2023 Forecast Accuracy Report and Forecasting Improvement Plan

29 November 2023

Purpose and agenda

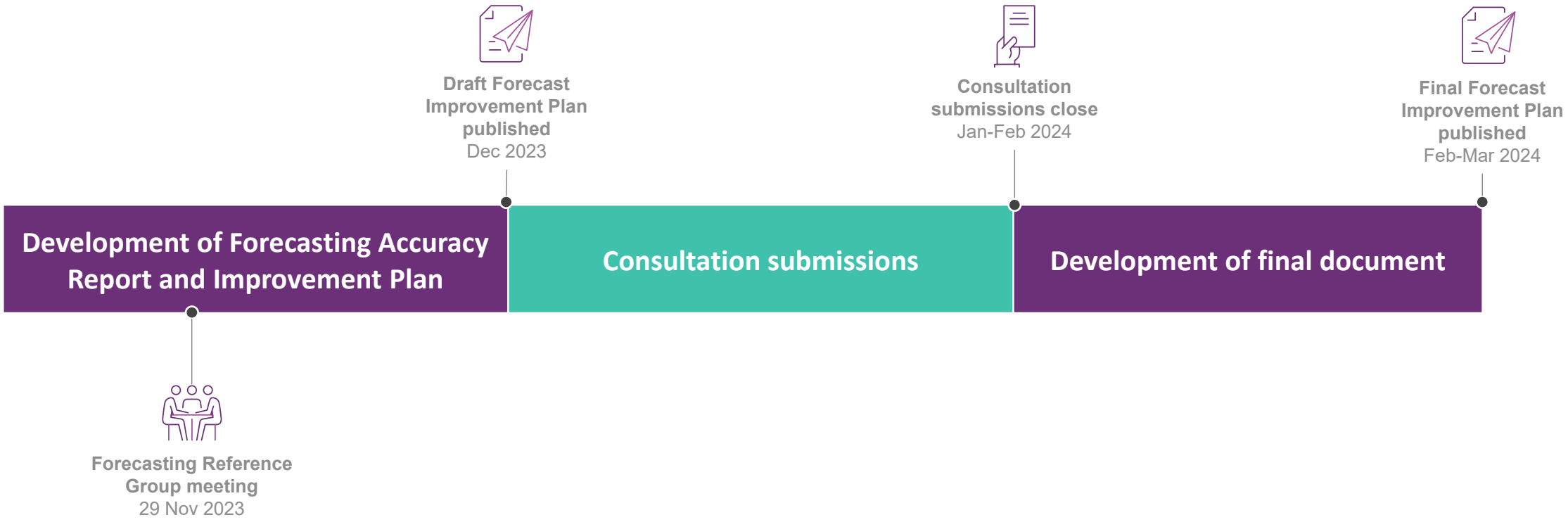
The purpose of this presentation is to *inform* the FRG of draft 2023 Forecasting Accuracy Report (FAR) results and *consult* on the forecasting challenges and improvement priorities that motivate the 2023 Forecast Improvement Plan (FIP).

Today's Agenda includes:

- Forecast accuracy results summary
  - Results Overview
  - Distributed PV
  - Consumption
  - Maximum and Minimum Demand
  - Supply availability
- Forecast Improvement Plan
- Discussion
- Appendix
  - 2022 FIP initiatives

Timing	Relevant topic	Responsible
Dec 22 – Feb 23	2022 Forecasting Improvement Plan consultation	All
Mar 23 FRG	Draft 2022-23 Summer demand review	AEMO
Aug 23 FRG	Synthetic wind traces	AEMO
Sep 23 FRG	Synthetic demand traces	AEMO
Today	**2023 Forecast Accuracy Report and Forecast Improvement Plan**	**AEMO**
Dec 23 –Feb 24	FAR publication and FIP consultation	All

Forecasting Improvement Plan Consultation timeline



Reach out to energy.forecasting@aemo.com.au

Inaccuracies are generally explainable

DRAFT

AEMO

Summary outcomes when assessing the accuracy of the 2022 ESOO central forecast

Forecasting results	NSW	QLD	SA	TAS	VIC	Assessability*	Comments
Energy Consumption	🟢	🟡	🟢	🔴	🟢	Moderate - Strong	Variance in Queensland was driven by unplanned outages of large loads. Variance in Tasmania was partially explained by operational variance from large industrial loads.
Summer maximum demand	🟢	🟢	🟢	🔴	🟢	Weak - Moderate	Good alignment between observed actuals and forecasts across most regions except Tasmania, where actual demand fell significantly under the forecast distribution.
Winter maximum demand	🟢	🟡	🟡	🔴	🟢	Weak - Moderate	Winter maximum demand outcomes in Queensland, South Australia and Tasmania were below the forecast distributions.
Annual minimum demand	🟡	🟡	🟢	🟢	🟡	Weak - Moderate	The actual annual minimum demand outcomes for New South Wales, Queensland and Victoria were just below the forecast distribution.
Demand side participation (DSP)	🟡	🟢	🟢	🟢	🟢	Weak - Moderate	More DSP was observed than forecast for higher price bands. New South Wales had a LOR2 called on the day but observed DSP was significantly lower than forecast.
Installed generation capacity	🟢	🟢	🟢	🟢	🟡	Strong	Delayed commissioning and higher capacity provided by participants than actual in Victoria resulted in lower availability than was modelled.
Summer supply availability	🟢	🟡	🟢	🟢	🟢	Moderate	Given the mild weather observed, availability should have been above the forecast range for all regions, but was instead within range for most regions. Availability in Queensland was low in range, likely due to economic decommitment and outages of coal units.

Key:

🟢 Forecast has performed as expected. No actions required.

🟡 Inaccuracy observed in forecast is explainable by inputs and assumptions. These inputs should be monitored and incrementally improved, provided the value is commensurate with cost.

🔴 Inaccuracy observed in forecast needs attention and should be prioritised for improvement.

* Assessability – the extent to which accuracy can be assessed based on a single year of actual data

DRAFT

Understanding distributed PV errors

ESOO 2022 distributed PV forecast

		NSW	QLD	SA	TAS	VIC
Rooftop PV	Estimated actual* (MW)	5,912	5,559	2,193	269	4,070
	Central forecast (MW)	5,700	5,399	2,184	265	4,056
	Central forecast error (%)	-3.6%	-2.9%	-0.4%	-1.5%	-0.3%
PVNSG	Estimated actual* (MW)	334	243	251	4	351
	Central forecast (MW)	369	272	241	10	388
	Central forecast error (%)	11%	12%	-4%	152%	11%
Total	**Central forecast error (%)**	-2.8%	-2.3%	-0.8%	0.7%	0.5%

***as installed at 30 June 2023**

Uptake higher than forecast, amidst higher energy prices.

Uptake identified to be lower than forecast, but actuals tend to be under-reported as accreditation lags physical installations.

No significant differences in error percentages from last year.

ESOO 2021 distributed PV forecast

		NSW	QLD	SA	TAS	VIC
Total	**Central forecast error (%)**	2%	2%	4%	1%	2%

DRAFT

Underestimated electric vehicle forecast

The accuracy of EV forecasts is included in the accuracy report for the first time. While AEMO has forecast the rapid uptake of EV for numerous years, correctly identifying the timing of uptake of this newly adopted technology is challenging for the accuracy of short-term forecasts.

ESOO 2022 electric vehicle forecast

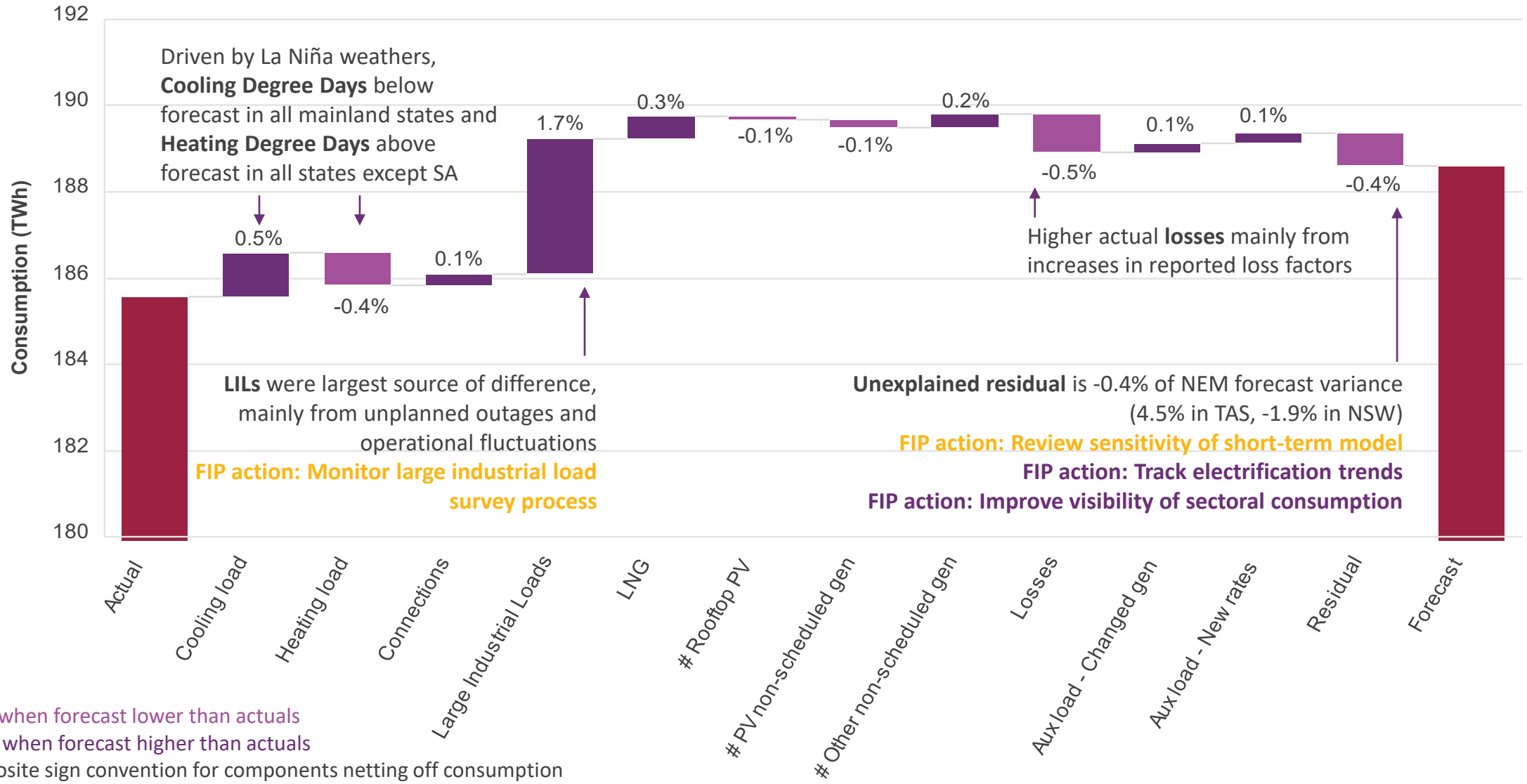
As on 30 June 2023		NSW	QLD	SA	TAS	VIC	NEM
Fleet size	Estimated actual (count)	46,010	25,656	7,486	2,424	35,503	117,079
	Central forecast (count)	26,530	14,987	3,959	1,539	22,984	69,999
	Central forecast error (%)	-42.3%	-41.6%	-47.1%	-36.5%	-35.3%	-40.2%
Fleet share	Estimated actual* (%)	0.71%	0.55%	0.48%	0.46%	0.65%	0.63%
	Central forecast (%)	0.43%	0.37%	0.28%	0.33%	0.47%	0.41%
	Central forecast error (%)	-39.3%	-32.5%	-40.8%	-28.1%	-28.0%	-34.1%

2022 forecasts underestimated actual fleet size figures across all NEM regions, by around 40%, however the impact on energy consumption and demand forecasts at the region level remains minor

FIP action: Improve short term EV forecast approaches

Higher consumption forecast mainly from explicable changes in industrial loads

DRAFT



Notes

-ve % when forecast lower than actuals

+ve % when forecast higher than actuals

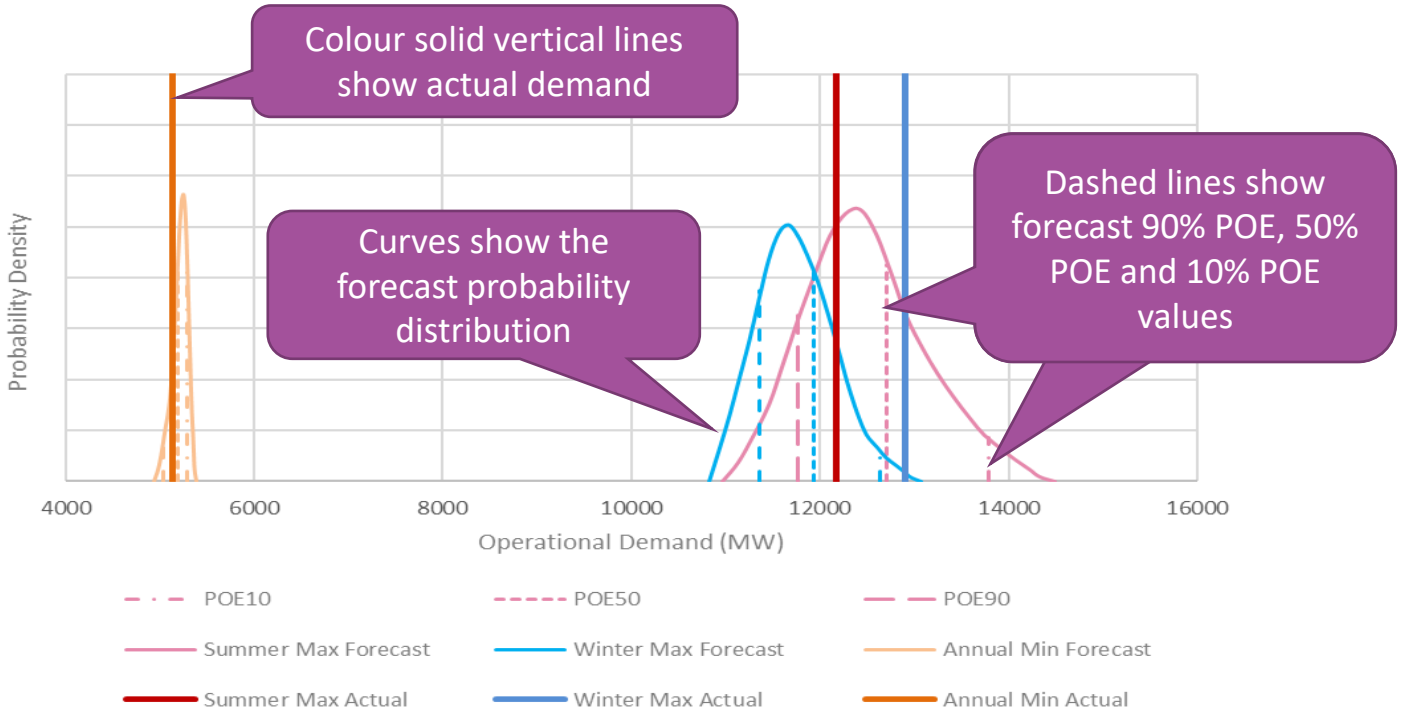
opposite sign convention for components netting off consumption

Understanding demand charts

DRAFT

How to interpret Demand Results

- Maximum/minimum demand forecasts are probability distributions.
- Each colour represents a different forecast distribution and actual outcome.



POE – Probability Of Exceedance

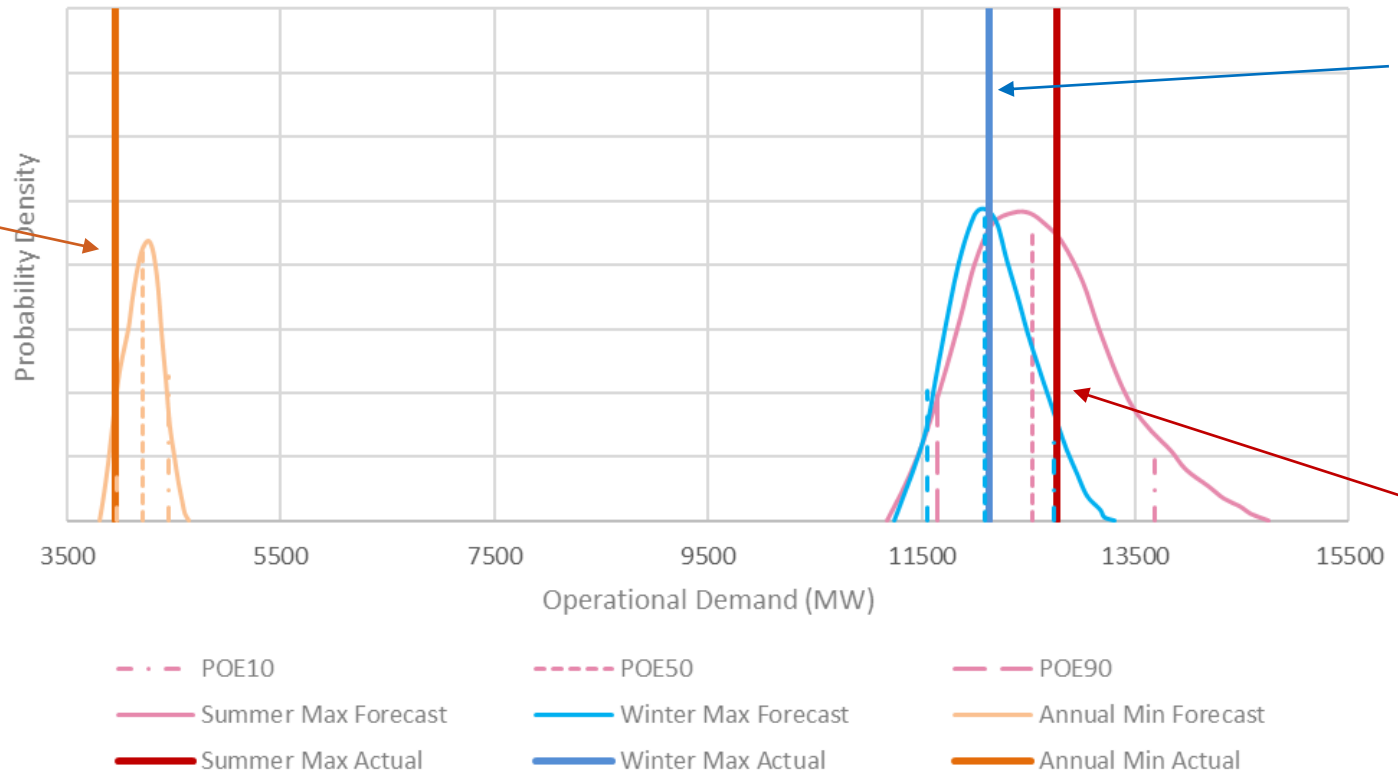
General 2023 themes:

- Strong summer La Niña (rain, cool daytime temperatures) drove milder summer demand outcomes in most cases before March. The sudden shift to El Niño Watch in significantly contributed to the warming on the East Coast, leading the summer peak in NSW and QLD both occurred in March.
- The intensification of El Niño, reaching El Niño Alter from June, has made the winter of 2023 one of the warmest in history, led to peak demand in QLD, SA and TAS falling below 90% POE
- Minimum demand fell below 90% POE in NSW, QLD and VIC. Under-forecast of installed PV capacity could be part of the explanation in two cases, but continued work required to understand changes in consumption at time of minimum demand.

New South Wales

DRAFT

Actual was just below 90% POE forecast. Installed rooftop PV forecast was ~200 MW too low which could at least partially explain the lower than forecast minimum demand outcome.



The winter forecast aligned well with the forecast distribution, with actual outcome consistent with the conditions on the day.

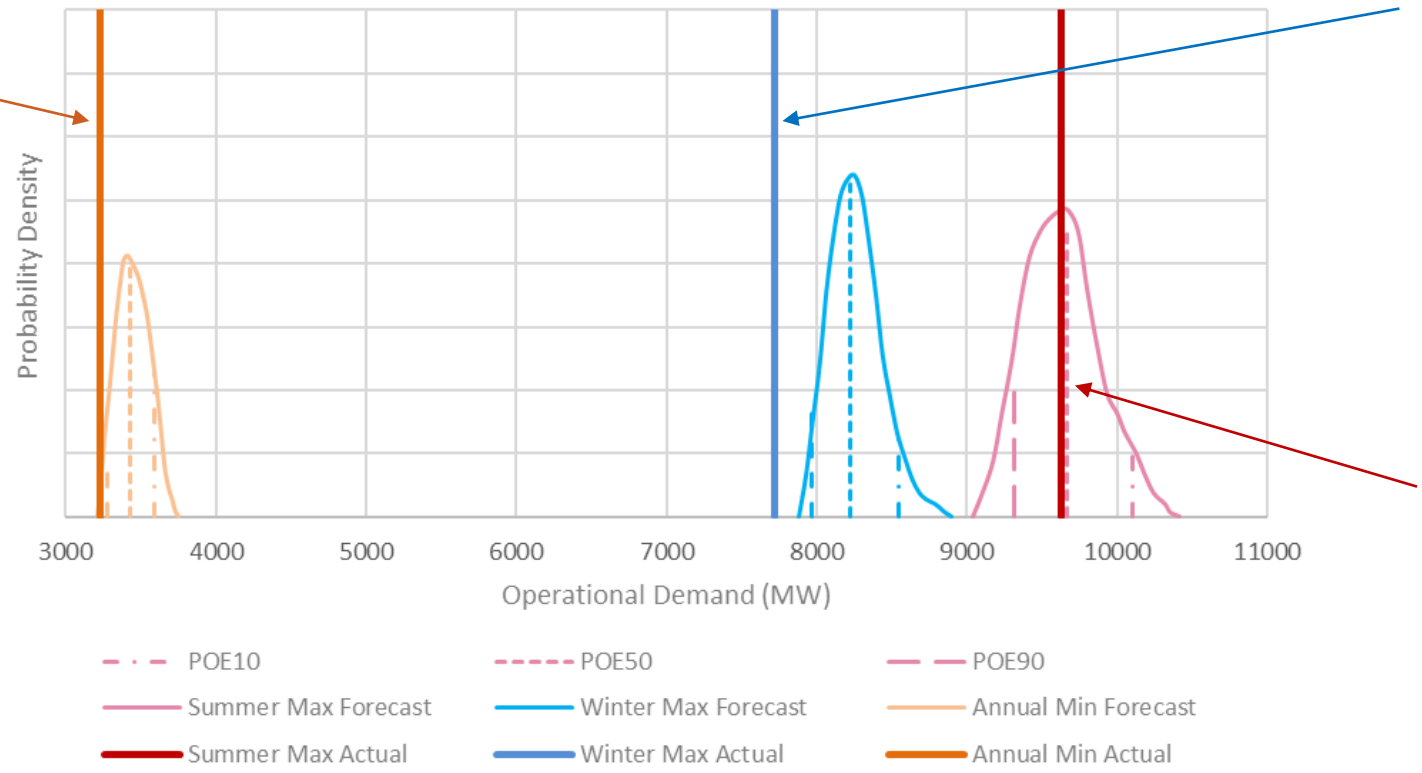
Summer actual outcome occurred in late summer, slightly exceeding 50% POE. This was attributed to a sudden shift from La Niña to El Niño Watch conditions, resulting in higher temperatures.

FIP action: Review minimum demand models

Queensland

DRAFT

Actual was just below 90% POE forecast. Installed rooftop PV forecast was ~130 MW too low which could at least partially explain the lower than forecast minimum demand outcome.



Winter actual below 90% POE driven by El Niño Alert conditions which made 2023 winter one of the warmest winters in NEM history

The summer actual aligned well with the forecast distribution, with the actual outcome consistent with the conditions on the day.

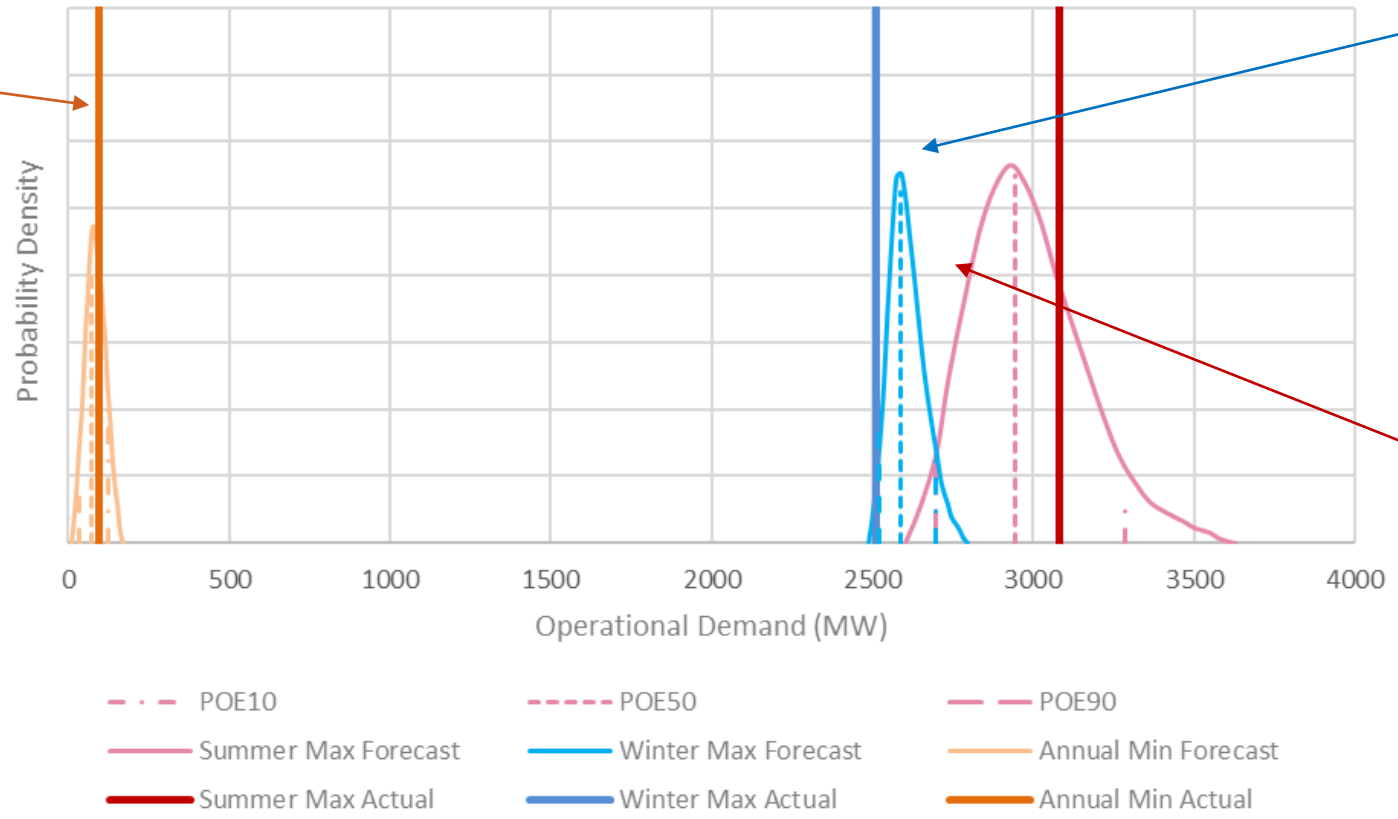
FIP action: Review minimum demand models

South Australia

DRAFT

Actual minimum demand outcome well aligned with forecast.

Winter actual below 90% POE driven by El Niño Alert conditions which made 2023 winter one of the warmest winter in NEM history



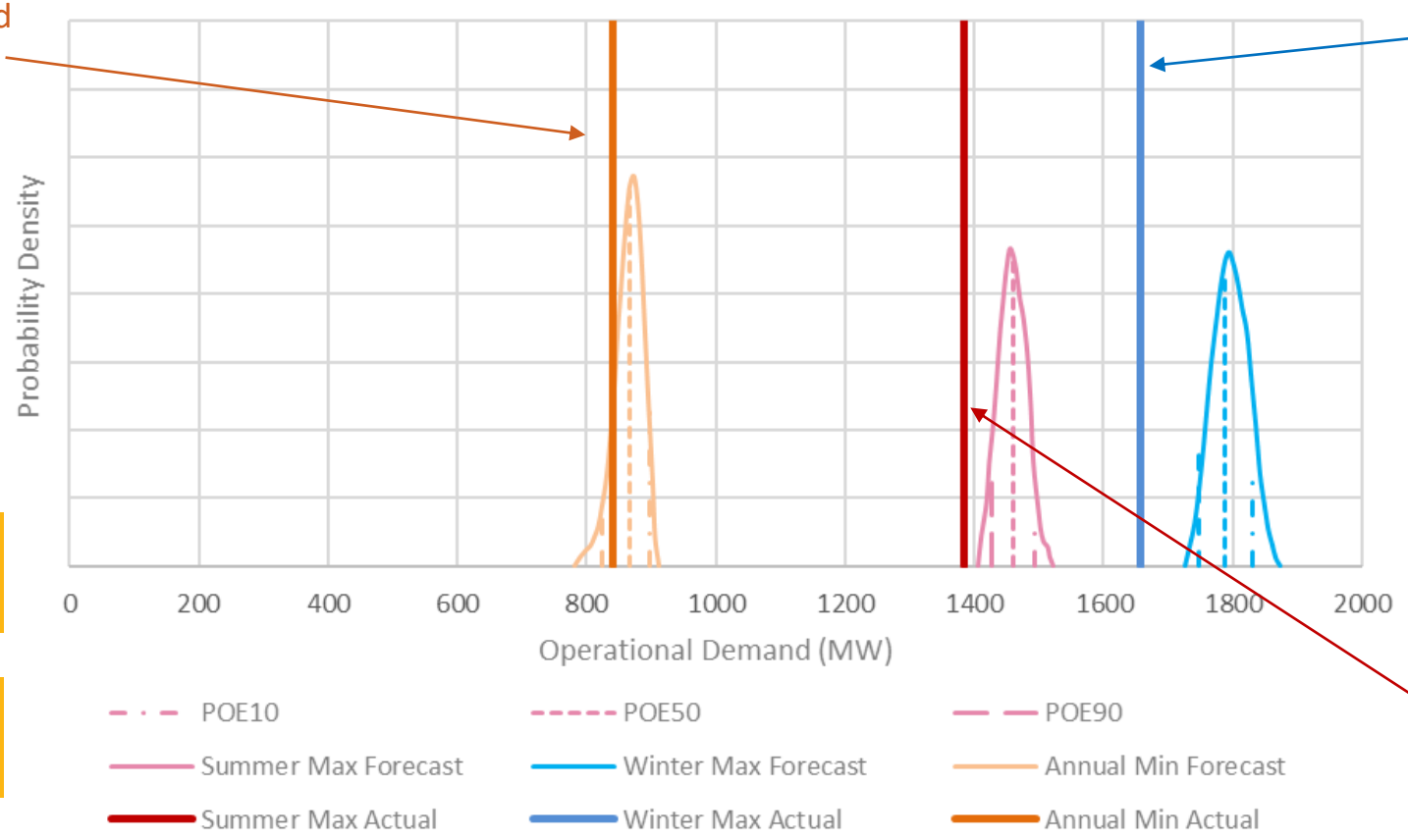
Summer outcome between 50% and 10% POE, driven by high temperature on the day and a heatwave that the preceding two days had max temperature exceeding 35°C

Tasmania

DRAFT

Actual minimum demand outcome well aligned with forecast.

Winter actual below 90% POE driven by the mild winter weather and over-forecasting large industrial loads. This subcomponent requires review. Also a potential impact from short-term consumption model, which should be reviewed.



FIP action: Monitor LIL survey process

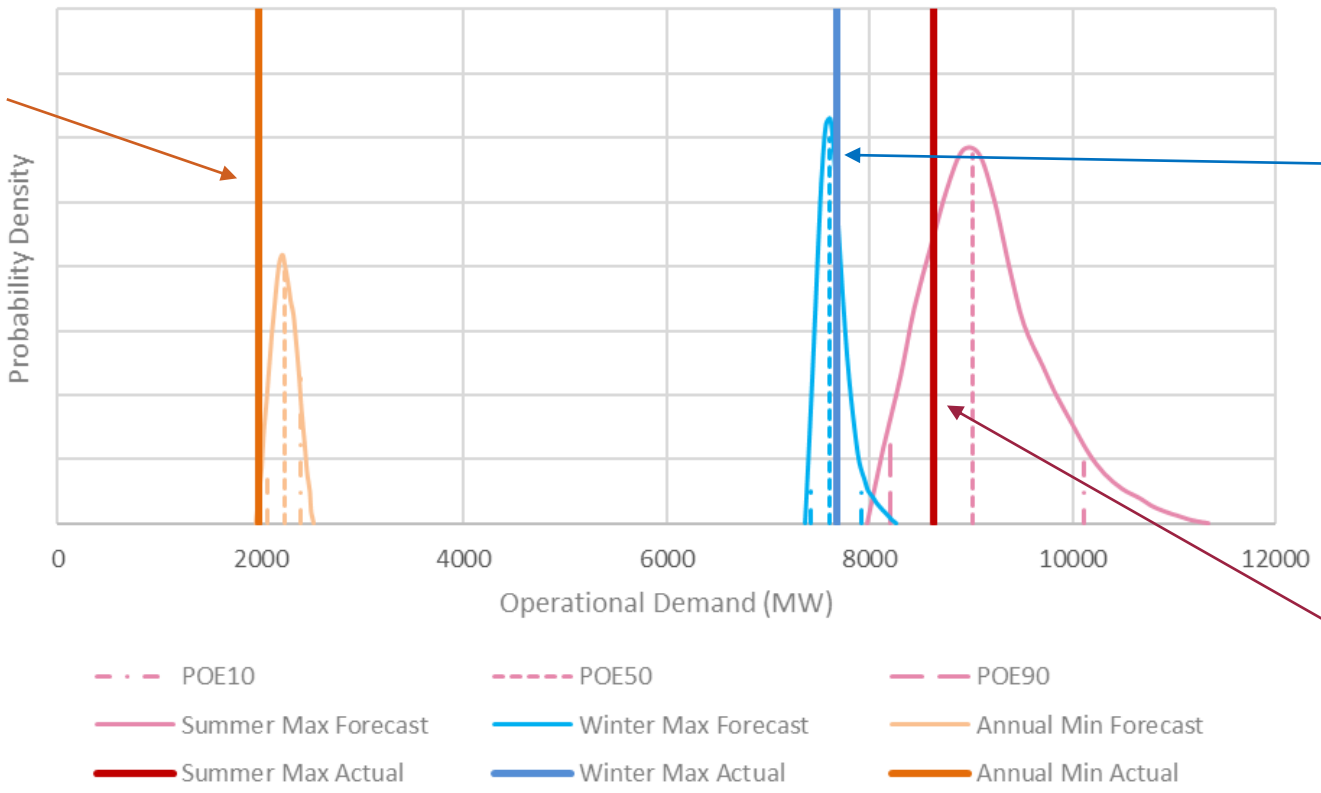
FIP action: Sensitivity of short-term model

Winter actual below 90% POE driven by over-forecasting large industrial loads. Potential impact from short-term consumption model too. These components require review.

Victoria

DRAFT

Actual was just below 90% POE forecast. This cannot be explained by PV forecast, which was reasonably accurate.



The winter actual is slightly above 50% POE while the temperature is towards the top end of the simulated range. The high gas prices at the time and the impact of electrification may have caused more to use electric heating

The summer actual aligned well with the forecast distribution, with actual outcome consistent with the conditions on the day and the previous two days had been relatively mild, the lack of heat build-up is likely to make the actual demand below 50% POE forecast.

FIP action: Review minimum demand models

Research: Electrification trends

Installed generation capacity over-forecast in several regions

DRAFT

Region	Forecast Installed Capacity (MW) by Summer 2022-23	Actual Operating Capacity (MW) by Summer 2022-23	Difference (forecast - actual)
New South Wales	19,082	19,057	0.1%
Queensland	15,881	15,843	0.8%
South Australia	5,776	5,661	2.0%
Tasmania	2,918	2,918	0%
Victoria	14,547	14,057	3.5%

Participant-provided full commercial use dates proved too optimistic for some projects in New South Wales, Queensland, South Australia and Victoria. Besides, some projects in South Australia and Victoria have more forecast capacity from participants than actual capacity.

In total, approximately 750 MW more generation capacity was forecast than was actually operating.

In 2023, AEMO consulted on, and implemented changes to apply project delays to address the ongoing over-forecast of participant advised installed capacity. The effectiveness of this change will be assessed in the 2024 accuracy report.

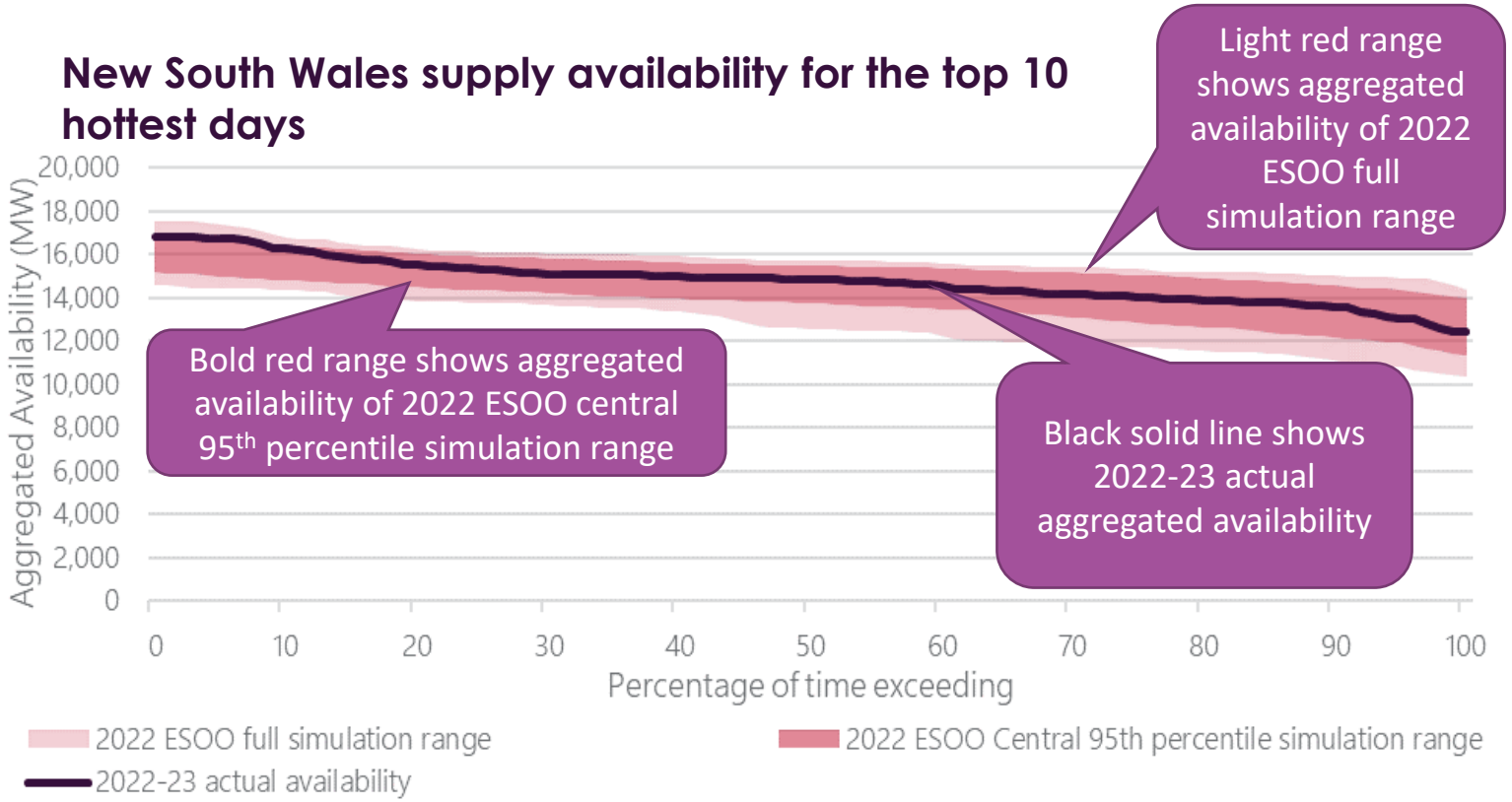
Understanding supply availability charts

DRAFT

How to interpret supply availability charts

- Aggregated availability represents availability of coal, gas and liquids, hydro, wind, and solar generators.
- The data is collated for the top ten hottest days of each year, ordered highest to lowest.
- Red ranges represent aggregated availability of 2022 ESOO full simulation range and central 95th percentile simulation range.
- Black solid line represents 2022-23 actual aggregated PASA availability.

New South Wales supply availability for the top 10 hottest days



General 2023 themes:

- Summer 2022-23 was a mild year, absent of high temperature days considered in participant provided Summer Peak ratings. Given the methodology applies these summer peak ratings, actual availability during mild years should be above the simulated range.

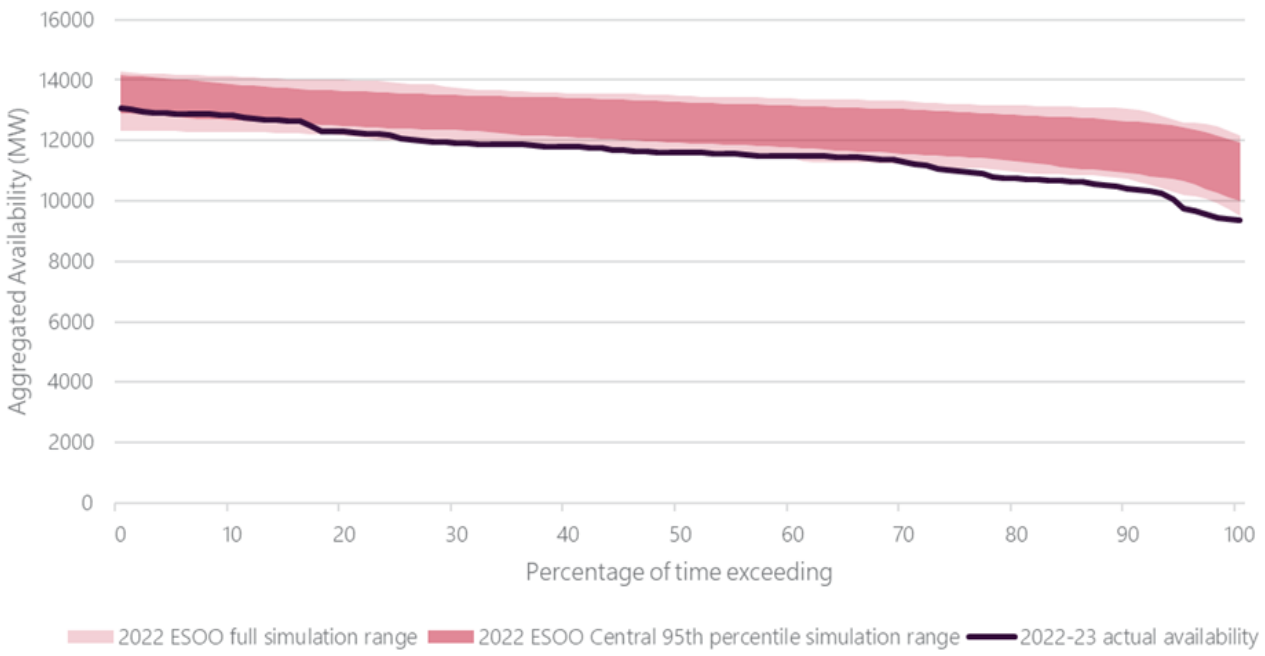
New South Wales outcomes:

- Actual availability is mostly within the 2022 ESOO simulated availability range in New South Wales, South Australia, Tasmania, and Victoria. This is mainly due to planned and unplanned outages during peak periods, which forecasts assume would not occur.

Summer supply availability benefited from mild weather, but QLD result did not match expectation

DRAFT

Queensland supply availability for the top 10 hottest days



Availability in Queensland was below the simulated range, driven by project commissioning delays and the reduced availability of the coal fleet due to Callide C unit 3 extended outage, plus planned and unplanned outages or potential unit decommitment.

Ongoing improvement: Monitor planned outages for scheduled generators during periods of supply scarcity

Forecast Improvement Plan

The Forecast Improvement Plan guides AEMO's ongoing technical improvements

DRAFT

Reliability Forecasting Guidelines – accuracy and fit for purpose Reliability Forecasts

Forecasting Best Practice Guidelines – stakeholder engagement

Forecasting Approach and register – logical layout of Forecasting Components, log of actions

Forecast Improvement Plan*

Actuals vs Forecast → Forecast Accuracy Report →

FAR methodology

Forecast improvement priorities for 2023

Ongoing research and improvement areas

Forecast improvement priorities for 2023

DRAFT

Forecast Accuracy issue	Forecasting Improvement Plan	Details
Under forecasting short term EV numbers, including PHEV	Improve EV forecast approaches	AEMO will work with its consultants to improve consideration of PHEV and newly available vehicle data in their short term models.
Variance in Tasmania that cannot be explained by input drivers is around 4.5% of operational consumption (as generated). This has already been revised downward in the 2023 ESOO	Review the sensitivity of short-term annual consumption models	While AEMO does not propose any changes to model structure and approach, AEMO proposes to expand the annual review of recent growth trends in actual consumption for Tasmania in particular
LIL contributed materially to regional consumption forecast residual and resulted in significant variance to Tasmania winter maximum demand.	Review large industrial load	Improvements to the LIL forecasts were already put in place for the 2023 ESOO however AEMO proposes to expand the annual review of LIL forecasting to monitor unplanned outages and significant operational variations.
Lower-than-POE90 results were recorded for minimum demand. AEMO has implemented a revised half-hourly demand forecasting model and showed improved accuracy	Review minimum demand models	A revised half-hourly demand forecasting model which demonstrated increased accuracy at time of both minimum and maximum demand has been implemented for 2023. Additionally, AEMO will undertake further review of its minimum demand forecast models to establish the drivers of inaccuracy observed.

Ongoing research and improvement areas

DRAFT

Forecast Accuracy issue	Forecasting Improvement Plan	Details
Need to better understand future load shapes and update/operation of EVs and battery storage	Understand changes in future load shape from technology uptake and usage	Assess EVs and battery storage data from Project Edge and Project Symphony and collaborate with stakeholders
Need to better understand the impacts of electrification on energy consumption and seasonal maximum/minimum demand	Track electrification trends	Investigate whether fuel switching trends from natural gas to electricity is observable in actual consumption and connection data
AEMO relies on traces for demand and renewable generation for consistent weather to ensure the supply modelling accuracy	Improve renewable generation and demand traces, including the quantity used, and their shape	Increase weather reference years modelled in the ESOO to better account for the growing share of weather-dependent generation.

Ongoing research and improvement areas

DRAFT

Forecast Accuracy issue	Forecasting Improvement Plan	Details
Limited ability to support sectoral level insights and inform future forecast development at sectoral level	Improve visibility of sectoral consumption	Continue to improve consumption breakdown of LILs and broader business mass market sector. Informed by research project on ANZSIC code mapping.
DSP forecasts incorporate actual wholesale demand response (WDR) data but the scheme is still infancy. WDR in Queensland and South Australia is very low.	Monitor demand side participation trends	Monitor how WDR is used compared to forecast, to guide any future updates of the DSP forecast. Monitor the response of large DSP providers during lack of reserve events.
Unexpected planned outages are observed during hot days in some regions	Monitor planned outage	AEMO has observed planned outages coincident with periods of supply scarcity and hot days. AEMO will monitor planned outages for scheduled generators during periods of high demand and potential supply scarcity.

Discussion

Stakeholders are asked to provide feedback on improvement priorities and the completeness of the draft FIP:

- Are there other initiatives, approaches or directions AEMO should pursue to improve forecast accuracy?
- How well do the draft FIP priorities reflect stakeholder input at the FRG and other engagement opportunities?
- What improvement initiatives would the FRG like to be kept updated on throughout the coming year, and how is that best done?

Put your questions in the chat or raise your hand to get involved in the discussion.

Appendix

Update on delivery of 2022 Forecast Improvement Plan

Improvement	Status
Improve renewable generation and demand traces, including the quantity used, and their shape AEMO planned for more weather reference years to be available for the 2023 ESOO, including a limited number of synthetic years, and expected to create demand traces for them	**In progress.** AEMO has progressed work that will allow weather years back to 2007 to be used as reference year basis. Estimated rooftop PV generation before that day is challenging as satellite data is not available, and AEMO is looking at methods to bias-correct ground-based irradiance measurements from before 2007 to align estimated PV generation in these years with estimates post 2008. AEMO expects to be able to use years going back to 2007 at least for the 2024 ESOO.
Improved visibility of sectoral consumption AEMO planned to continue work on this initiative, with the aim of improving the breakdown of both the existing LIL and the broader business mass market sectors.	**In progress**. Building on outcomes from the original project funded under the NEAR Program, the extended ANZSIC Project scope of works focuses on improving the address matching protocol to map NMIs to industry sectors, and piloting the use of other industry data sources.
Review initial year of forecast maximum and minimum demand distribution AEMO planned to continue this initiative, by reviewing the models used to set the starting points of the demand distributions	**In progress.** Significant improvements were made for the 2023 ESOO allowing the simulation model to set the starting points of the distribution directly. AEMO will continue to look for improvement opportunities in data (including methods for detrending), model formulation and tuning. It should be noted that the first year set by the model is the latest actual year and the first forecast year therefore also depends on the short-term trend of the consumption forecast which is also under review now.

Update on delivery of 2022 Forecast Improvement Plan

Improvement	Status
Review large industrial load and other non-scheduled generation forecast components AEMO planned to review both the LIL and ONSG forecast components, to better understand both their impacts on consumption and their contributions at time of maximum and minimum demand	**In progress.** AEMO receives survey information from LILs, and for the 2022 ESOO, this was reviewed more closely against actual consumption. Most variances related to unplanned outages. AEMO plans on monitoring LIL consumption on an ongoing basis to help with future forecast development. For maximum/minimum demand in the 2023 ESOO, AEMO implemented a random forest algorithm to reflect variability in LIL across the year and across the day. Variations in LIL can affect the maximum outcomes in regions with high proportion of LIL (Tasmania in particular) and minimum demand more generally as operational demand gets closer to or below zero. For its synthetic trace work, AEMO has been adjusting the methodology further to bootstrap historical LIL outcomes scaled according to LIL growth, which is found to improve the modelling of LIL and its contribution to maximum and minimum demand events even further.
Monitor data availability of uptake and usage of emerging technologies AEMO was monitoring a number of new and/or improved data sources for technologies such as EVs and batteries.	**Ongoing process.** For the specific items: • Batteries – AEMO purchased commercially available battery sales and projections data to inform its forecasts and forecasting approach • EVs – AEMO is liaising with various government agencies to determine the most effective data sources for forecasting and insights • AEMO participates in the ESP-Vic project (led by C4NET) to inform sub-transmission level electricity planning beyond 2030. This informs AEMO's thinking across PV integration, battery storage, EV adoption and electrification
Monitor demand side participation trends AEMO planned to monitor how wholesale demand response (WDR) is used compared to forecast, to guide any future updates of the DSP forecast	**Ongoing process.** AEMO reviewed the WDR data for the 2022/23 year and this informed revisions to the WDR forecast, in particular for Queensland and South Australia. AEMO will continue to review WDR data as it evolves.

Update on delivery of 2022 Forecast Improvement Plan

Improvement	Status
Energy adequacy scenarios AEMO planned different EAAP scenarios to better capture energy limits risks and required additional inputs and model changes to appropriately understand the risks of energy limits.	**Completed**. AEMO reached final determination on the consultation and published Reliability forecasting guidelines and methodology final report. Planned improvement has been implemented in 2023 ESOO.
Distributed energy resources and transmission commitment criteria implementation. AEMO planned to seek stakeholder input to determine an appropriate balance of over-forecasting or under-forecasting potential supply from new assets	**Completed**. AEMO reached final determination on the consultation and published Reliability forecasting guidelines and methodology final report. Planned improvement has been implemented in 2023 ESOO.
Random outage parameters AEMO proposed to collect and include additional outage categories in its reliability forecasts.	**Completed**. AEMO reached final determination on the consultation and published Reliability forecasting guidelines and methodology final report. Planned improvement has been implemented in 2023 ESOO.

Update on delivery of 2022 Forecast Improvement Plan

Improvement	Status
MT PASA generator status and recall times. AEMO proposed status codes consistent with the IEEE standard 762-2006, and recall times under a variety of unit status codes.	**Completed**. AEMO reached final determination on the consultation and published Reliability forecasting guidelines and methodology final report. Scheduled generators and integrated resource system participants have provided status codes and recall times for periods of unavailability from Oct 2023.
Reliability gap calculation AEMO proposed to adjust the calculation method for reliability gap periods, likely trading intervals and reliability gaps in megawatts.	**Completed.** AEMO reached final determination on the consultation and published Reliability forecasting guidelines and methodology final report. Planned improvement has been implemented in 2023 ESOO.

AEMO

AUSTRALIAN ENERGY MARKET OPERATOR

For more information visit

aemo.com.au

Energy.forecasting@aemo.com.au