



# Flexible Ramp Product discussion

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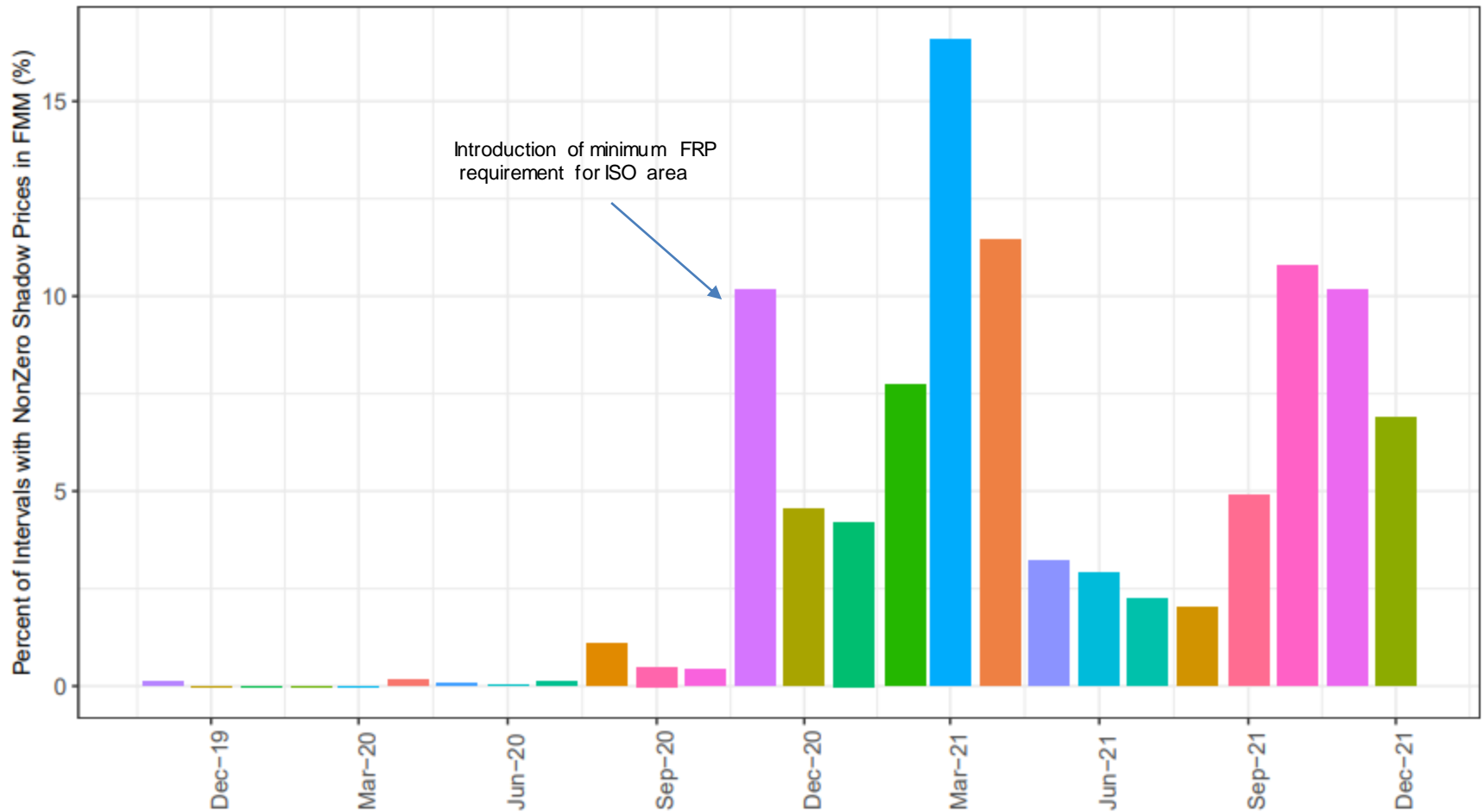
Market Analysis and Forecasting

Market Surveillance Committee Meeting

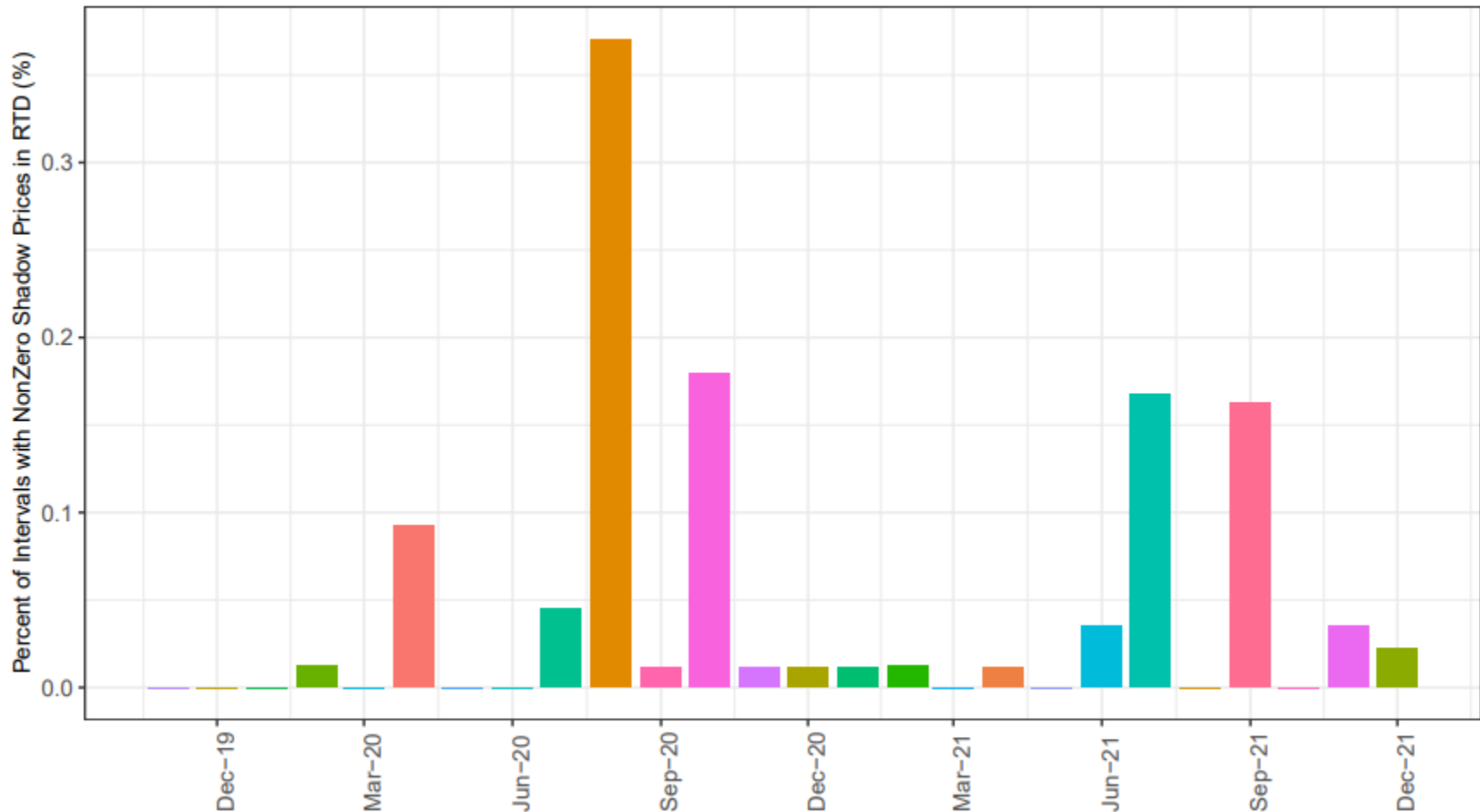
General Session

February 11, 2022

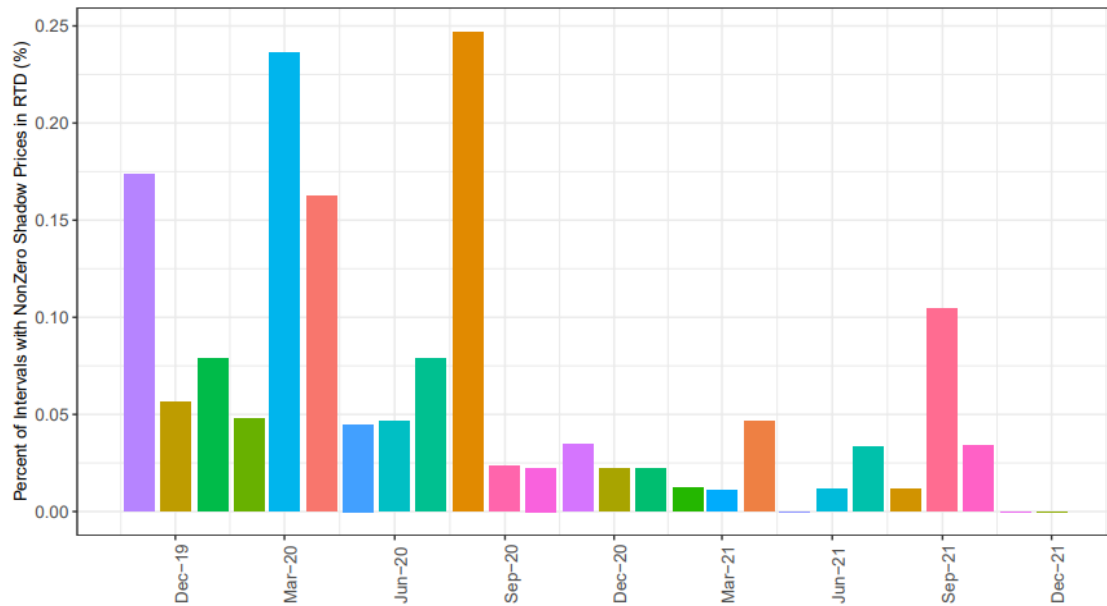
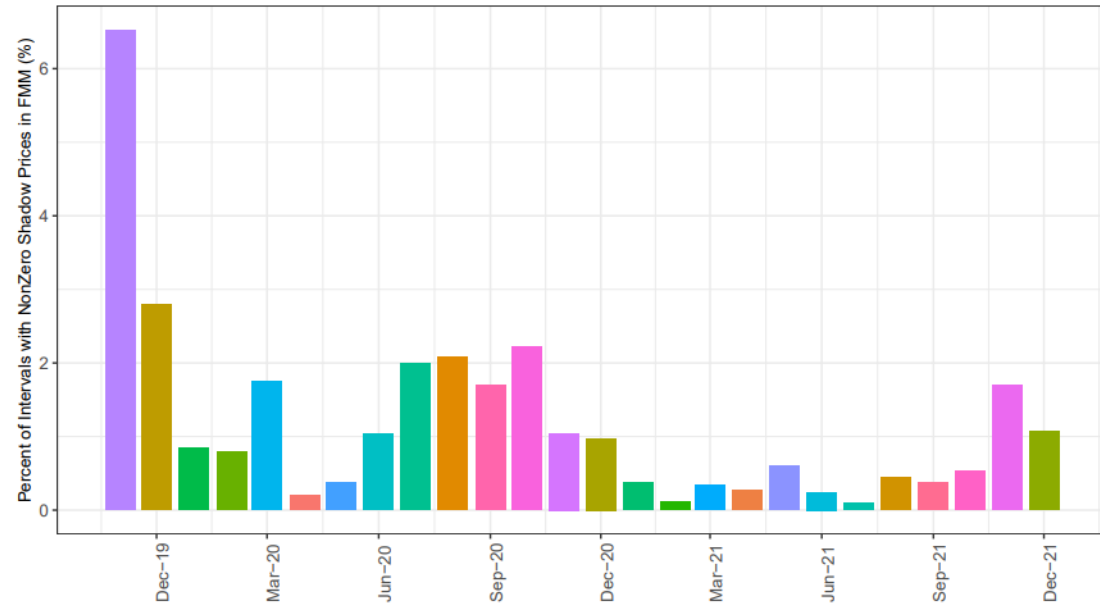
# The minimum FRP requirement for ISO area has driven up the frequency of nonzero prices for ISO area



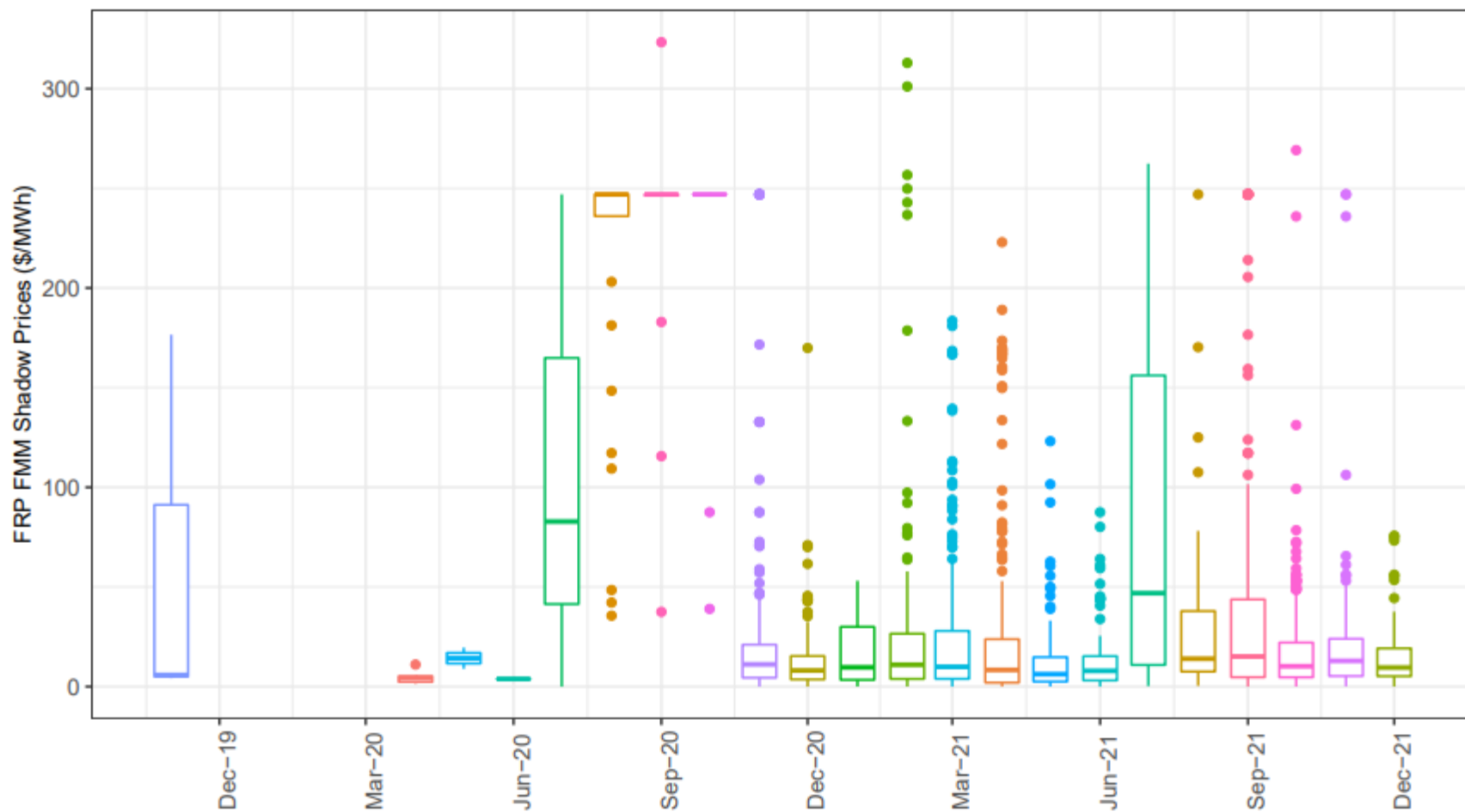
# Less than 1 percent of the time, FRP real time dispatch prices have been nonzero in ISO area



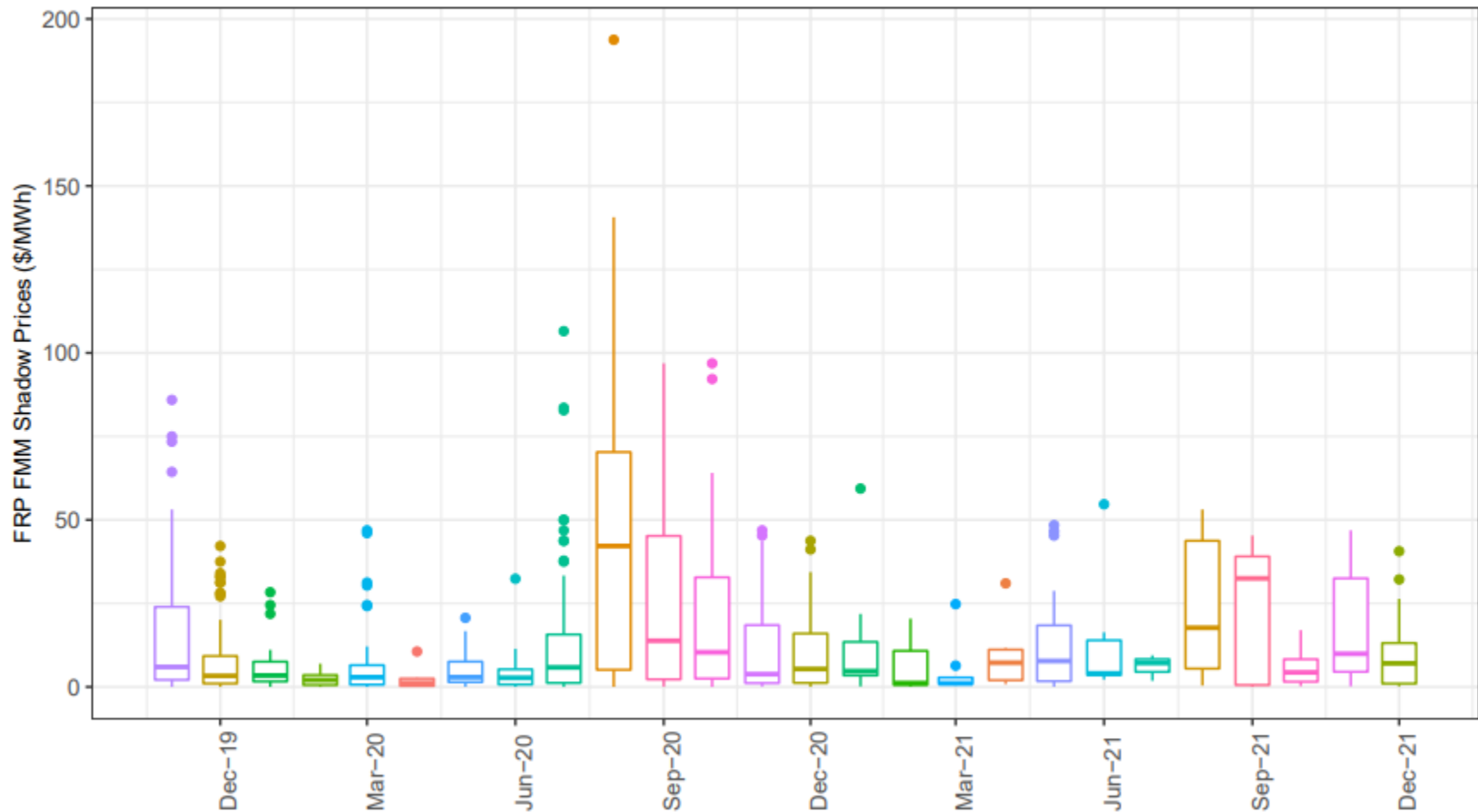
Likewise, prices in EIM system-wide area have been largely zero



# FRP prices for ISO area have been in the low range



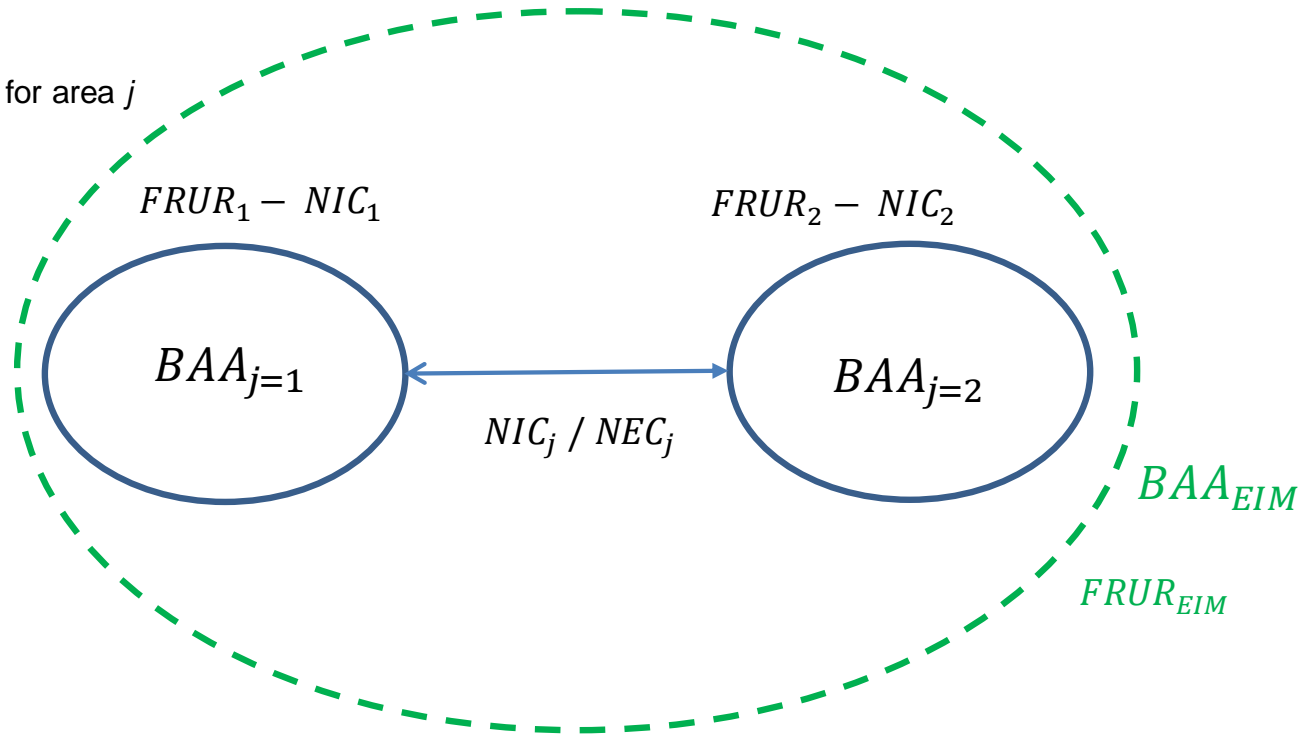
# EIM system-wide area prices for FRP have also been largely in the low range



# Uncertainty requirement vs effective FRP requirement

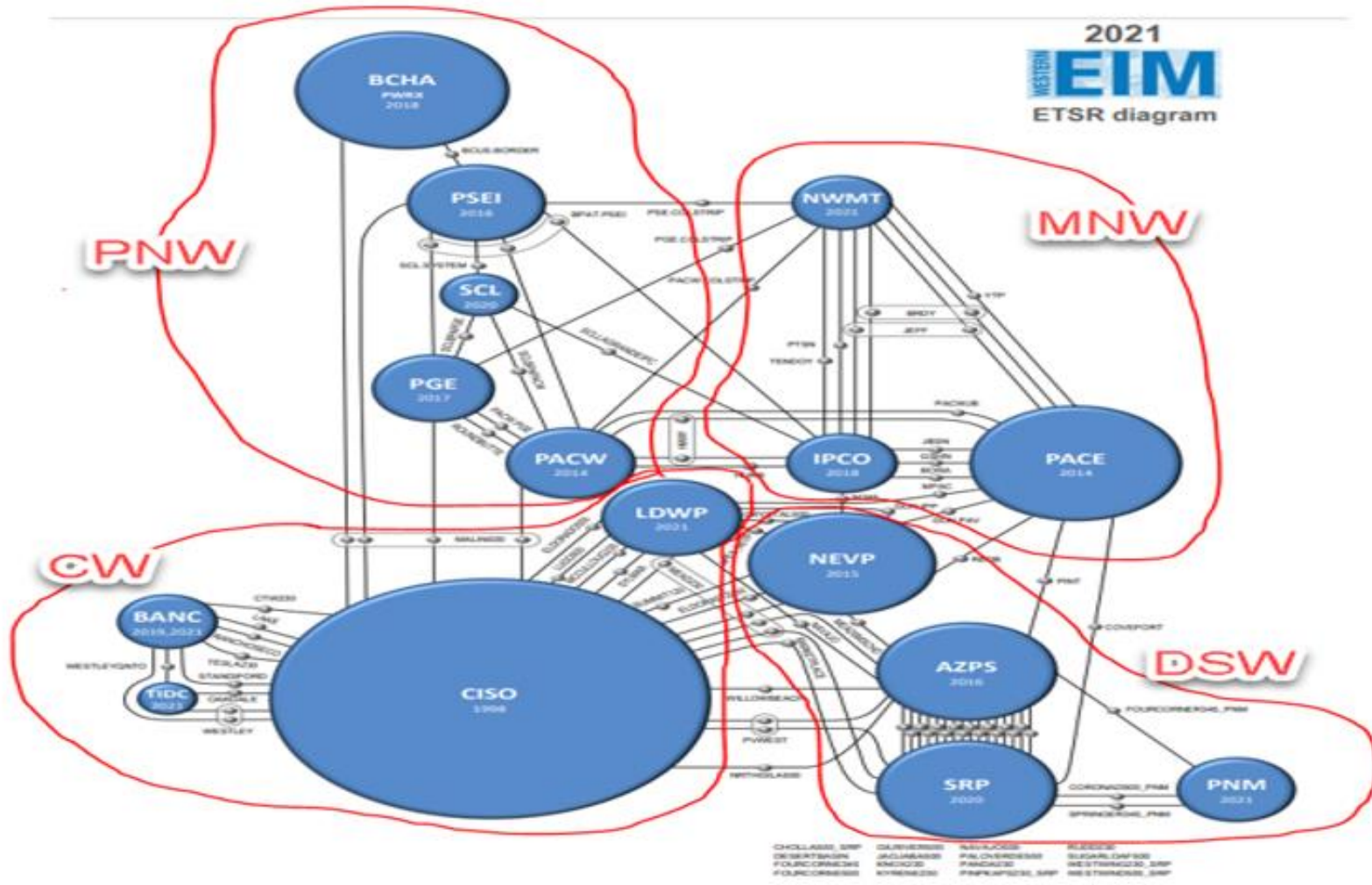
## NIC/NEC is a key piece in the price formation puzzle

$FRUR_j$  : Uncertainty requirement for area  $j$



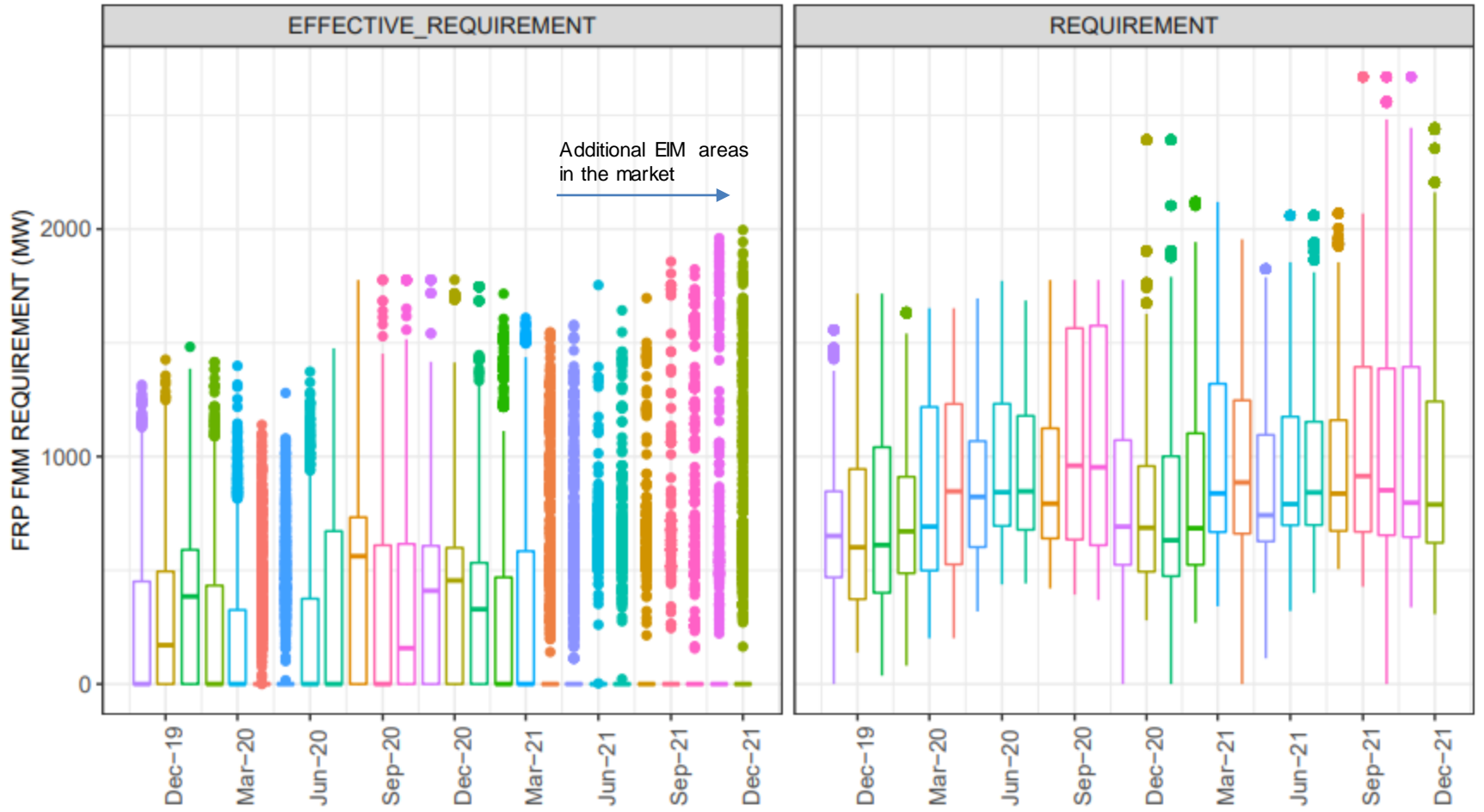
NIC/NEC will effectively reduce the requirement an individual area has to meet.  
Areas with large transfer capabilities ( $FRUR_j < NIC_j$ ) will not have FRP requirements driving local procurement

# Existing transfer capabilities create regional areas

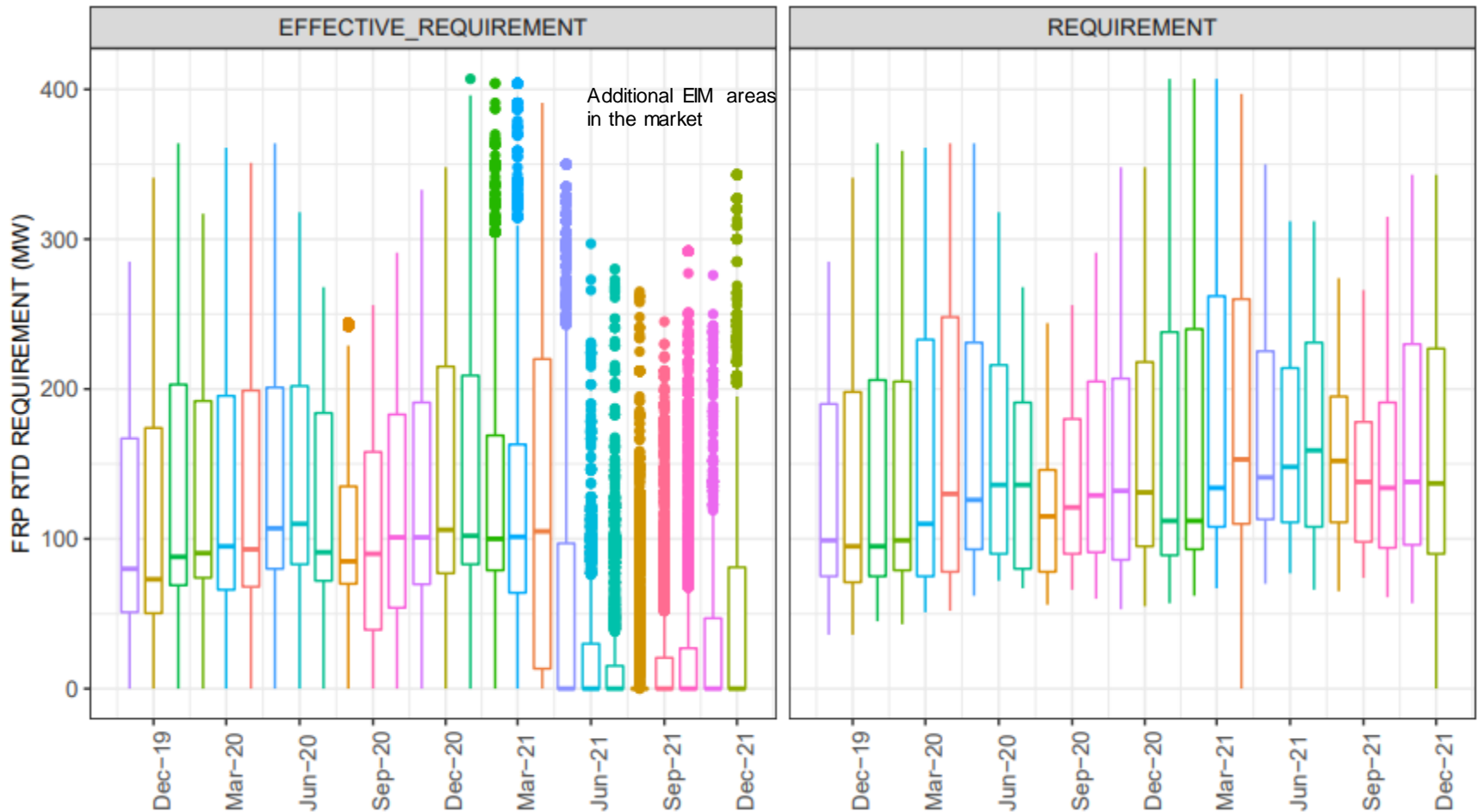




# Effective requirement for ISO area driving the procurement is largely reduced with the consideration of import capability



# Effective requirement for ISO area driving the procurement is largely reduced with the consideration of import capability



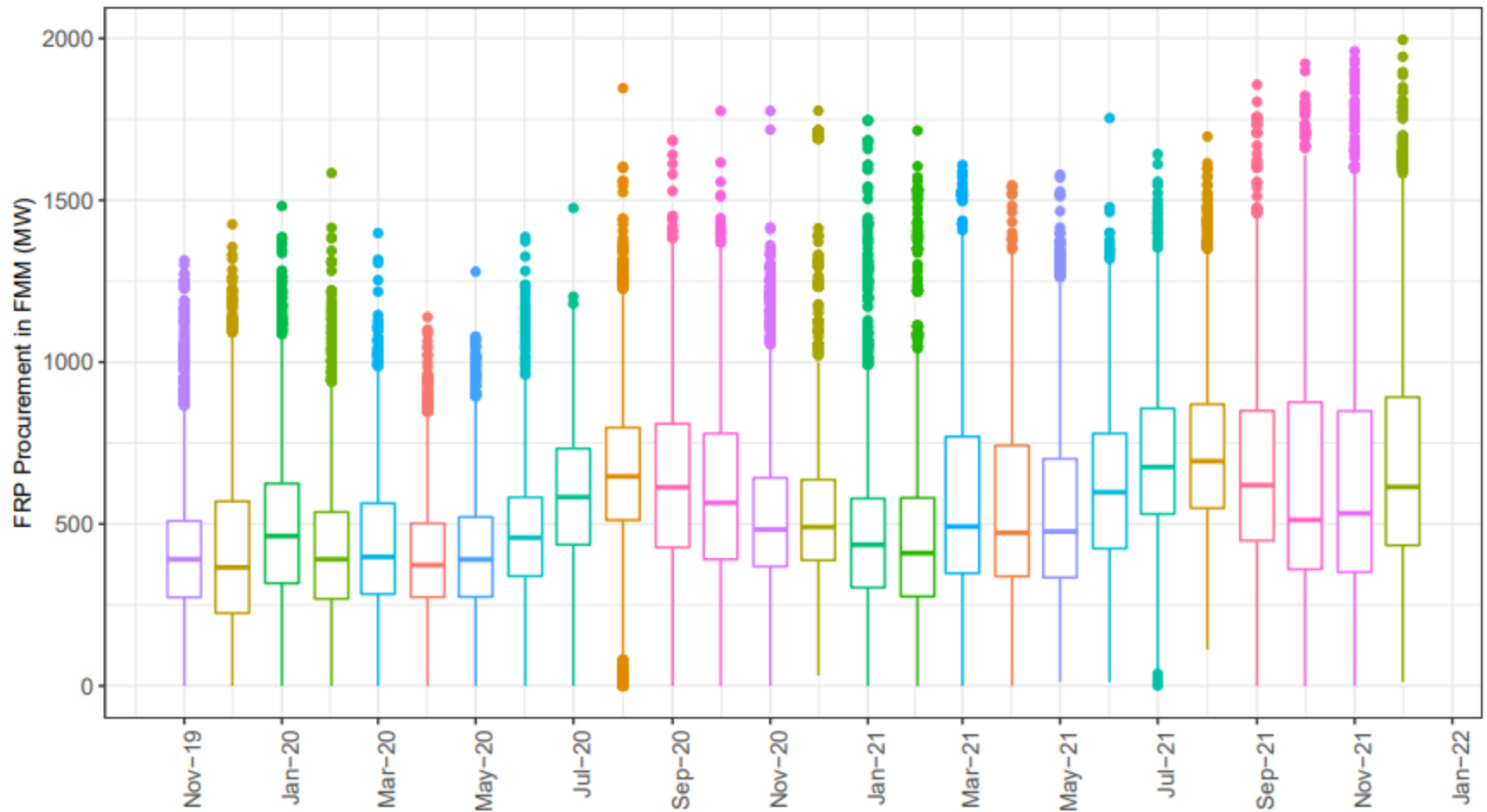
# The frequency of an effective FRP requirement greater than 0 MW varies by EIM area based on their import capability

Month	AZPS	BANC	CISO	IPCO	LADWP	NEVP	NWMT	PACE	PACW	PGE	PNM	PSEI	PWRX	SCL	SRP	TIDC
Feb-20	46.7	60.1	47.1	80.9		2.5		27.5	65.1	62.7		57.9	40.2			
Mar-20	38.1	61.3	29.7	86.2		0.9		22.6	69.9	74.3		58.8	19.8			
Apr-20	41.8	95.2	21.5	89.1		5.9		42.8	88.4	39.8		73.7	20.5	31.3	56.6	
May-20	11	95.2	24.4	86.6		8.3		49.5	90	34.9		88.7	15	35.1	9	
Jun-20	11.7	97	29.4	69.5		6.8		40.9	98.8	15.6		97.6	14.5	22.9	5	
Jul-20	19.6	98.9	49.5	73.6		5.8		29.3	99.2	14.9		96.6	3.8	23.8	10.2	
Aug-20	8.5	95.7	66.3	72.3		11.6		12.7	95.8	13.4		96	7.7	30.2	3.8	
Sep-20	5.9	98.9	44.7	91.2		4.8		11.8	91.6	30.3		95.2	24.2	27.7	4.5	
Oct-20	9.5	92.3	50.3	92.2		3.4		8.1	92.8	41		92	37.1	33.3	4	
Nov-20	2.8	86.6	93.4	83.3		3.8		16.7	86.4	62.2		91.8	36.3	38.8	3.7	
Dec-20	3.8	92.5	98.6	95.9		4.5		20	91.6	79.3		96.6	17.9	39.2	3.6	
Jan-21	3.3	92	93.6	95.3		2.9		25.3	90.8	85.4		92.5	34.3	41.9	2.1	
Feb-21	10.1	79.4	96.9	81.5		3.5		33.4	89.9	87.4		86.7	31.8	40.6	18.5	
Mar-21	2.9	82	99.5	92.5		4		34.6	88.9	81.4		93.5	25.5	27.1	3.7	33.7
Apr-21	1.8	22.1	96.1	98.9	3.7	2.6		25.8	93.2	61.6	36.4	95.6	14.2	11.5	3.4	83.2
May-21	3	3.9	89.2	98.4	1.3	2.2		18.2	87.1	67.7	71.8	90.9	29.8	8.5	1.4	90
Jun-21	3.3	4.3	92.7	98.1	1.5	2.6	5	10.3	91.3	36.6	51	73.2	25.1	14	13.8	84.9
Jul-21	7	10.7	88.2	98.6	2.1	3	8.3	13.3	71.8	24.5	23.2	46	19.3	5.7	17.3	89.6
Aug-21	4.6	7.6	81.7	99.5	1.8	2.2	12.9	6.4	84.6	30.5	23	43.2	26.3	5.3	30.2	91.3
Sep-21	4.2	9	89.2	99	1.7	1.1	49.2	5.3	44.3	22.4	31.3	30.9	20.1	1.9	7	89.8
Oct-21	1.2	13.1	90.5	96.5	3	1.4	86.7	23.5	76.7	31.1	53.4	34.4	33.5	6.6	4.3	81.1
Nov-21	1.5	12.6	92.2	96.1	1.5	1.1	13.1	12	85.8	51	54.1	56.9	56.3	8.7	7.6	74
Dec-21	2.5	7.2	93.5	98.9	3.8	2.3	8.3	15.6	94.5	37.7	37.3	52.5	17.5	7.1	11.1	81.9
Jan-22	2.8	10.2	89.3	97.3	3.1	3	3.2	20.6	90.9	33.3	51.1	54	20.2	5.4	4.7	78.2

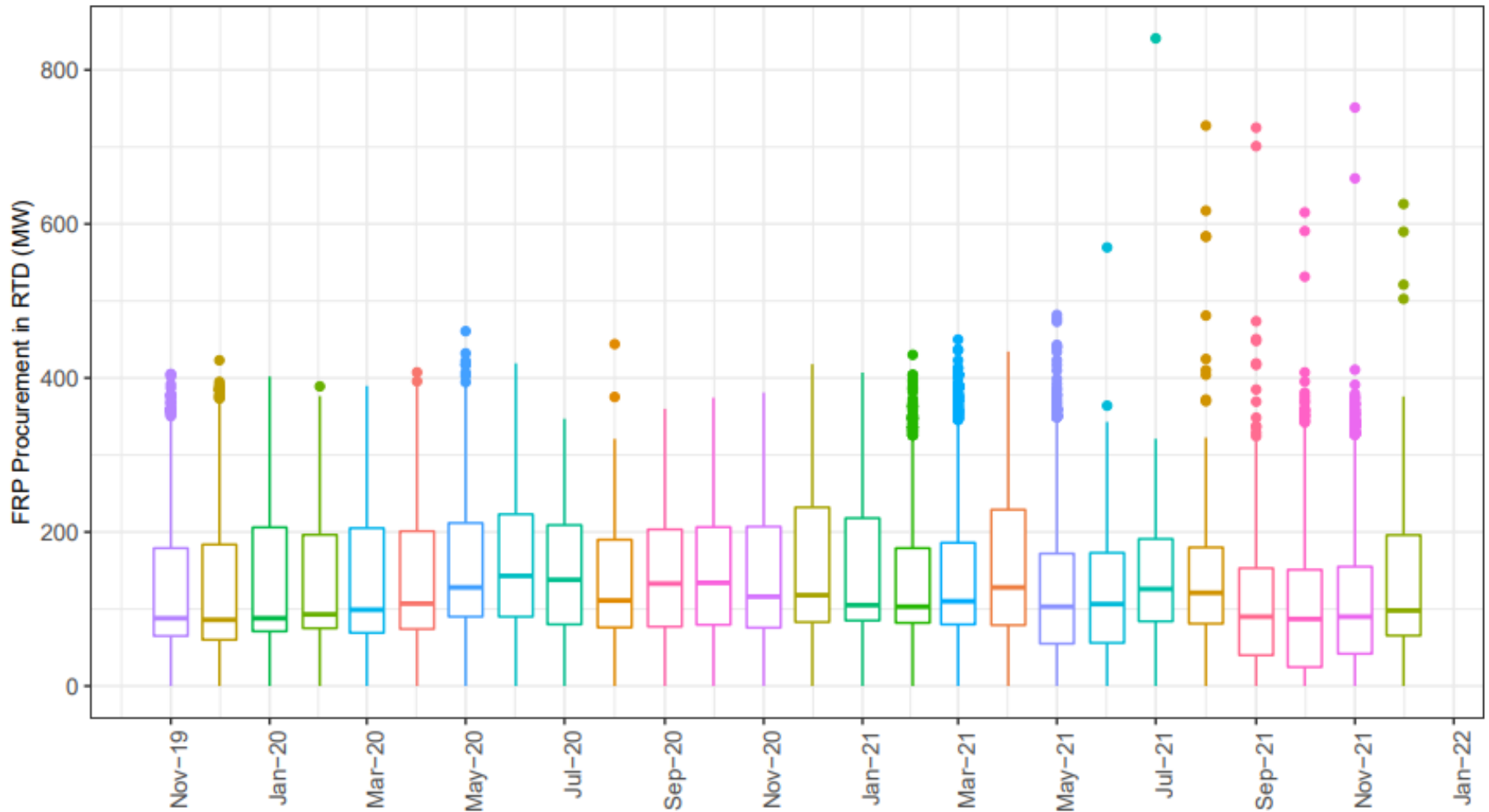
# The frequency of FRP FMM prices greater than \$0 have been consistently low

Month	AZPS	BANC	CISO	EIM	IPCO	LADWP	NEVP	NWMT	PACE	PACW	PGE	PNM	PSEI	PWRX	SCL	SRP	TIDC
Feb-20	1	0	0	0.8	0		0.5		0	0.1	0.1		0.6	0.5			
Mar-20	1.4	0	0	1.8	0		0.2		0.1	0.2	0.2		0	1.4			
Apr-20	0.1	0	0.2	0.2	0		0.8		0	0	0		0.1	0.2	0	4.9	
May-20	0.8	0	0.1	0.4	0.1		2.4		0.1	0	0.2		0	0.7	0	0.1	
Jun-20	0.2	0	0	1	0.3		2.4		0.1	0.1	0.6		0.4	1.1	0	0.5	
Jul-20	0	0	0.1	2	0.1		4.4		0.2	0.1	4.2		0.6	1.8	0.1	0.7	
Aug-20	0.1	0.4	1.1	2	0.2		7.3		0.4	0.2	1.5		0.7	2	0	1.6	
Sep-20	0.2	0.2	0.5	1.7	0		2.5		0.2	0.3	1.4		0.2	0.6	0.1	1	
Oct-20	1.2	0.2	0.4	2.2	0		1.6		0.5	0.2	0.7		0.3	0.9	0.1	1.8	
Nov-20	0.5	0	10.2	1	0.1		0.8		0	0.1	1.5		0.1	0.5	0.2	0.7	
Dec-20	0.3	0.1	4.5	1	0		0		0	0.1	0.2		0	0.4	0.2	0.3	
Jan-21	0.3	0	4.2	0.4	0		0.1		0.1	0.1	0.3		0	0.3	0	0.2	
Feb-21	0.6	0	7.7	0.1	0.1		0.3		0.1	0.1	0.4		0.1	0.1	0.1	8.9	
Mar-21	0.3	0.1	16.6	0.3	0.1		0.7		0.2	0.2	0.3		0.4	0.3	0.1	0.5	0.7
Apr-21	0	0	11.4	0.3	0	0.1	0.3		0.1	0.1	0.4	6.8	0.1	0.1	0	0.5	0.3
May-21	0.7	0	3.3	0.6	0	0.1	0.9		0.1	0.3	0.3	0.1	0.5	0.5	0	0.2	0.2
Jun-21	0	0	2.9	0.2	0	0.1	1.3	0.8	0.4	0	1.5	0.4	0.9	0.3	0	1	0
Jul-21	0.1	0.1	2.3	0.1	0.3	0.1	0.8	3	0.3	0.1	1.1	0.5	0.2	0.2	0.1	2.9	0.1
Aug-21	0.2	0	2	0.4	0.6	0	0.6	1.2	0.1	0.1	1.5	0.1	0.2	0.5	0	2.8	0.2
Sep-21	0.3	0	4.9	0.4	0.1	0	0.4	23.8	0.3	0.1	0.8	0.2	0	0.4	0.2	1.8	0.1
Oct-21	0	0	10.8	0.5	0	0.3	0.5	44.3	0.1	0	0.8	0.3	0.2	0.9	0.1	0.3	0.3
Nov-21	0.5	0	10.2	1.7	0	0.1	0	1.4	0.1	0.6	0.2	0.3	0.2	1.7	0.1	1.7	0
Dec-21	0	0	6.9	1.1	0	0.3	0.1	1.9	0.6	0.1	0.4	0.3	0.2	1.4	0.1	0.2	0
Jan-22	0	0	9.3	1.2	0.2	0	0	0.5	1.8	0.3	0.3	0.2	0	1.4	0	0.2	0.1

# The magnitude of FRP procurement for ISO areas has seen a moderate increase



# RTD procurement for ISO area remains low



# Original FRP Implementation – November 1, 2016

flexible ramping up (assume all BAA pass flex test)

## Individual EIM area requirement constraint

$$\sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t) + FRUS_j(t) \geq FRUR_j(t) - NIC_j(t)$$

↑
↑
↑
↑

Flex up variable
surplus variable
Uncertainty requirement
Net Import Capability

## EIM System-wide area requirement constraint

$$\sum_{i \in S_{FRC}} FRU_i(t) + \sum_{j \in EIM} FRUS_j(t) + FRUS_{EIM}(t) \geq FRUR_{EIM}(t)$$

↑
↑

Any relaxation of an individual EIM area is counted towards meeting the system-wide requirement
The system-wide area req can also be relaxed

## Original formulation posed some inefficiencies

- The surplus variables were unbounded, so it could result in clearing beyond what is deliverable
  - We implemented an upper bound to each area procurement  $FRUR_j(t) + NEC_j(t)$
- The surplus variables did not have upper bound
  - We introduced an upper bound
  - This had unintended impacts on price formation
  - Discussed it with the MSC in a 2018 session
- Brand-new formulation implemented in April 2018



# Current formulation for FRP procurement

## FRP Procurement

$$FRUR_j(t) - NIC_j(t) \leq \sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t) + \gamma_j(t) FRUS_j(t) \leq FRUR_j(t) + NEC_j(t)$$

- It's upper and lower bounded by uncertainty requirements
- Requirements are adjusted to account for NIC/NEC
- Requirement can be met with actual ramp and surplus variables
- Surplus variables for each EIM area may or may not contribute and are modelled with binary variables  $\gamma_j(t) = \{0,1\}$

The surplus variables are defined by how local requirement is met

- When an area is able to meet its requirement with its local capacity, the surplus variable is not active

$$FRUR_j(t) - NIC_j(t) - \sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t) \leq 0 \rightarrow \gamma_j(t) = 0$$

- When an area is NOT able to meet its requirement with its local capacity, the surplus variable is active

$$\text{If } FRUR_j(t) - NIC_j(t) - \sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t) > 0 \rightarrow \gamma_j(t) = 1$$

The surplus variable is also limited to not take higher values than needed to meet the local requirement

$$FRUS_j(t) \leq FRUR_j(t) - NIC_j(t) - \sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t)$$

- The local surplus variables may or may not be active to contribute to the system-wide requirement

$$\sum_{i \in S_{FRC}} FRU_i(t) + \sum_{j \in EIM} \gamma_j(t) FRUS_j(t) + FRUS_{EIM}(t) \geq FRUR_{EIM}(t)$$

In November 2020, we introduced a minimum requirement for ISO area in FMM

$$\sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t) + FRUS_j(t) \geq DF * FRUR_j(t)$$

Minimum requirement factor

# What are the pricing implications of this formulation?

- Areas with NIC/NEC larger than the uncertainty requirement will effectively have no requirements to meet, and will have no surplus variables contributions
- Any area can procure more than its local requirement to meet the system wide area requirement
- An area that meets its local requirement will not have a variable surplus which will not contribute to price in the system-wide area
- Any surplus variable used to meet local requirements will contribute to meet the system-wide area requirement
- The flex price for a resource in a local area will be the nested price of the local area plus the system-wide area price
- For an area that relies on its surplus variable to meet its local requirement, the surplus variable can be relaxed only up to meeting local need; it cannot be further used to meet EIM requirements

# July 9, 2021 resource sufficiency results

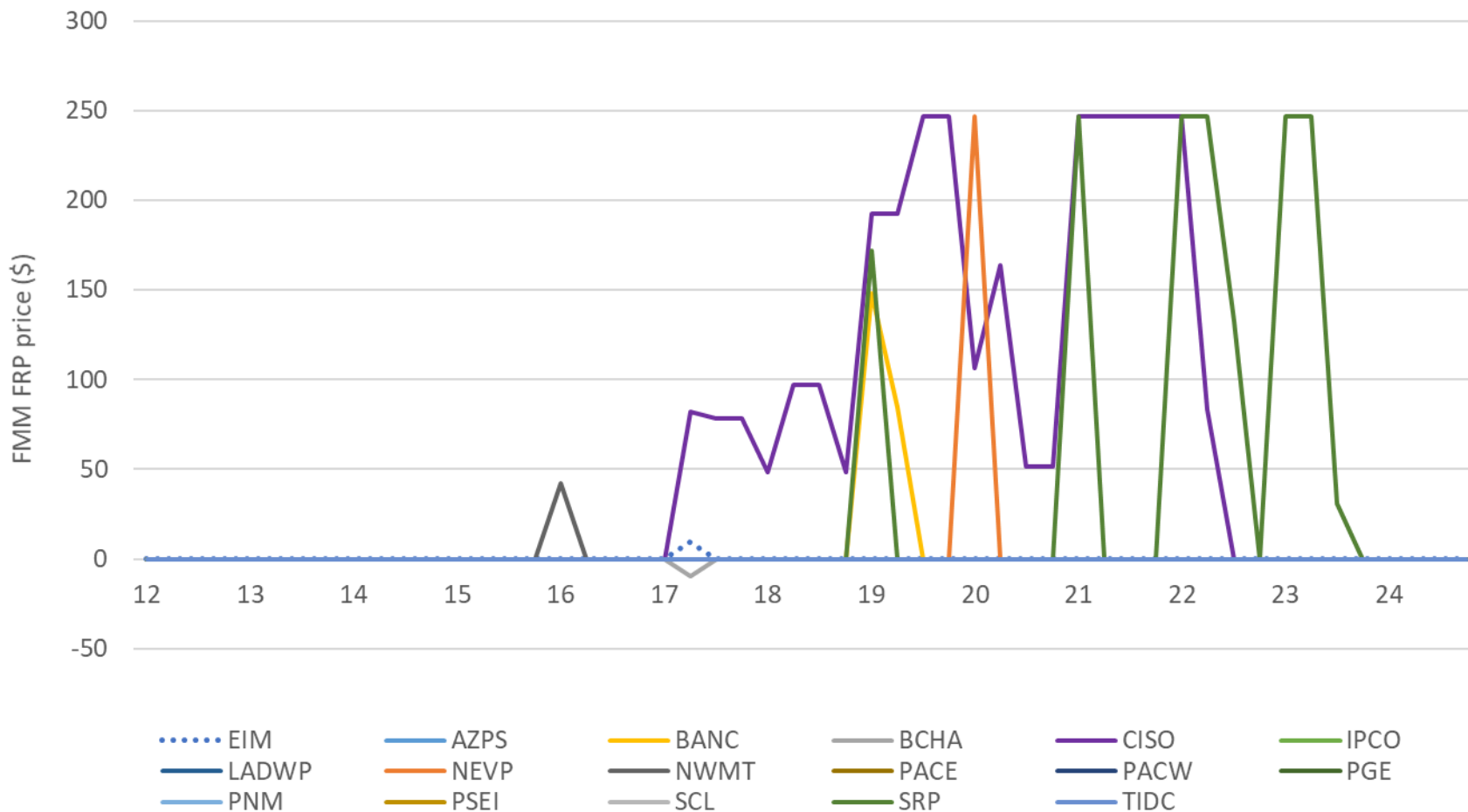
## Bid Range Capacity Failure

TradeDate	HE	Interval	BAA_NAME
7/9/2021	19	3	CISO
7/9/2021	19	4	CISO
7/9/2021	19	1	BANC
7/9/2021	19	2	BANC
7/9/2021	19	1	SRP
7/9/2021	20	1	BANC
7/9/2021	20	1	SRP
7/9/2021	20	2	SRP
7/9/2021	21	1	SRP
7/9/2021	22	1	NEVP
7/9/2021	22	1	SRP
7/9/2021	22	2	SRP
7/9/2021	23	1	SRP
7/9/2021	23	2	SRP
7/9/2021	23	3	SRP
7/9/2021	23	1	AZPS
7/9/2021	23	2	AZPS
7/9/2021	23	3	AZPS

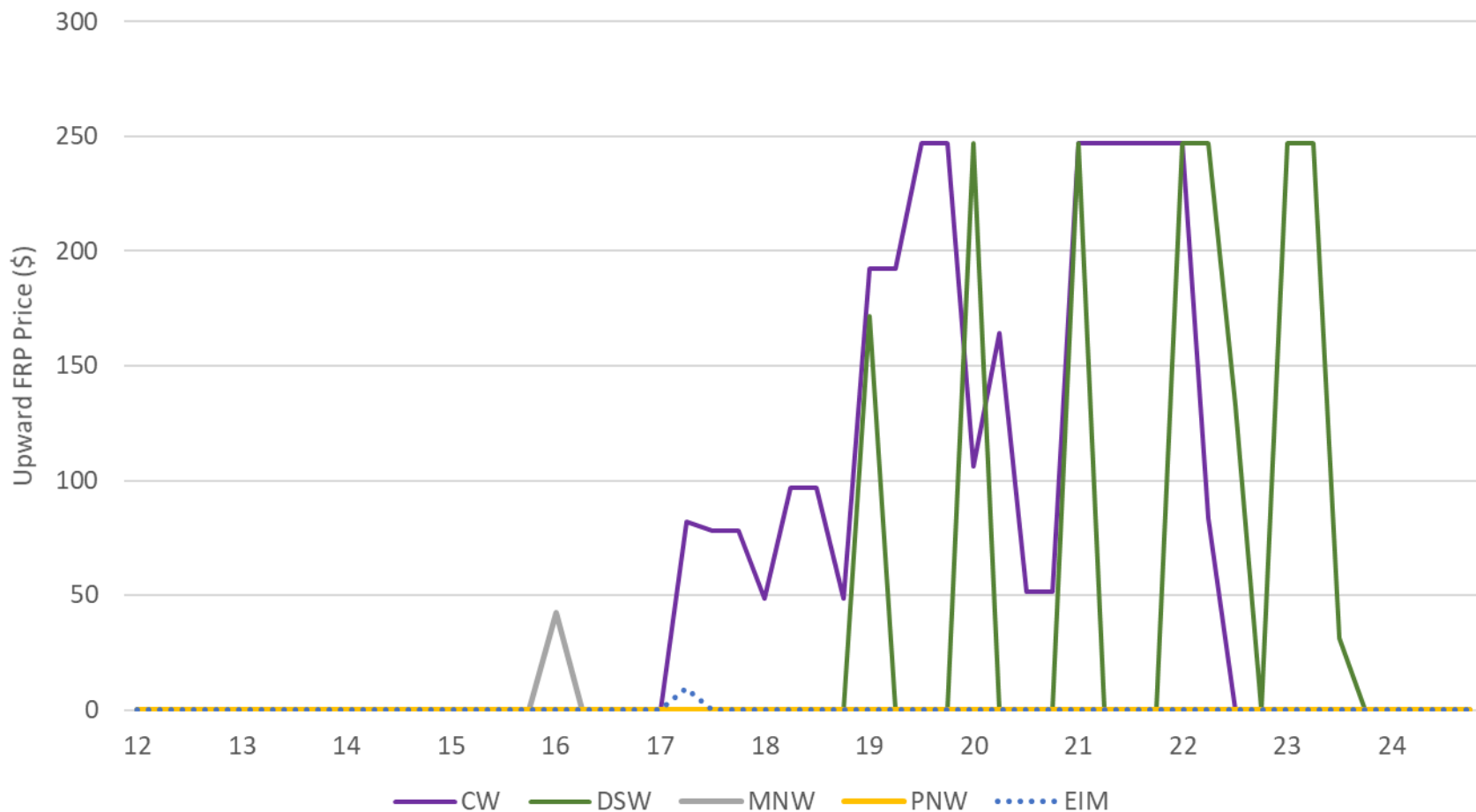
## Flex Ramp Sufficiency Failure

EDR_TRADE_DT_S	EDR_TRADE_HR_S	Interval	Baa_name
7/9/2021	16	1	NWMT
7/9/2021	16	2	NWMT
7/9/2021	19	4	CISO
7/9/2021	20	1	NEVP
7/9/2021	21	1	NWMT
7/9/2021	21	1	CISO
7/9/2021	21	2	CISO
7/9/2021	21	3	CISO
7/9/2021	21	4	CISO
7/9/2021	22	1	SRP
7/9/2021	22	1	CISO
7/9/2021	22	2	SRP
7/9/2021	22	3	SRP
7/9/2021	23	1	SRP
7/9/2021	23	2	SRP

# FMM BAA prices for July 9 shows only a few EIM areas with non-zero flex ramp prices

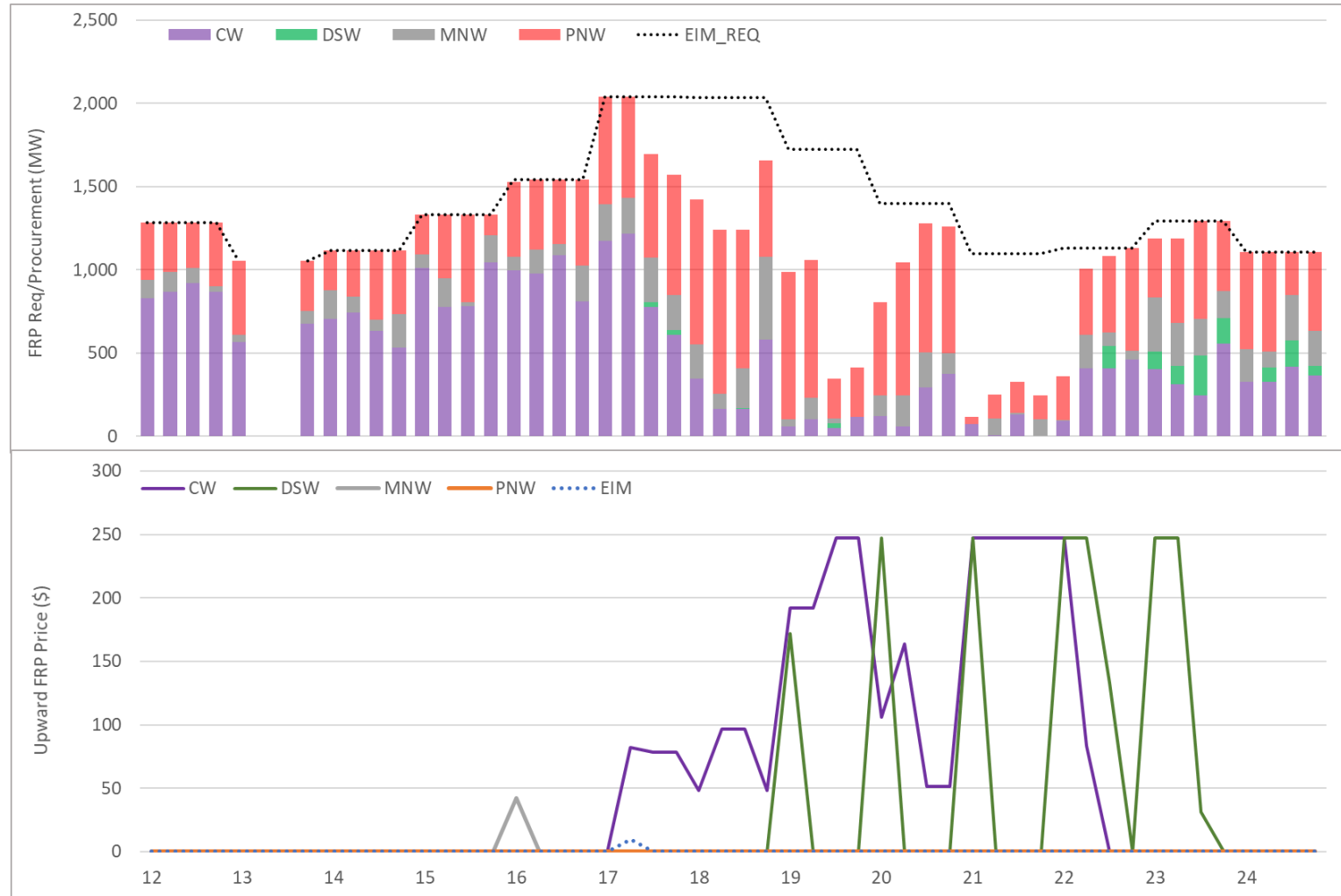


# Gathering prices by regions allows for a simpler trend across areas

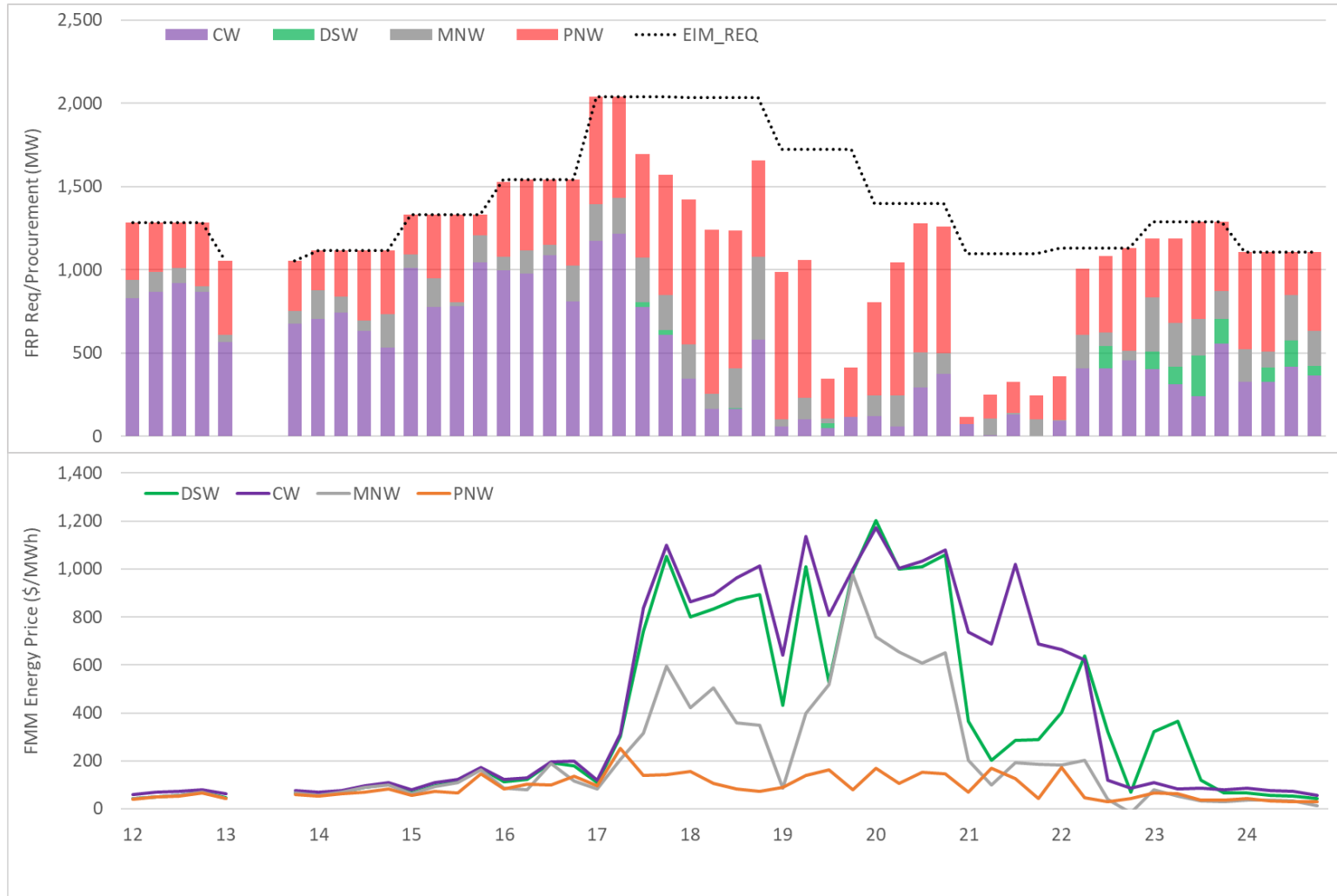




# Procurement and prices for flexible ramp shows California is being short of capacity with nonzero flex prices



# FMM energy prices reflected tight supply conditions for both California and DSW areas, tracking flex trends



Why FMM flex prices did not reflect tight supply conditions across the full EIM area?

# Flex ramp procurement was largely driven by EIM area requirements

BAA	Uncertainty Req (MW)	Effective Req (MW)	Min Req (MW)	Procurement (MW)	Relaxation (MW)	Flex Price (\$)	Energy Price (\$)
AZPS	169	0	0	0	0	0	762
BANC	51	51	0	196	0	0	1,000
CISO	1,810	925	925	581	344	78	855
IPCO	149	0	0	0	0	0	312
LADWP	191	0	0	0	0	0	751
NEVP	303	0	0	30	0	0	731
NWMT	78	0	0	19	0	0	192
PACE	377	0	0	250	0	0	442
PACW	117	0	0	102	0	0	335
PGE	158	0	0	148	0	0	85
PNM	183	0	0	0	0	0	714
PSEI	91	0	0	130	0	0	113
PWRX	161	0	0	161	0	0	53
SCL	19	0	0	78	0	0	116
SRP	124	0	0	0	0	0	761
TIDC	9	0	0	0	0	0	960
EIM	2,038	2,038	0	1,694	344	0	

# Price formation under current formulation

For all  $j$  in  $S_{FRC} = \{AZPS, BANC, IPCO, LADWP, NEVP, NWMT, PACE, PACW, PGE, PNM, PSEI, PWRX, SCL, SRP, TIDC\}$

$$\begin{aligned} \gamma_j(t) &= 0, \text{ thus } FRUS_j(t) \text{ not active,} \\ FRU_i(t) &\geq 0, \\ \sum_{i \in S_{FRC}} FRU_i(t) &= 1113 \end{aligned}$$

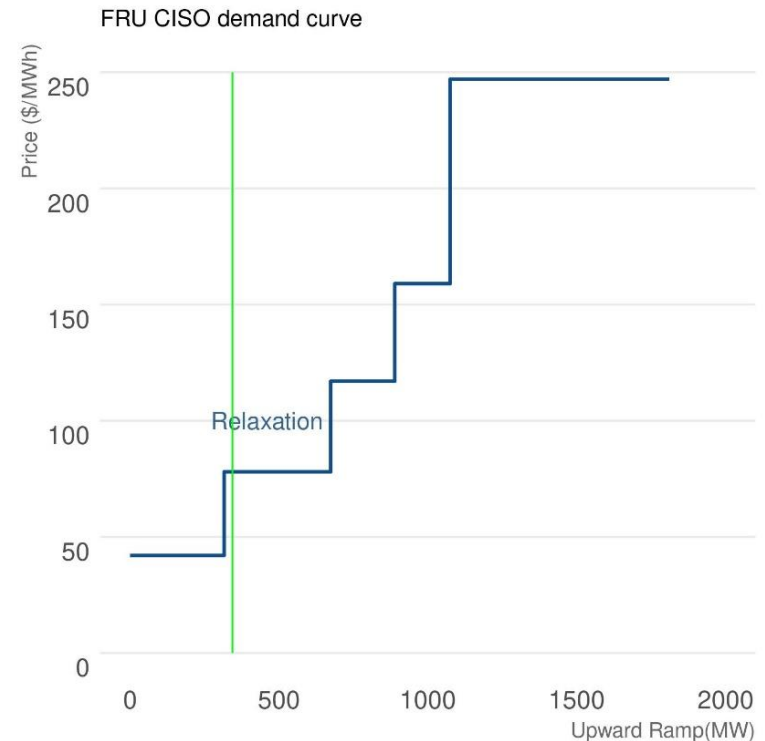
For  $j = CISO$

$$\begin{aligned} \gamma_j(t) &= 1, \text{ thus } FRUS_{j=CAISO}(t) \text{ active} \\ \sum_{i \in CISO} FRU_i(t) &= 581 < 925, \end{aligned}$$

$$FRUS_{CISO} = 344$$

For  $EIM$

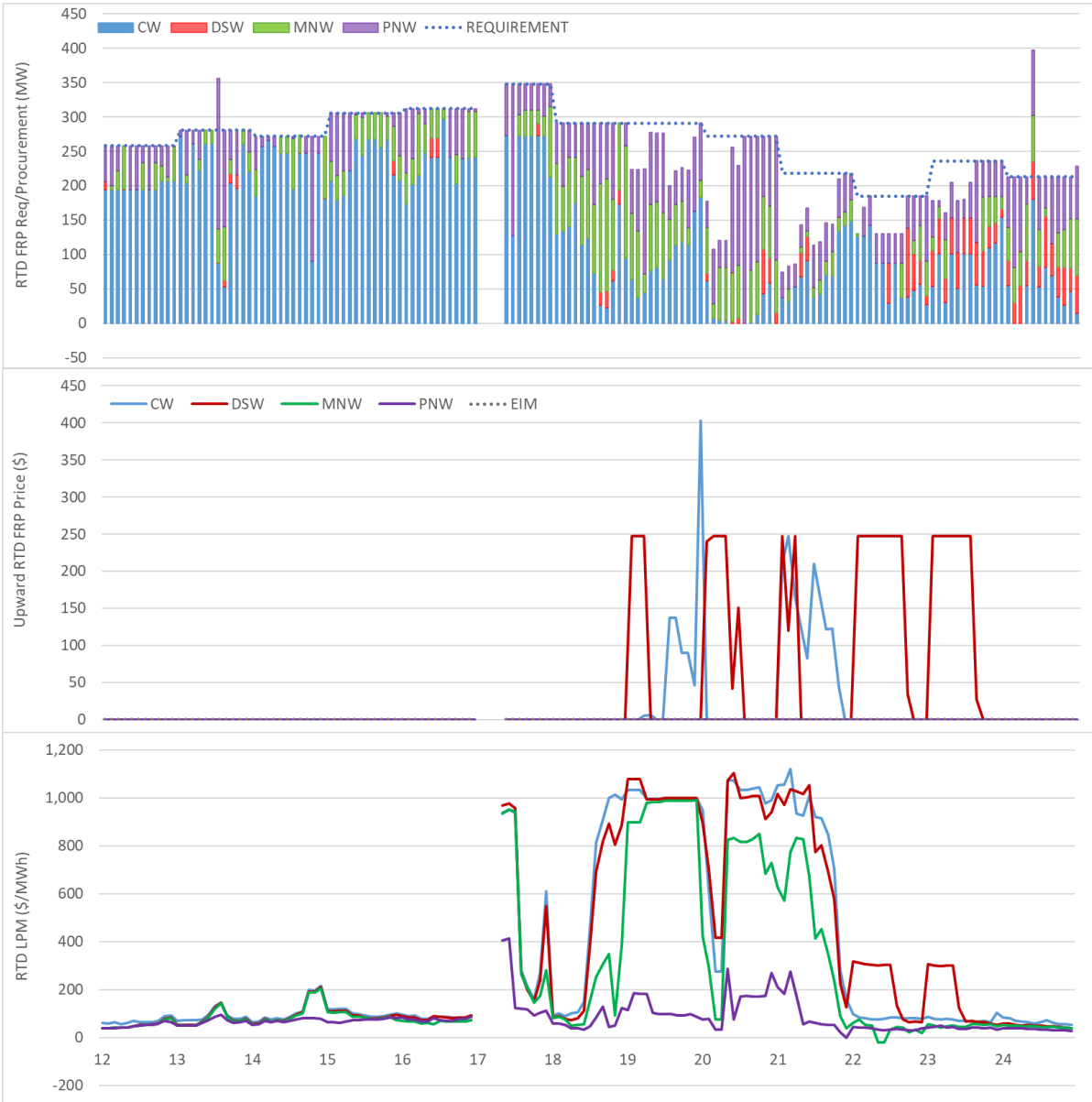
$$1113 + 581 + 344 + FRUS_{EIM} \geq 2038 \text{ thus } FRUS_{EIM} = 0, \text{ EIM price} = 0$$



## Why TID, LADWP, IPCO, AZPS, PNM and SRP procured 0 MW of flex ramp to the system?

- These areas had exhausted their supply bid stacks
- They also had an effective FRP requirement of 0 MW
- Their surplus variables are not active
- There is no opportunity cost to price FRP
- There is no need to relax the FRP demand curve since requirement is 0 MW
- Thus their FRP prices are \$0

Flex ramp prices were also \$0 in multiple RTD intervals of July 9 during peak hours



# Likewise, RDT FRP procurement was largely driven by EIM requirements

BAA	Uncertainty Req (MW)	Effective req (MW)	Procurement (MW)	Relaxation (MW)	FRP Price (\$)	Energy Price (\$)
AZPS	45	0	0	0	0	994
BANC	14	0	0	0	0	1001
CISO	273	0	127	0	0	994
IPCO	37	0	0	0	0	994
LADWP	69	0	0	0	0	994
NEVP	99	0	0	0	0	994
NWMT	23	0	0	0	0	994
PACE	86	0	0	0	0	960
PACW	30	0	0	0	0	151
PGE	28	0	0	0	0	151
PNM	53	0	0	0	0	994
PSEI	21	0	0	0	0	65
PWRX	47	38	143	0	0	65
SCL	5	5	78	0	0	65
SRP	36	0	0	0	0	994
TIDC	3	0	0	0	0	997
EIM	348	348	348	0	0	



# RTD FRP prices were \$0 across the EIM footprint

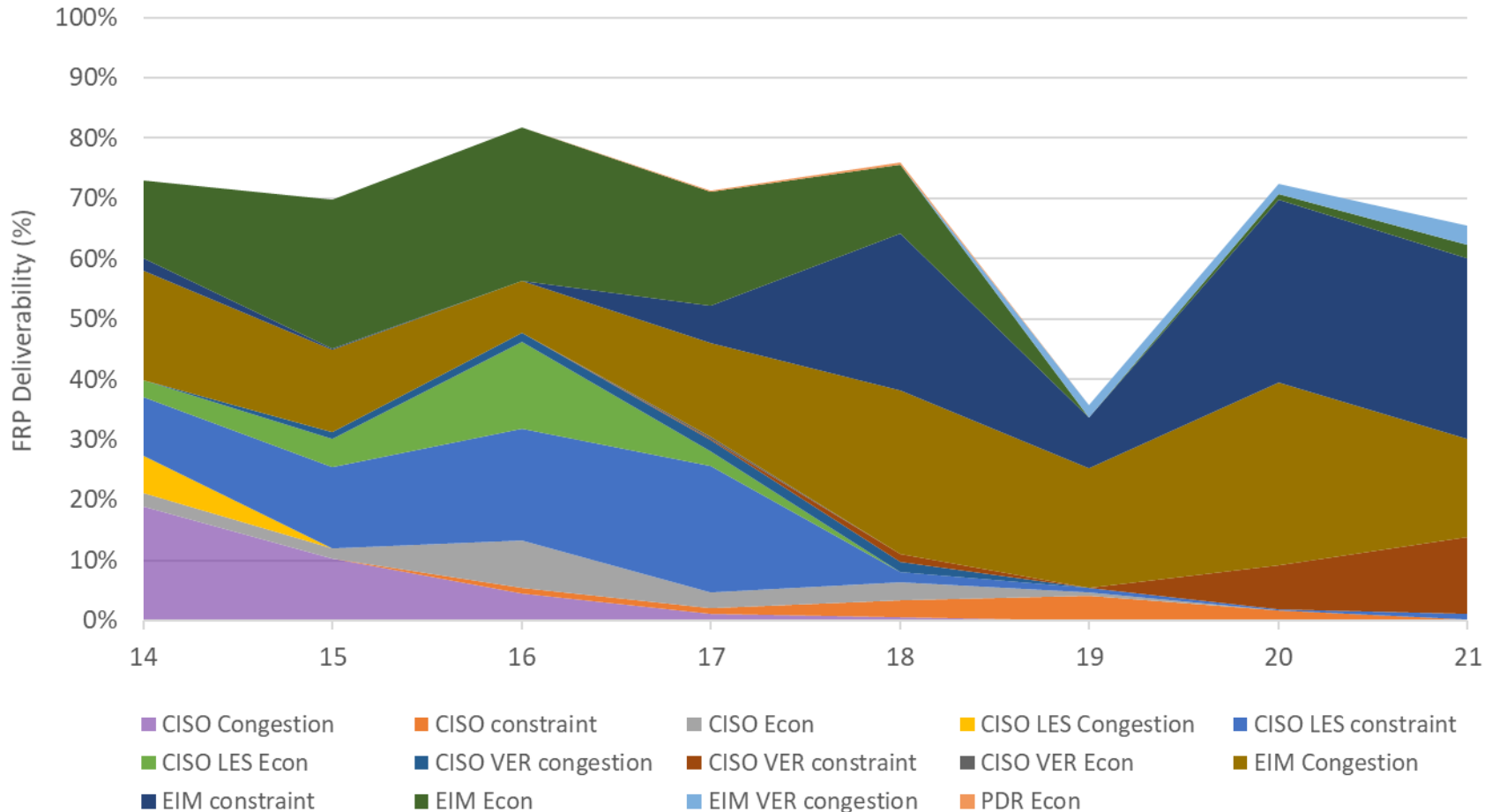
- Effective requirements were mostly 0 MW for the majority of EIM individual areas
- EIM area requirement is the main driver for procurement
- FRP awards meet EIM requirement but were not deliverable from a ISO's reference

NAME	BAA	RTD FRP Award	Reason
Gen 001	BCHA	143	PNW award
Gen 002	CISO	27	Internal Congestion
Gen 003	CISO	100	Energy Limit
Gen 003	SCL	78	PNW award

## FRP deliverability

- Deliverability was one of the main reasons identified impacting FRP efficacy
- FRP enhancements will rely on new formulation to tackle FRP deliverability
- FRP enhancements scheduled for Fall 2022
- ISO has updated analysis about FRP deliverability

# On July 9, 2021 FRP was partially deliverable due to either economics, congestion or resource constraints



# Limited FRP deliverability is a more persistent issue beyond the critical summer days

