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Wholesale Price Forecasts for Calculating Minimum Feed-In Tariff

Final Report for the Essential Services Commission | 14 February 2023

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Executive Summary

The ESC is required under the Electricity Industry Act 2000 (Vic) to determine one or more minimum rates to be paid by electricity retailers to customers who feed-in surplus renewable energy generation into the grid. The ESC is currently determining these rates for 2023/24.

As part of its determination of the FiT rates for 2023/24, the ESC has engaged Frontier Economics to project Victorian wholesale energy prices for 2023/24.

We have produced half-hourly forecasts over 2023/24 based on historical wholesale prices and ASXEnergy prices (which reflect future expectations of wholesale prices), and we present averages of these forecasts over:

- The entire annual forecast period
- Separately for day, early evening and overnight times during the forecast period and peak, shoulder and off-peak periods during the forecast period.

We also calculate solar export-weighted averages of our half hourly forecasts over the same periods.

These averages will be used to inform the ESC's 2023/24 determination of the minimum flat-rate and time-varying FiT rates.

Summary of results

We have summarised the results of our wholesale electricity price forecasts below. Two sets of results are presented:

- Projected *quarterly* average spot prices for 2023/24. These are based on ASXEnergy contract prices (adjusted to remove a 5 per cent contract premium)[1] using trade-weighted averaging over 12 months.
- Projected *annual* average spot prices, and day, early evening and overnight average spot prices, for 2023/24. These averages are presented both unweighted and weighted by solar PV exports.

[1] The price of ASXEnergy contracts is the price at which the future price of electricity can be 'locked in' today. So, for instance, a price for a Q1 2024 contract of $50/MWh would enable a market participant to 'lock in' that electricity price of $50/MWh for Q1 2024. The price of ASXEnergy contracts is related to expectations of what spot electricity prices will be in Q1 2024: if the market expects higher spot electricity prices in Q1 2024 we would expect the price of a futures contract for Q1 2024 to increase; if the market expects lower spot electricity prices in Q1 2024 we would expect the price of a futures contract for Q1 2024 to decrease. However, because the futures contract provides certainty (that is, it enables the future price to be 'locked in') retailers are generally prepared to pay a premium for the futures contract. What this means is that the ASXEnergy contract price will trade at a premium to the expected spot price. While this contract premium cannot be directly observed, our econometric analysis suggests that the contract premium is 5 per cent. What this means is that if market participants expect that the spot price will be $50/MWh for Q1 2024, market participants would be prepared to pay $52.50 for a contract to 'lock in' a price for Q1 2024 today. Therefore, to infer expectations of future spot prices from ASXEnergy contract prices we remove a 5 per cent contract premium from contract prices.

Projected quarterly average spot prices for 2023/24

To produce our forecasts, we first calculate the projected average price level for each quarter in the forecast period. These are based on the 12-month trade-weighted price of quarterly ASXEnergy base swap contracts (less a contract premium).

These projected quarterly average spot prices are presented **Table 1**.

Table 1: Projected average prices for 2023/24, using **trade-weighted** ASXEnergy contract prices (after removing 5 per cent contract premium) ($2023/24)

Calendar quarter	12 month average ($/MWh)
Q3 2023	$134.67
Q4 2023	$68.52
Q1 2024	$82.35
Q2 2024	$94.89

Average half-hourly prices in 2023/24

We use the projected quarterly average spot prices for 2023/24 presented in **Table 1**, and historical half-hourly prices for 2021/22, to develop forecasts of half-hourly spot prices for 2023/24.

The average of these half-hourly price forecasts for 2023/24 is presented in **Table 2** and **Table 3**, providing a flat annual average price, as well as prices for the various time periods for each of time-varying rate 1 and time-varying rate 2.

The results in **Table 2** and **Table 3** are both based on:

- trade-weighted ASXEnergy prices for 2023/24 (as presented in **Table 1**)
- a **12 month** trade-weighted average of ASXEnergy prices
- historical half-hourly prices for 2021/22.

Table 2 provides average half-hourly prices that do not take into account solar export data (that is, the half-hourly prices are time-weighted averages, or simple averages).

Table 2: Summary of half-hourly spot prices for 2023/24 (based on historical quarters Q3 2021 to Q2 2022), unweighted by solar exports ($2023/24)

Rate type		Average spot price (c/kWh)
Flat rate		9.49
Time-varying rate 1	Early evening	15.94
	Day	7.05
	Overnight	9.31
Time-varying rate 2	Peak	16.35
	Shoulder	8.81
	Off-peak	3.48

In contrast, **Table 3** provides average half-hourly prices that are weighted by solar exports in each half hour interval. These solar export-weighted prices are based on solar export data for 2021/22 for each distribution network service provider (DNSP), which was provided by the ESC.[2]

Table 3: Summary of half-hourly spot prices for 2023/24 (based on historical quarters Q3 2021 to Q2 2022), solar export-weighted ($2023/24)

Rate type		Export-weighted average spot price (c/kWh)
Flat rate		2.13
Time-varying rate 1	Early evening	6.28
	Day	1.62
	Overnight	8.19
Time-varying rate 2	Peak	7.46
	Shoulder	2.73
	Off-peak	1.13

Key factors responsible for lower solar export-weighted price forecasts

While our methodology has remained unchanged since we last advised the ESC on the FiT, we have updated our inputs to reflect more recent market data (including historical spot prices and historical exports for 2021/22) and the most recent market expectations with respect to wholesale electricity prices in 2023/24. These expectations are reflected in the latest ASXEnergy contract prices.[3]

The result of this updated information is that the flat-rate, solar export-weighted price for 2023/24 is 2.13 c/kWh, whereas the equivalent rate from our final report published in January (January 2022 report) for the 2022/23 FiT was 2.48 c/kWh. There are two key factors that drive changes in this flat-rate, solar export-weighted price:

2 Solar-weighting adjusts the unweighted wholesale price forecast to reflect the average value of electricity at exporting times rather than the average value of electricity at all times. Given the minimum FiT applies to exported electricity (which is predominantly solar), in our view solar-weighted wholesale price forecasts are more appropriate for use in determining minimum FiT rates.

3 Expectations of future spot prices, and hence contract prices, reflect market participants' understanding of future demand and supply conditions in the electricity market and how these will affect prices (e.g. information on generation investment, power plant closures, costs of different fuels etc.).

- Changes in the projected *average price* in each quarter (which is based on ASXEnergy base swap prices).
- Changes in the correlation between projected half-hourly prices and solar exports (which is based on the historical correlation between half-hourly prices and solar exports in 2021/22).

Changes in projected *average prices*

The average ASXEnergy prices used in this report have changed relative to our January 2022 report for the 2022/23 FiT. Compared with the ASXEnergy prices used for our January 2022 report for the 2022/23 FiT, ASXEnergy prices are significantly higher during all quarters.

The contract prices in the January 2022 report and this final report are compared in **Table 4**.

Table 4: Comparison of projected average prices based on ASXEnergy contract prices (after removing 5 per cent contract premium) ($2023/24)[4]

Period	Average projected price ($/MWh) – 2022/2023	Average projected price ($/MWh) – 2023/2024
Q3	$46.18	$134.67
Q4	$35.80	$68.52
Q1	$54.66	$82.35
Q2	$41.44	$94.89

If ASXEnergy prices were the only driver of the FiT, the difference in contract prices shown in **Table 4** then the FiT for 2023/24 would be higher than the FiT for 2022/23. However, the correlation between half-hourly prices and solar exports is also an important driver of the FiT.

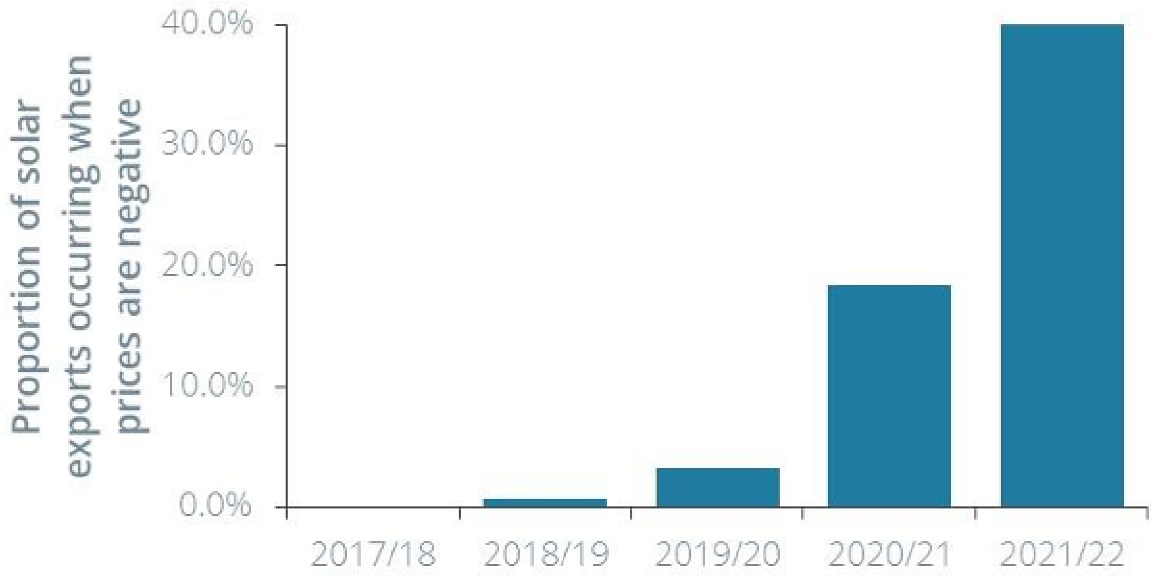
Changes in the correlation between projected half-hourly prices and solar exports

The correlation between projected half-hourly prices and solar exports has changed significantly over recent years, with spot prices tending to be much lower on average during the day when solar exports are occurring, and negative spot prices also tending to occur much more often when solar exports are occurring.

An indication of this is seen in **Figure 1**, which shows the proportion of total solar exports that have occurred at times when spot prices are negative. In 2017/18 and 2018/19 less than 1 percent of total solar exports occurred when spot prices are negative, but by 2021/22 – the historical year that is used for the 2023/24 FiT – this had increased to 41% of total solar exports occurring when spot prices are negative.

4 Projected 2021/22 prices from previous final report are escalated at an assumed CPI of 2.0% to put into $2022/23.

Figure 1: Proportion of solar exports occurring when prices are negative



Source: Frontier Economics analysis

It is because of these changing patterns of prices – spot prices tending to be lower during times of solar exports, and instances of negative prices increasing during times of solar exports – that the estimated solar export-weighted FiT has fallen from 2022/23 to 2023/24, even though the expected *average* price level (as indicated by contract prices) has increased from 2022/23 to 2023/24.

1 Introduction

Frontier Economics has been engaged to advise the Essential Services Commission (ESC) on wholesale price forecasts for the purpose of calculating a Feed-in Tariff (FiT).

1.1 Background

The ESC is required under the Electricity Industry Act 2000 (Vic) to determine one or more rates to be paid by electricity retailers to customers who feed-in renewable energy generation into the grid. In financial years 2018/19, through 2022/23 the ESC has published two minimum FiT rates:

- A flat-rate FiT
- A time-varying FiT (with day, early evening and overnight rates).

The ESC has engaged Frontier Economics to project Victorian wholesale electricity prices for 2023/24, to inform its determination of the FiT rates for 2023/24. This report details our approach, considerations, methodology and results.

Frontier Economics previously advised the ESC on Victorian wholesale electricity prices for 2019/20 through 2022/23 to inform the ESC's determination of FiT rates for those years.[5] The methodology that we have adopted for this final report is the same as we used previously.

1.2 Our approach

The value of small scale renewable energy fed into the grid is a function of wholesale spot prices for energy at the times of those exports. Therefore, it is necessary to develop a forecast of half-hourly prices that are appropriately correlated to forecasts of half-hourly solar PV exports in the relevant period. We achieve this by using historical half-hourly prices as the starting point for forecasting prices, and ensuring we select half-hourly prices from the same time period as that for which we have solar export data.

Preferably, we select for our starting point historical half-hourly prices that are from the same period as the *most recent* solar export data. Our view is that, generally speaking, more recent prices would be expected to better reflect future demand and supply conditions. However, as a precautionary measure, we analyse historical half-hourly prices to assess whether the half-hourly prices coinciding with the most recent solar export data seem to reflect any 'abnormal' outcomes that would not be expected to recur.

We then scale the selected historical half-hourly Victorian spot prices for energy to an estimate of the average spot price for 2023/24. The price at which a quarterly base swap for Victoria trades on ASXEnergy is generally taken to reflect the market's expectation of the average electricity spot price for Victoria for the relevant quarter (after adjusting for the implied contract premium). In our analysis we make use of forward contract prices for the FiT period (2023/24) from ASXEnergy. This scaling shifts the average of the historical half-hourly spot prices to reflect the contract price,

5 See, for example: Frontier Economics, *Wholesale Price Forecasts for Calculating Minimum Feed-in Tariff*, Final Report for the Essential Services Commission, 27 January 2022.

without altering the underlying pattern of half-hourly spot prices. In this way, the relationship between exports and price is maintained.

1.3 Best practice

The approach used in this report is consistent with what we consider to be best practice and reflects the approach that we have previously adopted in providing similar advice to other regulators. More specifically:

- The approach allows the correlation between half-hourly solar exports and half-hourly market prices to be maintained, so that the resulting FiT accurately reflects the relationship between the two.
- Price profiles have been scaled to meet future expectations of spot prices. Consistent with other work, we have inferred future price levels from ASXEnergy contract prices (adjusted for an assumed contract premium).
- In our previous advice to IPART, we accounted for uncertainty in customer load and solar export quantities by using a Monte Carlo simulation of available data.[6] Given that we have several financial years of export data from all 5 Distribution Network Service Providers (DNSPs), and corresponding wholesale electricity price data, Monte Carlo simulation is possible. However, we do not recommend the approach in this case. In recent years, it is clear that solar premiums[7] have fallen significantly (which is likely to be driven in part by increased solar PV penetration). Since solar premiums are a key driver of solar-weighted FiT results we think that in these circumstances a Monte Carlo simulation may inappropriately preserve historical correlations between prices and exports.

Overall, we consider the approach outlined in this report to be consistent with regulatory best practice. We also consider that the approach outlined in this report has the benefit of being relatively simple and transparent: it relies largely on publicly available data and, in principle, could be replicated by interested stakeholders (subject to the availability of reasonable data on half-hourly solar exports).

1.4 About this report

Throughout this final report, we make references to the four quarters of a calendar year (i.e. Q1, Q2, Q3 and Q4). The months associated with these quarters are:

- January to March for Q1.
- April to June for Q2.
- July to September for Q3.
- October to December for Q4.

6 Other aspects of our approach are similar to our previous advice to IPART: using historical data for exports and spot prices as a starting point; scaling prices to a forecast of future spot prices; weighting the forecast spot prices by exports; calculating an annual average (or day, early evening and overnight) FiTs based on this.

7 The solar premium is the solar-weighted wholesale price divided by the time-weighted wholesale price. A solar premium below one indicates that prices tend to be lower at times when solar exports occur. A solar premium above one indicates that prices tend to be higher at times when solar exports occur.

For the most part, references to quarters are coupled with a year e.g. 'Q1 2024'. However, in sections of the paper which deal with quarterly analysis over multiple years, we may refer to a quarter in general (without specifying a year). In these cases, 'Q2' for example, refers to the months April to June across all years under analysis.

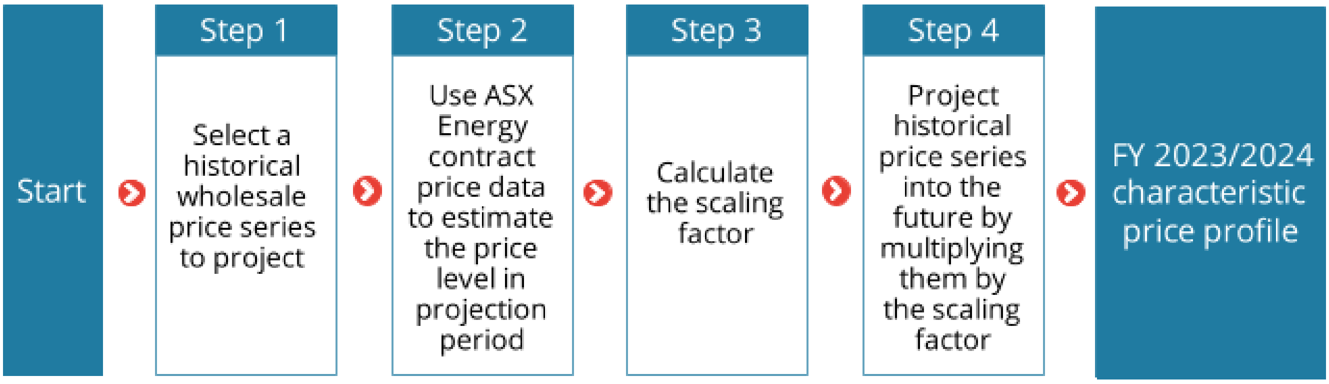
The remainder of this report is structured as follows:

- Section 2 outlines the methodology used to produce a wholesale price profile for 2023/24.
- Section 3 discusses our analysis of historical prices in Victoria.
- Section 4 presents our results.
- Section 5 compares the current report to results from our previous final report.

2 Methodology for projecting price

In this section, we set out our methodology for estimating the wholesale price profile for 2023/24, which is summarised in **Figure 2**:

Figure 2: Summary of methodology



Source: Frontier Economics

Our methodology consists of four steps:

- **Step 1: Select a historical wholesale price series to use as the basis for forecasts**

  Preferably, we select for our starting point historical half-hourly prices that are from the same period as the *most recent* solar export data. Our view is that, generally speaking, more recent prices would be expected to better reflect future demand and supply conditions. In other words, since the ESC has access to solar export data up to the end of Q2 2022, we would generally recommend using historical price data for Q3 2021 to Q2 2022.

  In some cases, there may be sufficient reason to believe this most recent wholesale price data series will not reflect future supply and demand conditions and another set of spot prices should be used as the basis for forecasts. This is why we assess historical price patterns to check whether recent prices exhibit abnormal 'shape' that is likely to be unreflective of future conditions.

  We note that this process of selection is informed by our assessment of historical pricing patterns and the availability of relevant solar export data. It may be that different circumstances in the future would suggest an alternative approach. For instance, a more unpredictable trend in the correlation between solar exports and prices may warrant a Monte Carlo analysis to generate a profile for solar exports and prices that are made up of outcomes over a number of historical years, though we do not consider this appropriate in this case for reasons discussed in Section 1.3.

- **Step 2: Calculate price level for 2023/24**

  The average price level for 2023/24 is represented by the average prices of 2023/24 quarterly base swaps (after adjusting for an assumed contract premium). In our calculations, we assume a contract premium of 5 per cent.

  Quarterly base swaps trade for a number of years in advance of maturity, meaning there is a time series of prices for these contracts. We calculate the average prices of quarterly base contracts using a 12-month trade-weighted average of base swap prices.

  Our view is that the 40-day average price provides the best indicator of the market's view of prices for 2023/24. Averaging prices over a longer period (such as 12 months) means giving weight to views of prices for 2023/24 that have since changed, likely as a result of updated information about market conditions in 2023/24.

  In the context of retail tariff regulation, retailers have argued in the past, and some regulators have accepted, that average prices over a longer period should be used. The justification given for this is generally that retailers will actually buy contracts over a longer period when hedging a retail load. While we do not dispute that retailers will likely buy contracts over a number of years leading up to the commencement of 2023/24 to hedge their retail load, we would still view the current market price as the best reflection of the economic value of those contracts and consider that decisions should be made on the basis of that economic value. The rationale for taking a 40-day average price, rather than the current market price on a single day, is to avoid the possibility of gaming the regulatory arrangement. The 40-day average approach is consistent with the approach that a number of regulators take to setting cost of capital parameters.

  However, there may be good reasons that a regulator will choose to base regulated prices on something other than 40-day average contract prices. For instance, a longer averaging period, such as 12 months or 24 months, would be expected to provide regulated prices that are more stable over time and would also likely result in regulated prices that are more reflective of incumbent retailers' actual costs (since most retailers will buy contracts over a number of years leading up to the year).

  Regarding the type of average to use, our view is that a time-weighted approach would generally provide the best indicator of prices for 2023/24. A trade-weighted[8] approach will give greater weight to a daily price on a day with many trades than on a day with fewer trades; but, in our view, a larger number of trades occurring on a day does not necessarily mean that the closing price conveys more reliable information about the market's view of future electricity prices. However, one advantage of a trade-weighted approach is that it will naturally exclude prices on those days on which no trade occurred, and on those days the published price is a less reliable indicator of the market's view of prices.

  In our results we have provided trade-weighted, 12-month average quarterly base swap prices, as requested by the ESC, and results based on these trade-weighted average quarterly prices. We have averaged prices for the relevant period up to and including 20 January 2023.

- **Step 3: Calculate the scaling factor**

  For each historical quarter (from Q3 2021 to Q2 2022), we calculate the average price for that quarter by taking a time-weighted average across all half-hourly prices. We then calculate the

[8] Trade-weighted contract prices are calculated by multiplying the number of trades by the closing price on each day over the averaging period (i.e. 40 days, 12-months or 24 months) then dividing by the total number of trades over the averaging period.

scaling factor for that quarter by dividing the relevant ASXEnergy price for the equivalent quarter by that time-weighted average price.

For example, we might find the following:

- if the average price for the historical quarter Q3 2021 was $80/MWh, and the ASXEnergy price for Q3 2023 was $100/MWh, the scaling factor for Q3 would be 1.25;
- if the average price for the historical quarter Q4 2021 was $100/MWh, and the ASXEnergy price for Q4 2023 was $110/MWh, the scaling factor for Q4 would be 1.1;
- and so on, for the other quarters.

- **Step 4: Apply scaling factor to starting point historical prices to develop a forecast of half-hourly prices**

  For each half-hourly price in the historical quarter, we multiply the half-hourly price by the relevant scaling factor for that quarter. This provides the resulting half-hourly prices for 2023/24.[9] We also perform checks to confirm that these half-hourly prices do not exceed the NEM Market Price Cap[10] (MPC) or Market Floor Price[11] (MFP). We also check that the prices do not exceed the Cumulative Price Threshold[12] (CPT).

  Once we have developed a forecast of half-hourly prices for 2023/24, we are able to calculate the *weighted average* of these prices by solar PV exports, and/or *average* these half-hourly prices in different ways in order to inform the ESC's determination of a FiT.

  For instance, we can average the half-hourly prices over the whole year to inform the ESC's determination of a flat-rate FiT. Or, we can average the half-hourly prices for various periods of the day to inform the ESC's determination of a time-varying FiT.

  For our draft report, we calculated a time-varying FiT using the definitions of day, early evening and overnight periods as shown in **Table 5**. For this final report, the ESC have also asked us to calculate a time-varying FiT using peak, shoulder and off-peak periods shown in **Table 6**.

  Formulae used to take average and weighted-average half-hourly prices are provided in **Table 7**.

9 The NEM adopted 5 minute settlement on 1 October 2021. In principle, from this date, for the purposes of determining the FiT, prices should be forecast for each 5 minute period, rather than for each 30 minute period. However, in practice, with no existing historical data on prices under 5 minute settlement, it is extremely difficult to forecast patterns of prices under 5 minute settlement. For this reason, we have chosen to continue with forecasting patterns of prices under 30 minute settlement.

10 AEMC 2021, *Schedule of Reliability Settings for 2020-21*, MPC for 2021/22, accessed 13 October 2021, < https://www.aemc.gov.au/news-centre/media-releases/aemc-publishes-schedule-reliability-settings-2021-22 >

11 AEMC 2021, *National Electricity Rules Version 160*, Chapter 3, Section 9.6, pg. 160. Accessed 13 October 2021, < https://www.aemc.gov.au/sites/default/files/2021-03/NER%20Version%20160%20-%20full.pdf >

12 AEMC 2021, *Schedule of Reliability Settings for 2020-21*, CPT for 2020/21, accessed 13 October 2021. <https://www.aemc.gov.au/news-centre/media-releases/schedule-reliability-settings-2020-2021>.

Table 5: Time of use classifications – time-varying rate 1

Period	Weekday	Weekend
Early evening	3pm – 9pm	N.A.
Day	7am – 3pm; 9pm – 10pm	7am – 10pm
Overnight	10pm – 7am	10pm – 7am

Source: Essential Services Commission

Table 6: Time of use classifications – time-varying rate 2

Period	Weekday	Weekend
Peak	4pm – 9pm	4pm – 9pm
Off-peak	10am – 2pm	10am – 2pm
Shoulder	All other times	All other times

Source: Essential Services Commission

Table 7: Simple (time-weighted) average and weighted average formulae

	Simple average	Weighted average formula
Whole period	$\frac{\sum \text{wholesale\_prices}}{\text{time\_periods}}$	$\frac{\sum \text{wholesale\_prices} * \text{solar\_weights}}{\sum \text{solar\_weights}}$
Overnight	$\frac{\sum \text{wholesale\_prices}_{\text{overnight}}}{\text{time\_periods}_{\text{overnight}}}$	$\frac{\sum \text{wholesale\_prices}_{\text{overnight}} * \text{solar\_weights}_{\text{overnight}}}{\sum \text{solar\_weights}_{\text{overnight}}}$
Early evening	$\frac{\sum \text{wholesale\_prices}_{\text{early evening}}}{\text{time\_periods}_{\text{early evening}}}$	$\frac{\sum \text{wholesale}_{\text{prices}_{\text{early evening}}} * \text{solar\_weights}_{\text{early evening}}}{\sum \text{solar\_weights}_{\text{early evening}}}$
Day	$\frac{\sum \text{wholesale\_prices}_{\text{day}}}{\text{time\_periods}_{\text{day}}}$	$\frac{\sum \text{wholesale\_prices}_{\text{day}} * \text{solar\_weights}_{\text{day}}}{\sum \text{solar\_weights}_{\text{day}}}$

Source: Frontier Economics

Note that in **Table 7**:

- **wholesale_prices** refer to half-hourly Victorian spot prices from 1/07/2021 to 30/06/2022
- **solar_weights** refer to half-hourly exports
- products of **wholesale_prices** and **solar_weights** that are taken in the weighted average formula are between corresponding half-hours (i.e. prices and exports of the same date and half-hour are multiplied).

3 Selecting an historical price series

In this section we select an historical price series to use as the basis for forecasts. As discussed in the methodology section, we prefer to use the most recent series of prices for which we have solar export data (start of Q3 2021 to the end of Q2 2022) but may not if there is sufficient reason to believe this most recent wholesale price data series will not reflect future supply and demand conditions.

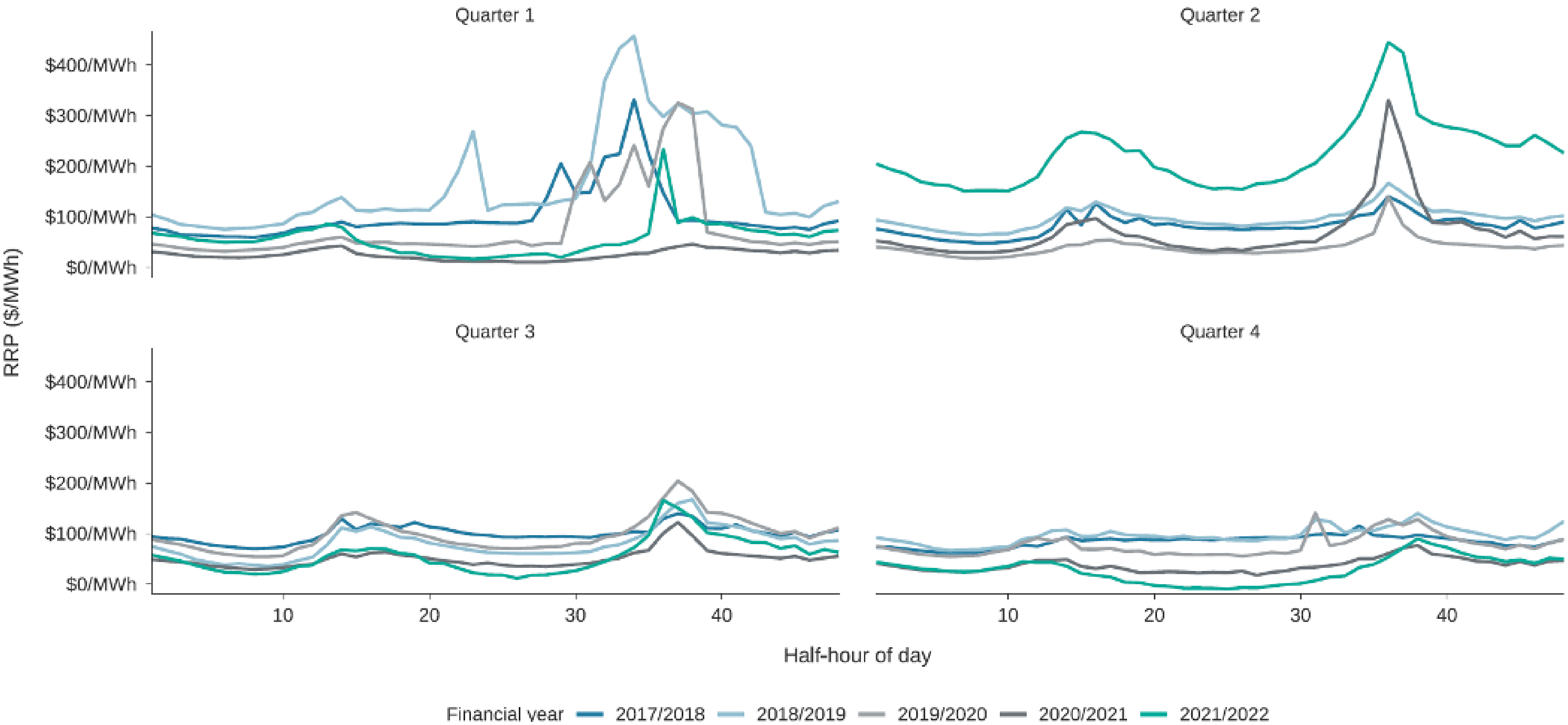
Importantly, we are primarily concerned with the shape of the historical half-hourly prices, not the absolute level of these prices since the average level of the prices is ultimately determined by ASXEnergy contract prices.

We analyse patterns of historical prices for Q3 2021 to Q2 2022 by comparing historical prices over a number of recent years. The analysis is conducted:

- On six years of historical half-hourly data on prices from Q3 2016 to Q2 2022.
- On a quarterly basis:
  - to understand seasonal differences in prices, and
  - to ensure analysis lines up with the quarterly contracts traded on ASXEnergy (which we use to determine average prices for 2023/24).

Figure 3 presents the average daily pattern of Victorian spot prices, for each quarter, over the period Q3 2017 to Q2 2022 (i.e. the last 5 financial years).

Figure 3: Price profiles of Victorian wholesale electricity prices for the last 5 financial years by quarter



Source: Frontier Economics analysis of AEMO spot price data

Our analysis of these historical half-hourly prices highlighted several observations. We find that, for the most part:

- Across the years, the daily price profiles were similar within each quarter, except for Q2 where prices in 2021/22 were much higher on average than previous years. This reflects the substantial increases in prices across the NEM that occurred from around April 2022. These increases in prices have been attributed to much higher prices for gas and coal (in turn driven by the war in Ukraine) as well as an earlier start to winter leading to higher demand and a higher than usual number of generator outages.
- Prices have tended to peak in similar trading intervals, or adjacent trading intervals. This is particularly the case in winter – Q2 and Q3 – where prices peak once in the morning (trading intervals 13 – 15 on working days and trading intervals 17 – 19 on non-working days) and once in the evening (between trading intervals 36 – 38). This is less apparent in summer – Q4 and Q1 – when outcomes are more volatile; but nevertheless, we see prices peaking in the late afternoon or early evening.
- Prices have tended to be at their lowest in similar trading intervals. Specifically, we tend to see prices at their lowest overnight and, increasingly with each passing year, during the middle of the day.

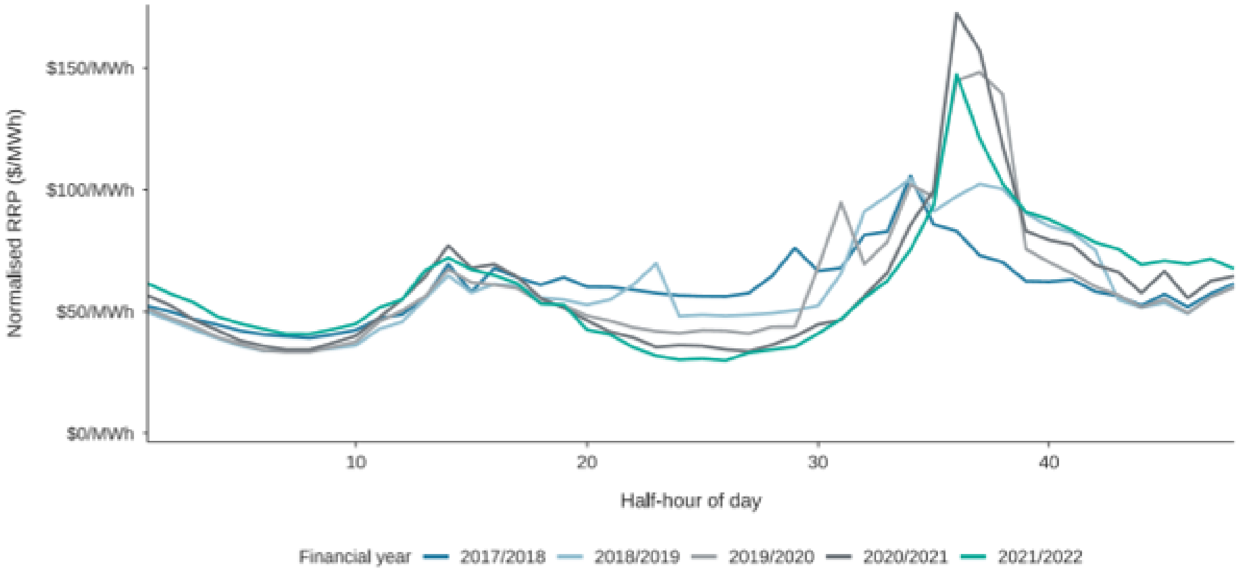
While, on the whole, we see similar pricing patterns over the years, suggesting that outcomes in 2021/22 were not 'abnormal', we do note that:

- Generally, half hourly prices in 2021/22 have been lower in Q1, Q3 and Q4 than in previous years. This has been most notable with prices during the middle of the day and likely reflects increasing amounts of solar generation, both from rooftop PV panels and from large solar farms.
- An exception to the lower half hourly prices in 2021/22 is Q2, when spot prices across the NEM were much higher than usual, as discussed above. Although the average prices were much higher than in previous years, the shape of spot prices in Q2 was similar to other years for the same quarter. In particular, prices in Q2 in 2021/22 exhibited a morning peak, and a higher evening peak, with depressed prices during the middle of the day, relative to the peaks.
- The ratio of evening prices (intervals 35 to 41) to midday prices (intervals 21 to 31) has tended to increase over each financial year, especially over the last three financial years, except for Q2.[13] We would expect this general result where there has been an increase in solar PV penetration over time, as has been the case in Victoria and throughout the NEM. This means that more cheap electricity is produced in the middle of the day, depressing midday prices, followed by a spike in evening demand as the sun goes down and people require energy sourced from the grid.

To further our understanding of the overall trend in the ratio of evening to midday prices we can examine yearly price profiles. **Figure 4** plots wholesale prices on average through the day, for each year for the last 5 financial years, normalised so that the average price in each year is $60/MWh to highlight changes in the *shape* of wholesale electricity prices.

[13] Q2 saw a decrease in ratio of average evening prices to average midday prices because all spot prices increased considerably, resulting in a lower ratio. However, Q2 still had the largest difference between the average midday price and average evening peak price, around $166/MWh, which is substantially higher in 2021/22 relative to any other financial years.

Figure 4: Normalised profiles of Victorian wholesale electricity prices for the last 5 financial years



Source: Frontier Economics analysis of AEMO spot price data

Note: Price in each year normalised such that the average price is $60/MWh

From inspection of the yearly price profiles, it is clear that the ratio of prices in the middle of the day to evening peak prices has increased over time, including in 2021/22. Moreover, in 2021/22 we observe a of lack of later afternoon peak prices (between 3pm and 4pm), traditionally driven by high price events in Q1 and Q4. These observations are in line with what we would expect: all else being equal, with further entry of rooftop and utility-scale solar over time, we should see lower prices in the middle of the day and less high price events at the times solar is exporting.

In our view, there is no reason to expect that this trend of lower average prices in the middle of the day would not continue into the medium term as solar entry persists, at least until large scale adoption of batteries, or the introduction of some other day-time load, increases demand for electricity during the middle of the day. As such, the 2022 financial year is likely to be the best starting point for projecting prices.

Based on this, we recommend using the historical prices for the most recent four quarters for which both historical prices and solar export data are available (the preferred series). These prices will be used to project prices for 2023/24.

4 Results on wholesale price projections

In this section we present the results on wholesale price projections for 2023/24 based on the methodology described in Section 2.[14] These modelling results are used by the ESC for the determination of the minimum FiT rates and are presented as follows:

- Projected **quarterly** average spot prices for 2023/24 (based on ASXEnergy contract prices adjusted to remove a 5 per cent contract premium) using trade-weighted averaging over 12 months. These prices are presented in Section 4.1.
- Projected **annual** average spot prices, and average spot prices for time-varying FiTs, for 2023/24. These averages are presented both unweighted and weighted by solar PV exports. These prices are presented in Section 4.2.

4.1 Projected quarterly average spot prices for 2023/24

Table 8 presents trade-weighted quarterly average spot prices for 2023/24. These are the results of Step 2 of our analysis, and are used to determine scaling factors and, ultimately, to forecast half-hourly prices for 2023/24.

Table 8: Projected average prices for 2023/24, using **trade-weighted** ASXEnergy contract prices (after removing 5 per cent contract premium) ($2023/24)

Calendar quarter	12 month average ($/MWh)
Q3 2023	$134.67
Q4 2023	$68.52
Q1 2024	$82.35
Q2 2024	$94.89

Source: Base swap price data from ASXEnergy and Analysis from Frontier Economics

14 As discussed in Section 2, our view is that the 40-day time-weighted average contract price provides the best indicator of the market's view of prices for 2023/24. We also provided reasons why longer averaging periods and trade-weighted averages may be valuable in regulatory contexts. Our understanding is that the ESC prefers the use of the 12-month trade-weighted average for the purposes of determining an appropriate minimum FiT, which is what the results presented in this section are based on.

4.2 Average half-hourly prices in 2023/24

Using the projected quarterly average spot prices for 2023/24 presented in Section 4.1, and historical half-hourly prices for 2021/22, we developed forecasts of half-hourly spot prices for 2023/24. These half-hourly spot prices are the results of Step 4 of our analysis.

This section summarises the average of these half-hourly price forecasts for 2023/24, providing a flat annual average price, as well as prices for the various time periods for each of time-varying rate 1 and time-varying rate 2.

The results in **Table 9** and **Table 10** are both based on:

- trade-weighted ASXEnergy prices for 2023/24 (as presented in **Table 8**)
- a **12 month** trade-weighted average of ASXEnergy prices
- historical half-hourly prices for 2021/22.

Table 9 provides average half-hourly prices that do not take into account solar export data (that is, the half-hourly prices are time-weighted averages, or simple averages), while **Table 10** provides average half-hourly prices that are weighted by solar exports in each half hour interval. These solar export-weighted prices are based on solar export data for 2021/22 from each DNSP, which was provided by the ESC.

The prices in **Table 9** and **Table 10** are higher than the equivalent prices from our draft report. The reason is that the 12 month average contract prices up to 20 January 2023 (used for this final report) are higher than the 12 month average contract prices up to 28 October (used for the draft report). While contract prices in the last few months are lower than they were earlier in the year, these prices in the last few months (which have been included in the averaging period since the draft report) are nevertheless higher than the prices towards at the end of 2021 (which have been excluded from the averaging period since the draft report).

Table 9: Summary of half-hourly spot prices for 2023/24 (based on historical quarters Q3 2021 to Q2 2022), unweighted by solar exports ($2023/24)

Rate type		Average spot price (c/kWh)
Flat rate		9.49
Time-varying rate 1	Early evening	15.94
	Day	7.05
	Overnight	9.31
Time-varying rate 2	Peak	16.35
	Shoulder	8.81
	Off-peak	3.48

Table 10: Summary of half-hourly spot prices for 2023/24 (based on historical quarters Q3 2021 to Q2 2022), solar export-weighted ($2023/24)

Rate type		Export-weighted average spot price (c/kWh)
Flat rate		2.13
Time-varying rate 1	Early evening	6.28
	Day	1.62
	Overnight	8.19
Time-varying rate 2	Peak	7.46
	Shoulder	2.73
	Off-peak	1.13

It is important to note that since **Table 10** presents prices that are based on solar export-weighted average prices, the relationship between these prices in different periods (day, early evening and overnight) does not necessarily correspond with the relationship between unweighted wholesale electricity prices during those same periods.

For example, looking at time-varying rate 1, average wholesale electricity prices in day periods and overnight periods differ only by approximately 2c/kWh, as we can see in **Table 9**. However, once we weight these wholesale electricity prices by solar exports, we see in **Table 10** that prices in day periods are far lower than prices in overnight periods (about a fifth). One reason for this is that day periods occur daily from 7 AM to 10 PM (excluding 3pm to 9pm on weekdays). This period captures the higher prices that tend to occur during the morning peak and evening peak, as well as the generally lower prices during the middle of the day (as we can see in **Figure 3**). However, when we take a solar-weighted average of prices in day periods (as in **Table 10**) the prices that receive most weight are the lower prices during the middle of the day, when most solar exports occur.

5 Comparison with 2022/23 FiT

This section briefly compares the results of our flat-rate FiT for 2023/24 with the equivalent result for 2022/23.

Frontier Economics previously advised the ESC on the forecast of wholesale electricity prices for the purpose of calculating minimum FiT rates for 2022/23.[15] As discussed, we used the same methodology for this final report that we previously used for the 2022/23 minimum FiT. In this section we explore what is driving the differences in results between the two reports.

Comparing the flat-rate, solar export-weighted half-hourly spot prices we see the following:

- The flat-rate, solar export-weighted price for 2022/23, from our January 2022 report, was 2.48 c/kWh.
- The flat-rate, solar export-weighted price for 2023/24, from this final report, is 2.13 c/kWh.

The value of the FiT depends on both the projected average price in each quarter (based on ASXEnergy base swap prices) and the correlation between projected half-hourly prices and solar export data. It is the combination of these factors that accounts for the decline in the FiT relative to 2022/23.

Average ASXEnergy prices

Broadly speaking, average ASXEnergy prices depend on what the market expects future electricity spot prices will be (and the premium participants are prepared to pay to 'lock in' prices). **Table 11** shows the average ASXEnergy prices used in this final report and the equivalent prices used in our January 2022 report.[16] Compared with the ASXEnergy prices used for our January 2022 report for the 2022/23 FiT, ASXEnergy prices are materially higher for all quarters. These changes in ASXEnergy prices reflect the market's changing expectations of average prices. While it is difficult to be certain about what drives the market's expectations of future prices, we observe that ASXEnergy forward prices generally respond to movements in spot prices. This has been the case recently, with generally higher ASXEnergy forward prices reflecting higher electricity spot prices.

If ASXEnergy prices were the only driver of the FiT, the difference in contract prices shown in **Table 11** then the FiT for 2023/24 would be higher than the FiT for 2022/23. However, the correlation between half-hourly prices and solar exports is also an important driver of the FiT.

[15] Frontier Economics, *Wholesale Price Forecasts for Calculating Minimum Feed-in Tariff*, A Report for the Essential Services Commission, 27 January 2022.

[16] Since projected average prices in both reports are based on ASXEnergy prices and calculated based on 12-month trade weighted average of ASXEnergy prices they therefore are directly comparable accounting for an assumed inflation rate.

Table 11: Comparison of projected average prices based on ASXEnergy contract prices (after removing 5 per cent contract premium) ($2023/24)[17]

Period	Average projected price ($/MWh) – 2022/2023	Average projected price ($/MWh) – 2023/2024
Q3	$46.18	$134.67
Q4	$35.80	$68.52
Q1	$54.66	$82.35
Q2	$41.44	$94.89

Correlation between projected half-hourly prices and solar export data

The correlation between projected half hourly wholesale electricity prices and solar exports also has an influence on FiT rates that are based on projected prices that are solar weighted.

As shown in **Figure 3** and **Figure 4**, spot prices have tended to be lower during the middle of the day with each passing year; and spot prices tended to be lower in the middle of the day in 2022/23 than in any prior year. Part of the reason for this is that spot prices in the NEM are negative during the day with increasing regularity.

Negative electricity prices occur because in some circumstances generators are prepared to bid negative prices (in other words, they are prepared to pay in order to remain operating). There are several reasons that generators are prepared to bid negative prices for some or all of their capacity. Coal-fired and gas-fired generators may be prepared to bid negative prices up to their minimum generating capacity (the capacity below which they would need to shut down) in order to avoid the costs that they face shutting down and restarting their power stations, and to avoid not operating for the time that it takes to shut down and restart their power stations. Renewable generators may be prepared to bid negative prices for all of their capacity in order to ensure that they continue to operate and can continue to create and sell Large-scale Generation Certificates (LGCs).

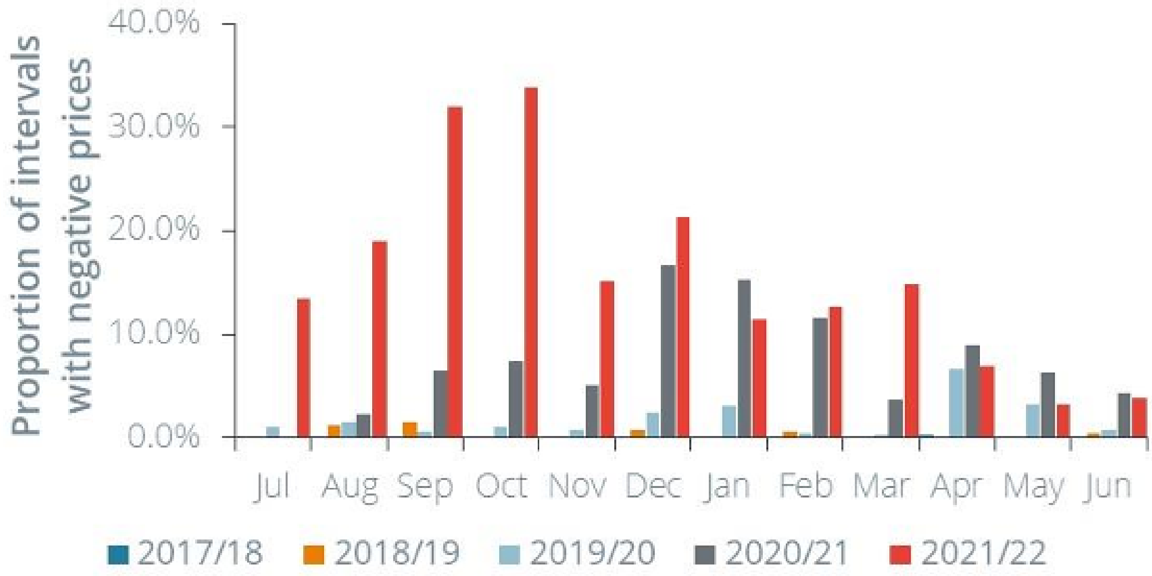
Negative bids and negative prices in the NEM are not a new phenomenon. However, negative prices are becoming increasingly common, particularly during the middle of the day. The reason is that the increase in rooftop PV (which reduces demand during the day) and the increase in utility-scale PV (which increases supply during the day) makes it more likely that the demand for electricity from utility-scale generation is lower than the available supply that is prepared to bid negative prices in order to remain operating.

An indication of this increasing frequency of negative prices is provided in **Figure 5**, which shows the proportion of all trading intervals in a month for which the spot price is negative. It is clear from **Figure 5** that as recently as 2017/18 and 2018/19, instances of negative prices in Victoria were very limited. There was some increase in negative prices in 2019/20, but then much more significant increases in both 2020/21 and 2021/22. In 2021/22, the historical year that we use in

17 Projected 2022/23 prices from previous final report are escalated at an assumed CPI of 3.5% to put into $2023/24, following the RBA's Statement of Monetary Policy, August 2022

estimating the FiT for 2023/24, we can see that in September and October more than 30 percent of intervals in the month had negative prices, and all other months from July through to March have more than 10 percent of intervals with negative prices. The instances of negative prices decreased in April, May and June, as spot prices generally reached very high levels. These very high spot prices were driven by unprecedented prices for gas and coal, unusually high demand and high levels of generation unavailability. Market conditions have moderated somewhat since then, and futures prices suggest that prices will be at more normal levels by April, May and June in 2024 (for the 2023/24 FiT). While not shown on **Figure 5**, data for the first few months of 2022/23 shows that the instances of negative prices have increased from the lows of April, May and June in 2022 and have returned to levels that are similar to those observed in the first few months of 2021/22.

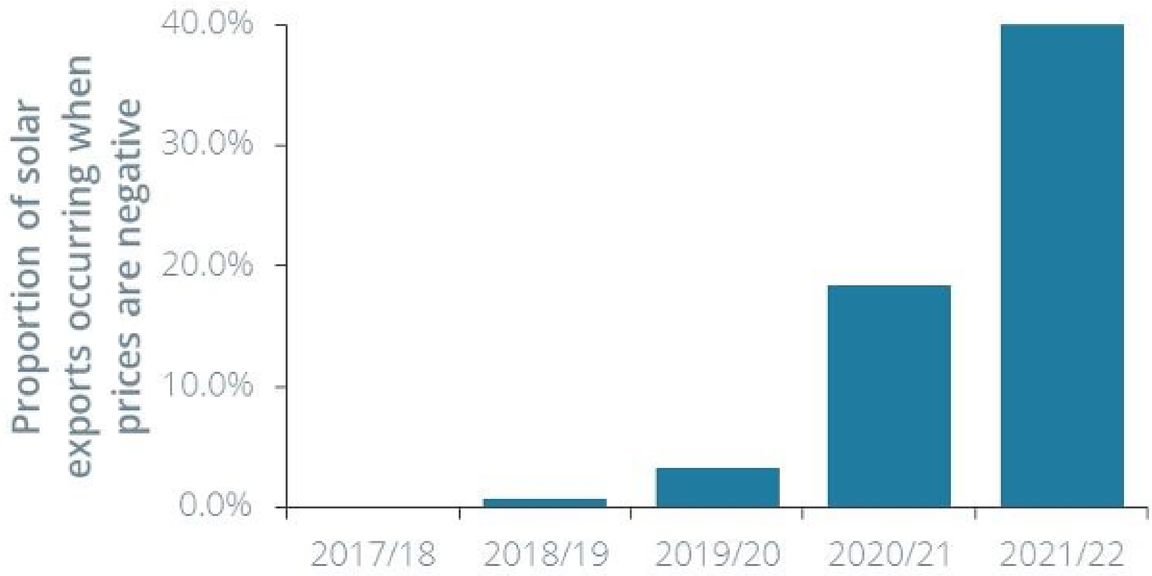
Figure 5: Proportion of intervals with negative spot prices in Victoria



Source: Frontier Economics analysis

The increasingly common negative prices tend to occur at times when solar exports occur. This is seen in **Figure 6**, which shows the proportion of total solar exports that have occurred at times when spot prices are negative. In 2017/18 and 2018/19 less than 1 percent of total solar exports occurred when spot prices are negative, but by 2021/22 this had increased to 41% of total solar exports occurring when spot prices are negative.

Figure 6: Proportion of solar exports occurring when prices are negative



Source: Frontier Economics analysis

It is because of these changing patterns of prices – spot prices tending to be lower during times of solar exports, and instances of negative prices increasing during times of solar exports – that the estimated solar export-weighted FiT has fallen from 2022/23 to 2023/24, even though the expected *average* price level (as indicated by contract prices) has increased from 2022/23 to 2023/24.

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