

Real-time pricing with 5-minute settlement in the Australian National Electricity Market

EPOC Winter Workshop 2023

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Executive summary

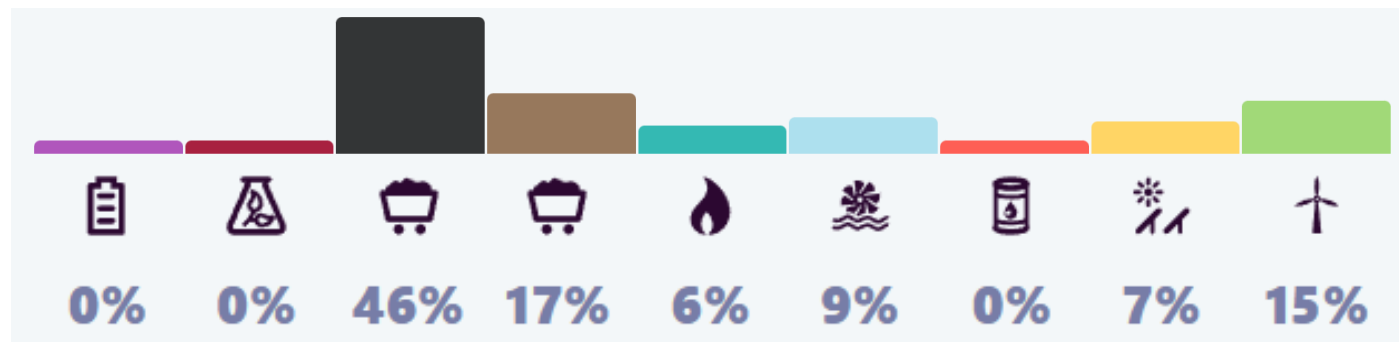
Key messages

- In October 2021, the Australian National Electricity Market moved to five-minute settlement in which operational dispatch and financial settlement were aligned on the same time interval of five minutes.
- A physical requirement of a power system is that supply and demand are matched. The underlying components of must-run supply and demand each change over varied time horizons leading to uncertainty in net demand and a requirement for flexible supply-side or demand-side solutions.
- A weather dependent power system is subject to stochastic forecasts of, and variable output from, solar generation and wind generation. This leads to uncertainty in the actual output from such generators.
- The optimal use of technologies like grid-scale batteries, or demand response, is to turn on for very short periods to meet the highest spikes that result within a weather dependent system. That may mean operating for only five to ten minutes at a time when the market demands it the most.
- A settlement process that relies on 30-minute averaging will flatten the value available to these technologies and will weaken incentives to deploy them.

The NEM and five-minute settlement (1/4)

The Australian National Electricity Market

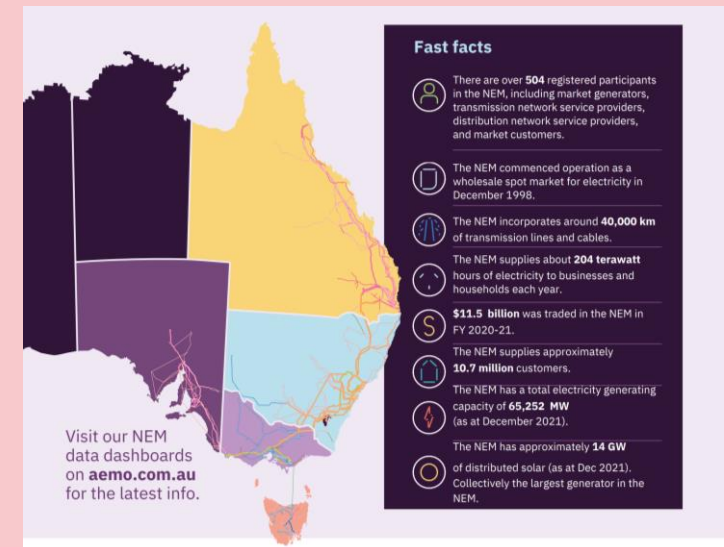
- The National Electricity Market on the East Coast of Australia began operation in the 1990's.
- The NEM was formed on the following basis:
 - Generators dispatch electricity on a five-minute basis; and,
 - Financial settlement occurs on a thirty-minute basis.
- In 2017, the Australian Energy Market Commission (AEMC) introduced a rule change in which operational dispatch and financial settlement were aligned on the same time interval of five minutes. It was implemented over a number of years.
- The change in rule by the AEMC originated from a request by Sun Metals Corporation (a demand-side participant) in 2015.
- In October 2021, the project was completed and the NEM moved to five-minute settlement.



AEMO: <https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem>

Background information

- The Australian National Electricity Market has historically been dominated by large volumes of thermal generation, including baseload coal-fired power stations.
- In the recent past, the NEM has observed an increasingly rapid build-out of intermittent renewable generation, distributed solar generation and storage solutions. This has been leading to large volumes of thermal substitution and a system that is ultimately more weather dependent.



AEMO: <https://aemo.com.au/-/media/files/electricity/nem/national-electricity-market-fact-sheet.pdf>

The NEM and five-minute settlement (2/4)

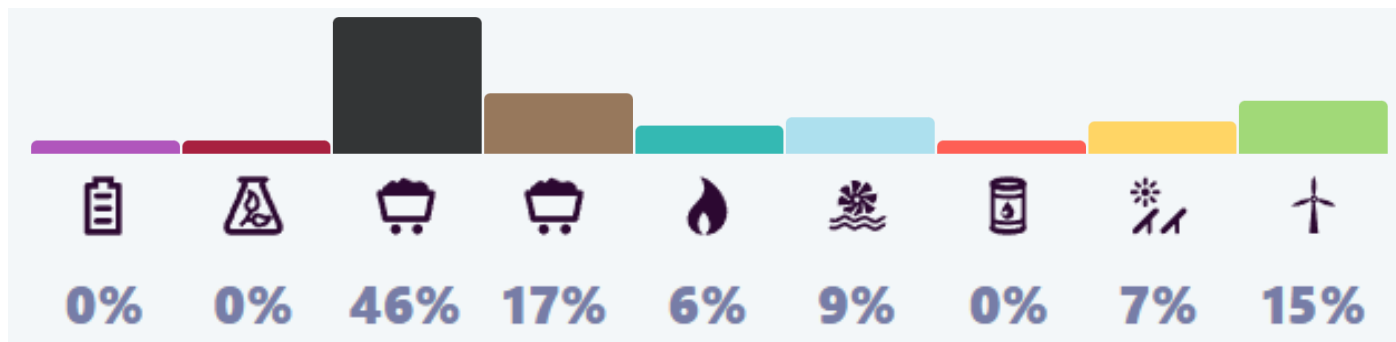
The Australian National Electricity Market

- The rule change was proposed by Sun Metals Corporation in December 2015, where they stated:

“The disparity between dispatch and settlement timeframes creates market distortions that lead to inefficiencies in operation and composition (generation mix and demand response) of the market.”

“In addition, the current market distortions represent an impediment to the entry into the market of fast response generation, and rapid demand-side response”

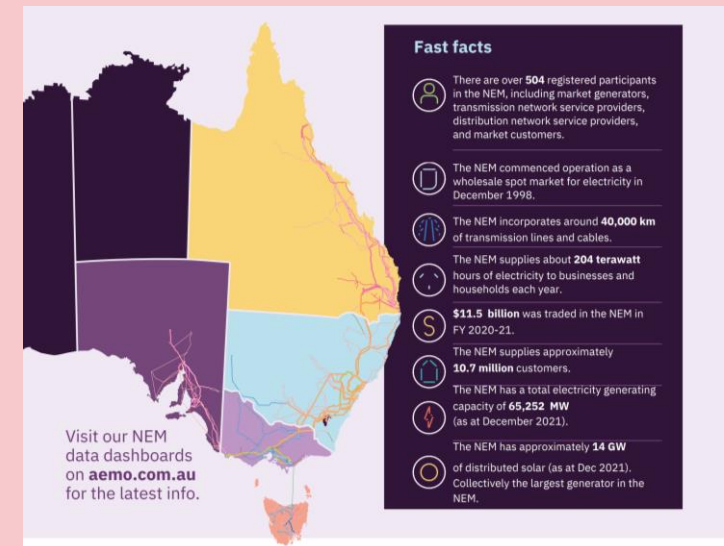
- AEMC considered five-minute pricing would have the following significant enduring benefits:
 - Improved price signals for more efficient generation and use of electricity;
 - Improved price signals for more efficient investment in capacity and demand response technologies to balance supply and demand; and,
 - Improved bidding incentives.



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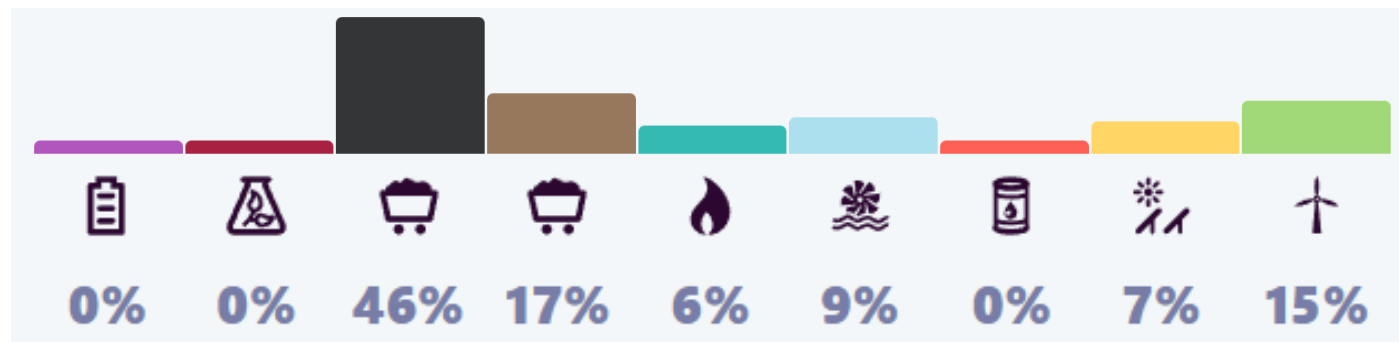
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The NEM and five-minute settlement (3/4)

The Australian National Electricity Market

- The rule change recognised the potential changes to five-minute and thirty-minute settlement as a consequence of increasing penetration of intermittent renewables.

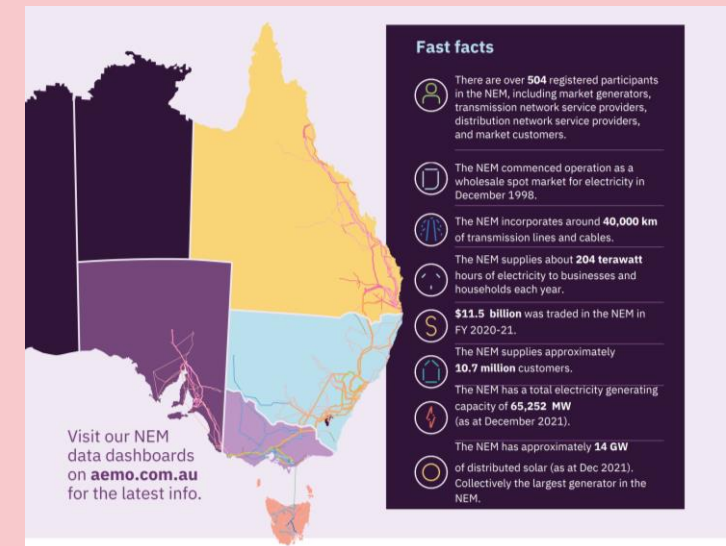
“Data shows that the differences between five-minute dispatch prices and thirty-minute settlement prices has become greater over the past few years, ...[this] is expected to increase in the future; hence the benefits of the improved price signal under five-minute settlement are likely to become greater over time.”



AEMO: <https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem>

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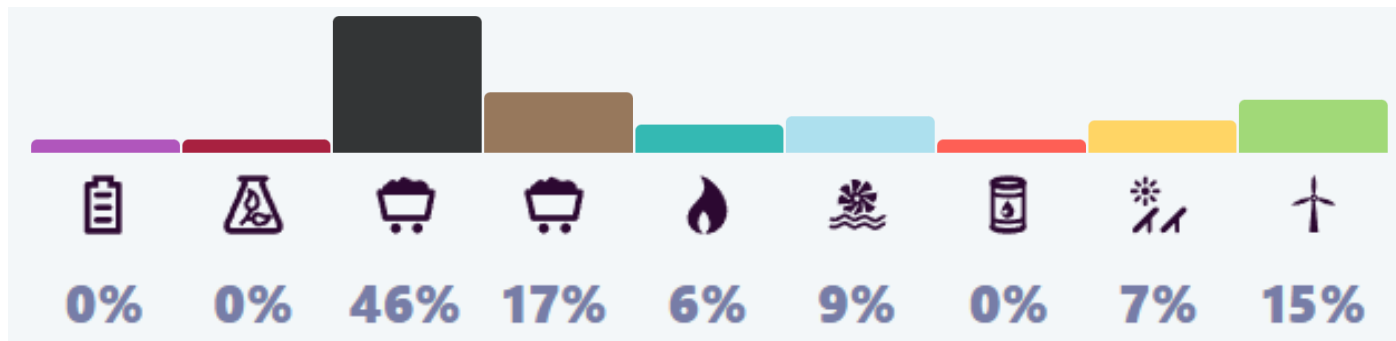
AEMO: <https://aemo.com.au/-/media/files/electricity/nem/national-electricity-market-fact-sheet.pdf>

The NEM and five-minute settlement (4/4)

The Australian National Electricity Market

- In implementing this change, the AEMC addressed two key concerns:
 - That five-minute pricing may encourage greater volumes of fast ramping capability (e.g. batteries) that is invisible to the Australian Energy Market Operator (AEMO), making it harder for AEMO to manage system security; and,
 - The change may impact the ability of gas-peaking generators to offer caps and remain financially viable, causing them to exit the market, reducing both system security and reliability.
- In response to this however, the following was considered:

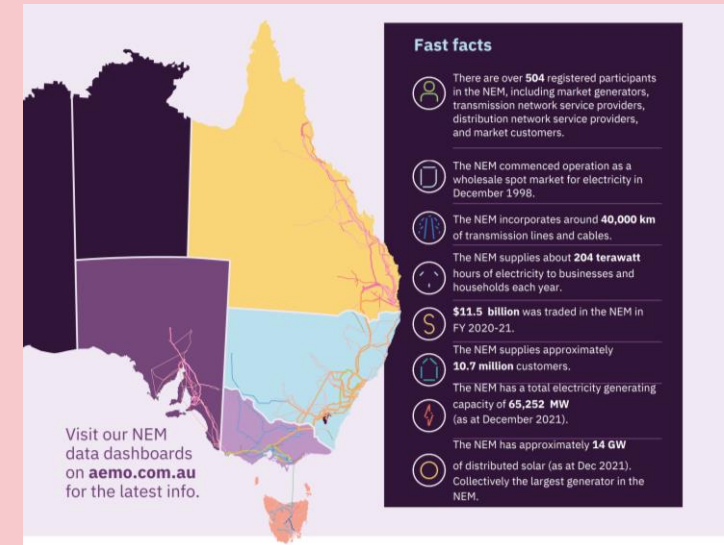
“The Commission recognises there are potential risks to system security and reliability with the introduction of five-minute settlement. However, given the large amount of work currently being undertaken to address system security and reliability issues, and the developments in the market, the Commission is satisfied that there is no direct threat to system security or reliability from implementing five-minute settlement.”



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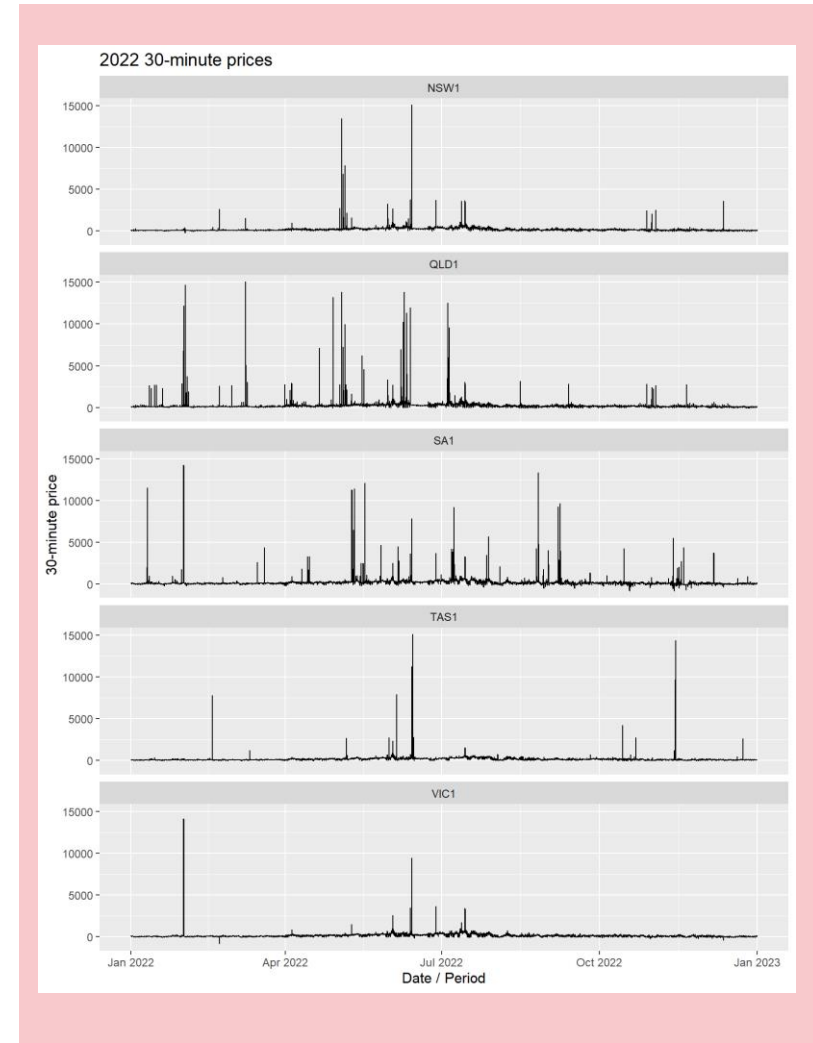
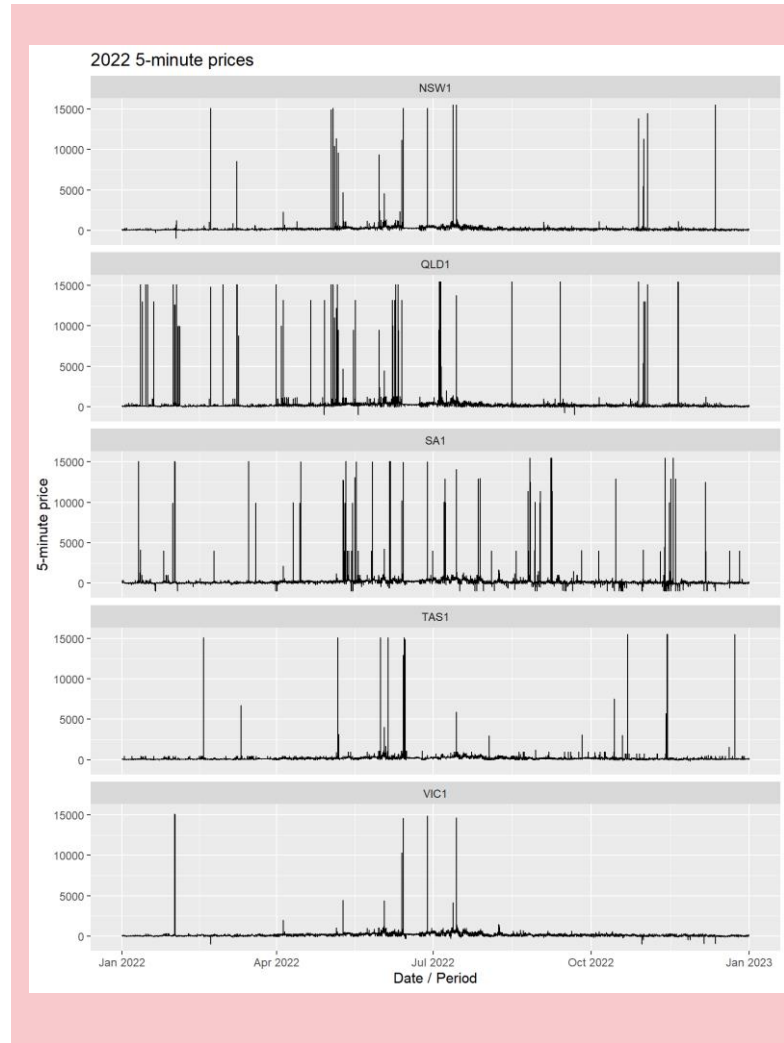


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Wholesale prices in the NEM (2022) (1/2)

Illustration of pricing outcomes

- The figures on the right-hand side present five-minute versus thirty-minute wholesale prices in each state of the NEM for Calendar Year 2022.
- This illustration demonstrates the elevated number of short-duration price spikes under five-minute pricing when compared to the flattened thirty-minute pricing.

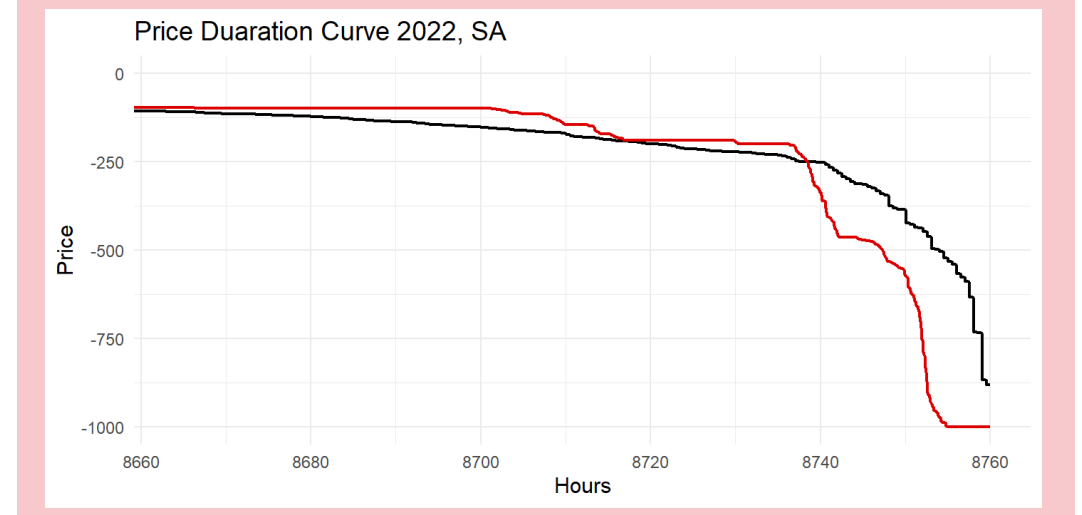
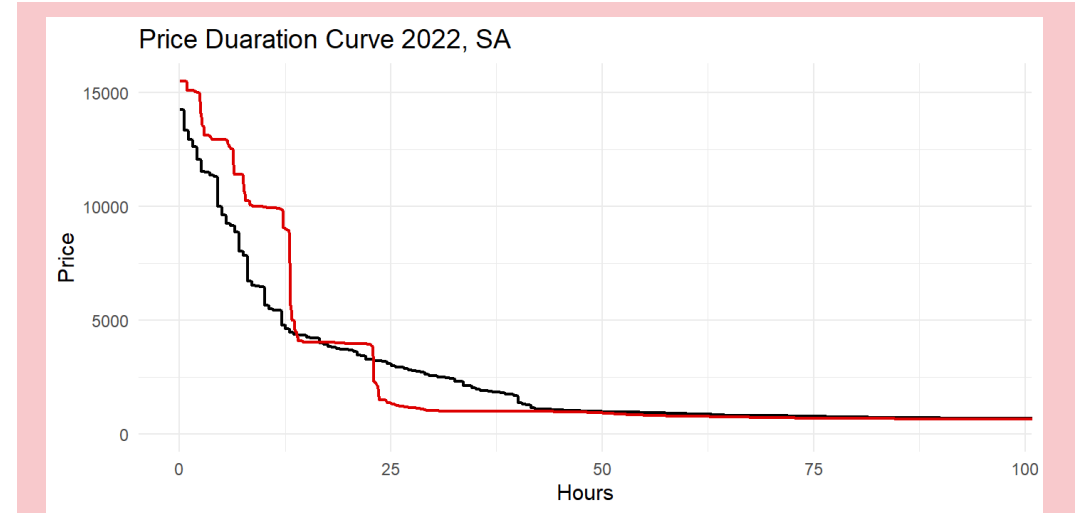
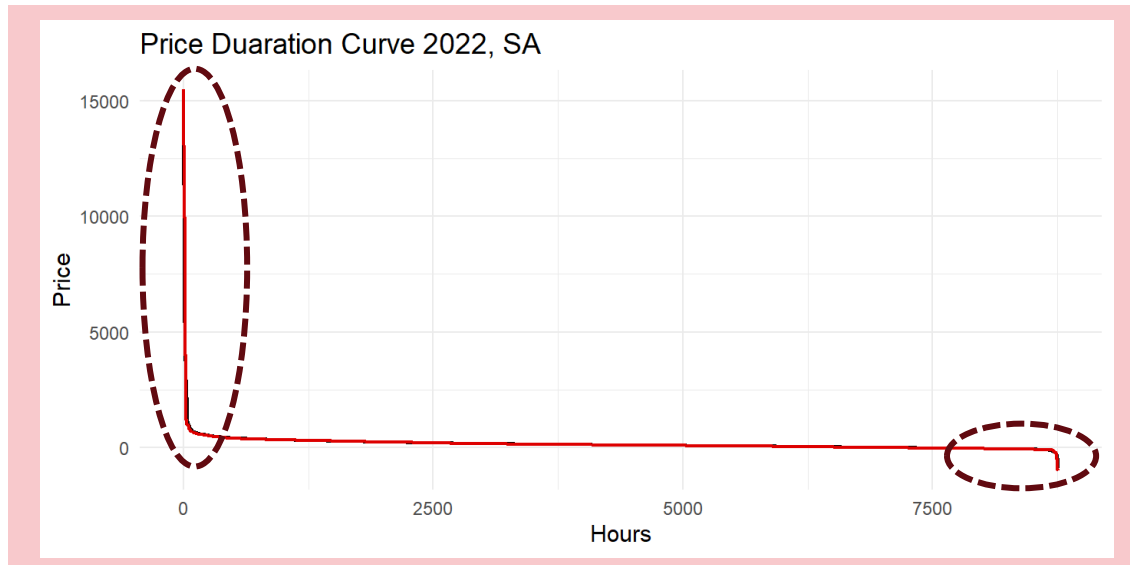


Wholesale prices in the NEM (2022) (2/2)

The pricing duration curves

- The wholesale pricing duration curve illustrated below presents a wide-range of pricing outcomes that are expanded upon on the right-hand side through duration curves at the upper and lower ends of the distribution.
- It is demonstrated through these plots that there is a steeper duration curve for wholesale pricing under five-minute versus thirty-minute averaged prices.

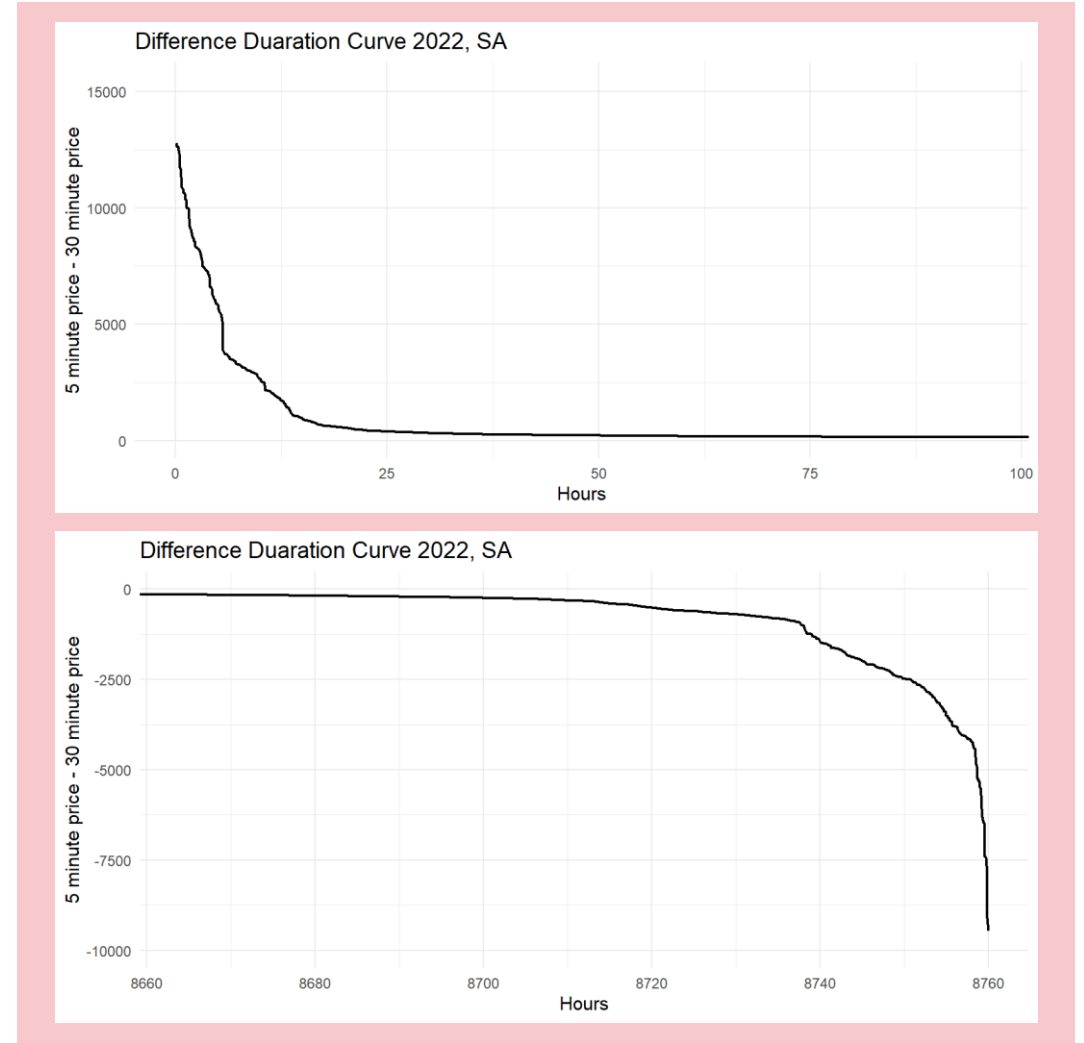
Five-minute prices ———
Thirty-minute prices ———



A market signal to reward flexibility

Difference between 5-minute and 30-minute prices

- The plots on the right show the high- and low-end of a duration curve for the difference between 5-minute and 30-minute prices.
- At the top-end of the graph, we see around 15 hours (180, 5-minute periods) where the 5-minute price is more than \$1000/MWh above the 30-minute price, and about 40 hours (480 periods) where the difference exceeds \$250/MWh.
- At the other end of the duration curve, we see the periods where the 5-minute price is much less than the 30-minute price.



Example 1: Baseload output

Baseload output: 30-minute versus 5-minute settlement

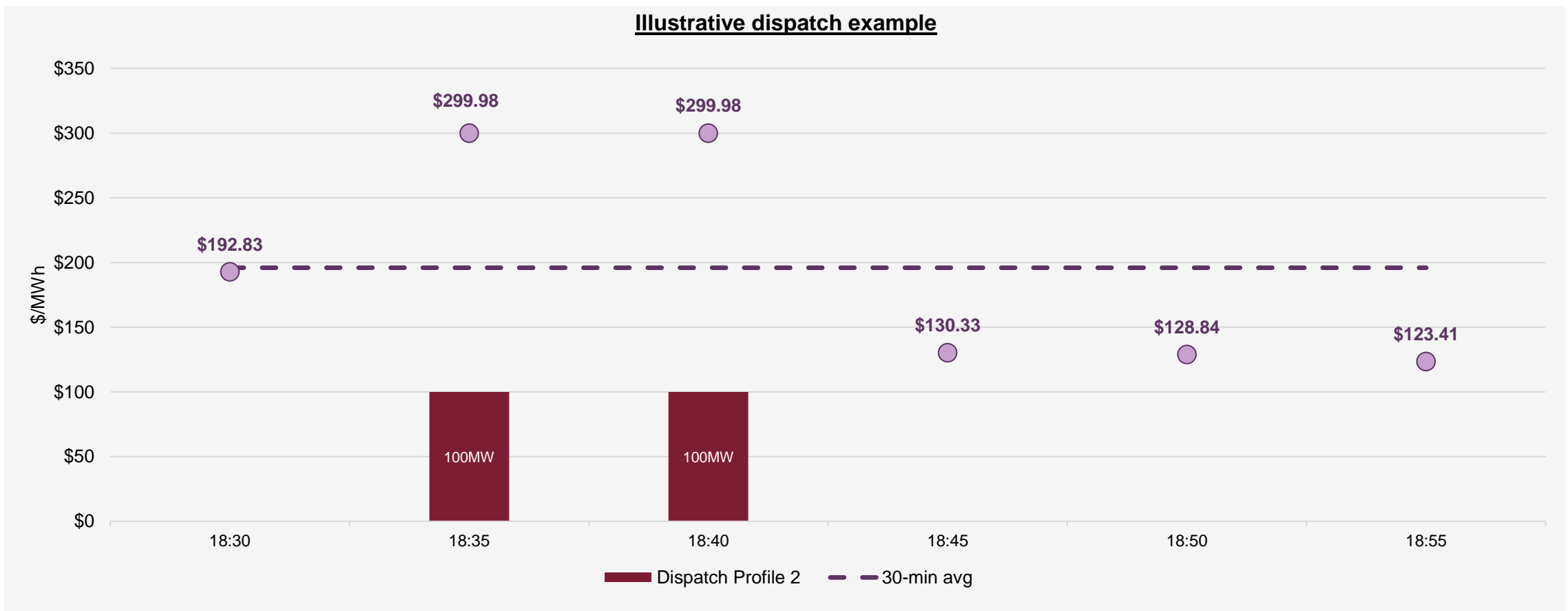
- There is no difference in the revenues or costs for a baseload profile under 30-minute versus 5-minute settlement.



Example 2: Flexible supply / demand-side response

Baseload output: 30-minute versus 5-minute settlement

- A flexible response receives a difference in the revenues or costs under 30-minute versus 5-minute settlement (not accounting for constraint payments).

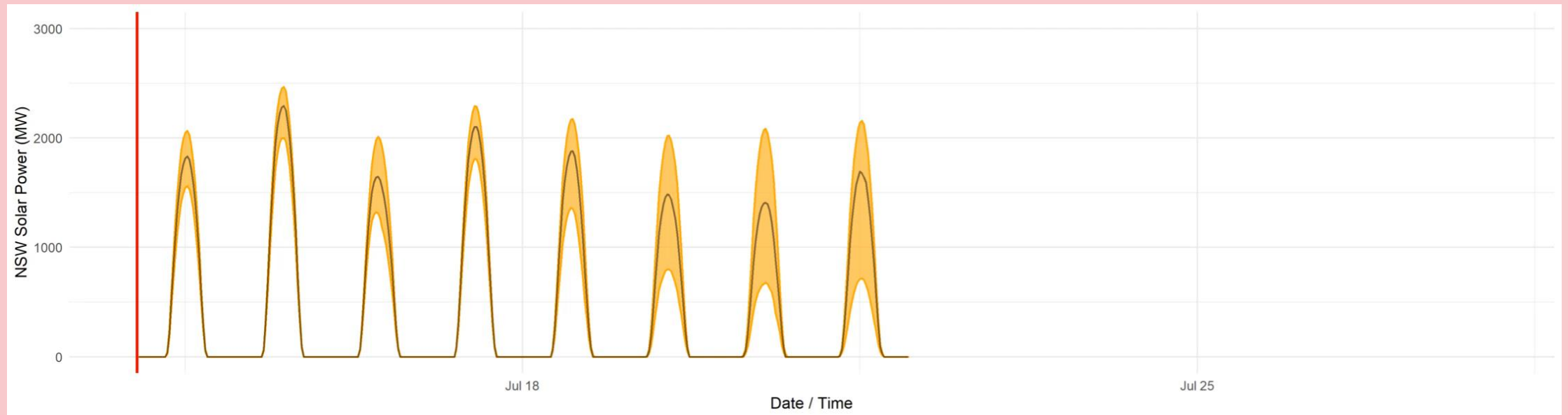


A weather dependent system (1/5)

A weather dependent system drives volatility across varied horizons

- The figure below illustrates a rolling, weekly forecast for solar generation from the NEM. It presents the mean power and associated p10 and p90 quantiles for New South Wales.
- There is uncertainty in solar power further into the week (versus the immediate days ahead).

Forecast solar output – a weekly forecast horizon

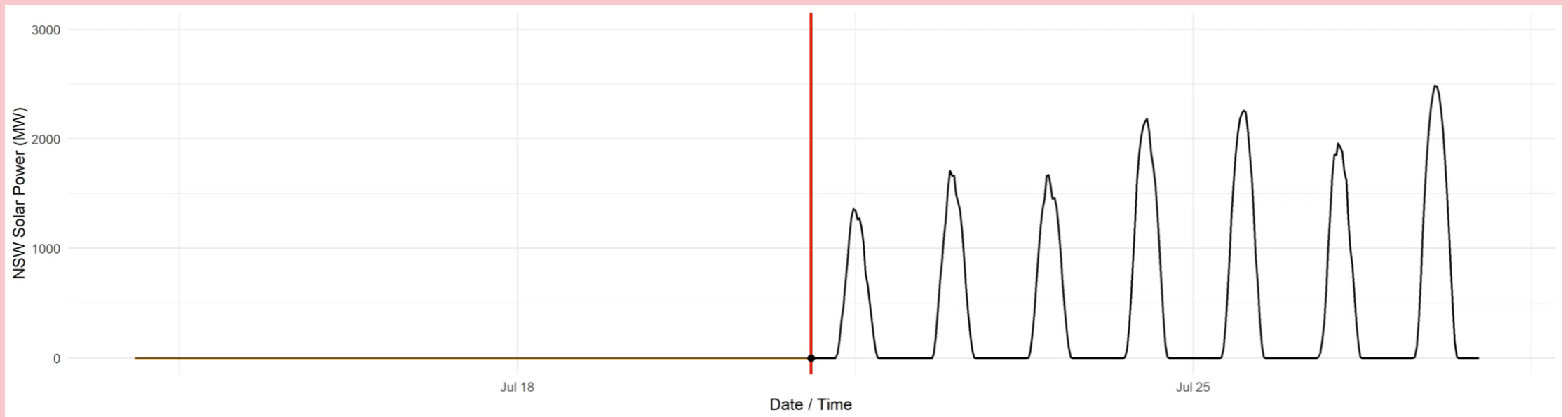


A weather dependent system (2/5)

A weather dependent system drives volatility across varied horizons

- The figure below illustrates the historically observed forecast for solar generation at a point in time. It presents the mean power and associated p10 and p90 quantiles for New South Wales over the period 21 – 27 July 2022.
- There remains uncertainty in solar power right up to real-time, five-minute pricing – this drives the need for flexible supply-side and demand-side solutions.

Forecast solar output – the forecast for a given point in time

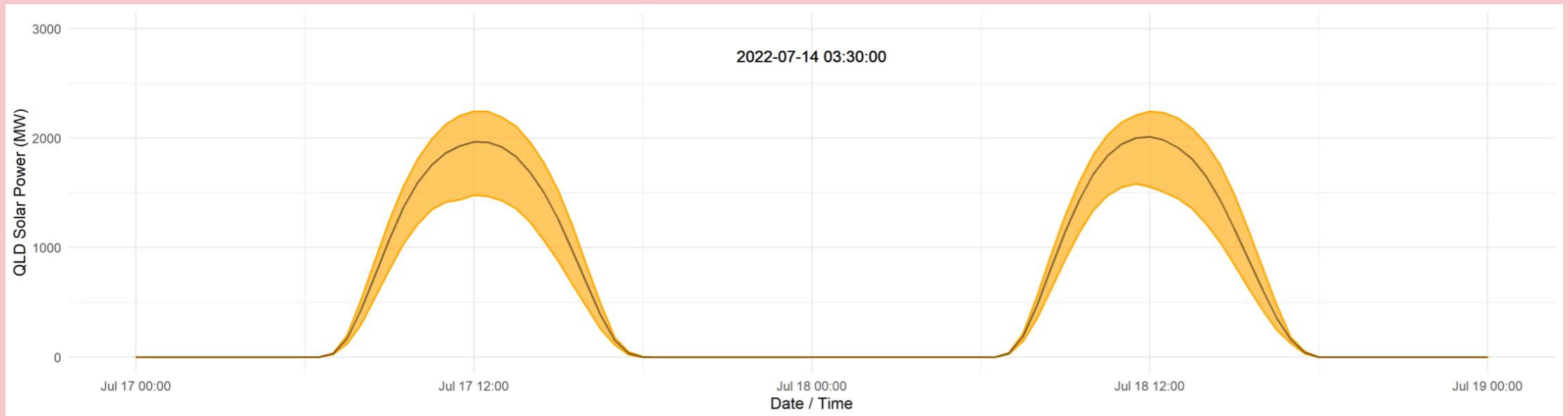


A weather dependent system (3/5)

A weather dependent system drives volatility across varied horizons

- The figure below illustrates daily forecasts for solar generation from the NEM. It presents the mean power and associated p10 and p90 quantiles for Queensland for 17 and 18 July 2022.
- There is considerable uncertainty in solar power over a given day – this drives the need for flexible supply-side and demand-side solutions.

Forecast solar output – a daily forecast horizon

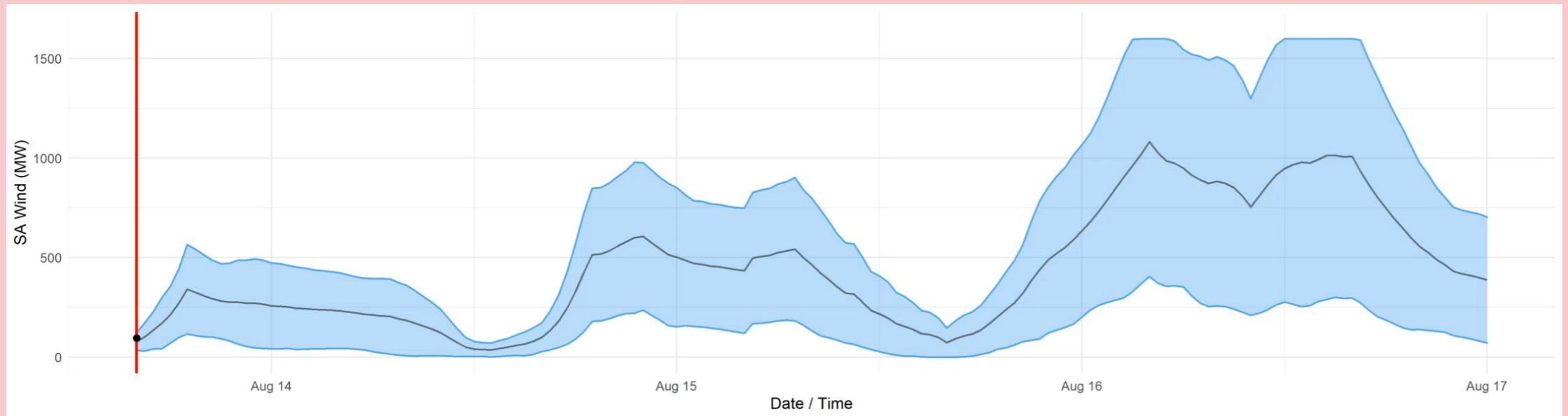


A weather dependent system (4/5)

A weather dependent system drives volatility across varied horizons

- The figure below illustrates the historically observed forecast for wind generation at a point in time. It presents the mean power and associated p10 and p90 quantiles for South Australia over the period August 11 through August 14 .
- There is more uncertainty in wind power when forecasting periods further in the future (versus the immediate hours ahead).
- There are two different aspects highlighted here: **(a)** short-term variability, **(b)** medium- and short-term forecast error.

Forecast wind output – the forecast for a given point in time

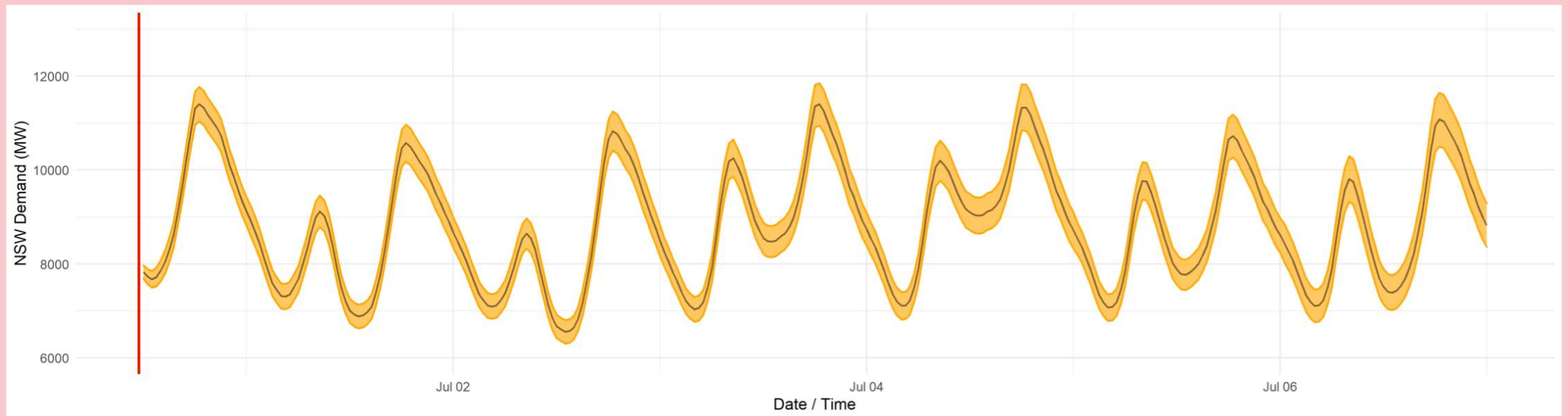


A weather dependent system (5/5)

A weather dependent system drives volatility across varied horizons

- The figure below illustrates a daily forecast for demand net of embedded generation from the NEM. It presents the mean power and associated p10 and p90 quantiles for New South Wales for the day.
- There is variability introduced through uncertain levels of demand in addition to uncertainty on the supply side.
- Together these unpredictable short-term variations increase the need for flexible generation / demand that can respond at short notice.

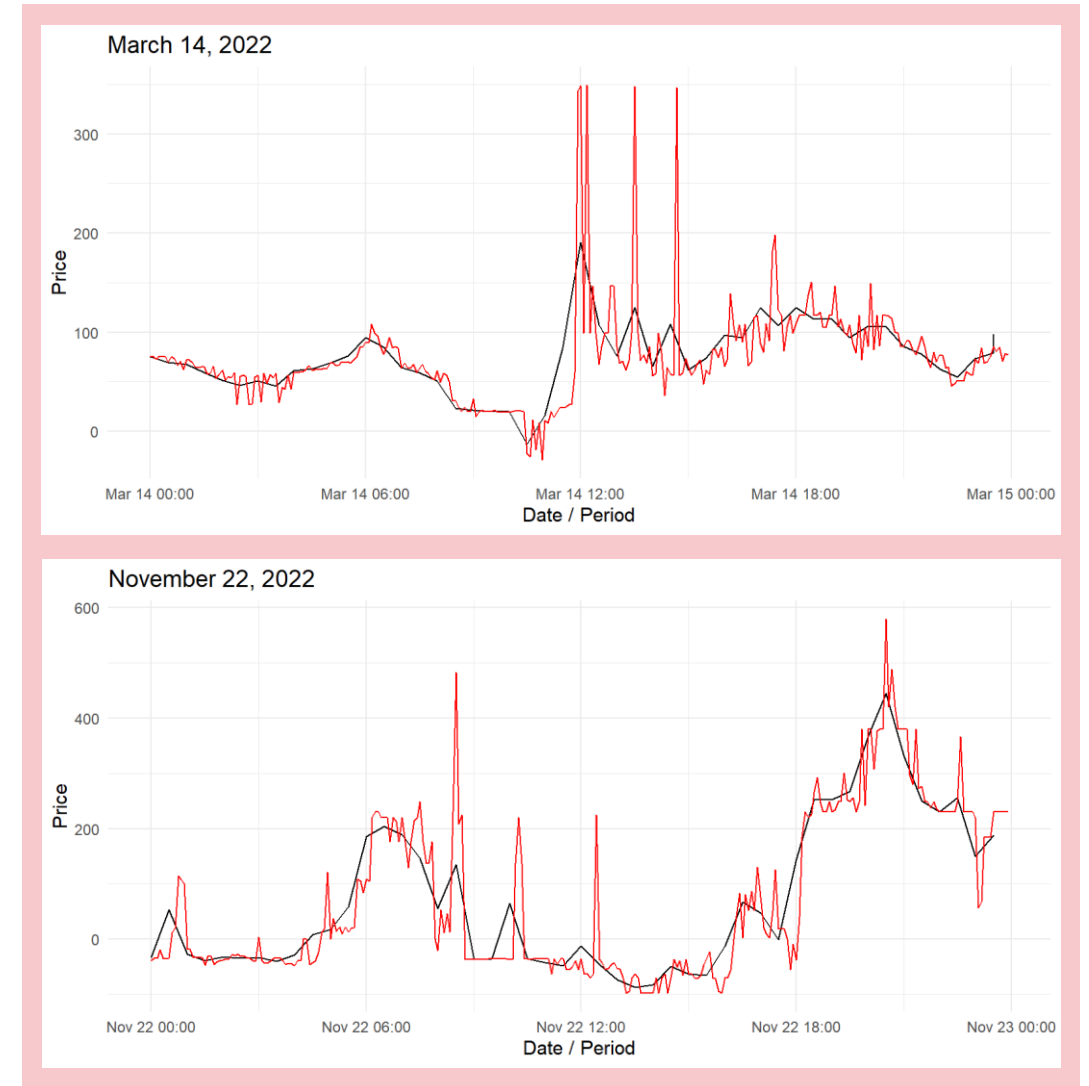
Forecast demand net of embedded generation – a weekly horizon



Prices in the NEM in 2022 (1/2)

Considerable volatility over short durations

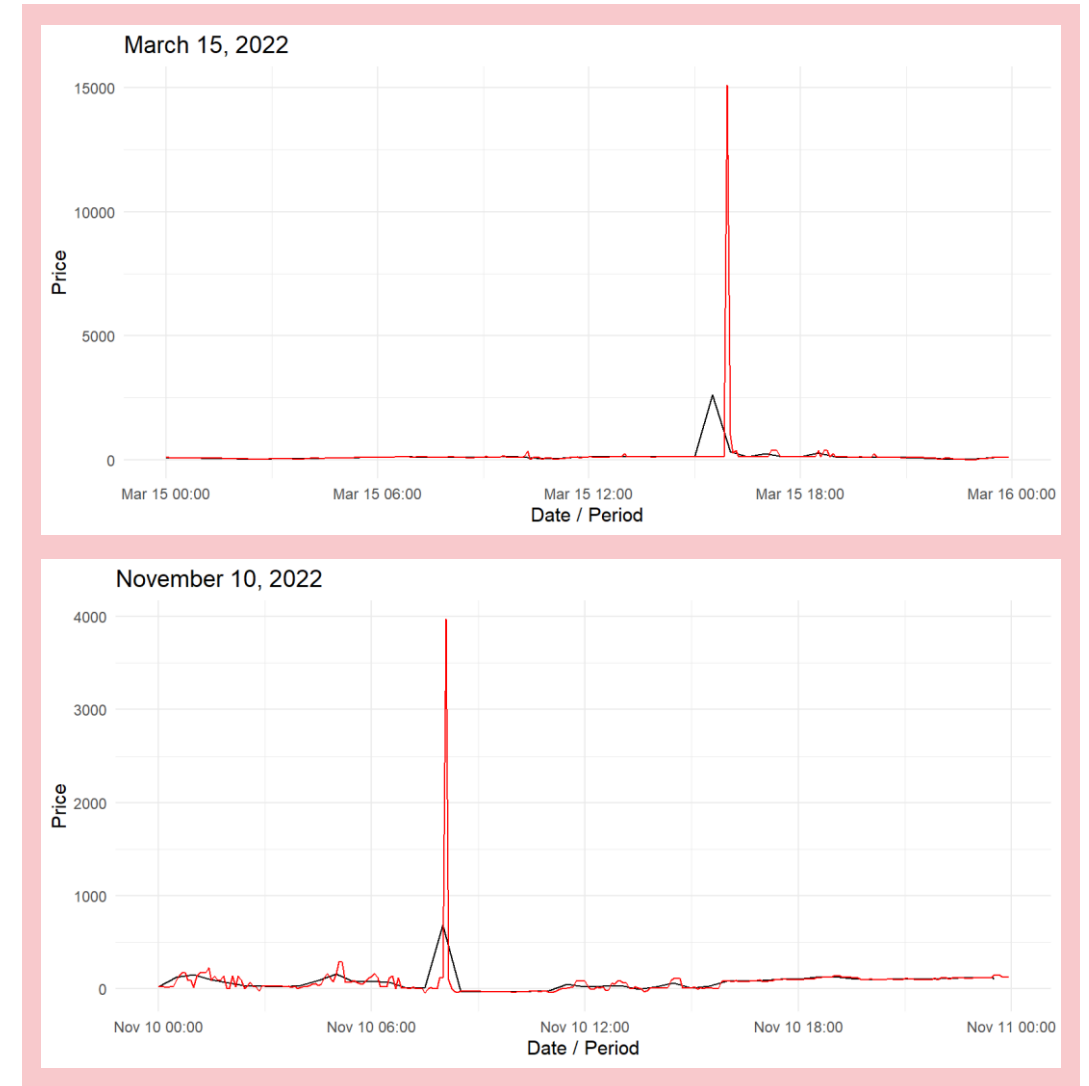
- To the right, the figures illustrate volatility in prices over entire days.
- On March 14 2022, prices jumped from ~\$25/MWh to over ~\$300/MWh, and then down to ~\$100/MWh within 20 minutes.
- On November 22 2022, prices jumped from over \$500/MWh to ~ – \$50/MWh within 20 minutes.
- This volatility can be met through flexible technologies and demand side participation.



Prices in the NEM in 2022 (2/2)

Short price spikes

- We also see days with very low volatility punctuated by single five-minute periods with extreme price spikes.
- Suppose there was a flexible demand agent, who offered to reduce consumption if the price exceeded \$10,000/MWh.
- On March 15, they would have been instructed to reduce load for 5 minutes.
- If 30-minute settlement were being used, the consumer who shed load would have saved about \$2,600/MWh for their load reduction, not the \$15,500/MWh which would have been avoided had 5-minute pricing been in effect.



Questions and discussion

Some considerations

- Flexible generators and load will benefit from responding to five-minute dispatch instructions, and generators and load that vary unpredictably will receive an average price lower than the TWAP for the period.
- If flexible supply and demand are not appropriately rewarded for the value they offer to the market, there may be weaker incentives to deploy these technologies.
- Will the benefits of transitioning to five-minute settlement for the wholesale market outweigh the costs?
- How much will the variability of five-minute prices increase, as the capacity of intermittent renewables increases?
- Can better short-term forecasting support the need for flexible generation and demand-side participation?
- What are the implications of short-duration volatility for existing frequency regulation services?
- Is the current approach of procuring reserves for a single trip risk adequate with increased intermittent renewable penetration?