SOLSTICE AI

One Year of Frequency Performance Payments:

Quantifying the Impact on Australian Solar Farms

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Executive Summary

Frequency Performance Payments (FPP) were introduced into Australia's National Electricity Market (NEM) on 8 June 2025 to improve system frequency performance through financial rewards and penalties. The reforms also fundamentally changed the way FCAS Regulation costs are allocated across market participants.

This report analyses the first year of FPP operation and quantifies its impact on utility-scale solar farms across the NEM between 8 June 2025 and 30 April 2026.

The results show that FPP has become a material component of frequency-related costs for solar farms and that the impact has been uneven across the sector. While average costs were relatively modest, some solar farms experienced considerably greater exposure than others, driven by a combination of weather conditions, market dynamics, and operational performance.

Key findings include:

- Solar farms accounted for 32.3% of all FPP penalties while producing only 8.7% of total NEM generation. This indicates that solar farms incurred a disproportionately large share of penalties under the new framework relative to their contribution to total energy production.
- Net FPP represented 35% of all frequency-related costs (FCAS Regulation plus FPP) incurred by solar farms. The introduction of FPP has therefore materially changed the composition of frequency-related costs faced by solar generators.
- Total frequency-related costs averaged $0.38/MWh generated, equivalent to 1.23% of wholesale market revenue. However, this average masks substantial variation between regions, across seasons, and between individual solar farms.
- Solar farms in New South Wales generally incurred the highest costs per MWh generated, while solar farms in South Australia incurred the lowest. These differences do not appear to be driven by FCAS Regulation prices, which are broadly consistent across the NEM, suggesting that local weather conditions play an important role.
- A significant portion of costs occurred outside daylight hours. Solar farms incurred approximately $1.47 million of overnight frequency-related costs, representing 22% of all FCAS and FPP costs during the period analysed.
- A small number of dispatch intervals accounted for a disproportionately large share of both wholesale market revenue and frequency-related costs. More than 12% of all solar farm wholesale revenue was earned during just 0.22% of intervals (17.5 hours of the year), while 19% of all FCAS and FPP costs occurred during only 4.4% of intervals (2 weeks of the year).

Several of the highest-cost events coincided with rapidly changing weather conditions, including sudden cloud formation and certain types of cloud patterns that caused significant deviations between actual and expected solar generation. These events demonstrate the strong relationship between weather-driven variability and frequency-related cost exposure.

The findings also suggest that operational decisions matter. Solar farms operating under similar weather conditions often experienced markedly different FPP outcomes, indicating that forecasting approaches, dispatch target tracking, plant controls, and bidding strategies can materially influence performance under the FPP framework.

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1. Introduction

On 8 June 2025, the Frequency Performance Payments (FPP) framework was introduced into Australia's National Electricity Market (NEM). The new framework was designed to improve power system frequency performance by creating financial incentives for market participants to reduce deviations from dispatch targets and disincentives for those that contribute to frequency disturbances.

The introduction of FPP represents one of the most significant changes to the market's frequency control arrangements in recent years. While the framework applies across the NEM, its impact on different generation types has varied considerably. For solar farm operators, there was concern that the new framework held the risk of increased exposure to frequency-related costs.

Despite considerable industry discussion surrounding FPP, there has so far been limited public analysis quantifying its impact on solar farms. Questions remain regarding the magnitude of FPP costs, how those costs vary between regions, the role of extreme price events, and the extent to which operational improvements such as more accurate forecasting may reduce exposure.

This report analyses the first year of FPP operation and examines its impact on utility-scale solar farms across the NEM. Using publicly available market data, it investigates the distribution of FPP costs and payments across the solar sector, explores differences between regions, and identifies the market conditions that drove the most significant outcomes.

The report also considers the broader implications of these findings for solar farm operators and highlights opportunities to improve performance under the FPP framework. While the primary focus is on understanding the first year of operation, the analysis also provides insight into how solar farms may adapt as the market continues to evolve.

2. Frequency Performance Payments: Background

Maintaining a stable system frequency is a fundamental requirement of operating an electricity grid. In Australia's National Electricity Market (NEM), the power system is designed to operate at a nominal frequency of 50 Hz. When generation and demand are balanced, frequency remains close to this target. However, unexpected changes in generation or demand can cause frequency to rise or fall, potentially affecting system security and reliability.

Historically, frequency deviations in the NEM were managed primarily through the Frequency Control Ancillary Services (FCAS) market. Under this framework, providers capable of adjusting their output in response to frequency deviations were paid to help maintain system stability. The costs of these services were then recovered from market participants through the Causer Pays framework.

As the generation mix has evolved, with increasing levels of inverter-based renewable generation and declining levels of synchronous generation, concerns emerged regarding the effectiveness of existing incentives to support good frequency performance. In response, the Australian Energy Market Commission (AEMC) developed the Frequency Performance Payments (FPP) framework, which commenced operation on 8 June 2025 [1].

The FPP reforms introduced two significant changes.

First, they introduced a new system of frequency performance payments. Market participants that contribute positively to frequency performance receive FPP rewards, while those that contribute negatively incur FPP penalties. This is a new pool of net-zero-sum rewards and penalties in which the total amount paid by “unhelpful” participants equals the total amount paid to “helpful” participants.

Second, the reforms changed how FCAS Regulation costs are allocated across the market. Previously, these costs were recovered through the Causer Pays framework. Under FPP, regulation FCAS costs are allocated using a new methodology that links cost recovery more directly to each participant's contribution to frequency performance.

Understanding the Cost Components

Throughout this report, frequency-related costs are grouped into six categories:

Quantity	Reward (+) or Cost (-)	Description
FPP Reward	+	Payments received by participants that improve frequency performance
FPP Penalty	-	Charges incurred by participants that worsen frequency performance
FCAS Raise – Used	-	Costs associated with raise regulation services that were actively used to correct frequency deviations
FCAS Lower – Used	-	Costs associated with lower regulation services that were actively used to correct frequency deviations
FCAS Raise – Unused	-	Costs associated with raise regulation services that were procured but ultimately not required
FCAS Lower – Unused	-	Costs associated with lower regulation services that were procured but ultimately not required

In some of the following figures it makes more sense to display “Net FPP”, which is simply the sum of FPP Rewards and FPP Penalties.

The distinction between "used" and "unused" services is important.

To maintain system security, AEMO procures regulation FCAS capacity ahead of time. Some of this capacity is subsequently activated to help correct frequency deviations. These costs are referred to in this report as **used regulation FCAS costs**.

However, not all procured regulation FCAS capacity is ultimately required. The cost of maintaining this available reserve capacity still needs to be recovered, even if it is never activated. These costs are referred to as **unused regulation FCAS costs**.

How FPP and FCAS Regulation Costs Work in Practice

A simplified view of how FPP and FCAS regulation costs are calculated and allocated is provided in Figure 1.

For each market interval (every 5 minutes), a solar farm operator submits bids and availability information. AEMO then determines a dispatch target, in MW, for the next interval using the NEMDE market engine. The solar farm's bids and availability information may be based on AEMO's solar forecasts (using ASEFS) or the operator's own forecast of expected generation.

AEMO runs NEMDE to determine the least-cost solution for dispatching generators and procuring FCAS services. FCAS regulation costs are determined through a market-based process using the merit order of FCAS bids, in a similar manner to wholesale electricity prices.

Within an interval, a solar farm generates according to local conditions, with an aim to achieve its dispatch target by the end of the interval. Throughout the interval, output is measured every 4 seconds. Deviations between actual and target output can either assist or oppose the actions required to maintain system frequency close to 50 Hz. A solar farm whose deviations tend to support frequency regulation will receive a positive contribution factor, while one whose deviations tend to increase regulation requirements will receive a negative contribution factor.

Following the interval, a solar farm's overall contribution to frequency regulation is assessed through its contribution factors. These contribution factors are calculated separately for each relevant regulation cost component, reflecting the solar farm's influence on system frequency performance.

The FCAS regulation costs allocated to a solar farm, and any FPP rewards or penalties it receives, are ultimately determined by both the cost of regulation services and the solar farm's contribution factors. Used FCAS regulation costs are allocated using instantaneous contribution factors that reflect performance during the interval, while unused FCAS regulation costs are allocated using longer-term average contribution factors.

It is important to note that both FCAS regulation costs and FPP rewards or penalties are influenced not only by the magnitude of a deviation, but also by prevailing system conditions, overall frequency performance, and the value of frequency regulation services at the time.

The introduction of FPP has therefore created both new incentives and new sources of financial exposure for market participants. Understanding how these costs and payments have been distributed during the framework's first year of operation is the focus of the remainder of this report.

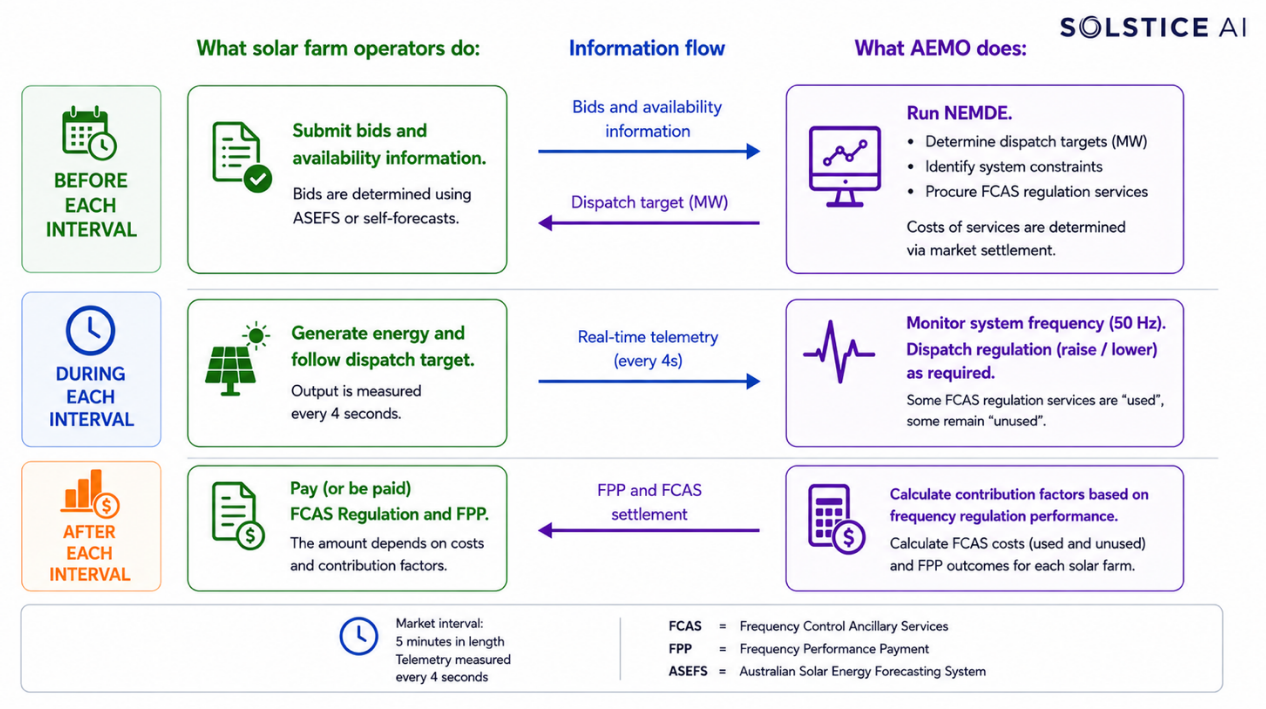

Figure 1: Simplified view of process for FCAS and FPP calculation and allocation

3. Impact on Solar Farms

The introduction of Frequency Performance Payments (FPP) has materially changed how frequency-related costs and payments are allocated across the National Electricity Market.

This section examines the impact on solar farms during the scheme's first year of operation. Unless otherwise stated, all results cover the period from 8 June 2025 (the commencement of FPP) to 30 April 2026 (the latest data available at the time of writing).

How Solar Compares to Other Generation Types for FPP

While the new FPP framework applies to all market participants, the impact was not evenly distributed between technologies. Figure 2 shows the breakdown by generation type. Solar farms accounted for 32.3% of all FPP penalties, despite contributing only 8.7% of total NEM generation over that period.

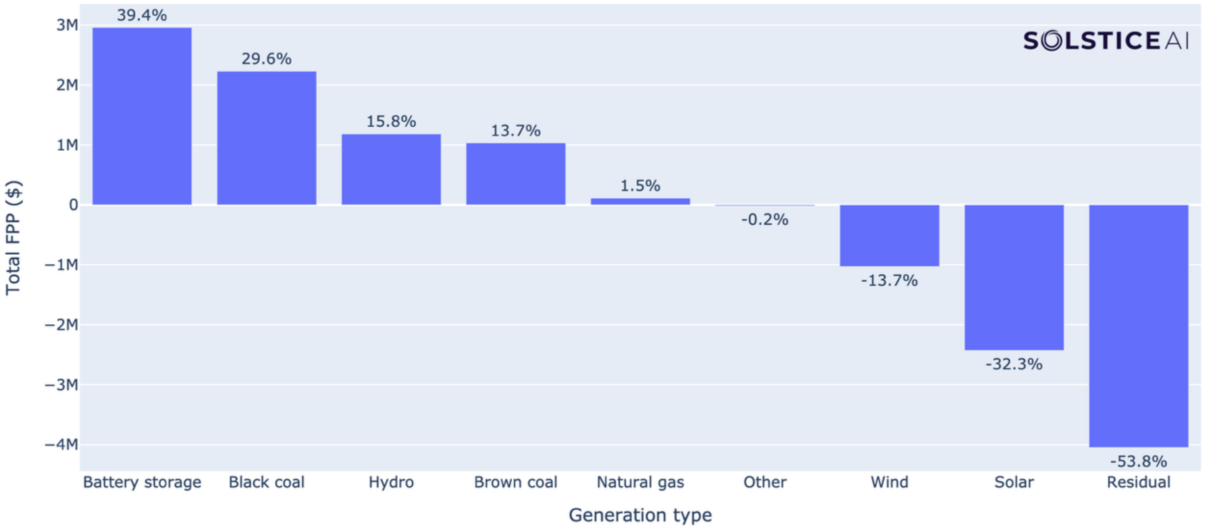

Figure 2: Total FPP rewards and penalties (percentages indicate % of total reward or penalty)[1]

While this appears to indicate an outsized penalty for solar farms, this is perhaps not entirely unexpected. Variable renewable generators are more exposed to deviations from dispatch targets during rapidly changing weather conditions, which can increase their contribution factors under the FPP framework. Controllable sources, on the other hand, have reduced risk of penalties and increased opportunity for rewards when stabilising frequency. Batteries, the most highly controllable of any of the resources, additionally have the opportunity to receive FPP rewards both while charging and discharging.

While Figure 2 shows total FPP rewards and penalties, each generation type provides significantly different amounts of generation. It is also helpful, therefore, to understand the FPP rewards and penalties per MWh for each technology – this is shown in Figure 3. As can be seen, battery storage obtains a high reward per MWh compared to other generation types, while solar incurs the largest penalty per MWh.

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[1] The category “Residual” represents all market participants that do not have 4-second SCADA metering capability. This includes residential and small commercial loads, rooftop solar PV, smaller distributed energy resources, and any other facilities without the real-time telemetry needed for an individual contribution factor calculation. The bulk of “Residual” is formed by end user consumption, i.e. retailers.

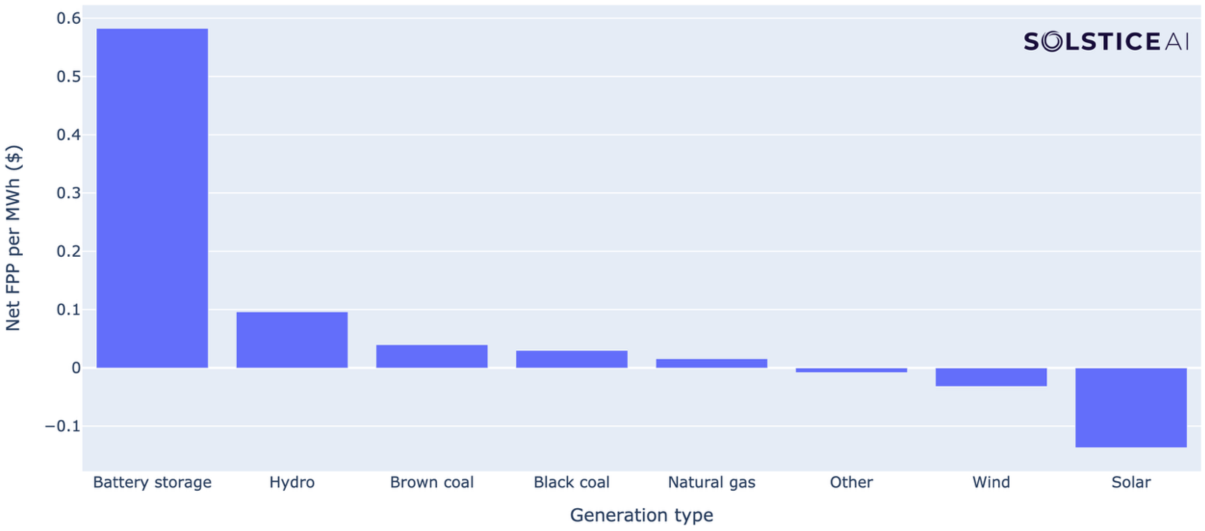

Figure 3: Net FPP per MWh generated or consumed[2]

Distribution Across Cost Components

Across all utility-scale solar farms analysed[3], total FPP penalties amounted to $7.49 million, offset by $5.06 million in FPP rewards, resulting in a net cost of $2.43 million. The total frequency-related costs (sum of FPP and FCAS Regulation) amounted to $6.58 million for the period studied (8-June-2025 to 30-April-2026). Extrapolating linearly to a full year of operation, that would equate to $7.34 million for the first year of FPP.

To place FPP costs in context, net FPP represented **35% of total FCAS Regulation and FPP costs incurred by solar farms** during the period analysed (Figure 4). The introduction of FPP therefore significantly altered the composition of frequency-related costs faced by solar generators.

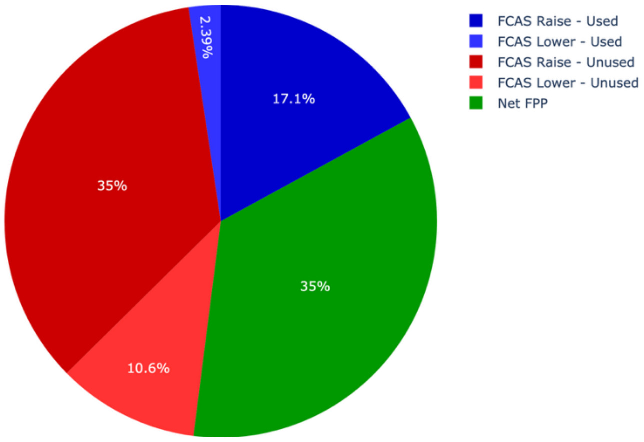

Figure 4: Cost components of FCAS and FPP for solar farms

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[2] Category "Battery storage" in Figure 3 includes penalties and rewards for both charging and discharging.

[3] A small number of solar farms were excluded from this analysis, since they were in a commissioning stage or part of an aggregated dispatch group – meaning that typical performance is not representative of a standard utility-scale solar farm. See Appendix A: Methodology for a list.

Distribution Across Months

Costs varied significantly month to month (Figure 5). Significantly higher costs in September to November 2025 were driven in part by higher FCAS regulation costs (Figure 6). Although average regulation raise costs in June look high, these are affected by a small number of intervals on 12 June when the price spiked for a short time, which had an overall small impact on total monthly FCAS regulation costs – this is discussed further in Section 5.

It is likely that variable weather during the months of September to November also contributed to solar farms deviating more from dispatch targets, leading to higher costs.

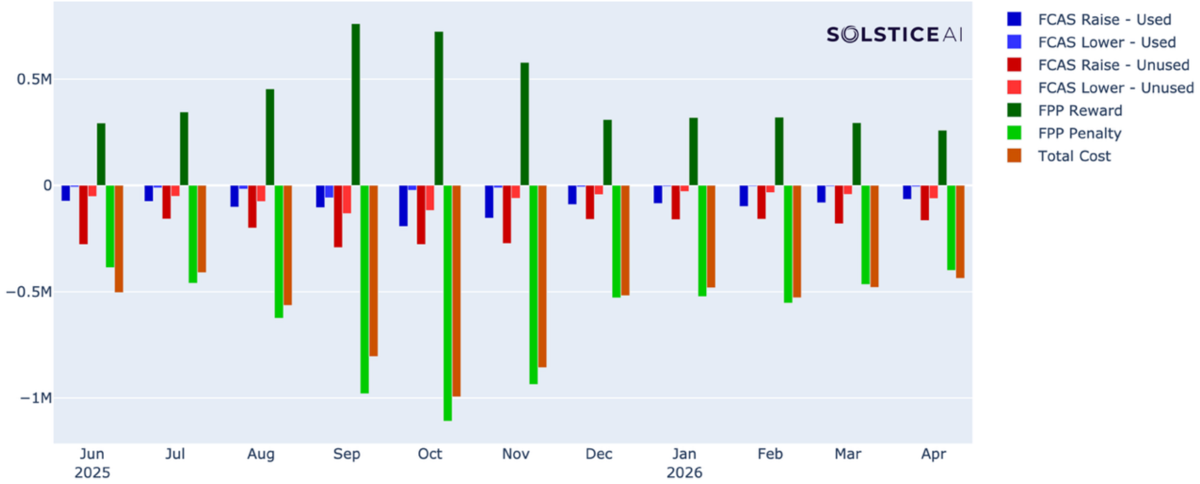


Figure 5: Distribution of cost components of FCAS and FPP across months of the year

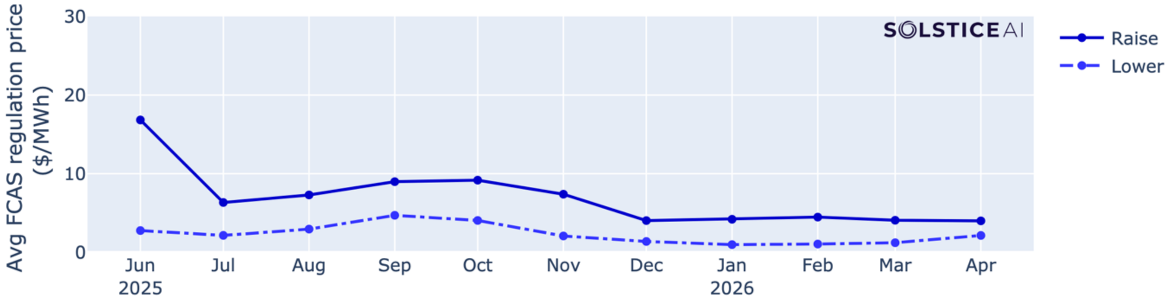


Figure 6: Average FCAS regulation prices (averaged across all regions)

Distribution Across Solar Farms

The total frequency-related costs for all solar farms, broken down by cost components, are shown in Figure 7 (each column represents one solar farm). The highest costs were incurred by Wellington North Solar Farm (AEMO export limit of 330MW), Western Downs Green Power Hub (400MW), and Wollar Solar Farm (280MW), in that order. This is not surprising given that they are all inside the top six largest solar farms in Australia, and therefore also generate the most.

At the other end of the spectrum, many small solar farms had very small costs. Bolivar Waste Water Treatment solar farm even managed to obtain a net reward of just over $5,000 across the year.

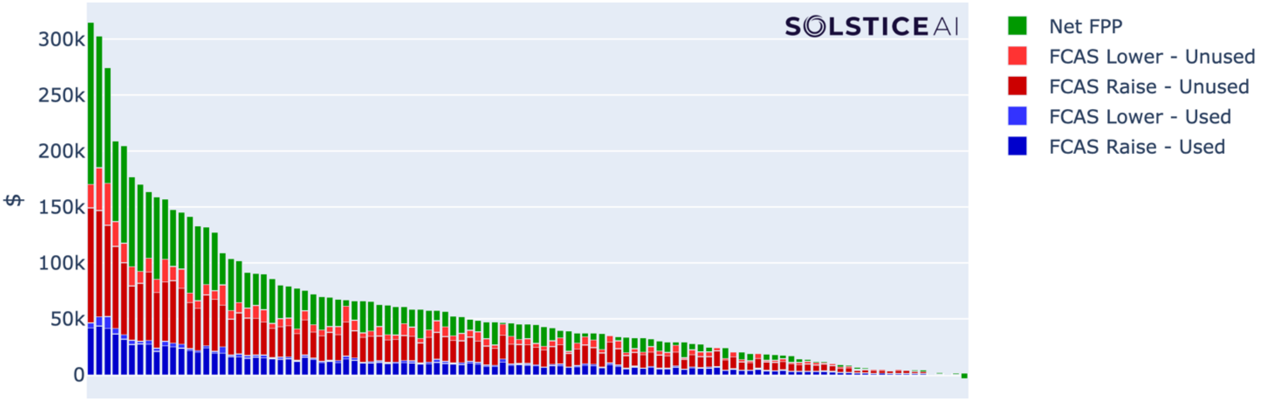


Figure 7: Total frequency-related costs for all solar farms

Frequency-Related Costs Relative to Generation or Wholesale Revenue

While Figure 7 provides a helpful view of the spread of costs across all solar farms, it is perhaps more insightful to explore frequency-related costs relative to other quantities.

Figure 8 shows total frequence-related costs per MWh generated for each solar farm, which averaged $0.38/MWh across all solar farms. The considerable variation from one solar farm to another suggests that local market conditions and operational performance played an important role.

In particular, solar farms in New South Wales appear to mostly (but not always) have incurred higher costs relative to generation volume, while solar farms in South Australia appear to mostly (but not always) incur lower costs. Local weather conditions (forecasting difficulty) and other operational factors likely played an important role – regional differences are further explored in Section 4.

If, on the other hand, we explore total costs as a percentage of wholesale revenue (Figure 9) then a different picture emerges. Across all solar farms analysed, total costs represented 1.23**%** of wholesale revenue. However, this average masks substantial variation between regions and between individual assets. For a subset of solar farms, FPP costs exceeded 2% of wholesale revenue, while for others the impact was comparatively minor. Solar farms in Victoria and Queensland had much higher relative costs than those in South Australia and New South Wales. This is likely driven by a small number of high price events during daytime hours in those states – the impact of extreme price intervals is further explored in Section 5.

Frequency-Related Costs Overnight

While solar farms do not generate during the night, as NEM market participants they still incur a share of unused FCAS regulation costs. The following analysis considers costs incurred by solar farms outside of daylight hours, using timing of sunrise and sunset specific to every individual solar farm.

It turns out that solar farms incurred overnight costs of $1.47 million – representing 22% of all frequency-related costs. A month by month breakdown is shown in Figure 10.

This may seem surprising, given that solar farms are presumably not participating in the market overnight. However, unused FCAS regulation costs are allocated using broader cost recovery mechanisms that apply to market participants irrespective of whether they are generating in a particular interval.

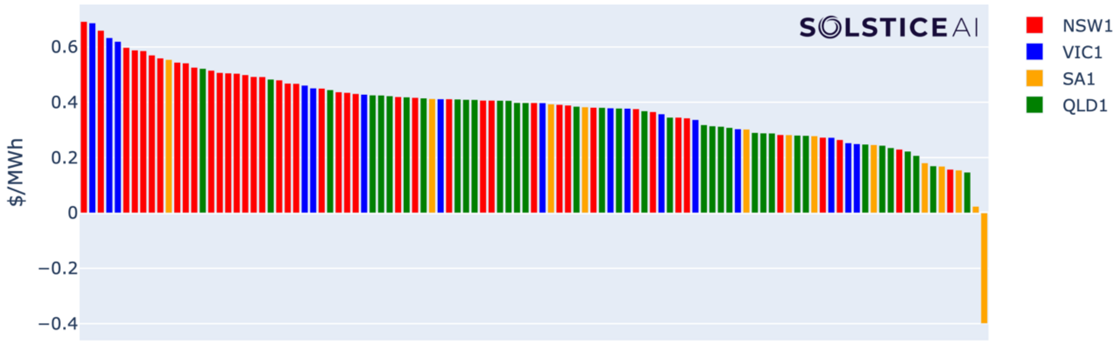


Figure 8: FCAS and FPP costs per MWh generated

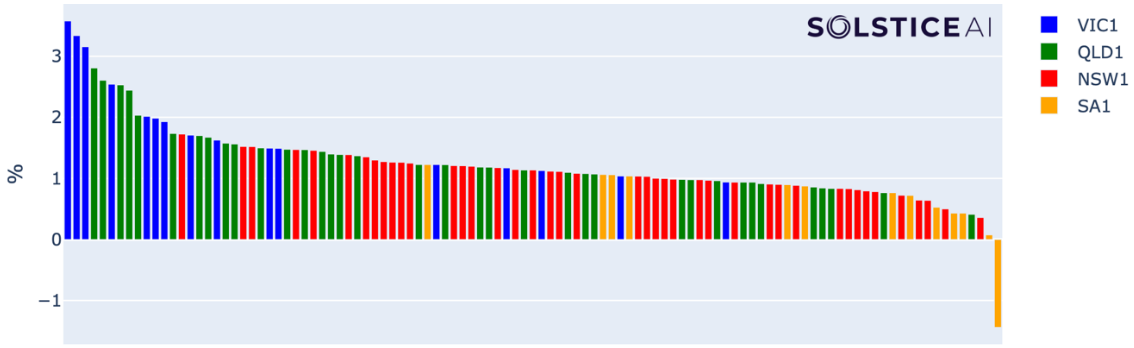


Figure 9: FCAS and FPP costs as percentage of wholesale revenue

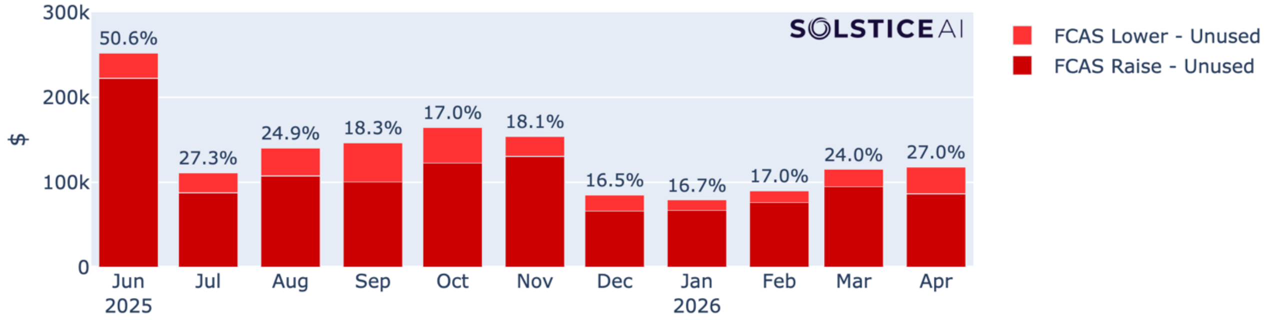


Figure 10: Cost of unused FCAS regulation overnight.
Percentage values indicate percent of total frequency-related costs (daytime plus nighttime).

4. Regional differences

The impact of Frequency Performance Payments varied considerably between market regions during the first year of operation.

Distribution Across Market Regions

Figure 11 shows the total FCAS and FPP costs broken down by market region. Over the period studied, solar farms in NSW had the highest total costs at $3.57M, while on the other end of the spectrum solar farms in SA had the lowest total costs at $219,000.

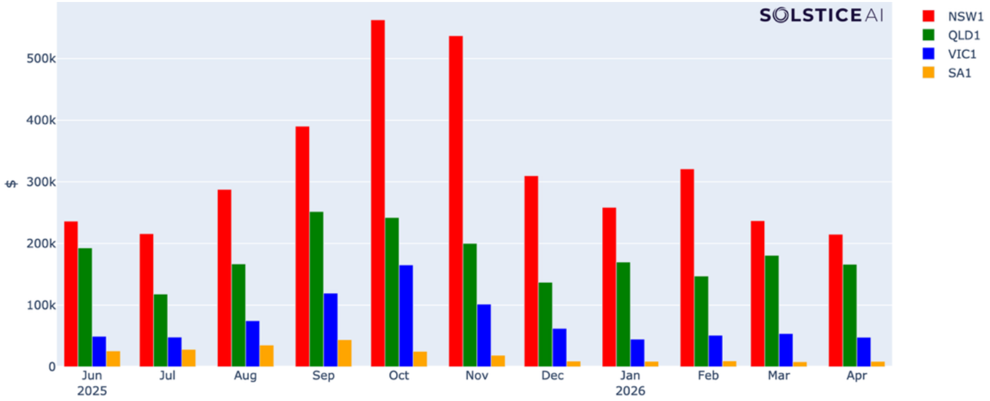


Figure 11: Total FCAS and FPP costs by market region

However, given that solar generation capacity varies significantly from one region to another, it is again more helpful to examine frequency-related costs relative to other quantities.

Frequency-Related Costs Relative to Generation

Figure 12 shows total frequency-related costs per MWh generated, month-by-month. Higher costs in the September to November period are partly the result of higher FCAS regulation prices, as previously shown in Figure 6.

State-by-state differences become clearer when considering the distribution for each region across all solar farms in that region, as shown in Figure 13. Solar farms in New South Wales had the highest median cost, while those in South Australia had the lowest median cost (but the largest spread). This is further confirmed by a geospatial view in Figure 14.

One might consider that this is at least partly related to differences in regulation prices from state to state. However, unlike wholesale prices, FCAS regulation prices are almost identical across all states, since the vast majority of the time they relate to global NEM requirements.

One likely explanation, therefore, is differences in local weather variability. More variable weather conditions in New South Wales and Victoria may make it harder for solar farms to accurately follow their dispatch targets, while comparatively more predictable weather in Queensland and South Australia may make it easier. Parts of New South Wales, in particular, may be more prone to sudden cloud-driven impacts on solar generation that are hard to predict.

Another factor contributing to this variability across states may be operational decisions by the solar farm operators themselves.

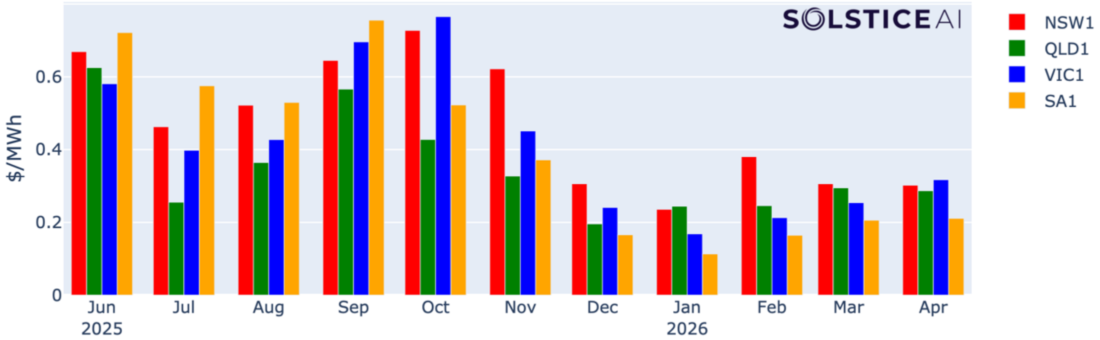


Figure 12: Total FCAS and FPP costs per MWh generated, by month

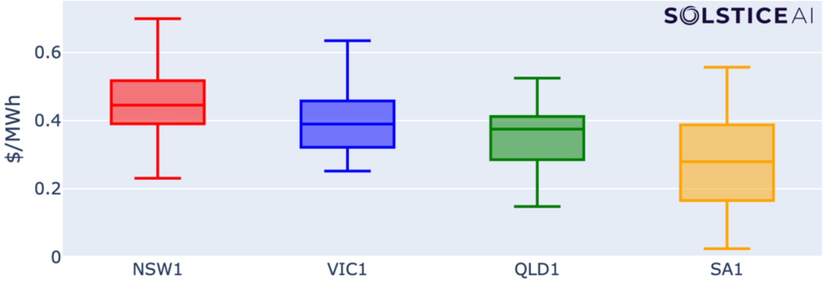


Figure 13: Total FCAS and FPP costs per MWh generated, showing distribution across all solar farms for each region

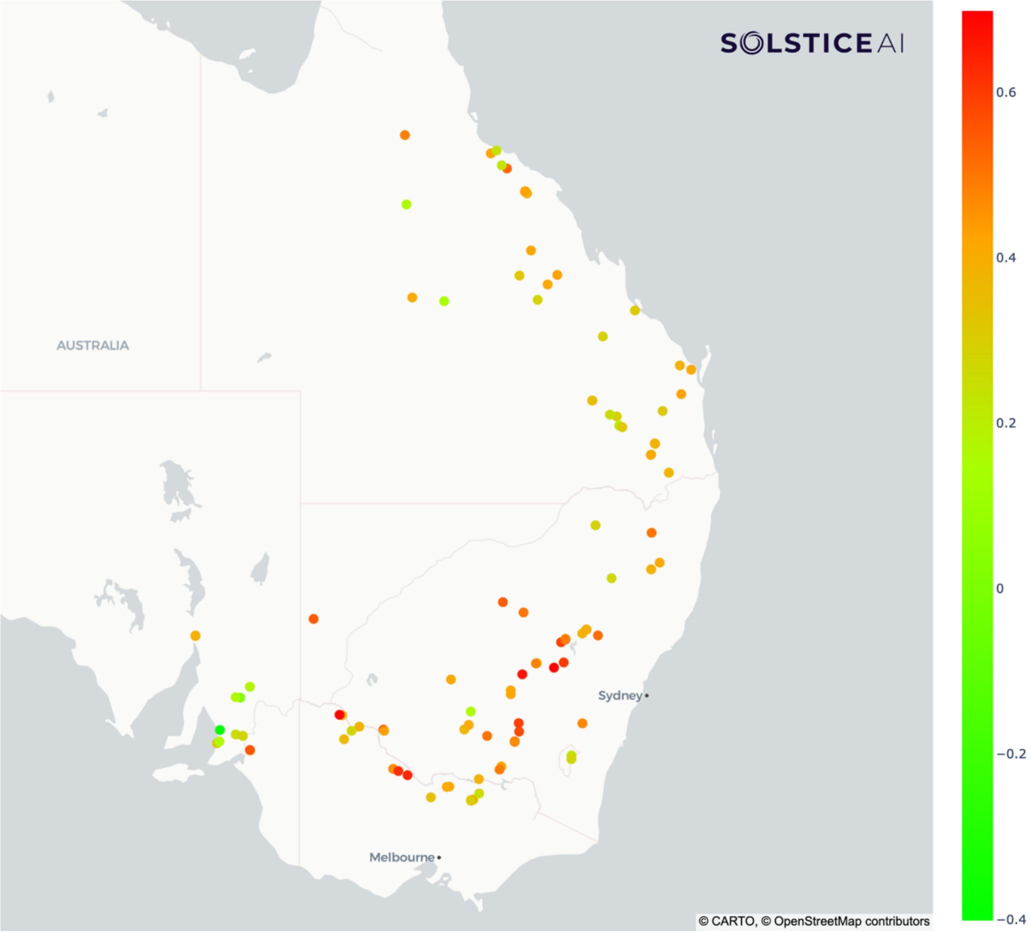


Figure 14: Geospatial view of total FCAS and FPP costs per MWh generated

Frequency-Related Costs Relative to Wholesale Revenue

Figure 15 shows total frequency-related costs relative to wholesale revenue. Two bars stand out in particular:

- In September 2025, solar farms in Queensland appear to have had extraordinarily high costs relative to wholesale revenue. However, the reason for this is in fact low revenue, rather than high costs – see Figure 16. In this month, low (and negative) prices occurred during a large number of daytime intervals, as well as significant negative price spikes on three consecutive days from Sep 28-30.

- In November 2025, solar farms in Victoria had overall negative costs relative to wholesale revenue – but this is due to a net negative wholesale revenue for solar farms across the state during this month, see again Figure 16. This is discussed further in Section 5.

In general, care must be taken not to draw the wrong conclusions when exploring frequency-related costs relative to wholesale revenue since:

- Typically only a small percentage of a solar farm's revenue stack is exposed to wholesale prices
- Wholesale prices are extremely spiky and sometimes a very small percentage of intervals define revenue across a whole month – as is discussed further in Section 5.

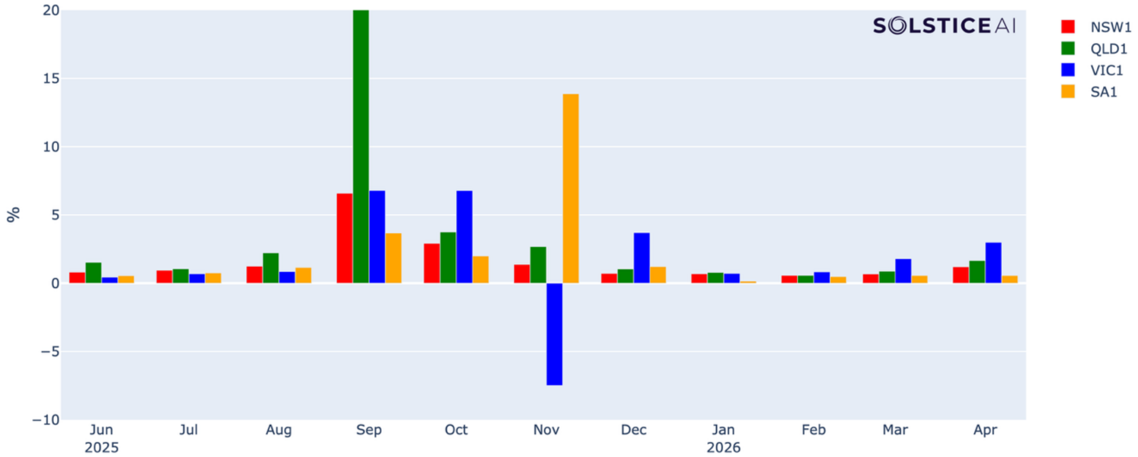


Figure 15: Total FCAS and FPP costs as a percentage of wholesale revenue

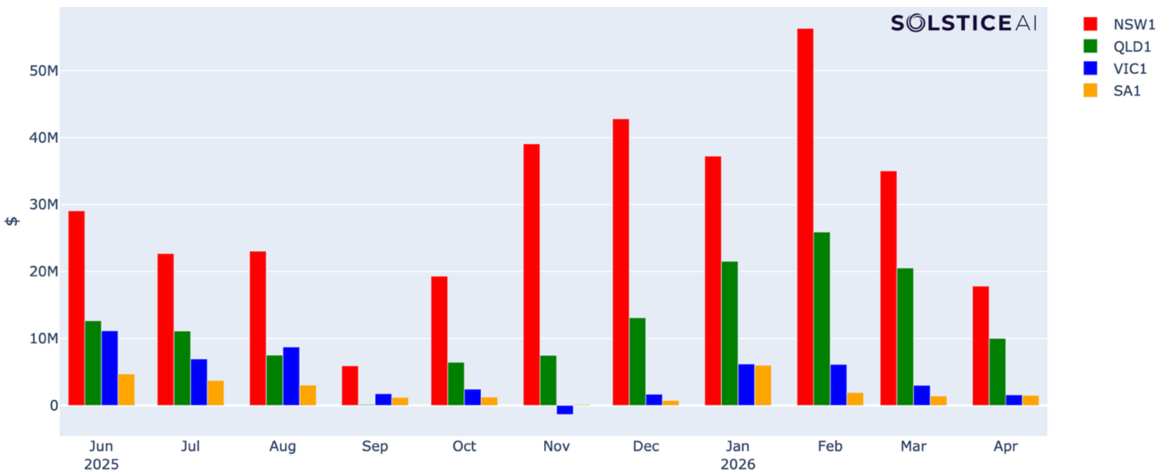


Figure 16: Total solar farm wholesale market revenue

Frequency-Related Costs Relative to Renewable Energy Penetration

It is also instructive to explore if there is a relationship between frequency-related costs and uptake of renewables. A common assumption may be that regions with higher renewable penetration are at risk of experiencing higher frequency regulation costs due to more unexpected fluctuations in generation. However, the period studied does not support that hypothesis, as shown in Figure 17. South Australia, with the highest renewable energy penetration, in fact experienced the lowest frequency-related costs per MWh generated.

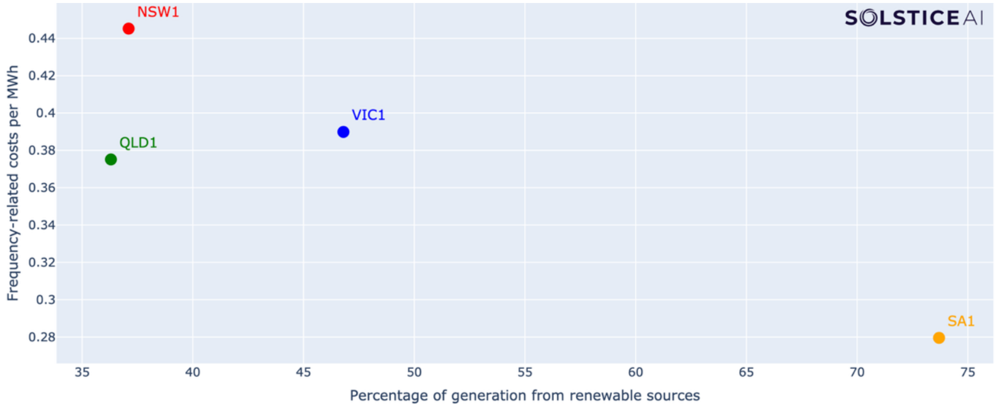


Figure 17: Frequency-related costs relative to renewable energy penetration

5. The Outsized Importance of Extreme Price Intervals

Although the NEM contains more than 105,000 five-minute dispatch intervals each year, a tiny fraction of these intervals accounted for a disproportionately large share of wholesale revenue, as well as FCAS and FPP costs. This section provides an overview of extreme price intervals and explores in detail several specific intervals and days that had an outsized impact.

The General Relationship Between Wholesale Prices and FCAS Regulation Prices

Figure 18 shows monthly spot and FCAS regulation prices (top). Spot prices vary significantly by state. FCAS regulation prices are typically almost identical from one state to another, so only the average across all states is shown. On a monthly basis, FCAS regulation prices seem to broadly (though not exactly) follow the same trends as wholesale spot prices, with June having the highest costs for both wholesale and regulation raise prices.

The relationship becomes a bit more interesting when digging deeper into individual months and days. The middle of Figure 18 zooms in to show how prices evolve throughout a month, while the bottom of Figure 18 shows how they evolve throughout one specific day, 12 June 2025. As can be seen, FCAS regulation costs sometimes spike when wholesale costs spike, but not always. (12 June 2025 was a particularly interesting day and is further discussed in a separate section below.)

In general, there is only a weak relationship between NEM spot prices and FCAS regulation prices. Some impacts might cause them both to rise and fall simultaneously, for example: large generator outages, interconnector constraints, or periods of rapid renewable energy ramps. However, other impacts might cause them both to move in opposite directions. For example, a sunny spring day may lead to low or negative spot prices due to solar over-supply, while also leading to higher FCAS regulation prices to properly manage frequency. For solar farms, such situations may lead to relatively high regulation cost exposure during periods when energy revenues are low.

Exploring most extreme events

The intervals having highest total revenue across all solar farms are shown in Figure 19, while the intervals having highest total costs are shown in Figure 20.

Intervals that led to high spot revenue are dominated by conditions in New South Wales. The primary reason for this is the number of high spot price intervals during daytime hours, as shown in Table 1.

Region	Intervals with RRP > $5,000	Of those, intervals within 8:00-16:00
NSW1	123	21
QLD1	44	0
SA1	168	5
VIC1	85	1

Table 1: Number of high spot price intervals for each market region

Intervals that led to high FCAS and FPP prices are dominated by the high FCAS regulation prices resulting from the unique conditions of 12 June 2025. This is discussed further below.

Notably, for solar farms, high revenue intervals do not coincide with high cost intervals. Within the top 100 revenue intervals, and the top 100 cost intervals, there is not a single overlap – confirming the weak relationship between spot prices and FCAS regulation prices for solar.

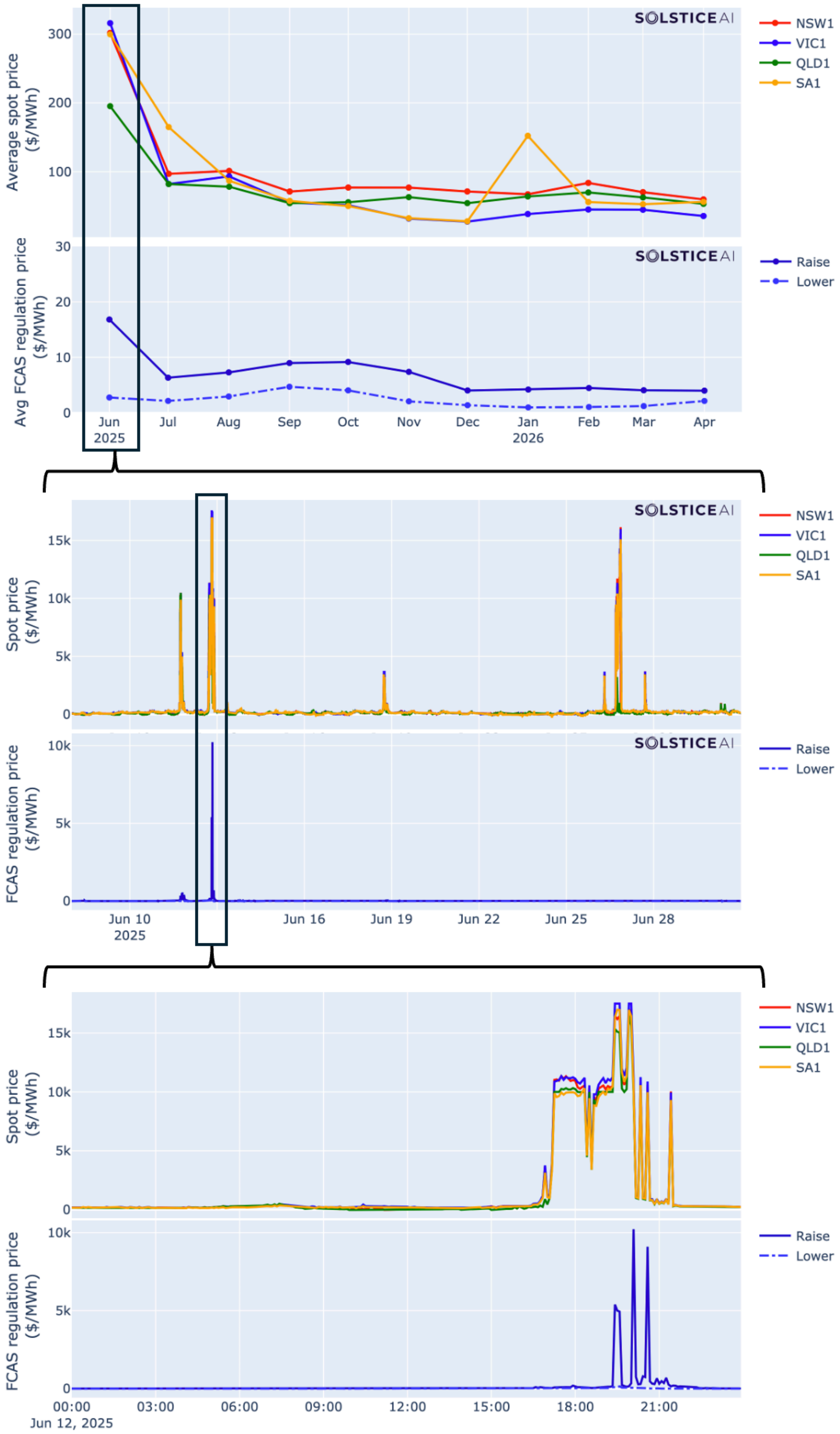


Figure 18: Spot prices and FCAS Regulation prices at different timescales

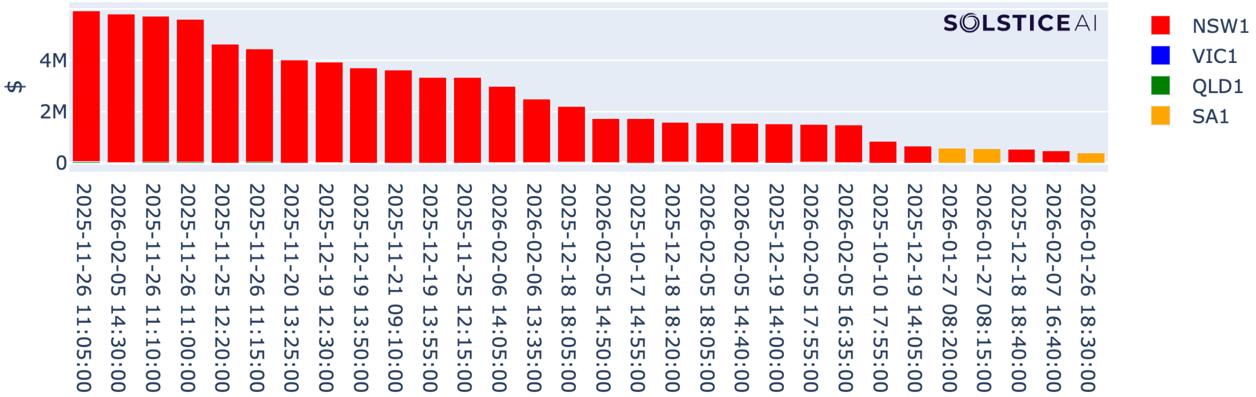


Figure 19: Intervals that led to highest spot revenue for solar farms

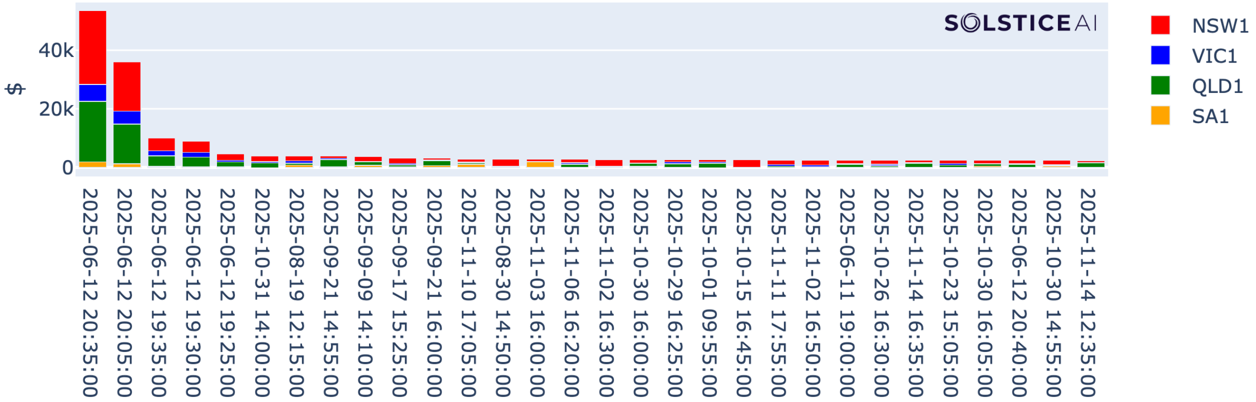


Figure 20: Intervals that led to highest FCAS and FPP costs for solar farms

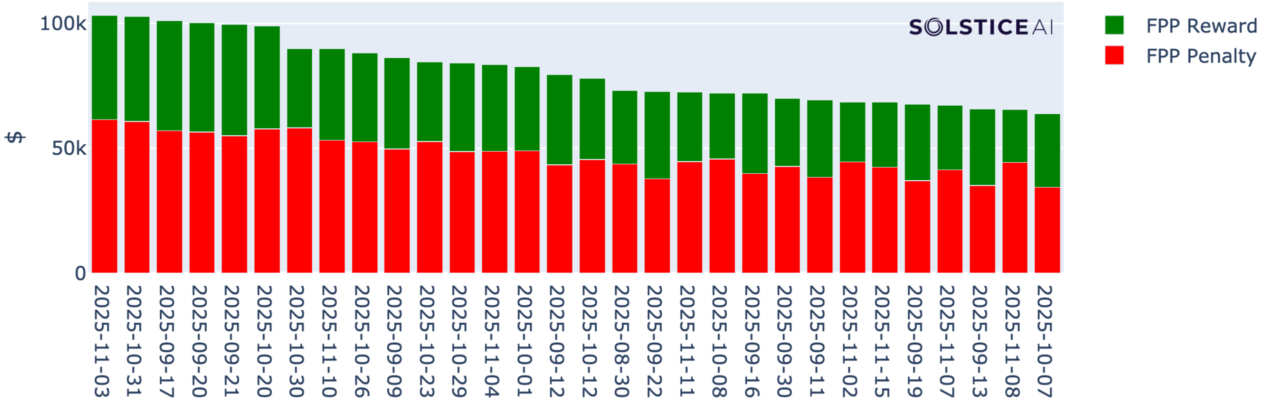


Figure 21: Days having the highest total amount of FPP transferred (sum of rewards and penalties)

Figure 21 shows an ordered listing of the days having the highest total amount of FPP transferred to and from solar farms. This figure shows FPP only, and does not include any FCAS regulation costs. What clearly stands out is that the top 30 intervals all occur between 30-Aug and 15-Nov. The likely explanation is that during this time – late spring across Australia – seasonal weather conditions include rapid cloud development, thunderstorms, convective cloud fields, and fast ramps in solar output. Those are exactly the kinds of conditions that can cause large deviations between dispatch targets and actual generation.

To understand the drivers behind the most extreme price intervals, it is helpful to dig into some of the more extreme events more deeply. Although a complete analysis of price spikes is beyond the scope of this report, some analysis of a few key days and months helps to better understand the impact of FCAS and FPP on solar farms.

12 June 2025: Highest FCAS Regulation Prices

12 June 2025 is considered one of the most extreme days in the history of the National Electricity Market (NEM) [2]. A combination of very cold weather, high demand, coal generator outages, and a significant reduction in wind generation across the NEM caused wholesale electricity prices to surge simultaneously in every mainland region. Spot prices briefly exceeded $15,000/MWh in all five NEM regions, approaching the market price cap. According to AEMO's Quarterly Energy Dynamics report: "12 June 2025 recorded the highest daily NEM-wide price since market start." [3]

This unique set of circumstances happened to occur just four days after the commencement of the new Frequency Performance Payments regime. As it turned out, 11-June and 12-June were the only days over the entire period studied here (8-June-2025 to 30 April 2026) on which FCAS regulation prices exceeded $150/MWh, and in one interval (12-June 20:05) even exceeded $10,000 (see Figure 18).

Why were FCAS regulation prices so high, considering the earlier analysis which concluded that the correlation between spot price and FCAS regulation is low? The reason is likely that the combined high prices across the entire NEM meant that resources across all market regions which normally provide cheap regulation FCAS may already have been heavily utilised for energy production to take advantage of high spot prices. The remaining FCAS providers therefore set much higher FCAS prices.

When analysing impact of FCAS and FPP, days like this may skew results. The earlier discussed average prices in Figure 6 are heavily influenced by this single, rare day, which should not be considered the norm for June.

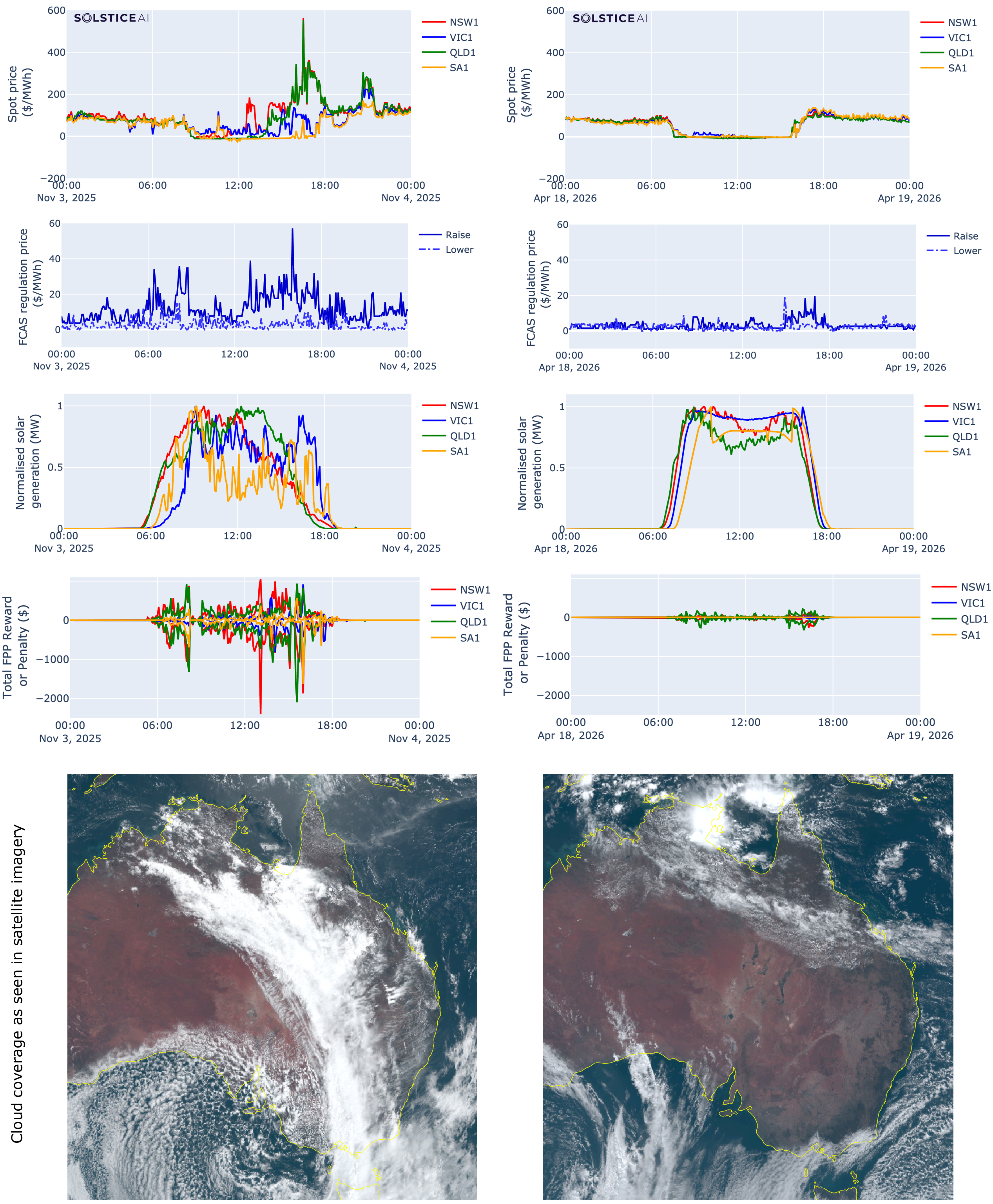
3 November 2025 vs 18 April 2026: Highest Total FPP vs Lowest Total FPP

3 November 2025 had the highest amount of total FPP penalties and rewards for solar farms, while 18 April 2026 had among the lowest. It is helpful, therefore, to compare the two side by side, to better understand what factors are most likely to lead to high FPP values.

Figure 22 shows side-by-side for both days: spot price, average FCAS regulation price, normalised solar generation, total FPP rewards and penalties, and cloud conditions over the NEM, as seen in satellite imagery. The main driver for the significant differences across both days appears to have been the cloud cover over south-eastern Australia, where most solar farms exist.

On 18 April 2026, cloud-free skies led to highly predictable solar output, leading to stable frequency, and low regulation and spot prices.

On 3 November 2025, on the other hand, much of south-eastern Australia was covered by cloud – partly thick cloud cover, and partly patchy, which leads to even higher ramp rates and unpredictability for solar generation. This led to highly variable solar output, likely driving up FCAS requirements, resulting in higher FPP and FCAS costs. Wholesale prices in NSW1 and QLD1 in reached high levels later in the day, presumably due in part to cloud conditions over the course of the day.



3 November 2025
High levels of FPP rewards and penalties

18 April 2026
Low levels of FPP rewards and penalties

2025-11-03 12:00 AEST

2026-04-18 12:00 AEST

Figure 22: Comparison of days having high FPP values and low FPP values

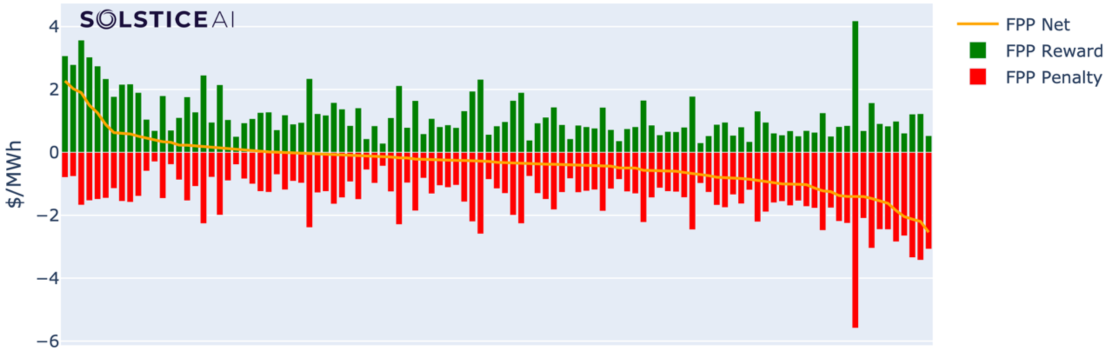


Figure 23: Impact of 3-Nov-2025 (high FPP day) across all solar farms

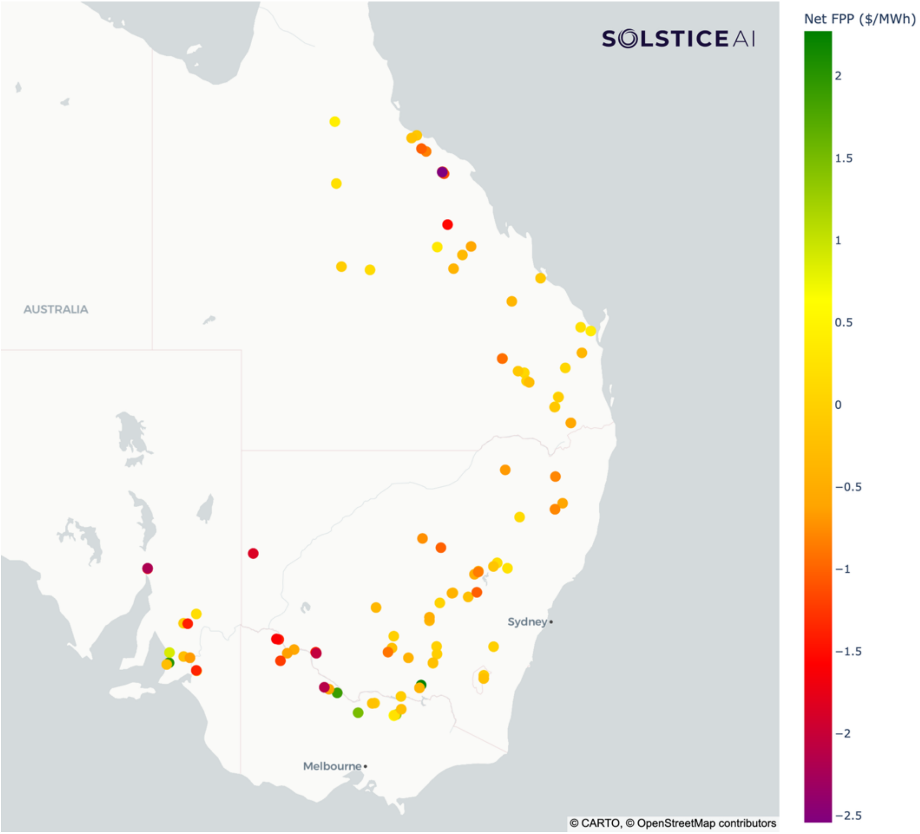


Figure 24: Geospatial distribution of net FPP on 3-Nov-2025

It is also worth exploring how individual solar farms fared on 3-November, given the amount of FPP transferred – this is shown in Figure 23. There is a very wide spread across all solar farms, with some actually having a net benefit of over $2/MWh across the day, while others had a net penalty of more than $2/MWh. A geospatial representation in shown in Figure 24.

Of particular note is that in some cases solar farms very close to one another had vastly different FPP outcomes, despite having been subject to very similar weather conditions and cloud cover. This suggests that operational decisions, too, have a big impact on how different solar farms fare when it comes to FPP, particularly on volatile days.

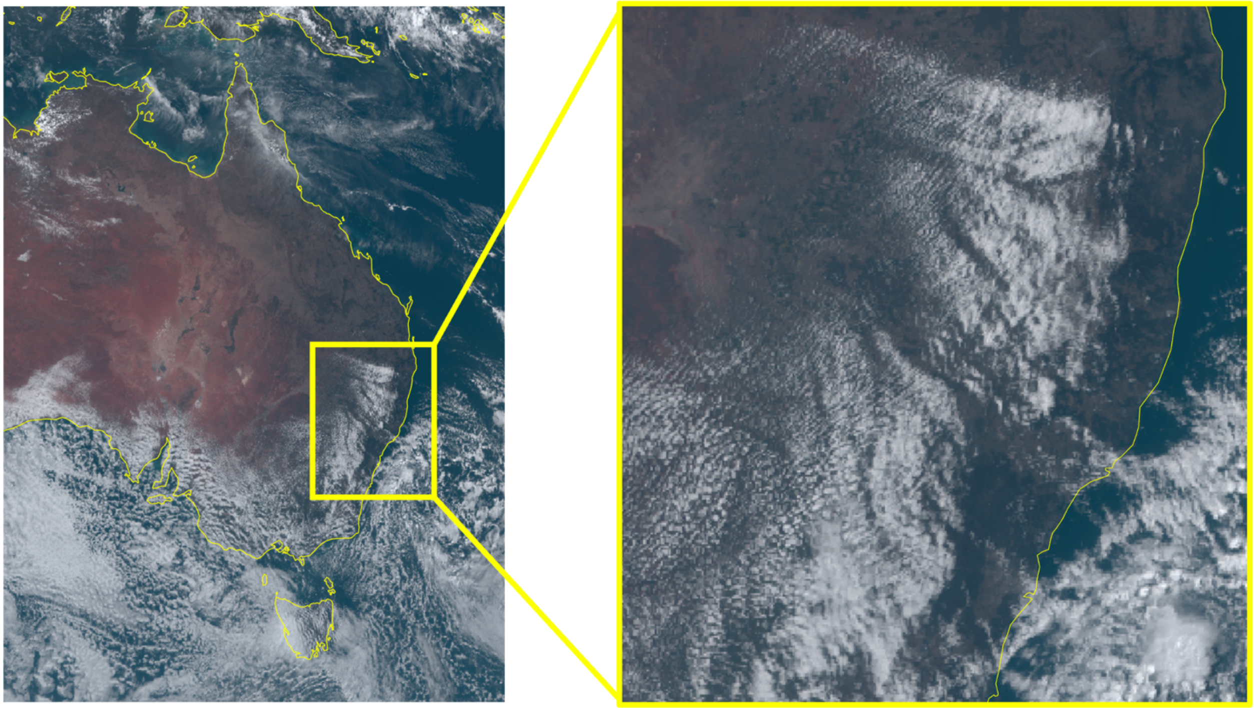


Figure 25: Cloud conditions on 30 August 2025 led to high FPP values

30 August 2025: Specific Cloud Conditions Lead to High FPP for NSW and QLD

While 3 November 2025 represented the day of highest FPP costs across the NEM, 30 August 2025 is also worth exploring: on this day, many solar farms in northeast New South Wales and southern Queensland had particularly high FPP values for parts of the day. Figure 25 shows cloud cover over the region during that time.

The zoomed-out view of eastern Australia already shows patchy cloud cover for the region, but the zoomed-in view of this specific area is of particular interest. On this day, long, stripe-like bands of low cloud (sometimes referred to as “cloud streets”) extended across eastern Australia. These conditions make it particularly difficult to forecast output (and set a dispatch target), and also make it particularly difficult to follow a steady trajectory to achieve a dispatch target. Cloud conditions such as these are therefore likely to be one of the biggest drivers of FPP (both rewards, and penalties) for solar farms.

November 2025: High Negative Prices Lead to Net-Negative Spot Revenue in Victoria

It was previously noted in Section 4 that across the whole month of November 2025, solar farms in Victoria recorded a net negative wholesale revenue. This was driven by consistently negative spot prices during daytime intervals throughout the month, with an example sequence shown in Figure 26.

It should be noted that this does not necessarily mean that solar farms themselves had negative revenue, since often only a small percentage of solar farm revenue is exposed to wholesale prices (with the rest subject to other contractual agreements). However, these dynamics do play into long-term solar farm economics and future contracting arrangements.

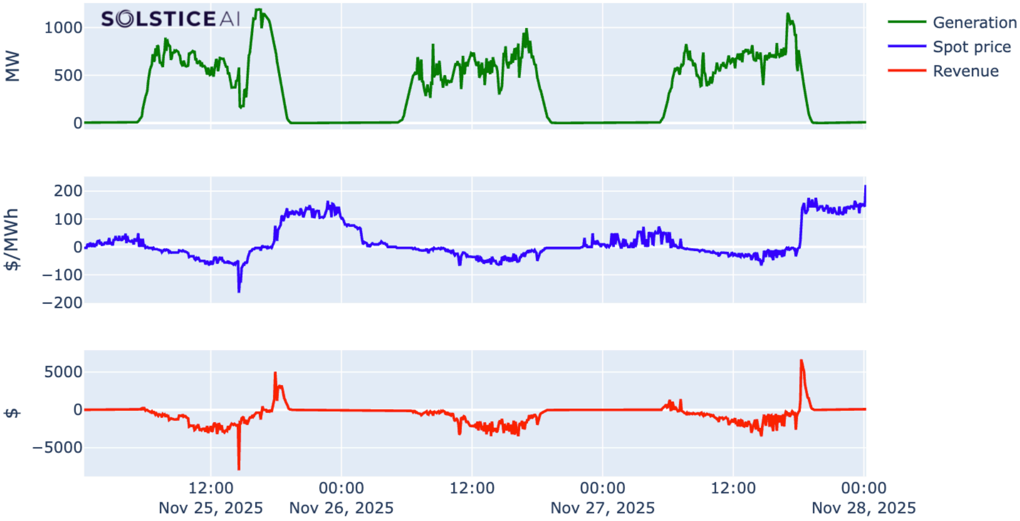
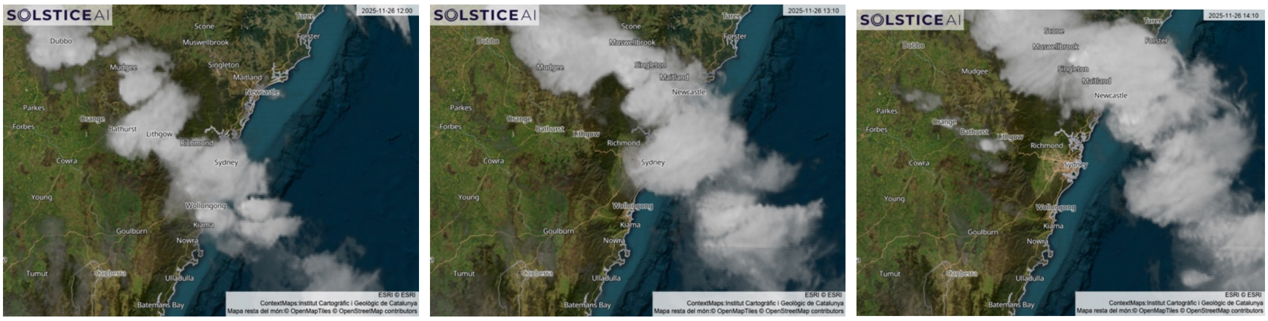


Figure 26: Consistent negative prices in Victoria in November 2025 led to net negative spot revenue for the month



11:10 12:10 13:10

Figure 27: Cloud cover over Sydney before, during, and after a series of price spikes on 26-Nov-2025

26 November 2025: Sudden Cloud Cover Over Sydney Leads to Price Spikes

On two subsequent days in November, wholesale prices repeatedly spiked in New South Wales. On 26 November in particular, the spot price hit the market cap ($20,300/MWh) for four consecutive intervals before falling to nearly the market floor (-$1,000/MWh) one hour later [4]. Thunderstorm cloud cover caused a sharp reduction in both rooftop and utility-scale solar generation, effectively increasing operational demand at a time when temperatures were high and air-conditioning load remained strong. At the same time, transmission constraints limited access to lower-cost generation from elsewhere in the NEM, requiring more expensive local generators to set the market price.

Figure 27 shows cloud cover over Sydney before, during, and after the spot price hit the market cap. A thick band of cloud rapidly formed and significantly reduced rooftop solar PV output across the region. This type of fast-forming cloud cover can be very hard to predict, and subsequently was one of the major contributors to price volatility on this day.

Accurately forecasting events like this can be highly valuable for solar farms, as it enables operators to anticipate periods of extreme market volatility, optimise bidding and battery charging strategies, and maximise revenue during rare intervals when electricity prices reach exceptionally high levels.

Quantifying the Impact of Extreme Intervals

It's helpful to understand exactly how much impact extreme intervals have.

- **High spot price intervals:**
  Within the dataset, there were 210 intervals where the spot price exceeded $5,000/MWh in any of the market regions. 210 intervals represent 0.22% of the total dataset – a tiny fraction, equivalent to 17.5 hours in total. However, these intervals were responsible for 12.17% of all solar farm spot revenue.

- **High FCAS price intervals:**
  We can similarly analyse intervals where the FCAS regulation price (raise or lower) exceeded $20/MWh. There were 4131 such intervals, representing 4.39% of the dataset (2 weeks of the year). These intervals alone accounted for 19.29%, in other words almost a fifth, of all FCAS and FPP costs.

- **Days with high FCAS and FPP costs:**
  The single day of highest costs (12 June 2025) represents only 0.3% of the period studied, but was responsible for 2.1% of all costs.
  If we take the 10 days of highest costs, these represent 3.0% of the period studied, but were responsible for 8.4% of costs.

6. Key Conclusions for Solar Farm Operators

The first year of Frequency Performance Payments has demonstrated that frequency-related costs are now a material consideration for solar farm operators.

While average costs were modest relative to wholesale market revenue, the impact was far from uniform. Costs varied significantly between regions, between individual solar farms, and across different periods of the year. Solar farms accounted for a disproportionately large share of FPP penalties relative to their contribution to total NEM generation, confirming that solar farm operators are particularly impacted by the new framework.

Key Observations

Several key observations emerge from the analysis:

FPP is now a significant component of frequency-related costs.
Net FPP represented approximately 35% of all FCAS Regulation and FPP costs incurred by solar farms.

Extreme intervals matter more than average conditions.
A relatively small number of dispatch intervals had an outsized impact on both wholesale revenue and frequency-related costs. Understanding and preparing for these rare but consequential events may be more valuable than optimising for average operating conditions alone.

Location matters.
Solar farms in New South Wales generally incurred higher frequency-related costs per MWh generated than those in other regions, while solar farms in South Australia generally incurred the lowest. Local weather conditions and local impacts on cloud formation and patterns are likely the largest driver for this.

Operational decisions have a large impact.
The large spread in costs between otherwise similar solar farms indicates that site-specific operational decisions significantly influence exposure to frequency-related costs. Differences in dispatch target tracking, plant control systems, bidding strategies, and forecasting approaches may all contribute to observed outcomes.

Forecasting accuracy is likely to become increasingly valuable.
Many of the highest-cost events were associated with rapidly changing weather conditions. Improved short-term forecasting may help operators better anticipate these events, improve dispatch target tracking, reduce frequency-related costs, and better position battery assets to respond to periods of extreme market volatility.

Outlook

A main driver of FCAS and FPP costs are FCAS regulation prices. These have varied significantly over the history of the NEM, but appear to be broadly trending downward over the past several years [5]. This is partly due to the increasing emergence of batteries as FCAS Regulation providers [6]. Since there is a large pipeline of utility-scale energy storage expected to be deployed in the coming years, it seems likely that FCAS regulation costs will continue to stay low.

On the other hand, extreme intervals can have a disproportionate impact on cost and revenue for the year. These are often driven by unique operating conditions that increasingly result from unexpected and extreme weather occurrences. In this context, accurate forecasts that have a high resolution (both in terms of time, and geospatially), are likely to become increasingly important – for both individual solar farm operational decisions, and to better forecast market-wide impacts.

For solar farms with co-located battery storage, these challenges and opportunities become even more significant. Operational decisions increasingly need to account not only for the next dispatch interval, but for market conditions over the coming hours and days. Given that more than 12% of annual solar farm spot revenue was earned in less than 18 hours of the year, the ability to anticipate and prepare for rare but high-impact events is likely to become an increasingly important source of competitive advantage.

Acknowledgements

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About Solstice AI

Julian de Hoog

This report was authored by Dr. Julian de Hoog, Cofounder and CEO of Solstice AI Pty Ltd, and Honorary Research Fellow at the University of Melbourne.

Solstice AI is an Australian technology company building the intelligence layer for a solar-dominated energy system. Headquartered in Melbourne, Australia, the company combines expertise in artificial intelligence, energy systems, and large-scale software engineering to deliver high-accuracy solar generation forecasts across utility-scale assets, distributed rooftop PV, and for entire regions.

The Solstice AI platform fuses multi-spectral satellite imagery, real-time device telemetry, and advanced machine-learning models that learn region-specific cloud formation and movement. This hybrid approach provides superior short-term forecasting accuracy compared to traditional numerical weather prediction methods — enabling better bidding decisions, improved VPP performance, and more stable grid operation.

Every solar farm is affected differently by Frequency Performance Payments. Solstice AI can help you understand your site's exposure and evaluate how improved forecasting could reduce costs and improve market outcomes. Contact us at info@solstice-ai.com.

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Appendix A: Methodology

All data used to generate the findings and figures in this report was extracted from AEMO's publicly available NEMweb database [7]. The method for determining each solar farm's FCAS and FPP costs is described in AEMO's Frequency Performance Payments (FPP) – Factor Calculation Guide [8].

At the time of this report's writing, data was available for the period 8 June 2025 to 30 April 2026.

Data was retrieved as follows:

- FPP contribution factors were retrieved from the table FPP_CONTRIBUTION_FACTOR
- Constraint data was retrieved from the table DISPATCH_FCAS_REQ_CONSTRAINT
- RCR and usage values were retrieved from the table SET_FCAS_REGULATION_TRK

Following the guidance in AEMO's documents, used FCAS regulation costs in each interval are calculated as follows:

TA = aggregate(TSFCAS x U x NCF) for all binding constraints

Where:
TA: Total amount
TSFCAS: Regulation service adjusted cost to be recovered
U: Usage factor
NCF: Negative contribution factor for that constraint and unit

Unused FCAS regulation costs in each interval are calculated as follows:

TA = aggregate(TSFCAS x (1-U) x DCF) for all binding constraints

Where:
TA: Total amount
TSFCAS: Regulation service adjusted cost to be recovered
U: Usage factor
DCF: Default contribution factor for that constraint and unit

Finally, FPP rewards and penalties are calculated as follows:

TA = aggregate(CF x P_{reg} / 12 x RCR) for all binding constraints

Where:
TA: total amount
CF: contribution factor (between -1 and 1) – unique to unit and constraint
P_{reg}: Adjusted marginal value or price of this constraint
RCR: Requirement for corrective response

For aggregate solar calculations, all generation sources listed as having a fuel source of "Solar" in AEMO's NEM Registration and Exemption list [9] were included.

For individual solar farm calculations and diagrams, 23 solar farms were excluded. These were in a commissioning stage or part of an aggregated dispatch group – meaning that typical performance was not representative of a standard utility-scale solar farm. The DUIDs of excluded solar farms were the following:

BRDDSF01, ADPPV3, SKSF1, CRWARP1, MULWASF1, MBPS2PV1, ADPPV2, QPSFB1, PAREPS1, GESF1, BAKING1, QPSFB2, MUCRKSF1, CESF1, BUSF1, NASF1, GOESF1, CBWWPV1, GUSF1, VALDORA1, KEPSF1, LANCSF1, CBWWPV2.