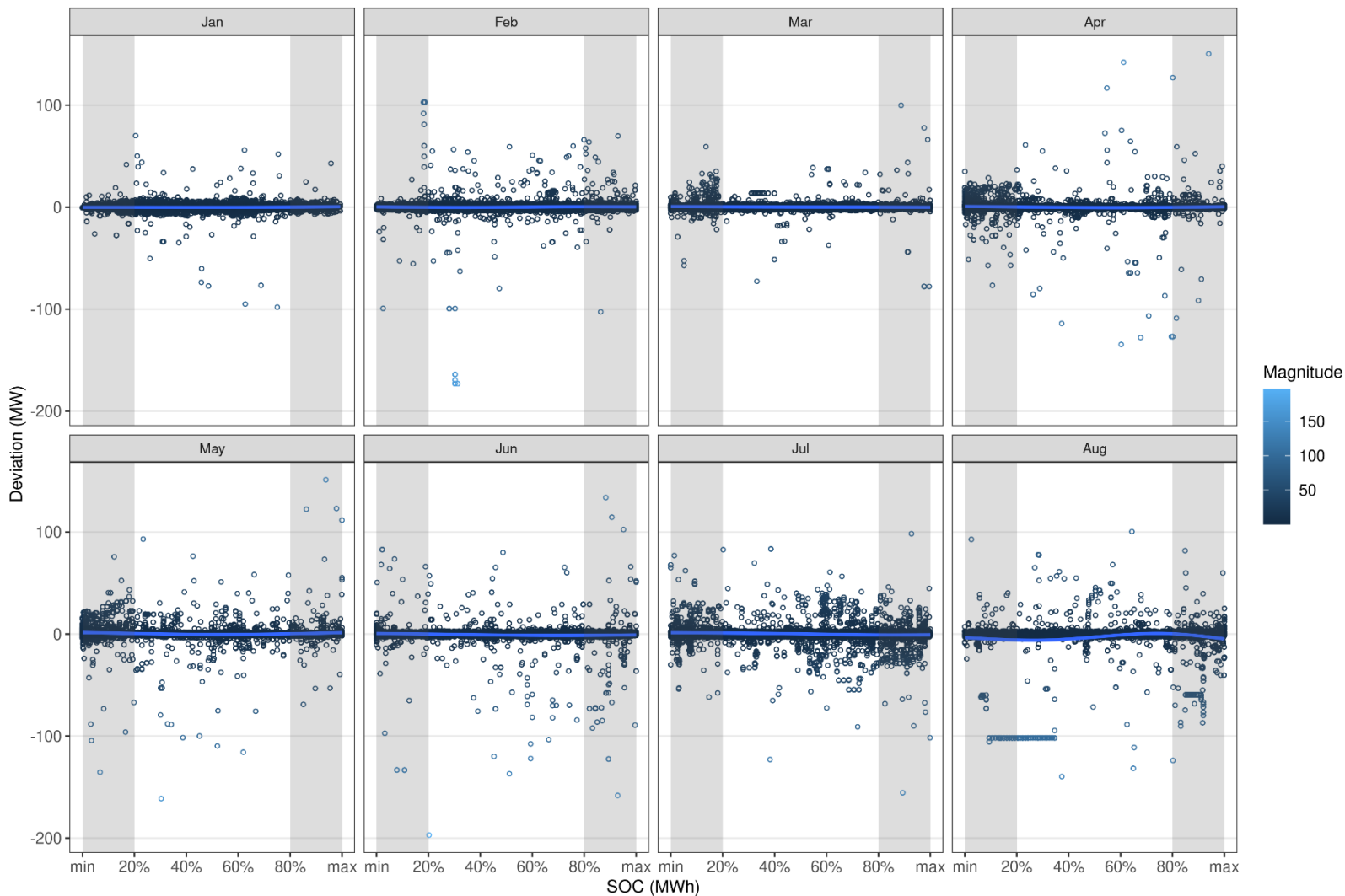
Resource 3



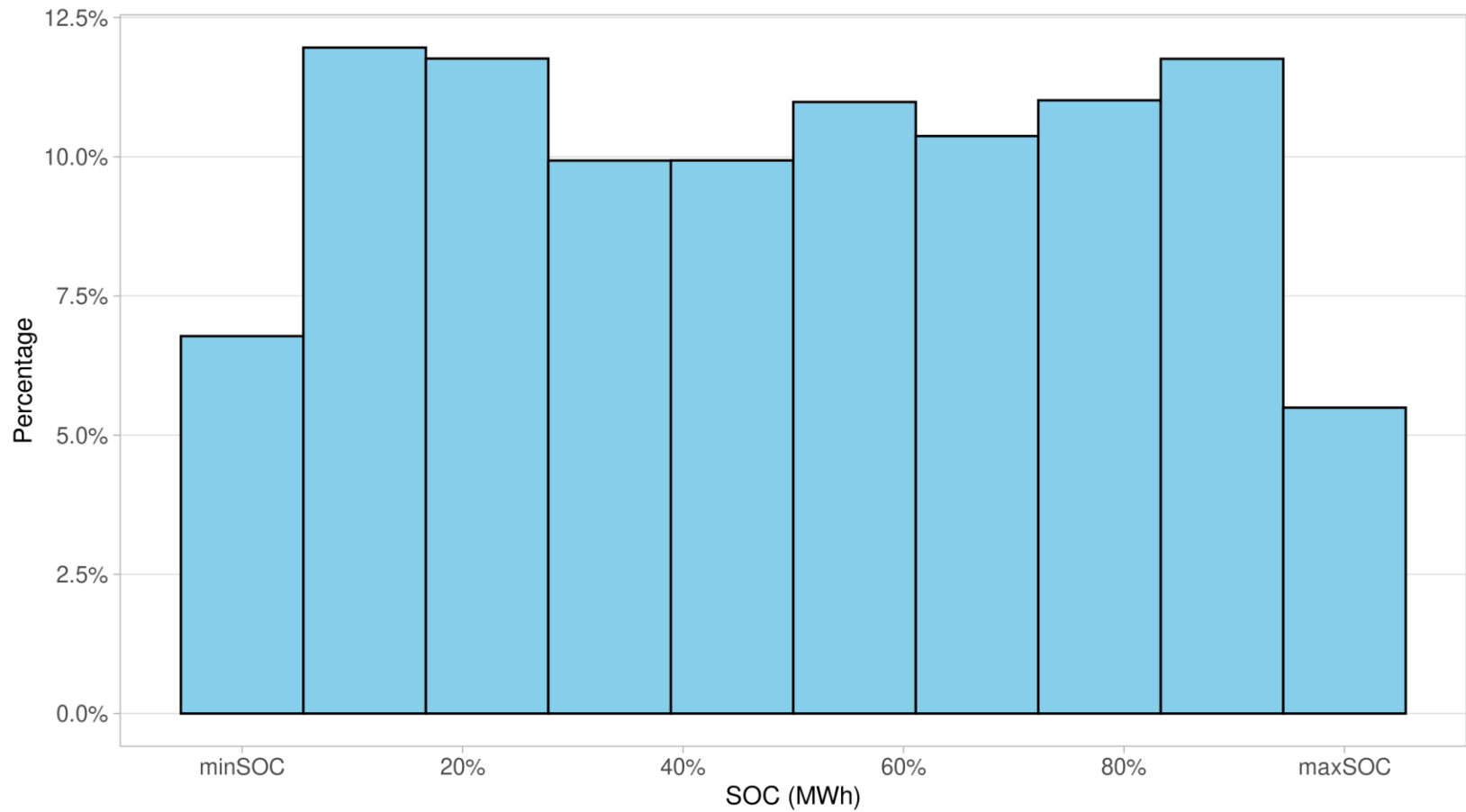
Resource 4



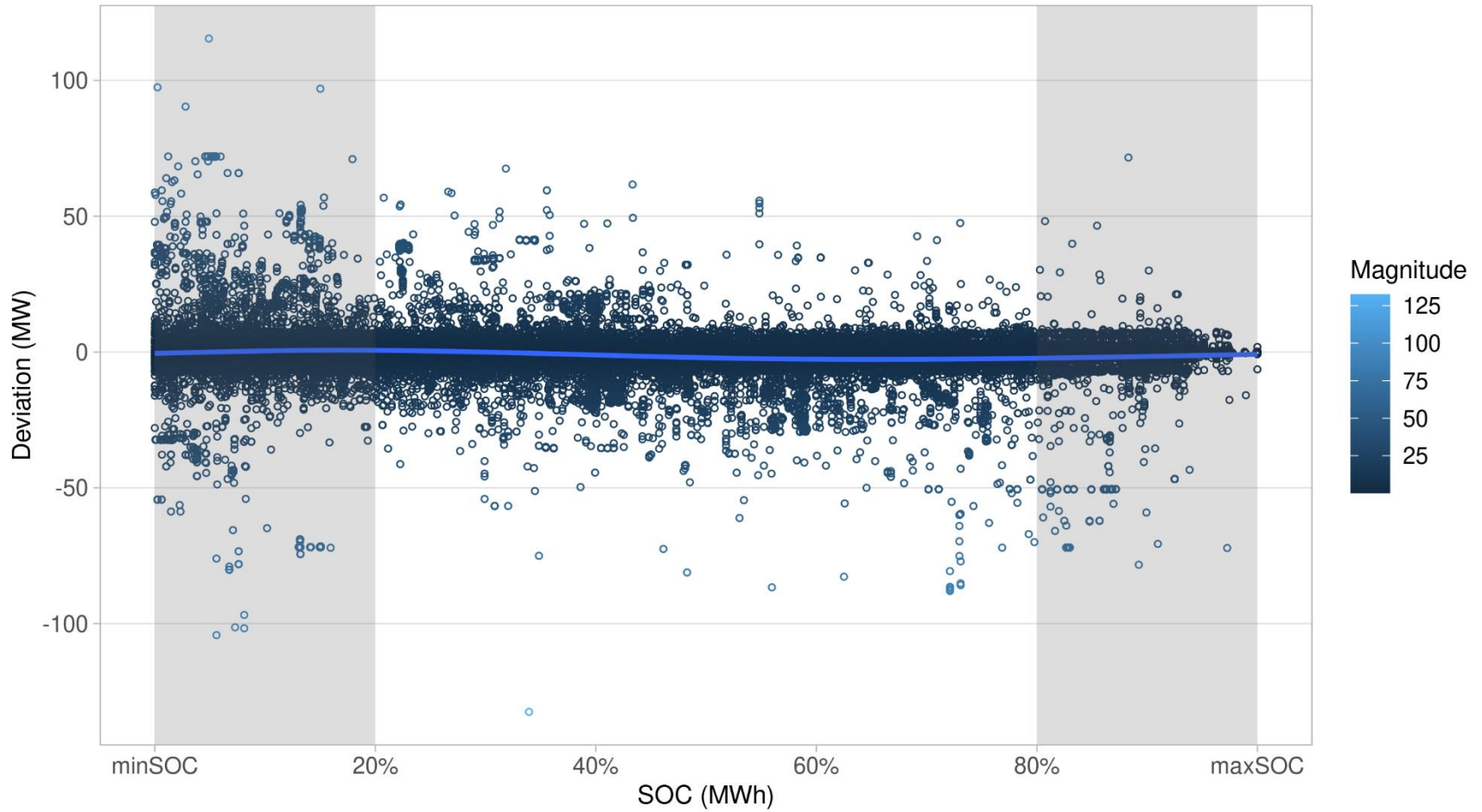
Resource 4



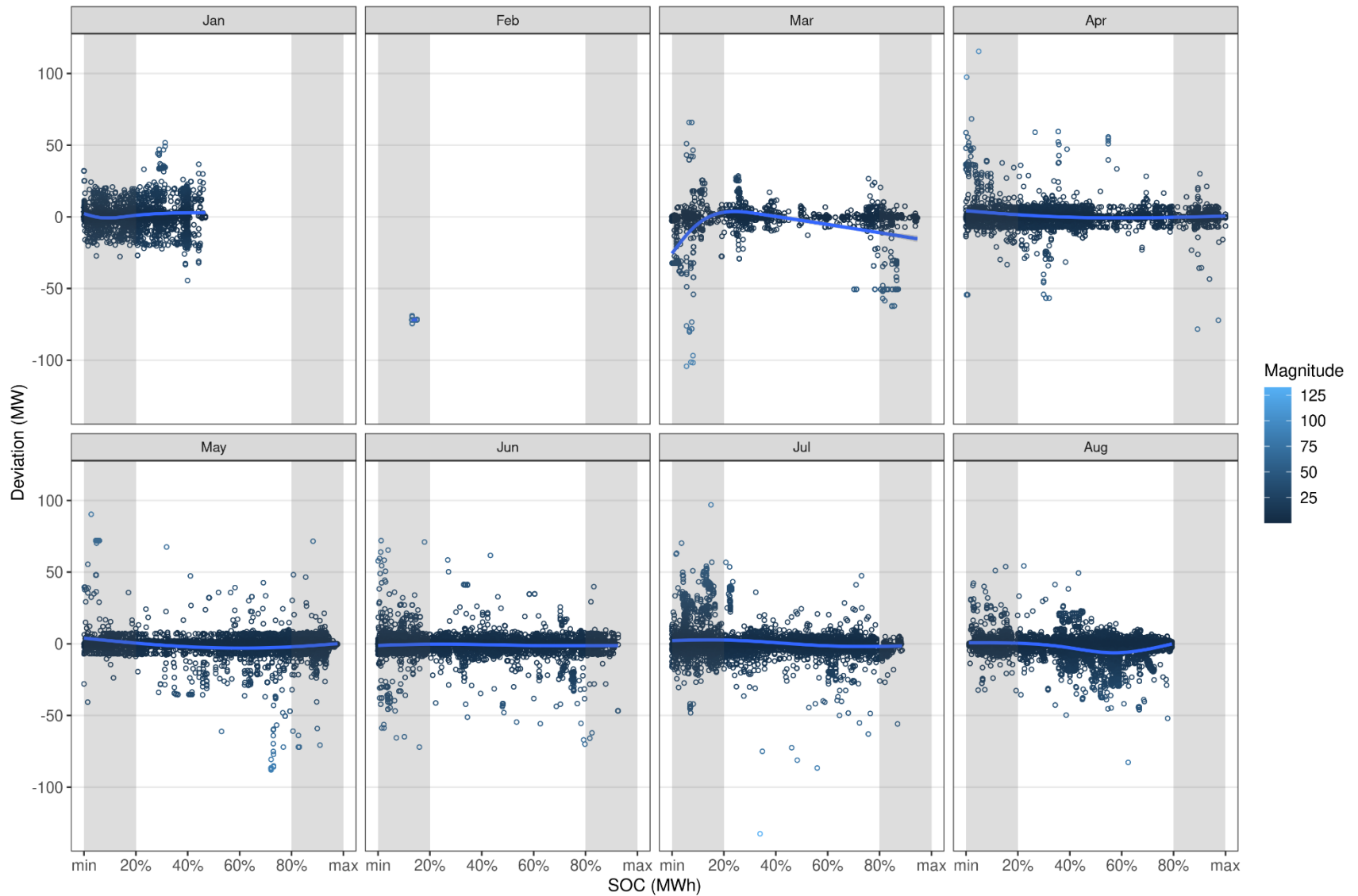
Resource 4



Resource 5



Resource 5



Resource 5

