Implementation of the National Electricity Amendment (Mandatory Primary Frequency Response) Rule 2020

Status as at 17 November 2022

A report for the National Electricity Market

Important notice

PURPOSE

AEMO publishes this report to inform industry about AEMO's implementation of the National Electricity Amendment (Mandatory Primary Frequency Response) Rule 2020 (Mandatory PFR Rule).

This publication has been prepared by AEMO using information available at 17 November 2022. This information will be updated and superseded by future implementation reports until full implementation.

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1. Summary

This report provides information on the implementation of the National Electricity Amendment (Mandatory Primary Frequency Response) Rule 2020[1] (Mandatory PFR Rule). It will be updated regularly as implementation proceeds.

The Mandatory PFR Rule affects *Scheduled Generators* and *Semi-Scheduled Generators* (Affected Generators), who were initially required to undertake a self-assessment of the ability of their *generating systems* (Affected GS) to provide *primary frequency response* (PFR) in accordance with the *primary frequency response parameters* (PFRP) specified in the interim *Primary Frequency Response Requirements* (IPFRR).

Implementation of the Mandatory PFR Rule has been carried out in three tranches, as specified in the IPFRR.

Implementation of setting changes for Tranche 1 Affected GSs commenced from late September 2020 and has now been completed for around 30,800 MW, or around 82% of Tranche 1[2] capacity.

Implementation of setting changes for Tranche 2 Affected GSs commenced from early 2021 and has now either commenced or been completed for around 8,100 MW, or around 45% of Tranche 2 capacity.

Implementation of setting changes for Tranche 3 Affected GSs commenced from early 2021 and has now either commenced or been completed for around 2,700 MW, or around 55% of Tranche 3 installed capacity.

The majority of capacity now remaining to implement setting changes consists of Semi-Scheduled Generators (i.e. Wind and PV), a number of which require control system software updates to meet the requirements of the Mandatory PFR rule. This work will be ongoing throughout 2022.

2. Self-Assessments

As outlined in the IPFRR, Affected Generators are required to undertake a Self-Assessment of their ability to comply with the requirements of the Mandatory PFR rule. As part of this process, they may apply for variations to the requirements, or apply for an exemption from the requirements.

Table 1 shows the number of results of the self-assessments (Results), applications for variation and exemption received by AEMO as at the date of this report.

Table 1 Results and Applications received

Number of Affected GS	Results	Applications for Variation	Applications for Exemption
Tranche 1	81	17	8
Tranche 2	115	22	14
Tranche 3	108	7	15

[1] Available at https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response.

[2] Tranche 1 Affected GS are those with a *Registered Capacity* above 200 MW. Tranche 2 Affected GS are between 80 and 200 MW. Tranche 3 are below 80 MW/. All Registered Capacities are the level of the individual DUID.

AEMO has received Results in respect of 304 Affected GSs across all three Tranches. AEMO has determined PFR settings for 284 of those, covering around 53,600 MW of installed capacity. Table 4 contains a register of Affected GSs where PFR Settings have been determined.

3. Applications for Variation

Table 2 details the number of applications for variation received in respect of Affected GSs, those granted and those still under consideration as at the date of this report.

Table 2 Variations

Number of Affected GS	Applications for Variation	Variations Granted	Variations not Granted	Variations being Assessed
Tranche 1	17	17		
Tranche 2	21	21		
Tranche 3	7	5	2	

4. Applications for Exemption

Table 3 details the number of applications for exemption received in respect of Affected GSs, those granted and those still under consideration as at the date of this report.

Table 3 Exemptions

Number of Affected GS	Applications for Exemption	Exemptions Granted	Exemptions not Granted	Exemptions being Assessed
Tranche 1	8		8	
Tranche 2	14	6	7	1
Tranche 3	15	8	5	2

5. Implementation of PFR Settings

5.1 Tranche 1 Implementation

Implementation of PFR Settings for approximately 82% of installed generation capacity in Tranche 1 has now been achieved. Information on actual and expected timing of setting changes in shown in Table 4.

Some Affected Generators indicated a preference to make staged changes to frequency response deadbands, in which case, more than one implementation date has been listed in Table 4. Other Affected Generators elected to alter settings in one step, and in these cases, a single implementation date is listed.

In some cases, actual implementation dates were later than those originally planned by Affected Generators. This occurred for several reasons, including:

- Affected GS forced outages.
- Delays in Affected GS returning from planned outages.
- Delays in provision of key information or advice from OEMs.
- Affected Generator resourcing constraints.
- Problems encountered when altering settings.

In all cases, the earliest reasonably achievable date, subject to these constraints, was determined, or re-determined (as applicable), after consultation with the relevant Affected Generator.

5.2 Implementation for Tranche 2 and 3

As required by the IPFRR, Tranche 2 and Tranche 3 Affected Generators were required to complete their self-assessments by 19 November 2020 and 17 February 2021, respectively.

Details on agreed dates for changes for Tranche 2 and Tranche 3 Affected Generators are shown in Table 4. Actual dates achieved may vary, for similar reasons as experienced with Tranche 1. At the time of writing, implementation of PFR Settings for approximately 45% of installed generation capacity in Tranche 2 and 55% of Tranche 3, respectively, has been achieved.

A number of Semi-Scheduled Affected GS from Tranches 2 and 3 are experiencing delays in implementation of PFR settings, and now form the majority of the Affected GS remaining to complete PFR setting changes. This is discussed in section 5.5.

5.3 Flexibility in Implementation Dates

Provided they consult with AEMO beforehand, Affected Generators may commence making setting changes earlier, or in an incremental manner, to achieve their PFR Settings by the specified implementation date.

Power system conditions, such as major network outages, could also require alterations to implementation dates, though this has not been necessary to date.

5.4 Generation providing PFR prior to Mandatory PFR Rule

Previous surveys of generator active power controls, and more recent engagement with Affected Generators indicated that no large Affected GSs were providing PFR that fully met the PFRP prior to the Mandatory PFR Rule.

AEMO has become aware of a several, typically smaller or low capacity factor Affected GSs, already operating in a way that meets the PFRP. These are identified in Table 4.

5.5 Implementation for Semi-Scheduled Generation

The Mandatory PFR Rule represents a material change to the operation of generation in the NEM, particularly for existing Semi-Scheduled generation, much of which has not continuously operated in frequency response mode to date.

Work to date has identified that many existing Semi-Scheduled generators require updates to control software, particularly to Power Plant Controllers (PPC) or similar, to comply with the IPFRR. This is materially different to Scheduled generation, where almost all Scheduled generators were able to meet the IPFRR by making setting changes to existing control systems.

To comply with the requirements of IPFRR, Semi-Scheduled generators will typically need control of active power that allow for simultaneous MW curtailment, MW ramping, frequency response outside a relatively small frequency deadband, and ongoing variation in input energy.

While such MW control capabilities do often exist in isolation, when they are tested simultaneously, and in an ongoing manner, software problems have often been found. This then requires further development, updates and testing to address, a process that has in some cases proven significantly more time consuming than initially expected

For new Semi-Scheduled generation sites, some OEMs are now able to provide control system software that meets the requirements of the IPFRR, allowing for these new sites to implement compliant control system settings prior to or at completion of commissioning. However, even for these OEMs this still leaves a significant body of work to implement similar software across the existing fleet of Semi-Scheduled generation.

Control system software updates to implement PFR for existing sites typically involves and require coordination from the site operator, the local NSP, multiple teams within AEMO, and in some cases 3rd party consultants. The risk of unintended changes in plant performance when making control system software updates must be handled carefully. Resource limitations across the industry have also been a factor in ongoing delays.

AEMO have been prioritising PFR implementation for existing Semi-Scheduled generation for those OEMs with the greatest installed MW capacity. With around 20 different OEMS in the NEM, this has delayed implementation for sites using equipment from OEMs used in a smaller number of sites, which in a number of cases is still yet to commence.

At the time of writing, PFR setting changes have either already been implemented, or an agreement is in place for implementation of settings changes, across 31 Semi-Scheduled Affected GSs using six major OEMs' equipment, as reported in Table 4.

While AEMO have agreed in-principle PFR settings for a number of additional existing Semi-Scheduled generators, in many cases it has been unable to confirm implementation dates, prior to having confirmed that suitable control software is available for a given site. Where PFR Settings have been agreed but a planned implementation date has not yet been confirmed, Table 4 will contain a "#" symbol for relevant Affected GSs in the relevant column regarding implementation date.

Work to rollout PFR across the semi-scheduled generation fleet remains ongoing.

5.6 Change to Automatic Generation Control (AGC)

Automatic Generation Control (AGC) is used by AEMO to remotely control the output of some generation. It is used both for ramping generation between 5-minute energy spot market targets, and for slower, centralised (secondary) response to changes in power system frequency. AEMO procures secondary frequency control MW reserves (Regulation FCAS) via a 5-minute spot market, for subsequent use by AEMO's AGC to support power system frequency control.

Following the changes in generator primary frequency control settings commencing in late September 2020, and the resultant changes in power system frequency conditions, a number of changes were made to AEMO's AGC area level tuning. These changes commenced from 9 December 2020 and were aimed at ensuring better utilisation of available Regulation FCAS.

Changes to AGC area level parameters covered AGC deadbands, minor adjustments to gains, changes to make integral area control error (ACE) more persistent and enablement of AGC basepoint adjustment. No changes were made to Regulation FCAS constraint equations, which govern the MW volume of Regulation FCAS reserve procurement, or to individual generator AGC tuning as part of this work.

Following these changes, the daily distribution of NEM frequency became narrower, suggesting these AGC changes improved the control of frequency under normal operating conditions. However, it was identified in early January 2021 that the introduction of AGC basepoint adjustment interfered with data transfer processes used by the existing causer pays process, which allocates Regulation FCAS costs.

To address the impacts on the causer pays process, the change to implement AGC basepoint adjustment was reversed on 18 January 2021. The impact of other AGC changes on power system frequency control continues to be monitored.

AEMO are also now considering how the Primary Frequency Response Incentive[3] rule, published on 8 September 2022, which include changes to the arrangements for allocation of Regulation FCAS costs, may affect AEMO's ability to tune AGC to better support power system frequency control. In particular, AEMO are assessing options to improve AGC performance prior to commencement of Primary Frequency Response Incentive rule in mid 2025.

5.7 Consultation on final Primary Frequency Response Requirements (PFRR)

The Interim PFRR[4] outlines the technical performance requirements for Affected Generating Systems to comply with the current Mandatory PFR rule. It also outlines a process for managing the initial transition of the current generation fleet to comply with the Mandatory PFR rule, including managing changes to control system settings on existing Affected GS.

The current PFRR are an interim document. The Primary Frequency Response Incentives rule, published on 8 September 2022, require AEMO to consult on and determine any amendments to the PFRR, and to publish a final PFRR by 8 May 2023.

AEMO will commence consultation on a final PFRR shortly.

[3] For more details on primary frequency response incentives see: https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements

[4] Available at: https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2020/interim-pfrr.pdf

6. Register of Affected GS

Table 4 details, for each Affected GS, the planned or actual dates for completion of implementation of the PFR Settings notified by AEMO in accordance with the IPFRR, and whether AEMO has granted an exemption or variation from the PFRP. Where a variation has been granted, the table also indicates which PFRP has been varied. Where further information regarding a variation or exemption is provided as a footnote, that information has been included with the consent of the Affected Generator.

A single implementation date under the 'Stage 1' column indicates that full implementation of the PFR Settings is to be, or has been, achieved by that date. The 'Stage 2' column will only be populated where the deadband is to be, or has been, tightened in two stages, or other control changes have been made in more than one step.

Tranche 2 is highlighted in blue font, and Tranche 3 in green font.

At the time of writing, Affected GSs across all three Tranches with an installed capacity of approximately 41,600 MW have either commenced, or fully implemented, PFR Settings, or were already providing PFR that meets the PFRP.

This represents approximately 70% of the approximately 59,400 MW of NEM installed capacity that is ultimately required to meet the Mandatory PFR Rule[5].

Table 4 Register of Affected GS

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Adelaide Desalination Plant PV	ADPPV1	19	#				
Adelaide Desalination Plant BESS	ADPBA1G	6	6 Aug 21				
Angaston PS	ANGAST1	50	25 Jun 21				
Ararat WF	ARWF1	241	#				
Avonlie SF	TBC[7]	190	Prior to or upon completion of commissioning				
Bairnsdale PS	BDL01	47	2 Dec 21				
Bairnsdale PS	BDL02	47	2 Dec 21				
Bald Hills WF	BALDHWF1	106	11 Aug 21				
Ballarat BESS	BALBG1	30	30 Oct 21				
Bango 973 WF	BANGOWF1	159	#				

[5] This figure excludes capacity that has been exempted from the provisions of the PFR rule.

[6] This column will be populated only when deadband adjustments will be made in two stages.

[7] To be confirmed following registration.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Bango 999 WF	BANGOWF2	84	#				
Barcaldine PS	BARCALDN	37	8 Jun 22				
Barker Inlet PS	BARKIPS1	211	Pre-existing			Yes	Response time[8]
Barron Gorge PS	BARRON-1	30	6 May 21				
Barron Gorge PS	BARRON-2	30	6 May 21				
Bastyan PS	BASTYAN	80	Pre-existing				
Bayswater PS	BW01	660	29 Sep 20	14 Oct 20			
Bayswater PS	BW02	660	16 Oct 20				
Bayswater PS	BW03	660	3 Nov 20				
Bayswater PS	BW04	660	29 Sep 20	14 Oct 20			
Bell Bay Three PS	BBTHREE1	35	Pre-existing				
Bell Bay Three PS	BBTHREE2	35	Pre-existing				
Bell Bay Three PS	BBTHREE3	35	Pre-existing				
Berrybank WF	BRYB1WF1	180	28 Oct 21				
Beryl SF	BERYLSF1	98	#				
Blowering PS	BLOWERNG	80			Yes[9]		
Boco Rock WF	BOCORWF1	113	#				
Bodangora WF	BODWF1	113	30 Dec 22				
Bogong / Mackay PS	MCKAY1	300	22 Oct 20				
Bolivar PS[10]	BOLIVPS1	123	30 Mar 21				
Bolivar Wastewater Plant PV	BOWWPV1	6	#				
Bolivar Wastewater Plant BESS	BOWWBA1G	3	13 May 22				
Bomen SF	BOMENSF1	121	#				
Braemar PS	BRAEMAR1	168	9 July 22				
Braemar PS	BRAEMAR2	168	30 Dec 22				
Braemar PS	BRAEMAR3	168	30 Dec 22				
Braemar 2 PS	BRAEMAR5	173	30 Mar 21	30 Mar 23			

[8] AEMO has granted a variation in respect of response time, where 12 sec is required to achieve a 5% change in output.

[9] AEMO has granted an exemption on the basis of environmental restrictions imposed by a 3rd party..

[10] Was previously SA Temporary Generation South, generating units relocated to new site.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Braemar 2 PS	BRAEMAR6	173	30 Mar 21	30 Mar 23			
Braemar 2 PS	BRAEMAR7	173	30 Mar 21	30 Mar 23			
Broken Hill SF	BROKENH1	53	#				
Callide B PS	CALL_B_1	350	8 Nov 20	18 Nov 20			
Callide B PS	CALL_B_2	350	30 Sep 20	28 Oct 20			
Callide C PS	CPP_3	420	9 Nov 20	26 Nov 20		Yes	Response time
Callide C PS	CPP_4	420	10 Dec 20			Yes	Response time
Cattle Hill WF	CLHLWF1	148	#				
Cethana PS	CETHANA	85	Pre-existing				
Cherry Tree WF	CHYTWF1	57	29 Nov 21				
Christies Beach WWTP BESS	CBWWBA1G	2	Prior to or upon completion of commissioning				
Clare SF	CLARESF1	110	#				
Clements Gap WF	CLEMGPWF	57			Yes[11]		
Clermont SF	CLERMSF1	92	#				
Coleambally SF	COLEASF1	180	#			Yes	Deadband[12]
Collector WF	COLWF01	226	Prior to or upon completion of commissioning				
Colongra PS	CG1	181	4 Jun 21				
Colongra PS	CG2	181	4 Jun 21				
Colongra PS	CG3	181	4 Jun 21				
Colongra PS	CG4	181	3 Jun 21				
Columboola SF	COLUMSF1	217	#				
Condamine PS	CPSA	144	19 May 21				
Coopers Gap WF	COOPGWF1	452	Prior to or upon completion of commissioning				
Corowa SF	CRWASF1	36	#				
Crookwell 2 WF	CROOK2WF	96	#				

[11] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

[12] The Affected GS will be operated with a deadband of ±0.020 Hz due to the 2-digit precision of the frequency measurement used.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Crowlands WF	CROWLWF1	79	6 Jun 22			Yes	Deadband[13]
Crudine Ridge WF	CRURWF1	138	#				
Darling Downs PS	DDPS1	644	15 Jun 20				
Darling Downs SF	DDSF1	121	#				
Darlington Point SF	DARLSF1	324	#				
Dartmouth PS	DARTM1	185	17 Nov 20				
Daydream SF	DAYDSF1	167	#				
Devils Gate PS	DEVILS_G	60	30 Jun 21				
Dry Creek PS	DRYCGT1	52	13 Jan 21				
Dry Creek PS	DRYCGT2	52	13 Jan 21				
Dry Creek PS	DRYCGT3	52	13 Jan 21				
Dundonnell 1 WF	DUNDWF1	168	8 Jun 22				
Dundonnell 2 WF	DUNDWF1	46	8 Jun 22				
Dundonnell 3 WF	DUNDWF1	121	8 Jun 22				
Eildon PS	EILDON1	60	11 Mar 21				
Eildon PS	EILDON2	60	11 Mar 21				
Elaine WF	ELAINWF1	83	26 Oct 22				
Emerald SF	EMERASF1	88	#				
Eraring PS	ER01	720	27 Oct 20			Yes	Response time
Eraring PS	ER02	720	16 Oct 20			Yes	Response time
Eraring PS	ER03	720	13 Oct 20			Yes	Response time
Eraring PS	ER04	720	20 Oct 20			Yes	Response time
Finley SF	FINLYSF1	162	#				
Fisher PS	FISHER	43	Pre-existing			Yes	Deadband, Response Time[14]
Gangarri SF	GANGARR1	162	#				
Gannawarra BESS	GANNBG1	30	25 May 21				

[13] The Affected GS will be operated with a deadband of ±0.075 Hz, to ensure that changes in active power output due to frequency always act to correct system frequency.

[14] AEMO has granted a variation to the deadband at ±100 mHz, and has recorded a response time of 15 seconds for a 5% change in output, based on the currently known capabilities of the Affected GS.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Gladstone PS[15]	GSTONE1	280					
Gladstone PS	GSTONE2	280					
Gladstone PS	GSTONE3	280					
Gladstone PS	GSTONE4	280					
Gladstone PS	GSTONE5	280					
Gladstone PS	GSTONE6	280					
Glenrowan West SF	GLRWNSF1	132	#				
Gordon PS	GORDON	432	Unit 1 – 16 Dec 20 Unit 2 – 28 Sep 20 Unit 3 – 29 Sep 20				
Granville Harbour WF	GRANWF1	111	7 May 21	21 Oct 21			
Gullen Range 1 WF	GULLRWF1	165	#				
Gullen Range 2 WF	GULLRWF2	110	#				
Gunning WF	GUNNING1	47	#				
Guthega PS	GUTHEGA	60	27 Jan 21				
Hallett PS[16]	AGLHAL	217	27 Oct 20				
Hallett WF	HALLWF1	95			Yes[17]		
Hallett 2 WF	HALLWF2	71			Yes[18]		
Happy Valley WWTP BESS	HVWWBA1G	8	17 June 22				
Happy Valley WWTP PV	HVWWPV1	4	#				
Haughton SF	HAUGHT11	132	#				
Hillston SF	HILLSTN1	85	#				
Hornsdale Power Reserve	HPRG1	150	9 March 21	7 Jul 22		Yes	Deadband
Hornsdale 1 WF	HDWF1	112	#				
Hornsdale 2 WF	HDWF2	102	#				

[15] In November 2021, CS Energy gave the AER a notice of non-compliance with the PFR requirements for Gladstone PS under the Queensland jurisdictional derogations in the National Electricity Rules. Clause 9.34.6 relieves CS Energy from compliance with a rules requirement if it is unable to obtain the necessary cooperation from the counterparties to the legacy agreements for the operation of Gladstone PS in the NEM. The AER is required to report quarterly on the non-compliance and its impact on the market under clause 9.34.6(l). The initial AER report can be found here

[16] Applicable to one *generating unit*, remainder previously complied with the PFRP.

[17] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

[18] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Hornsdale 3 WF	HDWF3	102	#				
Hume PS	HUMEV HUMENSW	58			Yes		
Jeeralang PS	JLA01	51	19 Jan 21				
Jeeralang PS	JLA02	51	19 Jan 21				
Jeeralang PS	JLA03	51	19 Jan 21				
Jeeralang PS	JLA04	51	19 Jan 21				
Jeeralang PS	JLB01	76	19 Jan 21				
Jeeralang PS	JLB02	76	19 Jan 21				
Jeeralang PS	JLB03	76	19 Jan 21				
Jemalong SF	JEMALNG1	50	#				
John Butters PS	JBUTTERS	144	1 Jul 21				
Junee SF	JUNEESF1	36	#				
Kaban WF	KABANWF1	152	Prior to or upon completion of commissioning				
Karadoc SF	KARSF1	104	#				
Kareeya PS	KAREEYA1	21	10 May 22				
Kareeya PS	KAREEYA2	21	24 May 22				
Kareeya PS	KAREEYA3	21	14 June 22				
Kareeya PS	KAREEYA4	21	24 Jan 22				
Kiamal SF	KIAMSF1	239	1 April 21				
Kiata WF	KIATAWF1	31	21 Jan 22				
Kidston SF	KSP1	50	#				
Kogan Creek PS	KPP_1	744	19 Nov 20	26 Nov 20			
Ladbroke Grove PS	LADBROK1	40	30 Aug 21				
Ladbroke Grove PS	LADBROK2	40	30 Aug 21				
Lake Bonney BESS	LBBG1	25	8 Dec 21				
Lake Bonney 2 WF	LKBONNY2	159			Yes[19]		

[19] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Lake Bonney 3 WF	LKBONNY3	39			Yes[20]		
Lake Echo PS	LK_ECHO	32	30 Dec 22			Yes	Deadband, Response Time[21]
Laverton Nth PS	LNGS1	156	13 April 22			Yes	Deadband[22]
Laverton Nth PS	LNGS2	156	13 April 22			Yes	Deadband[23]
Lemonthyme PS Wilmot PS	LEM_WIL	82	31 Mar 21			Yes[24]	
Liapootah PS Wayatinah PS Catagunya PS	LI_WY_CA	173	Liapootah – Settings already in place Wayatinah – 26 May 21 Catagunya Unit 1 – 26 May 21 Catagunya Unit 2 – 21 Jun 22				
Liddell PS	LD01	500	26 Nov 20				
Liddell PS	LD02	500	9 Feb 21				
Liddell PS	LD04	500	26 Nov 20				
Lilyvale SF	LILYSF1	118	#				
Limondale 1 SF	LIMOSF1	275	#				
Limondale 2 SF	LIMOSF2	38	#				
Lincoln Gap WF Stage 1	LGAPWF1	126	#				
Lonsdale PS	LONSDALE	21	30 Apr 25				
Loy Yang A PS	LYA1	560	14 Oct 20				
Loy Yang A PS	LYA2	530	14 Oct 20	11 Nov 20			
Loy Yang A PS	LYA3	560	17 Nov 20				
Loy Yang A PS	LYA4	560	15 Oct 20				
Loy Yang B PS	LOYYB1	500	15 Dec 20	18 Dec 20			

[20] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

[21] AEMO has granted a variation to the deadband at ±100 mHz, and has recorded a response time of 15 seconds for a 5% change in output, based on the currently known capabilities of the Affected GS.

[22] AEMO has granted a variation to the deadband at ±100 mHz based on the currently known capabilities of the Affected GS for a period of 12 months.

[23] AEMO has granted a variation to the deadband at ±100 mHz based on the currently known capabilities of the Affected GS for a period of 12 months.

[24] The *generating unit* at Lemonthyme PS is inherently incapable of meeting the PFR requirements. The *generating unit* at Wilmot PS meets all requirements.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Loy Yang B PS	LOYYB2	500	30 Sep 20	28 Oct 20			
Macarthur WF	MACARTH1	420	8 Feb 21				
Mackintosh PS	MACKNTSH	80	18 Mar 21				
Mannum Adelaide Pipe PV2	MAPS2PV1	13	#				
Mannum Adelaide Pipe PV3	MAPS3PV1	12	#				
Meadowbank PS	MEADOWBK	40	Pre-existing			Yes	Deadband[25]
Millmerran PS	MPP_1	426	1 Oct 20	28 Oct 20		Yes	Response time
Millmerran PS	MPP_2	426	12 Nov 20			Yes	Response time
Mintaro PS	MINTARO	90	27 Nov 20				
Moorabool WF	MOORAWF1	312	#			Yes	Deadband[26]
Moree SF	MOREESF1	57	#				
Morgan Whyalla Pump PV1	MWPS1PV1	6	#				
Morgan Whyalla Pump PV2	MWPS2PV1	6	#				
Morgan Whyalla Pump PV3	MWPS3PV1	8	#				
Morgan Whyalla Pump PV4	MWPS4PV1	6	#				
Mortlake PS	MORTLK11	283	30 Sep 20				
Mortlake PS	MORTLK12	283	6 Nov 20				
Mount Emerald WF	MEWF1	180	8 Oct 21				
Mt Gellibrand WF	MTGELWF1	138	#				
Mt Mercer WF	MERCER01	131	9 Nov 22			Yes[27]	
Mt Piper PS	MP1	730	21 Dec 20				
Mt Piper PS	MP2	700	29 Sep 20	28 Oct 20			
Mt Stuart PS	MSTUART3	131	22 Apr 21				
Murra Warra WF	MUWAWF1	231	#				
Murra Warra 2 WF	MUWAWF2	204	Prior to or upon completion of commissioning				

[25] AEMO has granted a variation to the deadband at ±150 mHz, based on the currently known capabilities of the Affected GS.

[26] AEMO has granted a variation to the deadband at ±100 mHz based on the currently known capabilities of the Affected GS..

[27] The Affected GS will provide frequency response only for rising frequency.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Murray PS[28]	MURRAY	1500	30 March 21				
Murray Bridge - Onkaparinga Pump Station No 2 PV	MBPS2PV1	10	#				
Musselroe WF	MUSSELR1	168	5 Aug 21	30 Mar 23			
Nevertire SF	NEVERSF1	132	#				
Newport PS	NPS	500	28 Sep 20	19 Oct 20			
North Brown Hill WF	NBHWF1	132			Yes[29]		
Numurkah SF	NUMURSF1	112	#			Yes	Deadband[30]
Nyngan SF	NYNGAN1	100	#				
Oakey PS	OAKEY1	144	30 Mar 21	2 Sep 21		Yes	Deadband
Oakey PS	OAKEY2	144	30 Mar 21	2 Sep 21		Yes	Deadband
Oakey 1 SF	OAKEY1SF	30	#				
Oakey 2 SF	OAKEY2SF	65	#				
Oaklands Hill WF	OAKLAND1	67			Yes[31]		
Osborne PS	OSB-AG	180	Pre-existing				
Parkes SF	PARSF1	55	#				
Pelican Point PS	PPCCGT	478	30 Sep 20				
Poatina PS	POAT220	200	Pre-existing			Yes	Deadband, Response Time[32]
Poatina PS	POAT110	100	Pre-existing			Yes	Deadband, Response Time[33]
Port Lincoln PS	POR01	50	Pre-existing				
Port Lincoln PS	POR03	23	17 Jun 21				
Port Stanvac PS	PTSTAN1	58	30 Dec 22				
Quarantine PS	QPS1	29	31 Aug 21				
Quarantine PS	QPS2	24	30 Jun 24				

[28] One *generating unit* (out of 14) will have PFR Settings implemented in Oct 2021.

[29] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements

[30] The Affected GS will be operated with a deadband of ±0.020 Hz due to the 2-digit precision of the frequency measurement used.

[31] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

[32] The variation to the deadband is at ±100 mHz. The variations were granted due to the inherent capability and design of the Affected GS.

[33] The variation to the deadband is at ±100 mHz. The variations were granted due to the inherent capability and design of the Affected GS.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Quarantine PS	QPS3	24	7 Feb 22				
Quarantine PS	QPS4	24	30 Jun 24				
Quarantine PS	QPS5	128	1 April 21				
Reece PS	REECE1	116	16 Mar 21				
Reece PS	REECE2	116	31 Mar 21				
Ross River SF	RRSF1	128	#			Yes	Deadband
Rugby Run SF	RUGBYR1	83	#				
Rye Park WF	DUID1[34]	128[35]	Prior to or upon completion of commissioning				
Rye Park WF	DUID2[36]	128[37]	Prior to or upon completion of commissioning				
Rye Park WF	DUID3[38]	128[39]	Prior to or upon completion of commissioning				
Salt Creek WF	SALTCRK1	54	23 Sept 21				
Sapphire WF	SAPHWF1	270	23 Mar 21				
Sebastapol SF	SEBSF01	90	#				
Shoalhaven PS	SHGEN	240	Bendeela Unit 1 – 30 Apr 23 Bendeela Unit 2 - 31 Aug 21 Kangaroo Valley Unit 3 -30 Nov 23 Kangaroo Valley Unit 4–17 Feb 22				
Silverton WF	STWF1	198	30 Dec 22				
Smithfield Energy Facility	SITHE01	185	Pre-existing				
Snapper Point PS	SNAPPER1	154	Pre-existing				

[34] To be confirmed following registration

[35] To be confirmed following registration

[36] To be confirmed following registration

[37] To be confirmed following registration

[38] To be confirmed following registration

[39] To be confirmed following registration

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Snowtown WF	SNOWTWN1	99			Yes		
Snowtown WF Stage 2	SNOWNTH1	144	#				
Snowtown Sth WF	SNOWSTH1	126	#				
Snuggery PS	SNUG1	63	Unit 1 – Pre Existing Unit 2 – 15 Jun 21 Unit 3 – Pre Existing			Yes	Response Time[40]
Somerton PS	AGLSOM	170	2 Jul 21				
Stanwell PS	STAN-1	365	27 Oct 20				
Stanwell PS	STAN-2	365	27 Oct 20				
Stanwell PS	STAN-3	365	27 Oct 20				
Stanwell PS	STAN-4	365	29 Oct 20				
Stockyard Hill WF	STOCKYD1	531	#			Yes	Deadband[41]
Sunraysia SF	SUNRSF1	228	#				
Susan River SF	SRSF1	85	#				
Swanbank E PS	SWAN_E	385	8 Dec 20			Yes	Response Time
Tallawarra PS	TALWA1	440	22 Apr 21				
Tamar Valley CCGT	TVCC201	208	Pre-existing				
Tamar Valley OCGT	TVPP104	58	24 Nov 21				
Taralga WF	TARALGA1	106	2 Aug 22				
Tarong North PS	TNPS1	443	21 Oct 20			Yes	Droop, Response Time[42]
Tarong PS	TARONG#1	350	27 Oct 20				
Tarong PS	TARONG#2	350	3 Nov 20				
Tarong PS	TARONG#3	350	27 Oct 20				
Tarong PS	TARONG#4	350	27 Oct 20				

[40] Unit 2 does not meet the response time requirement, requiring up to 30 seconds to achieve a 5% change in output.

[41] AEMO has granted a variation to the deadband at ±100 mHz based on the currently known capabilities of the Affected GS..

[42] The droop characteristics applied to the unit do not meet the requirement for a droop of 5% or less at all levels of frequency change.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Tarraleah PS	TARRALEA	90			Yes[43]		
The Bluff WF	BLUFF1	53			Yes[44]		
Torrens Island B PS	TORRB1	200	3 Mar 21			Yes	Droop[45]
Torrens Island B PS	TORRB2	200	3 Mar 21			Yes	Droop[46]
Torrens Island B PS	TORRB3	200	15 Mar 21			Yes	Droop[47]
Torrens Island B PS	TORRB4	200	2 Mar 21			Yes	Droop[48]
Townsville PS	YABULU	160	Pre-existing				
Townsville PS	YABULU2	82			Yes[49]		
Trevallyn PS	TREVALLN	93	Unit 1 - 28 Sep 22 Unit 2 - 31 Mar 21 Unit 3 - Pre-existing Unit 4 – 14 Jul 21			Yes	Response Time[50]
Tribute PS	TRIBUTE	83	Pre-existing				
Tumut 3 PS	TUMUT3	1500	17 Dec 20				
Tumut 1 & 2 PS	UPPTUMUT	616	18 Dec 20				
Tungatinah PS	TUNGATIN	125	14 Jul 21	24 May 22			
Uranquinty PS	URANQ11	166	30 Apr 21			Yes	Deadband[51]
Uranquinty PS	URANQ12	166	30 Apr 21			Yes	Deadband[52]
Uranquinty PS	URANQ13	166	30 Apr 21			Yes	Deadband[53]
Uranquinty PS	URANQ14	166	30 Apr 21			Yes	Deadband[54]
Vales Point B PS	VP5	660	30 Sep 20			Yes	Deadband[55]

[43] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

[44] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements

[45] Droop varies with loading level, and may exceed 5% at high output.

[46] Droop varies with loading level, and may exceed 5% at high output.

[47] Droop varies with loading level, and may exceed 5% at high output.

[48] Droop varies with loading level, and may exceed 5% at high output.

[49] This DUID is the Steam Turbine of a combined cycle unit, and as such is granted a standing exemption from the PFR requirements.

[50] Response Time for Units 1 & 2 is 11 seconds for a 5% change in output.

[51] AEMO has granted a variation to the deadband at ±100 mHz based on the unique condition of the Affected GS until Feb 2023.

[52] AEMO has granted a variation to the deadband at ±100 mHz based on the unique condition of the Affected GS until Feb 2023.

[53] AEMO has granted a variation to the deadband at ±100 mHz based on the unique condition of the Affected GS until Feb 2023.

[54] AEMO has granted a variation to the deadband at ±100 mHz based on the unique condition of the Affected GS until Feb 2023.

[55] AEMO has granted a variation to the DCS FCAS control deadband at ±100 mHz based on the unique condition of the Affected GS.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Vales Point B PS	VP6	660	30 Sep 20			Yes	Deadband[56]
Valley Power	VPGS1	50	16 Mar 21				
Valley Power	VPGS2	50	17 Mar 21				
Valley Power	VPGS3	50	17 Mar 21				
Valley Power	VPGS4	50	17 Mar 21				
Valley Power	VPGS5	50	18 Mar 21				
Valley Power	VPGS6	50	18 Mar 21				
Victorian Big Battery	VBBG1	300	16 Nov 21				
Wallgrove BESS	WALGRVG1	50	21 Dec 21	16 Nov 22			
Wandoan BESS	WANDBG1	100	3 Jun 22				
Wandoan SF 1	WANDSF1[57]	125[58]	Prior to or upon completion of commissioning				
Warwick 1 SF	WARWSF1	39	#				
Warwick 2 SF	WARWSF2	39	#				
Waterloo WF	WATERLWF	130			Yes[59]		
Wellington SF	WELLSF1	216	#				
Wemen SF	WEMENSF1	97	#				
West Kiewa PS	WKIEWA1	31	4 Aug 21				
West Kiewa PS	WKIEWA2	31	4 Aug 21				
Willogoleche WF	WGWF1	119	30 Dec 22				
Wivenhoe PS	W/HOE#1	285	26 Oct 20			Yes	Response Time
Wivenhoe PS	W/HOE#2	285	26 Oct 20			Yes	Response Time
Woodlawn WF	WOODLWN1	48			Yes[60]		
Yallourn W PS	YWPS1	360	28 Oct 20				
Yallourn W PS	YWPS2	360	29 Sep 20	28 Oct 20			
Yallourn W PS	YWPS3	380	29 Sep 20	28 Oct 20			

[56] AEMO has granted a variation to the DCS FCAS control deadband at ±100 mHz based on the unique condition of the Affected GS.

[57] To be confirmed following registration

[58] To be confirmed following registration

[59] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

[60] AEMO has granted an exemption on the basis of inherent incapability to meet the PFR requirements.

Affected GS Name	DUID	Reg Cap (MW)	PFR Settings changes to be (or have been) implemented for ongoing operation by		Exemption	Variation	PFRP Varied
			Stage 1	Stage 2[6]			
Yallourn W PS	YWPS4	380	29 Sep 20	28 Oct 20			
Yatpool SF	YATSF1	94	#				
Yendon WF	YENDWF1	144	#				

7. Impact on Frequency Performance

AEMO provides detailed reporting on power system frequency performance in its Frequency and Time Error Monitoring reports[61] published quarterly. The most recent report was published on 11 November 2022.

This report focuses on a sub-set of the matters raised in the quarterly report and provides some information focusing on relatively recent frequency performance to help capture impacts on power system frequency that are (at least in part) associated with the implementation of the Mandatory PFR Rule.

Figure 1 shows the monthly frequency distribution from January 2019. It covers a period from well prior to Affected Generators beginning to implementation of their PFR Settings from around the end of September 2020, until now.

This figure shows continued improvement in the closeness of the distribution of frequency around 50 Hz, particularly from the second half of October 2020, where many generators moved from interim to final PFR settings.

Figure 2 shows a comparison of the daily frequency distribution, from late September 2020, immediately before implementation of PFR setting changes commenced, and November 2022.

Figure 1 Monthly frequency distribution (data from 01 Jan 2019 to 31 Oct 2022)

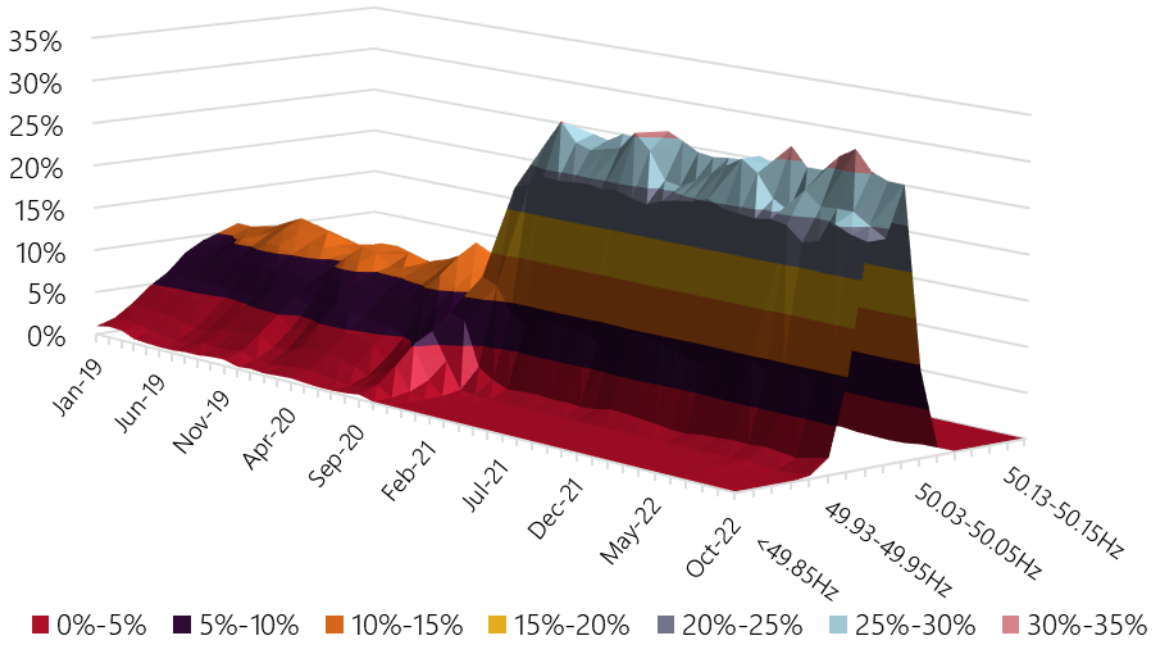
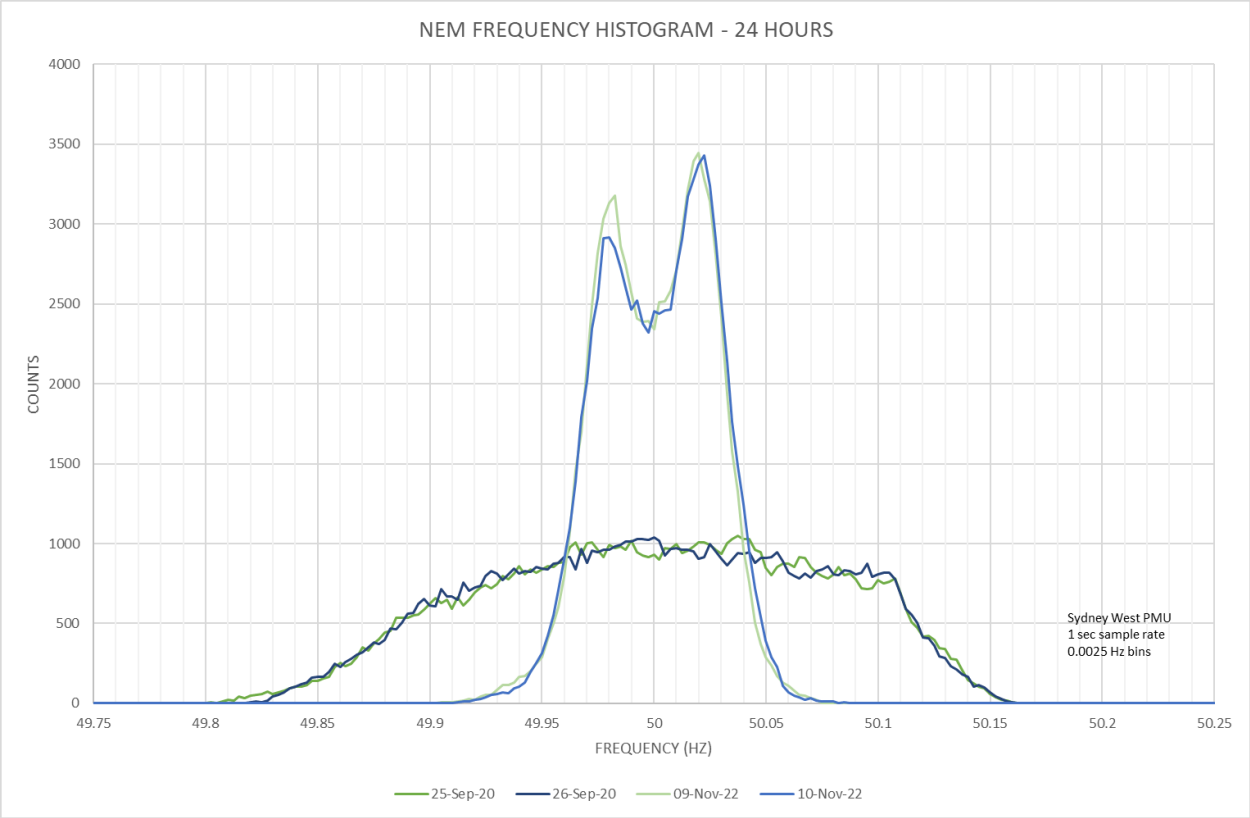


Figure 2 Comparison of NEM frequency distribution – Sep 2020 vs Nov 2022

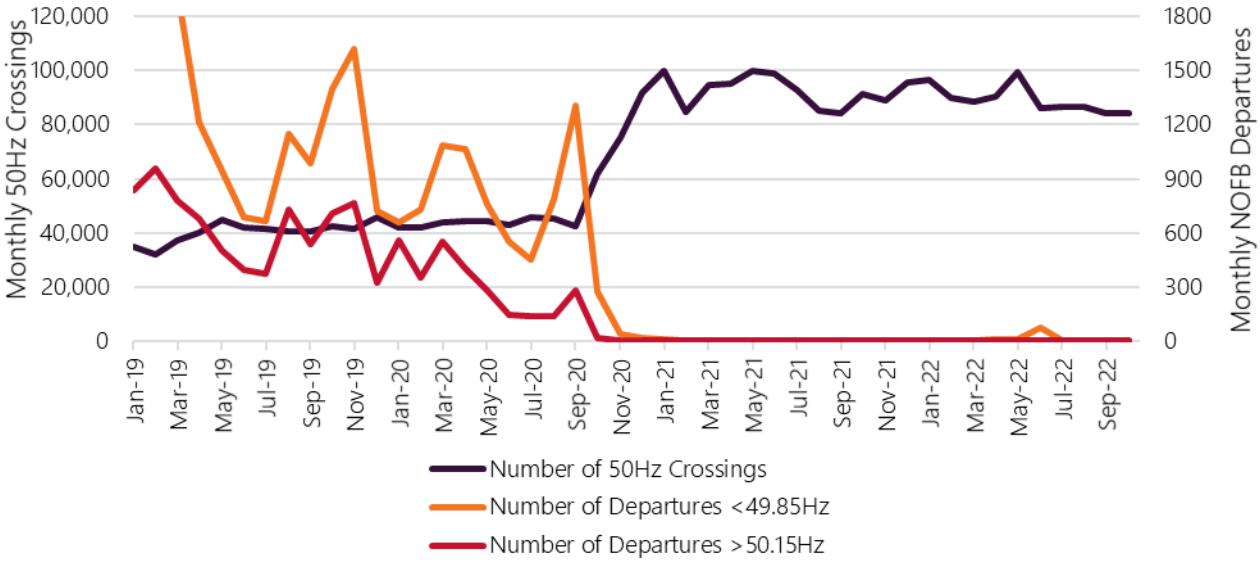
[61] Available at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/frequency-and-time-deviation-monitoring.



The total number of departures from the normal operating frequency band (NOFB) and the number of times frequency crossed the nominal 50 Hz is shown on a day-by-day basis in Figure 23Figure 3.

These figures show a significant reduction in the number of excursions outside the NOFB following the commencement of implementation of PFR setting changes from the end of September 2020. This trend is particularly evident since mid-October 2020, and has persisted since that time.

Figure 3 Monthly frequency crossings – under 49.85 Hz, across 50 Hz, beyond 50.15 Hz



Glossary

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

Term	Definition
Affected Generator	As defined in the IPFRR.
Affected GS	As defined in the IPFRR.
AEMC	Australian Energy Markets Commission
AER	Australian Energy Regulator
AGC	Automatic Generation Control
BESS	Battery Energy Storage System
CCGT	Combined Cycle Gas Turbine.
DUID	Dispatchable unit identification.
GT	Gas Turbine
HP	Hold Point. A point during commissioning of new *plant* determined by reference to *generation* output.
IPFRR	Interim Primary Frequency Response Requirements.
Mandatory PFR Rule	National Electricity Amendment (Mandatory Primary Frequency Response) Rule 2020.
NOFB	*normal operating frequency band.*
PFR	*primary frequency response.*
PFR Settings	The settings to achieve the provision of PFR in accordance with the IPFRR, as notified to an Affected Generator by AEMO.
PFRP	*primary frequency response parameters.*
PS	Power Station.
PV	Photovoltaic
Results	As defined in the IPFRR.
RTS	Return to service following an *outage*.
SF	Solar Farm.
Tranche 1	Affected GS with a *nameplate rating* of >200 MW.
Tranche 2	Affected GS with a *nameplate rating* between 80 MW and 200 MW.
Tranche 3	Affected GS with a *nameplate rating* of <80 MW.
WF	Wind Farm.