On Real-Time Pricing in the NZEM

EPOC Winter Workshop 2023

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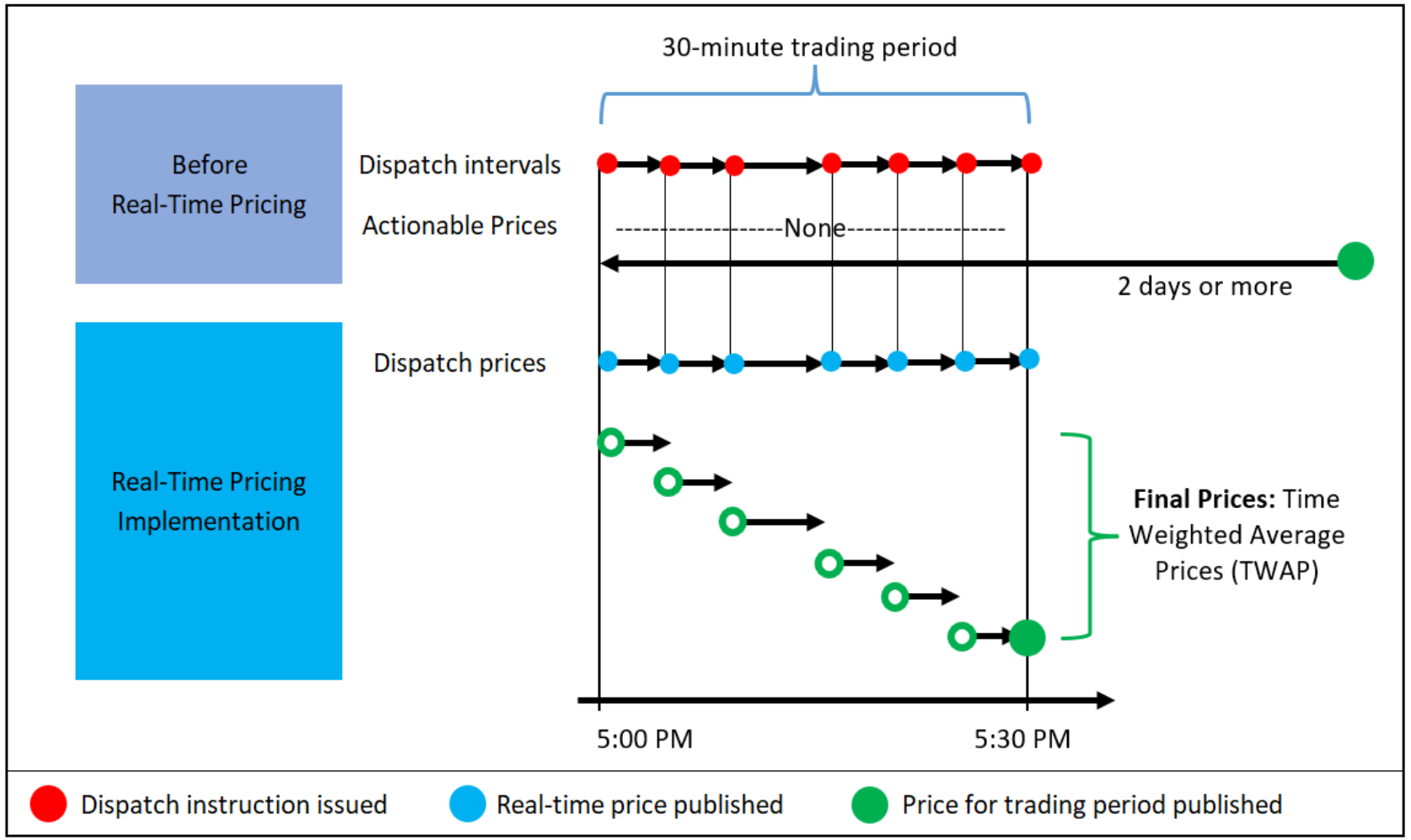
Outline

- Real-time prices
- Time Weighted Average Prices (TWAP)
- Forecast Prices
- Conclusions

Real-time Pricing (RTP)



Source: Adapted from Electricity Authority

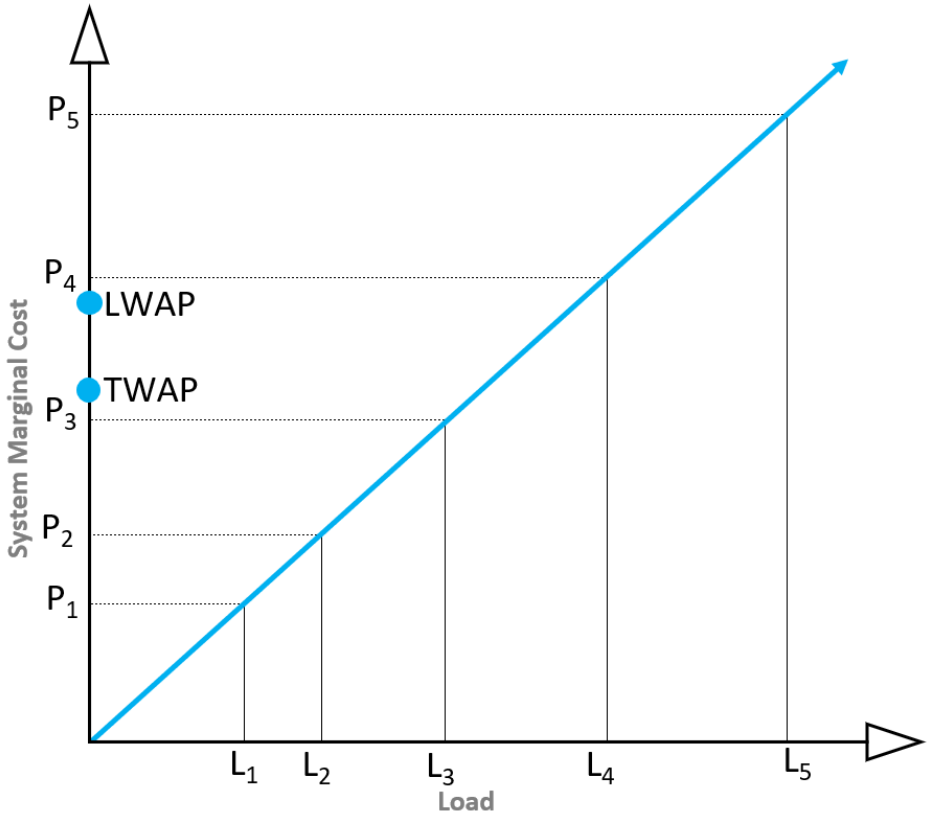
Research Questions

- **Time-Weighted Average Prices (TWAP)**
  - How is TWAP different from other metrics?
  - What incentives does TWAP give to a load or a generator?
- **Forecast Prices**
  - Is the latest short price-responsive schedule (PRSS) the best price to be used for final settlement if the real-time dispatch price is unavailable?
- **Real-Time Pricing Effectiveness**
  - What measures can we take to improve RTP?

Time-Weighted Average Prices

TWAP or LWAP/GWAP?

Single-node model



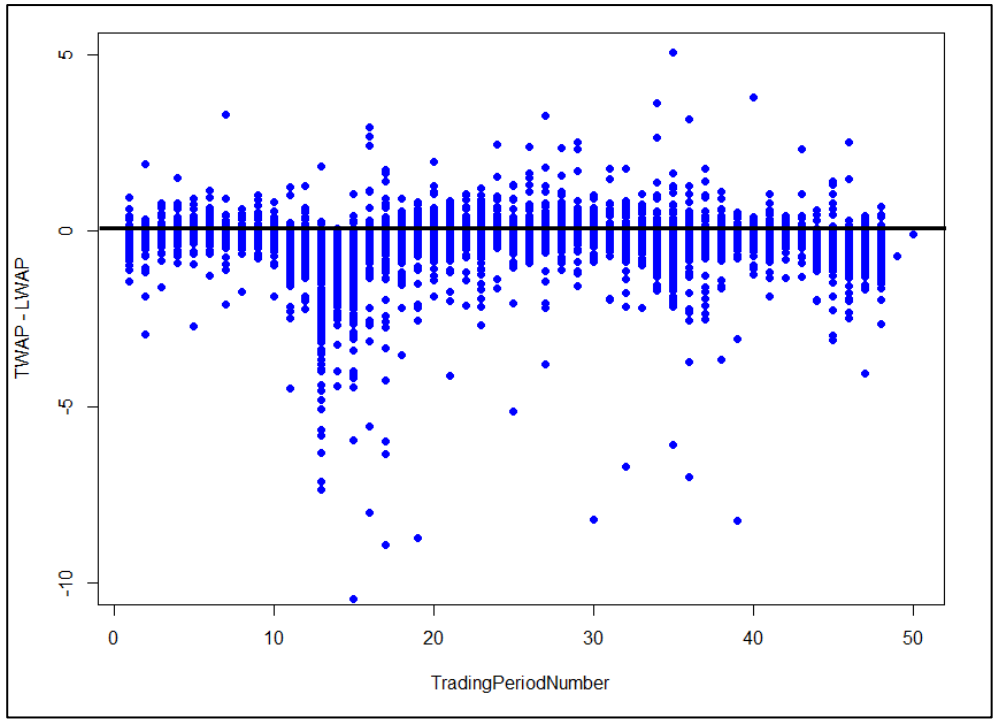
Assumption: Equal time duration for all points

$$LWAP = \frac{\sum_{i=1}^{5} L_i P_i}{\sum_{i=1}^{5} L_i}$$

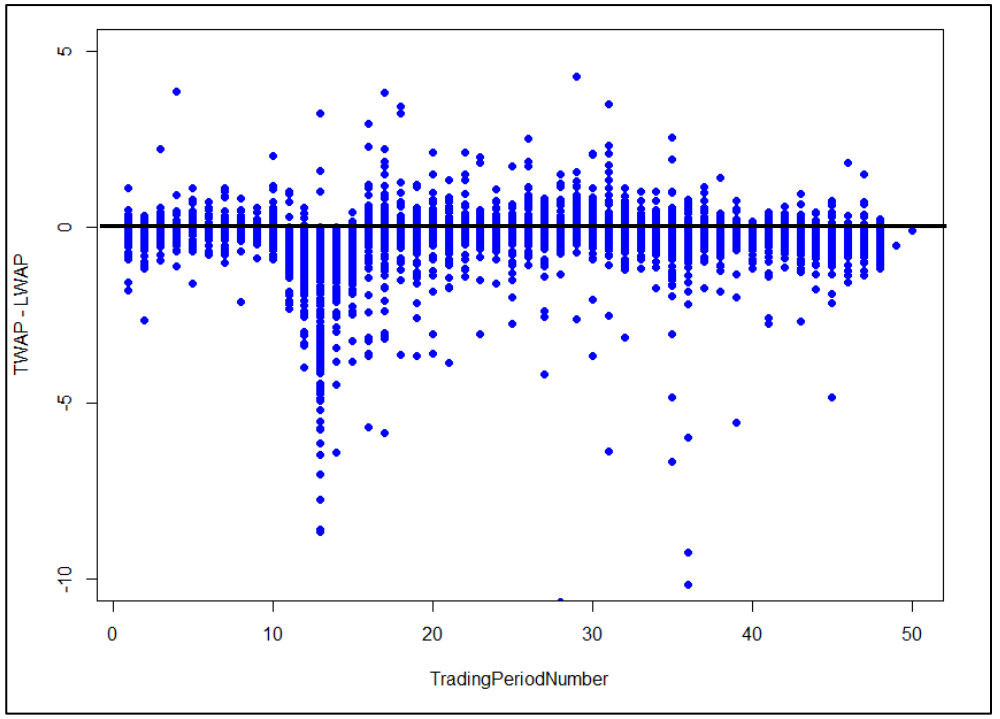
$$GWAP = \frac{\sum_{i=1}^{5} G_i P_i}{\sum_{i=1}^{5} G_i}$$

$$TWAP = \frac{\sum_{i=1}^{5} P_i}{5}$$

TWAP vs LWAP



(a) Scatter plot of the difference between TWAP and LWAP for HAY0331 (GXP)



(b) Scatter plot of the difference between TWAP and LWAP for HLY0331 (GXP)

Data Source: EMI Datasets

01 November 2022 to 30 June 2023

- TWAP is lower than LWAP most of the time
- Significantly lower TWAP observed at trading periods 12 to 16

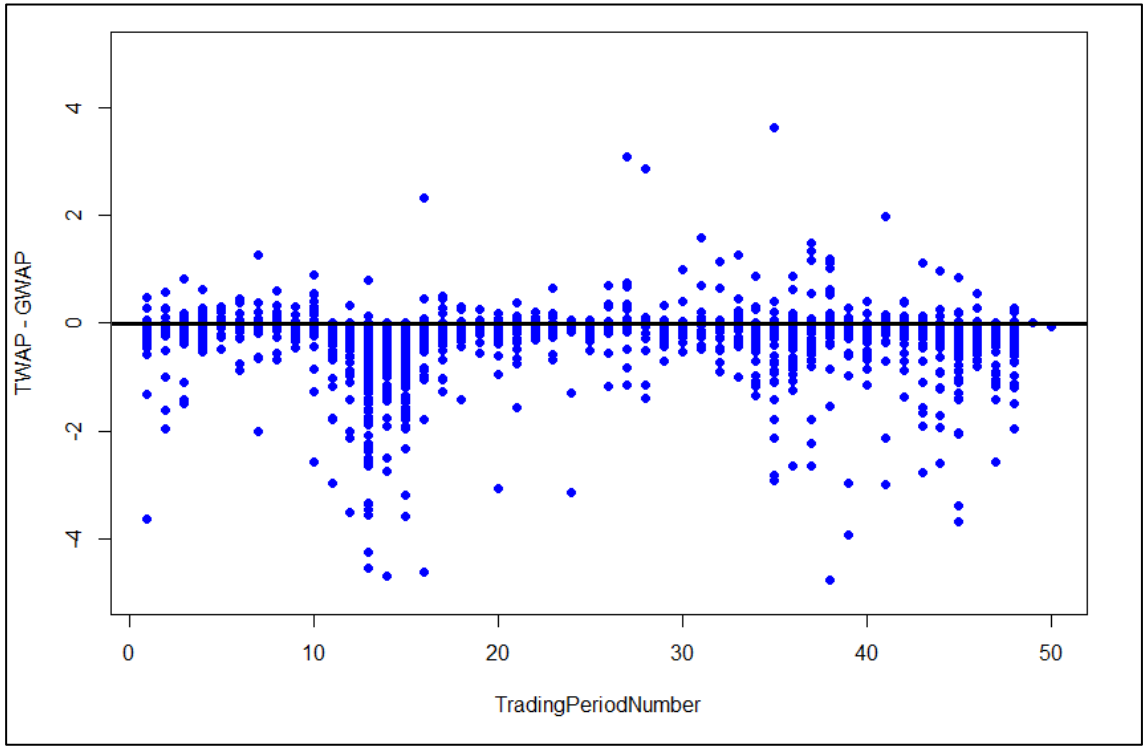
TWAP vs GWAP

Block Dispatch: Waitaki Chain

Point of Connection Code	Unit Code	Plant Name
AVI2201	AVI0	Aviemore
BEN2202	BEN0	Benmore
OHA2201	OHA0	Ōhau A
OHB2201	OHB0	Ōhau B
OHC2201	OHC0	Ōhau C
WTK0111	WTK0	Waitaki

Dispatch Prices: BEN2202 Prices

Total Generation: Sum of the initial megawatts



Scatter plot of the difference between TWAP and GWAP for the Waitaki Chain

Data Source: EMI Datasets

01 November 2022 to 30 June 2023

- TWAP is lower than GWAP most of the time
- Significantly lower TWAP is observed at trading periods 12 to 16 and 34 to 37

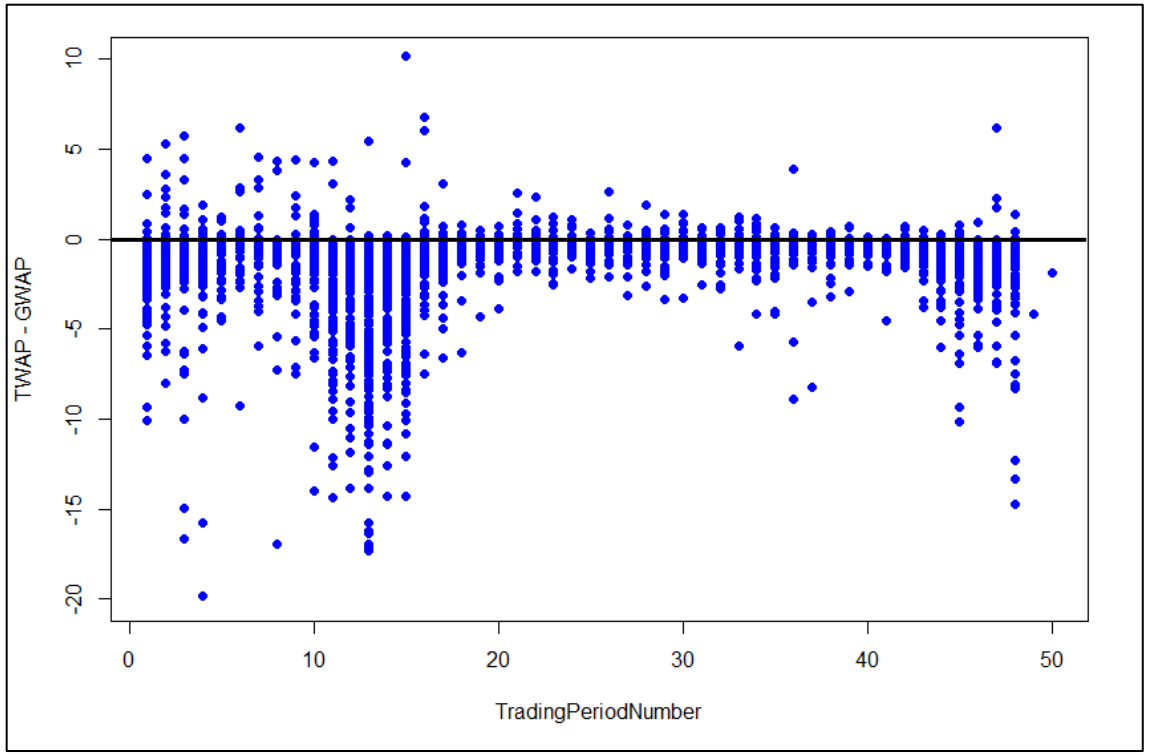
TWAP vs GWAP

Block Dispatch: Upper Waikato Chain

Point of Connection Code	Unit Code	Plant Name
ARA2201	ARA0	Aratiatia
ATI2201	ATI0	Ātiamuri
OHK2201	OHK0	Ōhakuri
WKM2201	WKM0	Whakamaru

Dispatch Prices: WKM2201 Prices

Total Generation: Sum of the initial megawatts



Scatter plot of the difference between TWAP and GWAP for Upper Waikato Chain

Data Source: EMI Datasets

01 November 2022 to 30 June 2023

- TWAP is lower than GWAP most of the time
- Significantly lower TWAP observed at trading periods 10 to 15

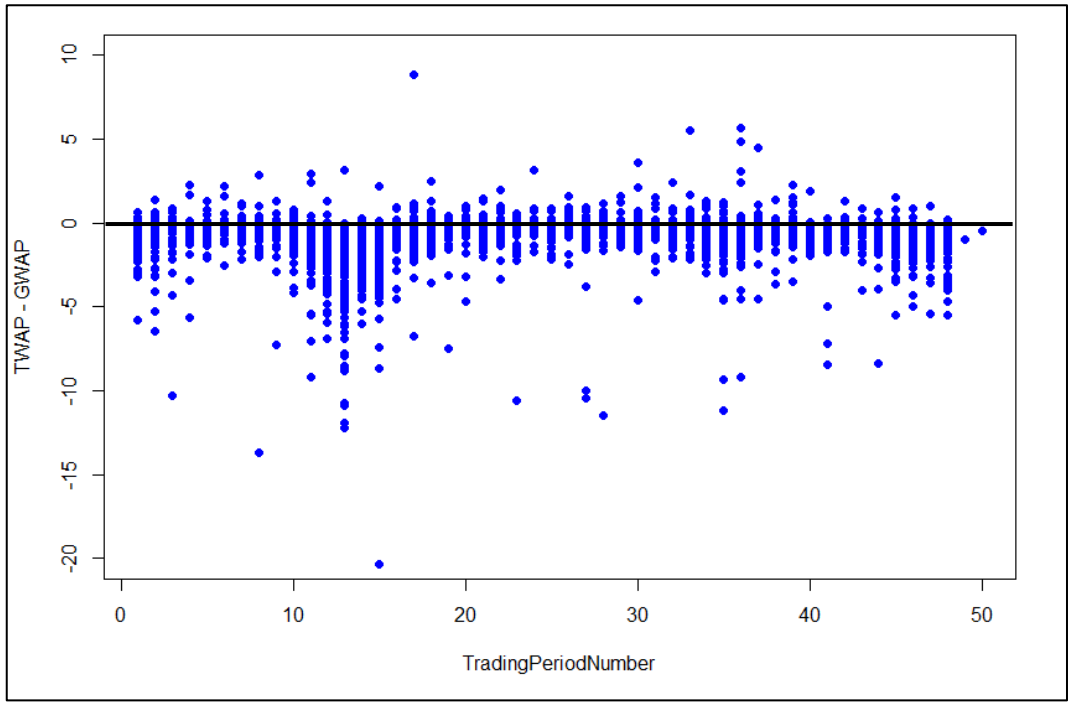
TWAP vs GWAP

Block Dispatch: Lower Waikato Chain

Point of Connection Code	Unit Code	Plant Name
ARI1101	ARI0	Arapuni
ARI1102	ARI0	Arapuni
KPO1101	KPO0	Karāpiro
MTI2201	MTI0	Maraetai
WPA2201	WPA0	Waipāpa

Dispatch Prices: Average of ARI1101 and ARI1102 Prices

Total Generation: Sum of the initial megawatts



Scatter plot of the difference between TWAP and GWAP for Lower Waikato Chain

Data Source: EMI Datasets

01 November 2022 to 30 June 2023

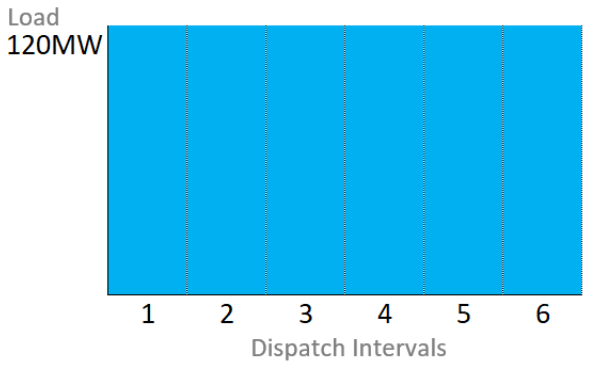
- TWAP is lower than GWAP most of the time
- Significantly lower TWAP observed at trading periods 12 to 15

Incentives for loads

Example: Price-taking load with value of energy equals $200/MWh reduces consumption when the price quadruples. Savings for consumers is compared under TWAP and LWAP.

Scenario A: Status Quo

$/MWh	100	100	400	100	100	100

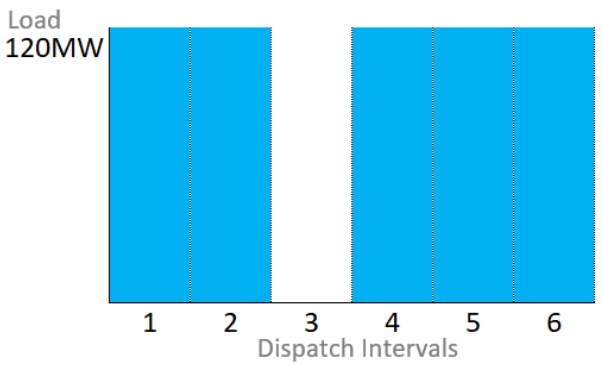


TWAP	
Final Price, $/MWh	150
Consumption, MWh	60
Total Cost, $	9,000

LWAP	
Final Price, $/MWh	150
Consumption, MWh	60
Total Cost, $	9,000

Scenario B: 120MW load reduction during high prices

$/MWh	100	100	400	100	100	100



TWAP	
Final Price, $/MWh	150
Consumption, MWh	50
Total Cost, $	7,500
Reduced Consumption, MWh	10
Savings, $	1,500
Cost of Reduction, $	2,000
Value Gain/(Loss), $	(500)

LWAP	
Final Price, $/MWh	100
Consumption, MWh	50
Total Cost, $	5,000
Reduced Consumption, MWh	10
Savings, $	4,000
Cost of Reduction, $	2,000
Value Gain/(Loss), $	2,000

Comparison of TWAP and LWAP from (a) status quo scenario and (b) after load reduction load during high prices

Incentives for generators

Example: Peaking Plant

Marginal Cost = $200/MWh

Dispatch Duration: 5 Minutes

TWAP

Cost = $200/MWh

Revenue= $150/MWh

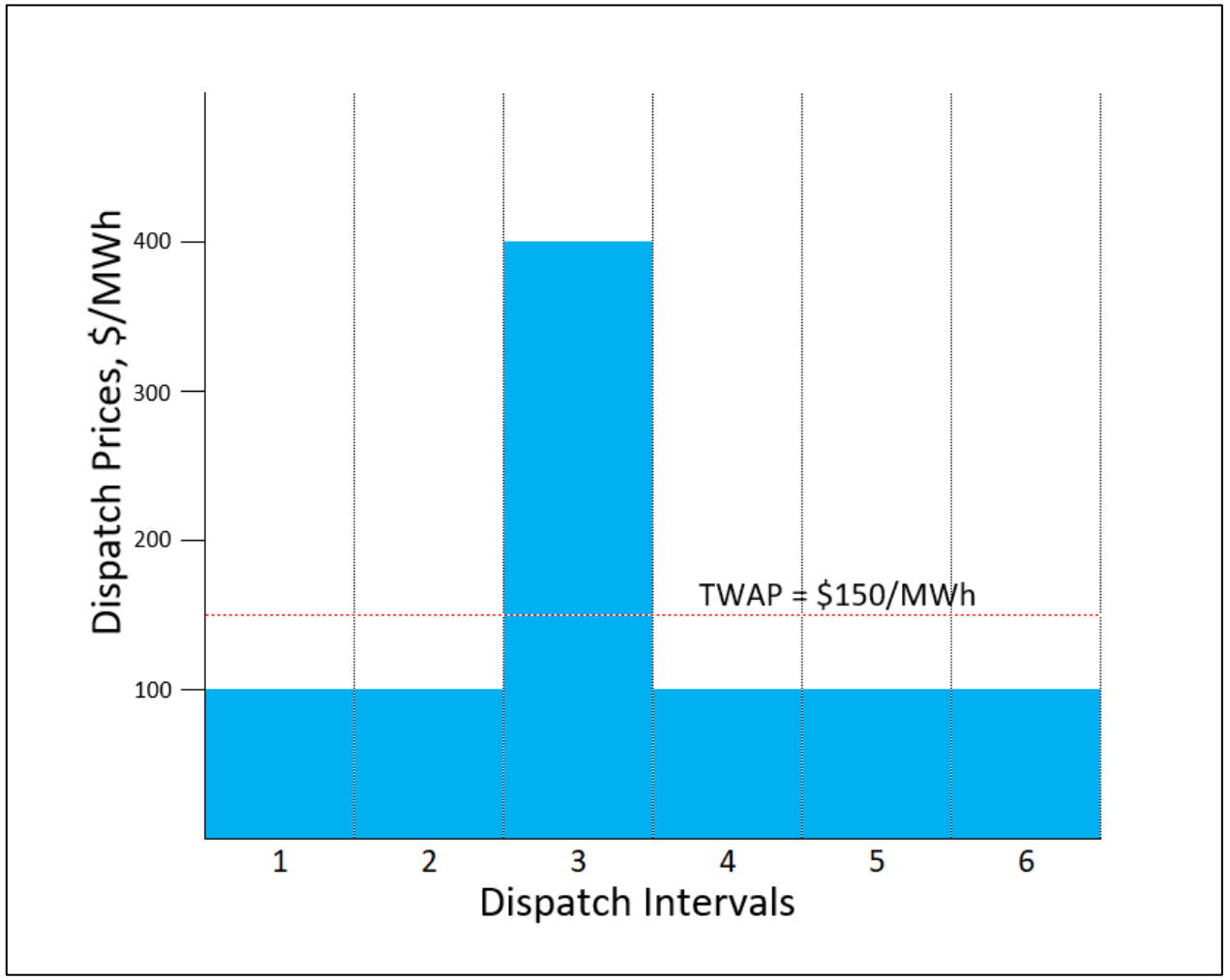
Loss = $50/MWh

GWAP

Cost = $200/MWh

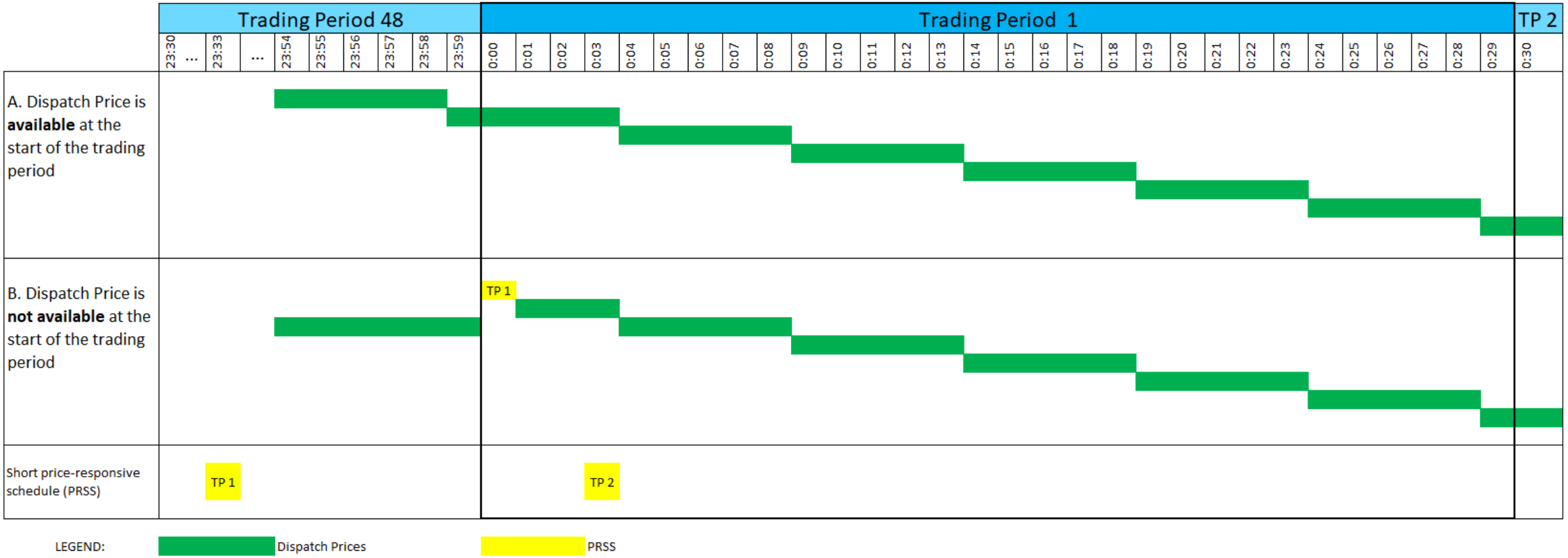
Revenue = $400/MWh

Gain = $200/MWh



Forecast Prices

Forecast Prices



Forecast Prices

Forecast Price - the latest short price-responsive schedule (PRSS) that was used due to the unavailability of real-time dispatch prices.

Short price-responsive schedule (PRSS) - produced every 30 minutes at the 3rd and 33rd minutes, including the existing and succeeding 7 trading periods.

PRSS Timetable Example

Trading Period	Time Start	0:03 Run	0:33 Run	1:03 Run	1:33 Run	2:03 Run	2:33 Run	3:03 Run	3:33 Run
TP 1	0:00	1							
TP 2	0:30	2	1						
TP 3	1:00	3	2	1					
TP 4	1:30	4	3	2	1				
TP 5	2:00	5	4	3	2	1			
TP 6	2:30	6	5	4	3	2	1		
TP 7	3:00	7	6	5	4	3	2	1	
TP 8	3:30	8	7	6	5	4	3	**2**	1
TP 9	4:00		8	7	6	5	4	3	2
TP 10	4:30			8	7	6	5	4	3
TP 11	5:00				8	7	6	5	4

Forecast Price

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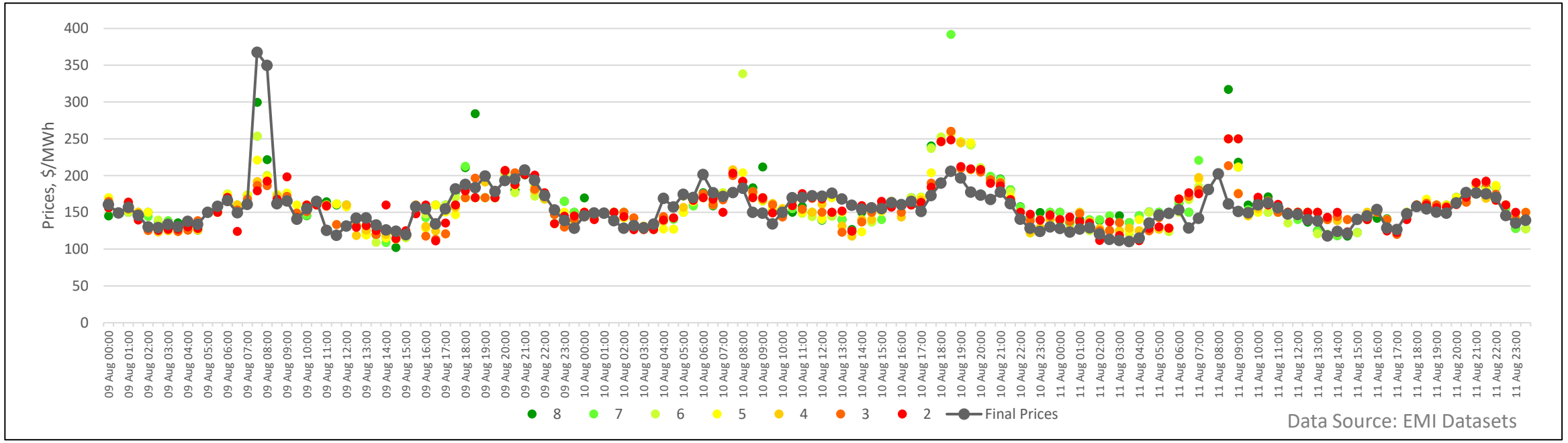
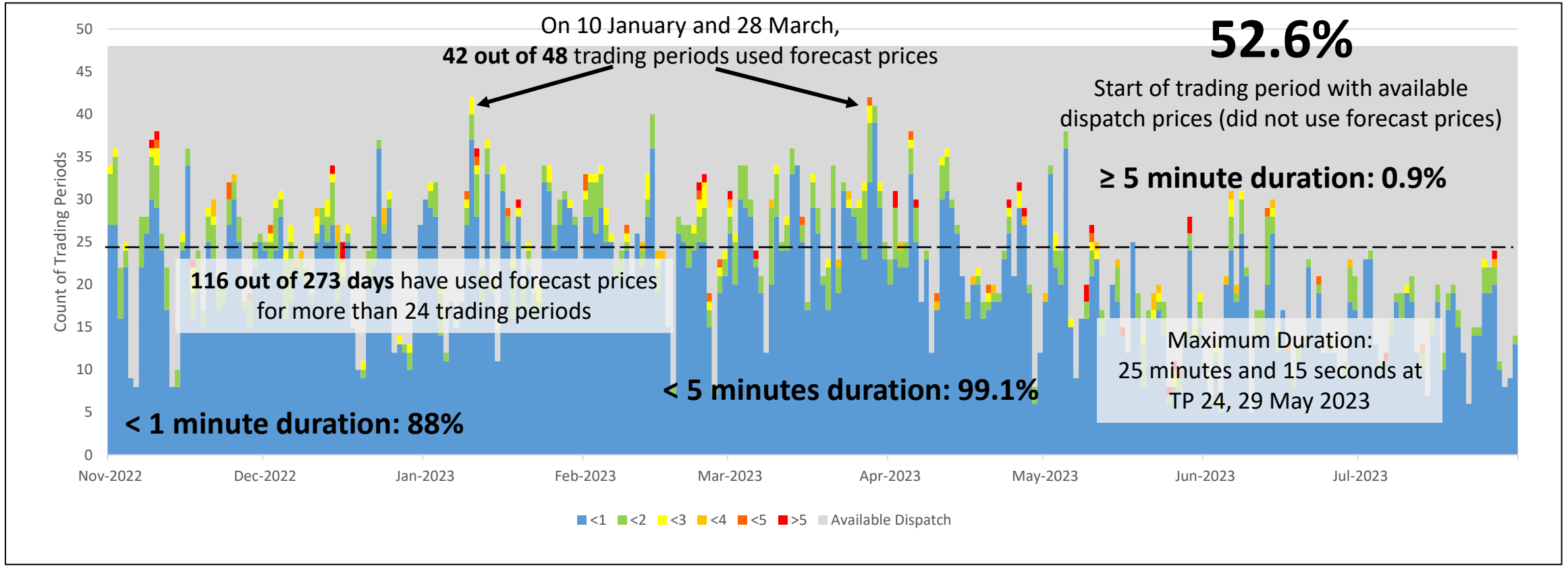
TP 1	0:00	1							
TP 2	0:30	2	1						
TP 3	1:00	3	2	1					
TP 4	1:30	4	3	2	1				
TP 5	2:00	5	4	3	2	1			
TP 6	2:30	6	5	4	3	2	1		
TP 7	3:00	7	6	5	4	3	2	1	
TP 8	3:30	8	7	6	5	4	3	2	1
TP 9	4:00		8	7	6	5	4	3	2
TP 10	4:30			8	7	6	5	4	3
TP 11	5:00				8	7	6	5	4

Forecast and Final Prices



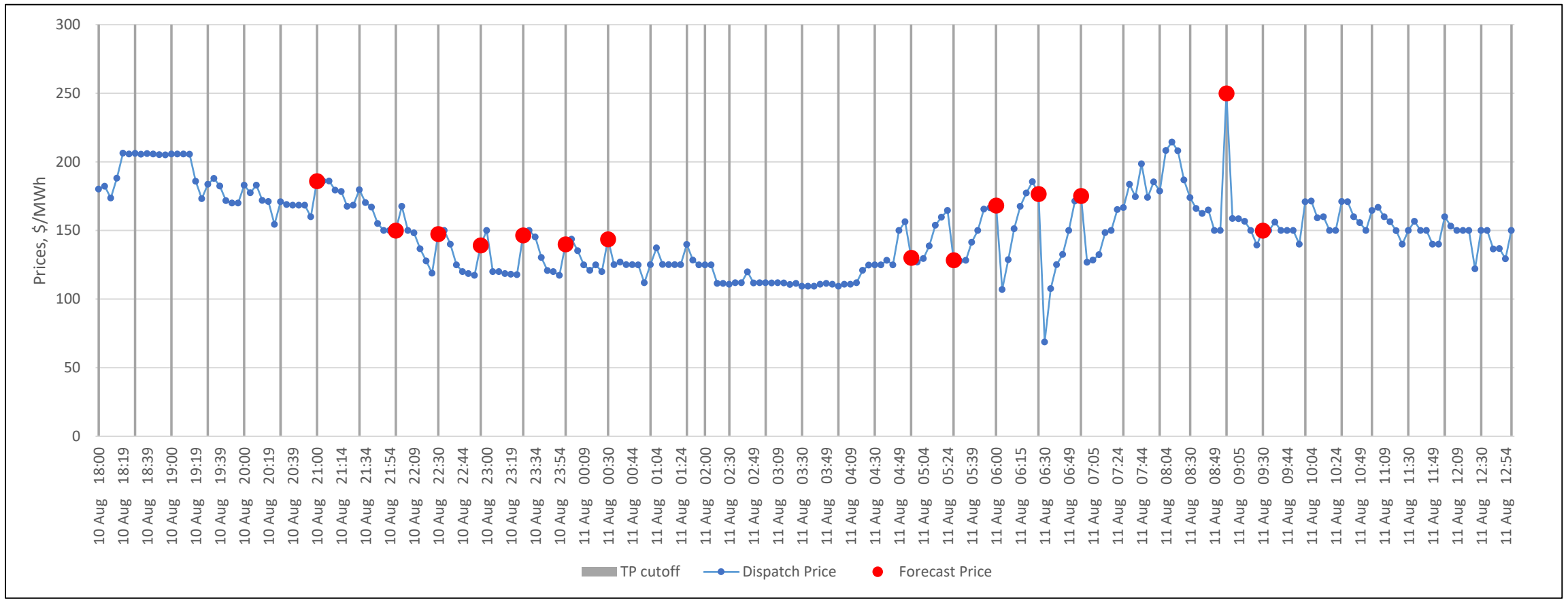
Forecast Prices

Utilisation of Forecast Prices from 01 November 2022 to 31 July 2023



Data Source: EMI Datasets

Forecast Prices



Data Source: EMI Datasets

Conclusions

Conclusions

- When prices are high, RTP is intended to incentivise loads to decrease consumption or generators to increase production.
- Time-weighted average pricing (TWAP) attenuates these incentives.
- Price forecasts using the PRSS data can give unexpected prices that may deviate from the other prices within the trading period.
- Recommendations:
  - Limitation of the use of forecast prices from PRSS; only if there is still no dispatch price after a certain period (e.g. 10 minutes)
  - Real-time pricing settlement for each dispatch interval

Thank you!