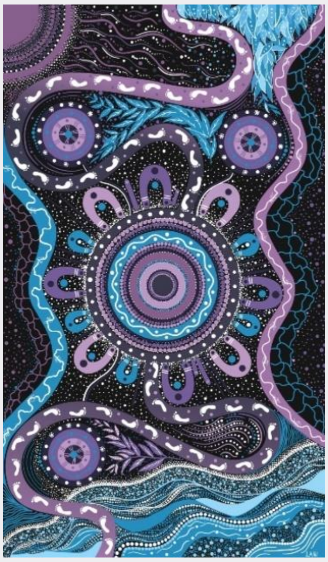
WEM Annual Congestion Report

March 2025

Analysis of constraints in the Wholesale Electricity Market

For the period from 1st October 2023 to 1st October 2024



We acknowledge the Traditional Custodians of the land, seas and waters across Australia. We honour the wisdom of Aboriginal and Torres Strait Islander Elders past and present and embrace future generations.

We acknowledge that, wherever we work, we do so on Aboriginal and Torres Strait Islander lands. We pay respect to the world's oldest continuing culture and First Nations peoples' deep and continuing connection to Country; and hope that our work can benefit both people and Country.

'Journey of unity: AEMO's Reconciliation Path' by Lani Balzan

AEMO Group is proud to have launched its first Reconciliation Action Plan in May 2024. 'Journey of unity: AEMO's Reconciliation Path' was created by Wiradjuri artist Lani Balzan to visually narrate our ongoing journey towards reconciliation - a collaborative endeavour that honours First Nations cultures, fosters mutual understanding, and paves the way for a brighter, more inclusive future.

Important notice

Purpose

The purpose of this publication is to provide information about Network congestion to Rule Participants and other interested stakeholders to enable them to understand patterns of Network congestion and the market impact of Network congestion.

AEMO publishes the WEM Annual Congestion Report under clause 2.27B.6 of the WEM Rules. This publication is based on information available to AEMO as at 1 December 2024.

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1 Introduction

This Annual Congestion Report for the Wholesale Electricity Market (WEM) is prepared in accordance with WEM Rule 2.27B.6. It aims to provide information to Rule Participants and other interested stakeholders to enable them to understand patterns of Network congestion and the market impact of Network congestion.

This report contains a summary of Constraint Equations that bound or violated in the Central Dispatch Process for Primary Dispatch Intervals in the 2023-24 Capacity Year (8:00am 1st October 2023 to 8:00am 1st October 2024), as well as details of future changes that could affect Network congestion.

In addition to the report, a data pack is provided that contains a complete record of constraint that bound or violated in the 2023-24 Capacity Year extracted from WEM Dispatch Engine (WEMDE) dispatch data[1] as of 1st December 2024. The data pack is designed to assist any interested stakeholders who would like to conduct further analysis on constraint results but is not designed to replace other sources of WEMDE dispatch data. Hence, in the case of any inconsistencies the WEM dispatch data should be considered the source of truth.

The remainder of the report is layout as follows:

- Section 2 provides background information to help interpret constraints and constraint results.
- Section 3 summarises thermal constraints that impacted dispatch, disaggregated by region.
- Section 4 summarises non-thermal constraints that impacted dispatch.
- Section 5 summarises the results of Defined Contingencies.
- Section 6 summarises all other library constraints that impacted dispatch.
- Section 7 summarises the results of Discretionary constraints.
- Section 8 outlines future changes to the Network, to generation, and to load, that could affect Network congestion in the coming years.

[1] Case and solutions file are available to download from the AEMO Market Data website, or from the WEM Dispatch APIs.

2 Background

This section provides background information for understanding constraints and interpreting constraint results.

2.1 Binding and violating constraints

A constraint is **binding** if the value of its left-hand side (LHS) and right-hand side (RHS) are equal. If a constraint is binding, it is likely that WEMDE adjusted dispatch to satisfy the constraint. However, this is not necessarily the case (for example: a Facility that is not being dispatched due to a low Market Clearing Price is constrained to 0 MW with a constraint).

A constraint is **violating** if WEMDE was not able to adjust dispatch to satisfy the constraint. For example, if a constraint of the form "LHS ≤ RHS" is violating, the LHS value is greater than the RHS. It is likely that WEMDE adjusted dispatch as much as possible to reduce the constraint's violation quantity (difference between LHS and RHS values).

2.2 Shadow price

The **shadow price** of a constraint is the change in WEMDE's objective function per unit increase of the RHS of the constraint. It can be used as an indicator for the relative impact of a constraint on the market. Shadow prices are calculated by WEMDE and published in the solution files.

Shadow prices cannot be interpreted as a "real" market cost in dollars. WEMDE's objective function is to minimise the total offered cost of dispatch, including any penalty[2] for violating any constraints. If any penalties are present in the objective function (or would be present for a unit increase of a constraint's RHS) then a constraint's shadow price can be influenced by the penalties, and hence no longer solely represents a change in the total market cost of dispatch.

Note that constraints of the form "LHS ≤ RHS" have a negative shadow price, "LHS >= RHS" constraints have a positive shadow price and "LHS = RHS" constraints can have either depending on how they impact dispatch. However, all shadow prices shown in this report are absolute values.

2.3 Constraint type

Every constraint has a constraint type:

- **Formulation**: constraints that are included in WEMDE by default, such as a ramp rate limit or ESS (Essential System Service) enablement minimum/maximum. These constraints are not covered in this report. All non-formulation constraints are collectively called **generic constraints**.

[2] Penalties are proportional to the Constraint Violation Quantity (how much a constraint was violated by) and the Constraint Violation Penalty (a multiplier that is fixed for each constraint). See Appendix B of WEM Procedure: Dispatch Algorithm Formulation for a table of Constraint Violation Penalty values.

- **Network**: constraints representing a network limit[3]. Refer to “Limit Type” for additional information.
- **Facility Risk / Network Risk**: constraints representing a possible Largest Credible Supply Contingency associated with one Facility / multiple Facilities. Constraints with these two types are collectively called **Defined Contingencies**.
- **NCESS**: constraints relating to an NCESS (Non-Co-optimised Essential System Service) contract.
- **Other**: constraints that don’t meet the above criteria.

2.4 Limit type

Every network constraint (see section 2.3) has a **limit type**:

- **Thermal**: represents a thermal overload of network equipment. These constraints contain “>” in the ID.
- **Voltage Stability / Transient Stability[4] / Oscillatory Stability**: constraints that prevent various types of power system instability. Voltage stability constraint contain “^” in the ID, whereas transient and oscillatory stability constraint would contain “:” (none have been created yet). These are collectively called non-thermal constraints.
- **Other**: network constraints that do not meet the above criteria[5]. These constraints contain “*” in the ID.

Note that constraints that do not have a constraint type of “Network” have also been given a limit type of “Other”.

2.5 Library vs discretionary constraints

Generic (non-formulation) constraints can be split into the following two categories:

- **Library constraint**: constraints that forms part of the Constraints Library[6].
- **Discretionary constraint**: temporary constraints created for the purpose of real-time operations[7].

2.6 System normal vs outage constraints

Network constraints can be split into the following two categories:

- **System normal**: constraints that apply to the normal state of the network.
- **Outage**: constraints that only apply during the outage (or reconfiguration) of certain network equipment.

[3] WEM Rule 7.7.8A allows for the creation of “Network” type constraints that do not represent network limits. However, this rule came into effect after the period covered by this report.

[4] No transient stability constraints have yet been created. However, prior to 13th March 2024, “Other” was not an available option, so many constraints created before this are labelled with a limit type of “Transient Stability”. For this report, such constraints are considered to have a limit type of “Other”.

[5] Examples of this include constraining a Facility off because it is disconnected from the network, or a constraint to prevent WEMDE altering a Facility’s dispatch if it’s operating in an islanded region separated from the SWIS.

[6] Published on the WEM Congestion Information Resource.

[7] The ID of discretionary constraints starts with “DCCE” (prior to 2nd May 2024) or “#E” (starting 2nd May 2024).

2.7 Constraint naming convention

The naming convention for thermal constraint ID is:

SYSCONFIG SYMBOL **{**CONTINGENCY**}** **[**OVERLOAD **(**DIRECTION**)]**

where the parts have the following meanings:

- **SYSCONFIG** describes the system configuration, typically which network equipment is on outage (NIL means no equipment is on outage).
- **SYMBOL** is “>” for thermal constraints (see section 2.4).
- **CONTINGENCY** describes the network contingency, typically the line or transformer that trips.
- **OVERLOAD** is the network equipment at risk of thermal overload.
- **DIRECTION** describes the direction of the thermal overload (RGN~ means “out of Regans” and RGN- means “into Regans”).

Other constraints follow this same naming convention where possible.

2.8 Network equipment naming convention

The naming convention for transmission lines is:

AAA-BBB XY	(for two-ended lines)
AA-BB-CC XY	(for three-ended lines)
AAXY-ABC	(for a specific end of a three-ended line)

where the placeholders have the following meaning:

- **AAA**, **BBB**, and **CCC** are the names of the substations to which the line is connected[8].
- **ABC** is the abbreviation for a three-ended line (example “KCM” instead of “KW-CC-MED”).
- **X** is the voltage code (“9” for 330 kV, “X” for 220 kV, “8” for 132 kV, “7” for 66 kV).
- **Y** is a circuit number to ensure the line name is unique if there are multiple (typically “1”).

Other equipment is identified as follows:

- Transformers are identified using the substation code and a unique identifier separated by a space. For example, the “NBT T2” transformer is “Neerabup Terminal Transformer 2”.
- Busbars are identified using the substation code and a unique identifier separated with an underscore. The unique identifier starts with a voltage code. For example, the “PJR_8Y” busbar is the “Pinjar 132 kV Y” busbar.

[8] See Appendix C of Western Power’s 2023 Transmission System Plan for a list of substation names and codes.

- Circuit breakers are identified using the substation code and a unique identifier joined without any separation. The unique identifier starts with a voltage code. For example, “MUL810” is a 132 kV circuit breaker in the Mullaloo substation.
- Special Protection Schemes (also known as Network Reinforcement Schemes) are identified by a prefix of “SPS”. For example, “SPS_WWF” refers to the line-overload runback scheme of Walkaway Wind Farm. Short explanations of the schemes can be found within the constraint descriptions.

3 Thermal constraints

This section summarises which thermal constraints bound and how frequently. The constraints are categorised into regions consistent with those used in Western Power's Transmission System Plan, which contains transmission maps of each region. Only constraints that bound for at least 20 Dispatch Intervals have been included in this section.

Multiple constraint IDs have been grouped into the same row if they represent the same physical thermal overload. Reasons for multiple different IDs include:

- The name of a line changed. For example, "MRT-NOR 81" became "MRT-NOR-CNS 81" after CNS substation was commissioned and connected.
- After 1st Feb 2024, constraint IDs no longer specify which end of the contingency network equipment the power flow is measured at (i.e. "{PJR-CTB 81 (PJR)}" has been changed to "{PJR-CTB 81}") and a more standardised way of referring to a single end of a multi-ended line was adopted (example: "[KW-CC-MED 81 (KW~)]" became "[KW81-KCM (KW~)]").
- The "Lack of Reserves" version of a constraint (starting with "NIL, LOR") is the same constraint except with a constraint violation penalty (CVP) of zero, which prevents them from impacting dispatch. These constraints were used to allow the control room to manually manage thermal overloads during Lack of Reserve conditions in the first summer after go-live. After 1st Oct 2024 these constraints are no longer used but are still maintained as a backup option.
- The "CVP0" version of a constraint (containing "CVP0") also has a CVP of zero. These constraints don't impact dispatch but indicate when an overload is typically managed by an action other than redispatch (for example, utilising network open points). If the appropriate action was determined in real-time to be redispatch, then the normal version of this constraint would have been invoked, or a discretionary constraint may have been created.

3.1 North Region

The North Region covers the northern most part of the Perth metropolitan area, from Landsdale and Wangara in the south to Yanchep in the north, extending into northern rural areas via Pinjar and Muchea, and to Geraldton at the northern extremity of the Western Power transmission network. Refer to Western Power's Transmission System Plan for a network diagram.

Table 1 Top binding/violating thermal constraint in North Region

#	Constraint IDs[9]	System configuration	Binding/ violating intervals	Accumulated shadow price
1	NIL > {PJR-CTB 81 (PJR)} [PJR-RGN 81 (RGN~)] NIL > {PJR-CTB 81} [PJR-RGN 81 (RGN~)]	System normal	9257	2254148

[9] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

#	Constraint IDs[9]	System configuration	Binding/ violating intervals	Accumulated shadow price
2	NIL > {MGA-TS 81 (MGA)} [TS-MBA 81 (MBA~)]	System normal	3460	501672
3	NIL > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)] NIL, LOR > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]	System normal	791	785800
4	NIL > {NBT-NT 91, SPS_MARNET} [NBT-WNO 81 (NBT~)] NIL, LOR > {NBT-NT 91, SPS_MARNET} [NBT-WNO 81 (NBT~)]	System normal	392	424855
5	NBT-NT 91, TST-TS 81, Off(SPS_MARNET), TS806, ENB-TS 81 > {NT-PJR 81} [JDP-WNO 81 (WNO~)]	Network outage	244	49679
6	NBT-NT 91, TST-TS 81, Off(SPS_MARNET) > {NT-PJR 81} [JDP-WNO 81 (WNO~)]	Network outage	191	23754
7	NBT-NT 91, TST-TS 81, Off(SPS_MARNET), TS806 > {NT-PJR 81} [JDP-WNO 81 (WNO~)]	Network outage	181	20073
8	NIL, LOR > {NBT-NT 91, SPS_MARNET} [JDP-MUL 81 (JDP~)]	System normal	138	0
9	NT-PJR 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]	Network outage	117	46812
10	NBT T2 > {PJR-CTB 81 (PJR)} [PJR-RGN 81 (RGN~)]	System normal[10]	100	24690
11	NIL > {PJR-YP 81 (PJR)} [NBT-WNO 81 (NBT~)] NIL, LOR > {PJR-YP 81 (PJR)} [NBT-WNO 81 (NBT~)]	System normal	54	221411
12	NIL > {TS-MBA 81 (MBA)} [MGA-TS 81 (MGA~)]	System normal	42	41667
13	HBK-MUC 81 > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]	Network outage	28	51634

Constraints in rows #2 and #12 are for southbound congestion at Three Springs, driven by high generation and low load in North Country. All the remaining constraints are for southbound congestion from the North Region to the Metro North Region, associated with periods of high generation in the North Region, typically driven by high wind and solar availability.

3.2 South Region

The South Region covers the Great Southern and Southern West part of the Western Power transmission network. The west part of this region covers from Alcoa Pinjarra in the north to Augusta in south. The east part of the region extends from Muja Power Station to Manjimup and Beenup in the south-west, Albany to the south- east, Boddington to the north and Narrogin in the north-east. Refer to Western Power's Transmission System Plan for a network diagram.

[10] An outage of NBT T2 (Neerabup Terminal Transformer 2) is considered system normal since it typically increases power transfer capacity and hence has historically been used as an open point during period of high demand and low non-scheduled generation availability.

Table 2 Top binding thermal constraints in South Region

#	Constraint IDs[11]	System configuration	Binding/ violating intervals	Accumulated shadow price
1	NIL > CVP0 {MRT-NOR 81} [MU-NGS X1 (MU~)] NIL > CVP0 {MRT-NOR-CNS 81} [MU-NGS X1 (MU~)] NIL > {MRT-NOR 81 (MRT)} [MU-NGS X1 (MU~)] NIL > {MRT-NOR 81} [MU-NGS X1 (MU~)] NIL > {MRT-NOR-CNS 81} [MU-NGS X1 (MU~)] NIL, LOR > {MRT-NOR 81 (MRT)} [MU-NGS X1 (MU~)]	System normal	4357	46807411
2	MRT-NOR 81 > CVP0 {WMK G501} [MU-NGS X1 (MU~)] MRT-NOR 81 > {WMK G501} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > CVP0 {WMK G501} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > {WMK G501} [MU-NGS X1 (MU~)]	Network outage	673	1469325
3	NIL > CVP0 {KEM-MRR 81} [KEM-MRR 82 (KEM~)] NIL > {KEM-MRR 81 (KEM)} [KEM-MRR 82 (KEM~)] NIL, LOR > {KEM-MRR 81 (KEM)} [KEM-MRR 82 (KEM~)]	System normal	548	2030340
4	NIL > CVP0 {PIC-PNJ-BSN-KEM 81} [PNJ-APJ 81 (APJ~)] NIL > {PIC-PNJ-BSN-KEM 81} [PNJ-APJ 81 (APJ~)] NIL, LOR > {PIC-PNJ-BSN-KEM 81} [PNJ-APJ 81 (APJ~)]	System normal	518	161773
5	MRT-NOR 81 > CVP0 {BLD-PCY-PKS 81} [MU-NGS X1 (MU~)] MRT-NOR 81 > {BLD-PCY-PKS 81} [MU-NGS X1 (MU~)]	Network outage	350	2550467
6	MRT-NOR 81 > CVP0 {WMS G501} [MU-NGS X1 (MU~)] MRT-NOR 81 > {WMS G501} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > CVP0 {WMS G501} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > {WMS G501} [MU-NGS X1 (MU~)]	Network outage	335	790173
7	NIL > CVP0 {RO-WAI 81} [PNJ-APJ 81 (APJ~)] NIL > {RO-WAI 81 (RO)} [PNJ-APJ 81 (APJ~)] NIL, LOR > {RO-WAI 81 (RO)} [PNJ-APJ 81 (APJ~)]	System normal	177	128526
8	NIL > {MBR-ALB 81} [KOJ81-KAF (KOJ-)]	System normal	135	5292
9	NIL > CVP0 {SNR-WGP-APJ 81} [PNJ-APJ 81 (APJ~)] NIL > {SNR-WGP-APJ 81} [PNJ-APJ 81 (APJ~)] NIL, LOR > {SNR-WGP-APJ 81} [PNJ-APJ 81 (APJ~)]	System normal	128	1868
10	MRT-NOR 81 > CVP0 {MRS-MRT X1} [MU-NGS X1 (MU~)] MRT-NOR 81 > {MRS-MRT X1} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > CVP0 {MRS-MRT X1} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > {MRS-MRT X1} [MU-NGS X1 (MU~)]	Network outage	93	245013
11	NIL > CVP0 {MU BTT1} [PIC-MRR 81 (MRR~)] NIL, LOR > {MU BTT1 (9)} [PIC-MRR 81 (MRR~)]	System normal	72	0
12	MRT-NOR 81 > CVP0 {MDP-MRT 81} [MU-NGS X1 (MU~)] MRT-NOR-CNS 81 > CVP0 {MDP-MRT 81} [MU-NGS X1 (MU~)]	Network outage	65	0
13	NIL > CVP0 {D-SVY 81} [MU-NGS X1 (MU~)] NIL > Commitment {D-SVY 81 (D)} [MU-NGS X1 (MU~)] NIL > {D-SVY 81 (D)} [MU-NGS X1 (MU~)] NIL, LOR > {D-SVY 81 (D)} [MU-NGS X1 (MU~)]	System normal	54	319309
14	MRT-NOR 81 > CVP0 {NIL} [MU-NGS X1 (MU~)] MRT-NOR 81 > {NIL} [MU-NGS X1 (MU~)]	Network outage	44	24582
15	NIL > CVP0 {NOR-SVY 81} [MU-NGS X1 (MU~)] NIL, LOR > {NOR-SVY 81 (NOR)} [MU-NGS X1 (MU~)]	System normal	38	0
16	NIL > CVP0 {MU-NT 91} [MU-NGS X1 (MU~)] NIL, LOR > {MU-NT 91 (MU)} [MU-NGS X1 (MU~)]	System normal	36	0

Most of the constraints above relate to the overload of MU-NGS X1 line, which limits power exported from Muja toward Eastern Goldfields (EGF) on the 220 kV line during periods of high EGF load and low wind and solar

[11] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

availability. In system normal conditions, the post-contingent thermal overload of MU-NGS X1 is most often for the contingency of MRT-NOR-CNS 81 line (or sometimes D-SVY 81). Outages of MRT-NOR-CNS 81 result in MU-NGS X1 thermal overload constraints binding more frequently, on loss of generation in the East Region.

Constraints in rows #3 and #11 limit flows from KEM (Kemerton) towards MRR (Marriot Road) and PIC (Picton), they are associated with high regional loads. They typically limit the output of some regional generators but regularly violate due to low quantities of dispatchable generation in the region that could be used to relieve the overloads.

Rows #4, #7, and #9 relate to overloads of PNJ-APJ 81 on loss of various lines. These constraints typically bind during high load around MH (Mandurah) and PNJ (Pinjarra) and limit the export of ALINTA_PNJ_U1 (and other Facilities to a lesser extent).

Row #8 is associated with high wind generation in the Albany area.

3.3 East Region

The East Region covers the network east of (and including) Sawyers Valley, through to Kondinin, Kalgoorlie and the Goldfields. Refer to Western Power's Transmission System Plan for a network diagram.

Table 3 Top binding thermal constraint in East Region

#	Constraint IDs[12]	System configuration	Binding/violating intervals	Accumulated shadow price
1	NT-NOR 81 > {D-SVY 81 (D)} [MW-WUN 71 (WUN-)]	Network outage	68	266540
2	NIL > CVP0 {WMS G501} [CGT-YLN X1 (YLN-)]	System normal	43	0
3	NIL > {NIL} [YLN-WKT X1 (WKT-)][13]	System normal	38	8413200
4	D-SVY 81 > {NT-NOR 81} [MW-WUN 71 (WUN-)]	Network outage	30	3289

Constraints #1 and #4 are related to planned or forced outages of transmission lines in the East Region. These constraints typically bind only for a short period as they are usually resolved by network reconfiguration (use of an open point). Constraints #2 and #3 are associated with high regional load in the Eastern Goldfields. Constraint #3 has not bound since the rating for this line was increased on the 21st Nov 2023.

3.4 Metro North Region

The Metro North Region covers the northern extent of the Perth metropolitan area and is bound by coastal and western suburbs in the west, Malaga and North Beach in the north, and the eastern suburbs and foothills areas of

[12] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

[13] The line rating associated with this constraint was increased in Nov 2023, the constraint did not bind or violate after that.

Forrestfield and Darlington in the east. Refer to Western Power's Transmission System Plan for a network diagram.

Table 4 Top binding thermal constraint in Metro North Region

#	Constraint IDs[14]	System configuration	Binding/violating intervals	Accumulated shadow price
1	NIL > {D-MJ 81 (D)} [GLT-FFD 81 (GLT~)] NIL > {D-MJ 81} [GLT-FFD 81 (GLT~)] NIL, LOR > {D-MJ 81 (D)} [GLT-FFD 81 (GLT~)]	System normal	140	5158242

This constraint causes increased generation from Facilities at Northam, Cunderdin, and the Eastern Goldfields during periods of high local load between Guildford and Northam.

3.5 Metro South Region

The Metro South Region covers a large area, including most of the urban Perth metropolitan networks south of the river, from the Cannington Terminal in the east to the Southern and South Fremantle Terminal towards the west. The region also covers the southern metropolitan coastal strip from Kwinana through to Rockingham and Mandurah and extends east to encompass the Pinjarra Substation. Refer to Western Power's Transmission System Plan for a network diagram.

Table 5 Top binding thermal constraint in Metro South Region

#	Constraint IDs[15]	System configuration	Binding/violating intervals	Accumulated shadow price
1	KW_8BA1 > {KW-CC-MED 81} [KW-BIB 81 (KW~)]	Network outage	267	21056
2	NIL > {CT-MSS-PNJ 81} [MH-PNJ 81 (PNJ~)] NIL, LOR > {CT-MSS-PNJ 81} [MH-PNJ 81 (PNJ~)]	System normal	215	6982111
3	NIL > CVP0 {MH-PNJ 81} [PNJ81-CMP (PNJ-)]	System normal	178	0
4	NIL > {KW-CC-MED 81} [WM-MSR-OFE 81 (WM-)] NIL > {KW-CC-MED 81} [WM81-MWO (WM-)]	System normal	38	5436766

Rows #1 and #4 relate to high generation in the KW8 (Kwinana 132 kV) and MSR (Mason Road) areas. Rows #2 and #3 are driven by high loads in the MH (Mandurah) and PNJ (Pinjarra) area; these constraints typically reduce generation for the KW8 and MSR areas at the same time as increasing generation from the APJ (Alcoa Pinjarra) area.

3.6 East Perth/CBD Region

The East Perth and CBD Region covers the Perth CBD, the City of Subiaco and the City of Vincent. Refer to Western Power's Transmission System Plan for a network diagram.

No constraints in this region bound/violated for 20 intervals.

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[14] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

[15] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

4 Non-thermal constraints

This section summarises which non-thermal constraint bound and how frequently.

Table 6 shows that only a single non-thermal constraint bound during the 2023/24 Capacity Year. It curtailed WARRADARGE_WF1 to 0 MW during a forced outage of ENT-YDT 91 on 17th Oct 2023, due to advice from Western Power indicating a possible risk of voltage instability in the TS (Three Springs) area.

Table 6 Top binding non-thermal constraints

Constraint IDs[16]	System configuration	Limit type	Binding/violating intervals	Accumulated shadow price
ENT-YDT 91, Off(SPS_MARNET) ^ {NIL} [TST-TS 81]	Network outage	Voltage Stability	87	19261800

[16] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

5 Defined contingencies

Defined Contingencies are constraints that allow WEMDE to calculate the size of the Largest Credible Supply Contingency (LCSC). WEMDE co-optimises LCSC and the Contingency Raise requirement, meaning the largest contingencies are curtailed if it's more cost efficient than procuring more Contingency Raise service.

Table 7 Summary of Defined Contingencies

Facility or Constraint ID	Constraint type	Intervals as largest contingency		Max size[17] (MW)	Average[18] size (MW)
NEWGEN_KWINANA_CCG1	Facility risk	44498	42%	373	278
NIL * {NBT-NT 91, SPS_MARNET} [LargestContingency][19]	Network risk	27292	26%	388	276
COLLIE_G1	Facility risk	14264	14%	398	306
BW2_BLUEWATERS_G1	Facility risk	8557	8%	350	242
BW1_BLUEWATERS_G2	Facility risk	8456	8%	350	240
MUJA_G8	Facility risk	3511	3%	350	237
ALINTA_WGP_GT	Facility risk	3065	3%	298	242
ALINTA_WGP_U2	Facility risk	2353	2%	285	238
COCKBURN_CCG1	Facility risk	2173	2%	322	248
YANDIN_WF1	Facility risk	1906	2%	300	238
MUJA_G7	Facility risk	1807	2%	350	225
NEWGEN_NEERABUP_GT1	Facility risk	1230	1%	351	324
MUJA_G6	Facility risk	1137	1%	291	230

Table 7 shows Defined Contingencies that set the LCSC for at least 1% of intervals. Note that in 13% of intervals multiple Defined Contingencies were equal largest, hence the percentage column totals to more than 100%.

[17] The contingency size includes the distributed photovoltaic (DPV) and loads expected to trip off following a fault at the location of the Facility, not just the output of the relevant facility.

[18] Averaged over the intervals in which the contingency was setting the Largest Credible Supply Contingency.

[19] The facilities affected by this network contingency are YANDIN_WF1 and WARRADARGE_WF1.

6 Other constraints

This section summarises all library constraints that are not thermal constraint, non-thermal constraints, or Define Contingency constraints.

6.1 Network unavailability

These constraints set a Facility's setpoint to 0 MW to ensure WEMDE does not dispatch Facilities that are disconnected during network outages or are otherwise not allowed to generate such as due to risk of protection maloperation. Only Facilities constrained for at least 20 intervals are shown.

Table 8 Top binding network unavailability constraints

Facility	Constraint IDs[20]	Binding/ violating intervals	Accumulated shadow price
COLLIE_G1	CPS-SHO 91 * {NIL} [Off(COLLIE_G1)]	27613	6113518200
GREENOUGH_RIVER_PV1	MGA-MGS 81 * {NIL} [Off(GREENOUGH_RIVER_PV1)]	1289	285384600
KEMERTON_GT11	KMP-KEM 91 * {NIL} [Off(KEMERTON_GT11)]	1103	244204200
KEMERTON_GT12	KMP-KEM 91 * {NIL} [Off(KEMERTON_GT12)]	1103	244204200
YANDIN_WF1	NBT-NT 91, SPS_MARNET * {NIL} [Off(YANDIN_WF1)] NBT-YDT 91, SPS_MARNET * {NIL} [Off(YANDIN_WF1)] YDW-YDT 91 * {NIL} [Off(YANDIN_WF1)]	1026	227156400
INVESTEC_COLLGAR_WF1	CGT-CGW X1, CGT-CGW X2 * {NIL} [Off(INVESTEC_COLLGAR_WF1)]	582	128854800
MERSOLAR_PV1	MRS-MRT X1 * {NIL} [Off(MERSOLAR_PV1)]	581	128633400
NAMKKN_MERR_SG1	MDP-MRT 81 * {NIL} [Off(NAMKKN_MERR_SG1)]	581	128633400
TESLA_NORTHAM_G1	MRT-NOR 81, NOR-SVY 81, NOR-WUN 71 * {NIL} [Off(TESLA_NORTHAM_G1)] MRT-NOR 81, NT-NOR 81, NOR-WUN 71 * {NIL} [Off(TESLA_NORTHAM_G1)]	377	83467800
FLATROCKS_WF1	KOJ-ALB-FRW 81 * {NIL} [Off(FLATROCKS_WF1)]	165	36531000
GRASMERE_WF1	ALB522 * {NIL} [Off(GRASMERE_WF1)]	88	19483200
WARRADARGE_WF1	ENT-YDT 91, SPS_MARNET * {NIL} [Off(WARRADARGE_WF1)] NBT-NT 91, SPS_MARNET * {NIL} [Off(WARRADARGE_WF1)] NBT-YDT 91, SPS_MARNET * {NIL} [Off(WARRADARGE_WF1)]	66	14612400
SBSOLAR1_CUNDERDIN_PV1	MRT-NOR-CNS 81 * {NIL} [Off(SBSOLAR1_CUNDERDIN_PV1)]	42	9298800
STHRNCRS_EG	BLD-WMS 81 * {NIL} [Off(STHRNCRS_EG)]	39	8634600

Table 8 shows the longest duration of outage was associated with COLLIE_G1 which was disconnected for a total of 96 days due to works at Shotts substation.

[20] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

6.2 Island constraints

These constraints prevent WEMDE from adjusting a Facility's dispatch when the Facility is operating in an island. They effectively allow a facility's dispatch to be managed manually or through isochronous control, hence "Manual" in the constraint ID. Further constraints prevent WEMDE from procuring ESS from islanded facilities (only required if the Facility is accredited for ESS).

Table 9 Top binding island constraints

Constraint ID[21]	Binding/violating intervals	Accumulated shadow price
MSR-KMK 81 * {NIL} [RegLower(TIWEST_COG1)]	3881	27613
MSR-KMK 81 * {NIL} [RegRaise(TIWEST_COG1)]	3881	1289
MSR-KMK 81 * {NIL} [Manual(TIWEST_COG1)]	3881	1103
Island(EGF) * {NIL} [Manual(STHRNCRS_EG)]	3060	1103
Island(EGF) * {NIL} [Manual(WEST_KALGOORLIE_GT3)]	3060	1026
Island(EGF) * {NIL} [Manual(PRK_AG)]	3060	582
Island(EGF) * {NIL} [Manual(WEST_KALGOORLIE_GT2)]	3060	581
Island(NC) * {NIL} [Manual(MUNGARRA_GT3)]	971	581
Island(NC) * {NIL} [Manual(MUNGARRA_GT1)]	971	377
Island(NC) * {NIL} [Manual(MWF_MUMBIDA_WF1)]	971	165
Island(NC) * {NIL} [Manual(ALINTA_WWF)]	971	88
Island(NC) * {NIL} [Manual(GREENOUGH_RIVER_PV1)]	971	66
Island(NC) * {NIL} [Manual(TESLA_GERALDTON_G1)]	971	42

The "Island(NC)" constraints in Table 9 were used during islanding of North Country (disconnected from the SWIS at Three Springs substation). The "Island(EGF)" constraints were used during islanding of Eastern Goldfields (disconnected at West Kalgoorlie substation). "MSR-KMK 81" constraints were used during islanding of the Tiwest Pigment Plant (disconnected between Mason Road and Kerr McGee Kwinana substations).

6.3 Anti-islanding constraints

These constraints turn off Facilities due to the risk of a line trip creating an uncontrolled island (supplying loads without frequency control leading to instability and possible damage). There is no risk of uncontrolled island where a facility has adequate anti-islanding protection, which is typical of newer facilities.

Table 10 Top binding anti-islanding constraints

Constraint IDs[22]	System configuration	Binding/violating intervals	Accumulated shadow price
ALINTA_WWF	MGA-GTN 81 * {MGA-WWF 81} [Island(ALINTA_WWF)] MGA-MBA 81 * {MGA-TS 81} [Island(ALINTA_WWF)] MGA-TS 81 * {MGA-MBA 81} [Island(ALINTA_WWF)] MGA-TS 81 * {TS-MBA 81} [Island(ALINTA_WWF)]	5278	1390834800

[21] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

[22] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

Constraint IDs[22]	System configuration	Binding/violating intervals	Accumulated shadow price
	MGA-WWF 81 * {MGA-GTN 81} [Island(ALINTA_WWF)] TS-MBA 81 * {MGA-TS 81} [Island(ALINTA_WWF)]		
INVESTEC_COLLGAR_WF1	KDN-MRT X1, YLN-WKT X1 * {MRT-NOR 81} [Island(INVESTEC_COLLGAR_WF1)]	2344	518961600
NAMKKN_MERR_SG1	KDN-MRT X1, YLN-WKT X1 * {MRT-NOR 81} [Island(NAMKKN_MERR_SG1)]	2344	518961600
ALCOA_WGP	SNR-WGP-APJ 81 * {WGP-WOR 81} [Island(ALCOA_WGP)]	1363	301768200

Table 10 shows ALINTA_WWF was curtailed for a total of 18 days; the various constraints are due to the various network outages that result in an islanding risk. INVESTEC_COLLGAR_WF1 and NAMKKN_MERR_SG1 were curtailed for a total of 8 days, 98% of which was during the 220 kV outage from 19th to 27th January 2024.

6.4 Communication outage constraints

These constraints prevent WEMDE from adjusting the setpoint of a facility during a comms outage (similar to the "Manual" constraints in section 0). Further constraints prevent WEMDE from procuring Regulation Raise and Lower during a comms outage, however these constraints have been omitted from Table 11 for brevity.

Table 11 Top binding communications outage constraints

Constraint ID[23] [24]	Binding/violating intervals	Accumulated shadow price
NoComms(PJR) * {NIL} [Manual(PINJAR_GT4)]	116	578961000
NoComms(PJR) * {NIL} [Manual(PINJAR_GT7)]	116	553132122
NoComms(PJR) * {NIL} [Manual(PINJAR_GT2)]	116	244733570
NoComms(PJR) * {NIL} [Manual(PINJAR_GT10)]	116	227609997
NoComms(PJR) * {NIL} [Manual(PINJAR_GT9)]	116	219165402
NoComms(PJR) * {NIL} [Manual(PINJAR_GT3)]	116	208104359
NoComms(PJR) * {NIL} [Manual(PINJAR_GT5)]	116	188213619
NoComms(PJR) * {NIL} [Manual(PINJAR_GT1)]	116	170511485
NoComms(PJR) * {NIL} [Manual(PINJAR_GT11)]	116	27273886
NoComms(PJR) * {NIL} [Manual(PINJAR_GT4)]	116	578961000
NoComms(PJR) * {NIL} [Manual(PINJAR_GT7)]	116	553132122
NoComms(PJR) * {NIL} [Manual(PINJAR_GT2)]	116	244733570

The constraints in Table 11 were invoked on four separate occasions to manage the outage communications with Pinjar substation, for a combined total of about 10 hours.

[23] Results from previous versions of these constraints (with IDs starting with "NIL, NoComms" instead of "NoComms") have been included.

[24] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

6.5 Miscellaneous constraints

Table 12 shows library constraints that bound/violated but do not fit in any of the above categories. A description of the intent of the constraint is included in the table.

Table 12 Top binding miscellaneous constraints

Constraint ID[25]	Description	Binding/violating intervals	Accumulated shadow price
NIL * {NIL} [InjectionLimit(KWINANA_ESR1)][26]	Avoid system security issues associated with clearing for energy and ESS that cannot be met based on current state of charge of KWINANA_ESR1.	10039	1675249615
NIL * {NIL} [WithdrawalLimit(KWINANA_ESR1)]		9684	157390
NIL * {Partial(SIMCOA_IPT_LD_01)} [ContingencyRaise]	Limit Contingency Raise cleared by SIMCOA_IPT_LD_01 based on its current withdrawal.	4322	270392939
NIL * {SHO-WLT-PMB 91} [LoadContingency]	Prevent the load contingency associated with trip of SHO-WLT-PMB 91 from exceeding the allowable limit for the Largest Credible Load Contingency (LCLC).	872	518686
NIL * {SHO-WLT-PMB 91} [ContingencyLower]	Ensure enough Contingency Lower is procured to cover the load contingency associated with the trip of SHO-WLT-PMB 91.	318	38114

[25] Refer to the Constraints Library on the Congestion Information Resource for a description of each constraint.

[26] Results from a previous version of this constraints (with “ContinuousDischarge” instead of “InjectionLimit” in the constraint ID) have been included.

7 Discretionary constraints

Discretionary constraints are temporary constraints created by AEMO's control room in real-time. Such constraints typically affect a single Facility (for example "PRK_AG >= 1 MW")[27]. Only Facilities that were constrained for at least 100 intervals are reported in this section.

7.1 Facilities constrained up

There are two instances where a Facilities is constrained **up** by discretionary constraints:

- applying a lower limit (FACILITY >= VALUE); or
- setting a Facility's setpoint to a specific value (FACILITY = VALUE) in intervals where the Facility would have been dispatched lower.

Table 13 Facilities commonly constrained up with discretionary constraints

Facility	Binding/violating intervals	Number of discretionary constraints	Accumulated shadow price
PRK_AG	2426	48	527715283
NAMKKN_MERR_SG1	1831	65	162459262
TESLA_GERALDTON_G1	567	23	25363399
TESLA_NORTHAM_G1	484	18	20264272
TESLA_PICTON_G1	482	19	9441190
TESLA_KEMERTON_G1	479	18	18066197
KWINANA_ESR1	422	31	7332463
ALINTA_WGP_GT	408	18	271402376
ALINTA_WGP_U2	328	16	229291660
KEMERTON_GT11	324	18	150319519
KEMERTON_GT12	216	15	143784507
PINJAR_GT7	206	6	12576999
NEWGEN_NEERABUP_GT1	202	12	75230740
PINJAR_GT3	190	4	15925888
KWINANA_GT3	187	4	8198362
KWINANA_GT2	178	4	4353208
PINJAR_GT5	152	7	14379213
MUNGARRA_GT1	116	8	53715403
PINJAR_GT2	115	4	14998334
GREENOUGH_RIVER_PV1	114	2	444684

[27] Discretionary constraints that affect multiple Facilities (for example "KEMERTON_GT12 + KEMERTON_GT11 <= 0MW") have been counted towards the totals of each Facility.

Table 13 shows that PRK_AG was constrained up for a total of 8 days and NAMKKN_MERR_SG1 for a total of 6 days, the vast majority of these were to manage the thermal overload on MU-NGS X1 (see section 3.2).

7.2 Facilities constrained down

There are two instances where a Facilities is constrained **down** by discretionary constraints:

- applying an upper limit (FACILITY <= VALUE); or
- setting a Facility's setpoint to a specific value (FACILITY = VALUE) in intervals where the Facility would have been dispatched higher.

Table 14 Facilities commonly constrained down with discretionary constraints

Facility	Binding/violating intervals	Number of discretionary constraints	Accumulated shadow price
NAMKKN_MERR_SG1	5586	16	7256168991
COLLIE_G1	5039	13	1558192285
MUNGARRA_GT3	1308	6	238329480
MWF_MUMBIDA_WF1	1247	6	262620754
GREENOUGH_RIVER_PV1	938	18	391133566
KWINANA_ESR1	706	45	488611182
MUNGARRA_GT1	610	8	2281940
ALINTA_WWF	591	7	108149360
GRASMERE_WF1	484	6	370003680
EDWFMAN_WF1	462	11	47972843
COCKBURN_CCG1	453	9	911976121
PINJAR_GT5	449	5	99408600
KEMERTON_GT11	421	11	100028520
MERSOLAR_PV1	404	7	105519610
BADGINGARRA_WF1	361	9	17894658
YANDIN_WF1	331	10	97780851
TESLA_NORTHAM_G1	297	4	110390040
INVESTEC_COLLGAR_WF1	274	2	59557349
PINJAR_GT1	239	4	56014200
FLATROCKS_WF1	216	4	64059916
NEWGEN_KWINANA_CCG1	216	3	41280730
KEMERTON_GT12	197	4	41994796
PINJAR_GT2	184	3	43217280
KWINANA_GT2	164	3	15509910
STHRNCRS_EG	160	2	35424000
KWINANA_GT3	155	5	9975082
PINJAR_GT11	150	8	40459535

Facility	Binding/violating intervals	Number of discretionary constraints	Accumulated shadow price
TESLA_GERALDTON_G1	121	3	26759943
BW1_BLUEWATERS_G2	105	3	189739800

Table 14 show that NAMKKN_MERR_SG1 was constrained down for 19 days due to risk of forming an uncontrolled island during outage of MRT-NOR-CNS 81 line and MRT T2 transformer. COLLIE_G1 was constrained down for 17 days, mostly driven by network outages around Shotts substation that prevented the facility from generating.

8 Future changes

This section summarises future changes that are likely to affect Network congestion, such as Network augmentations, the commissioning of new Facilities, decommissioning of retiring Facilities, and changes to the demand profile.

8.1 Changes to the Network

8.1.1 Clean Energy Link – North Region

Clean Energy Link – North Region[28] [29] is a collection of several transmission network projects that increase transmission capacity in the Wheatbelt and Mid-West. The program's target completion date is 2027, however the various components of the program each have their own timelines and staging with complex interdependencies.

- **Upgrades to strengthen the 330 kV connection from North Terminal to Three Springs Terminal.** This will significantly increase the capacity to transfer power from north to south during periods of high wind and solar availability.
- **Reconfigure the 132 kV network around Three Springs such that North Country is supplied radially from the 330 kV network at Three Springs Terminal**. This prevents Facilities in the area from contributing to the north-to-south congestion on the 132 kV network.
- **Reconfigure the 132 kV network such that Mullaloo, Joondalup, and Wanneroo are supplied radially from Neerabup Transformer.** This prevents any generation contributing to congestion in the area, particularly Facilities in North Region during periods of high wind availability.
- **Reconfigure network around Regans so that it's supplied radially from the 330 kV network.** This prevents congestion on the 132 kV lines supplying Regans, such as PJR-RGN 81**.**
- **Upgrades to the 132 kV network between NBT and ENT.** This strengthens the network in the area.

8.1.2 East Region Energy Project

AEMO understands that there are committed projects to increase the transfer capacity predominantly on the 220 kV line between Muja and West Kalgoorlie[30]. This is likely to reduce congestion on existing facilities during periods of low non-scheduled generation and allow the connection of new generating projects in the region.

8.1.3 Kwinana Region Transmission Upgrades

AEMO is aware of plans for augmentations to the Kwinana region, including:

[28] Also known as the North Region Energy Program (NREP).

[29] More information can be found here: https://www.westernpower.com.au/resources-education/our-network-the-grid/future-of-the-grid/clean-energy-link-program/clean-energy-link-north/.

[30] For more information see the 2024-25 SWIS Transmission Planning Update

- A new 132 kV line from Kwinana to Leath Road is planned (KW-LTH 81)[31]. If committed this may impact Network congestion by allowing slightly more power from Facilities around Mason Road (PERTHENERGY_KWINANA_GT1, TIWEST_COG1, and ERRRF_WTE_G1) to flow through Kwinana rather than towards Rockingham.
- Upgrades of portions of Kwinana and Mason Road substation to 330 kV and the removal of limitations associated with "fault level ratings" [32]. If committed, this is likely to increase export limits for Facilities in the Kwinana region.

8.1.4 Greater Southern Transmission Upgrades

AEMO is aware of plans to increase the transfer capacity between Muja and Kojonup[33], which may reduce congestion for Facilities between Muja and Albany.

8.1.5 Open point at Merredin Terminal

Since November 2024, the Merredin end of the 132 kV between Merredin Terminal, Northam, and Cunderdin (MRT-NOR-CNS 81) has been used as an open point (disconnected) to facilitate the connection of SBSOLAR1_CUNDERDIN_PV1[34]. This open point contributes to Network congestion on the 220 kV line between Muja and Narrogin South (MU-NGS X1) if used during periods of low wind and solar availability, since all the Eastern Goldfields' load must be supplied via the MU-NGS X1 line.

8.1.6 Dynamic Line Ratings

AEMO is aware that Western Power plans to implement Dynamic Line Ratings (DLR). This is likely to reduce congestion during evening periods (after sunset) when the lower ambient temperatures and lower direct solar irradiance allow for higher power flows.

8.2 Changes to Generation

The following are changes to generation that have occurred since the start of this reporting period (1st Oct 2023) or are expected to occur in the next two years. This list is not comprehensive but is provided as a guide for projects to consider when modelling future Network congestion.

- KWINANA_ESR1: 100 MW battery at Kwinana 330 kV, completed commissioning during 2023-24 Capacity Year.
- FLATROCKS_WF1: 75 MW wind farm between Albany and Kojonup substations, completed commissioning during 2023-24 Capacity Year.

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[31] See 2024 RCM Limit Advice

[32] See Stage 1 projects in the SWIS Demand Assessment 2023-24

[33] See Stage 1 projects in the SWIS Demand Assessment 2023-24

[34] See Non-Thermal Limit Advice #32

- COLLIE_ESR1: 200 MW battery near Shotts substation, completed commissioning during 2023-24 Capacity Year.
- SBSOLAR1_CUNDERDIN_PV1: 100 MW solar and battery project between Merredin Terminal and Northam, completed commissioning in March 2025.
- KWINANA_ESR2: New 225 MW battery at Kwinana 330 kV, currently commissioning.
- PHOENIX_KWINANA_WTE_G1: New 43 MW Waste to Energy project in Kwinana, commissioning soon.
- COLLIE_BESS2: New 300 MW battery near Shotts substation, commissioning soon.
- ALINTA_WGP_ESR1: New battery at Landwehr Terminal, holds 100 MW of Capacity Credits for the 2026-27 Capacity Year.
- ARROWSMITH_EAST_G1: New gas plant between Three Springs and Mumbida substations, holds 85 MW of Capacity Credits for the 2026-27 Capacity Year.
- COLLIE_ESR4 and COLLIE_ESR5: New battery Facilities near Shotts substation, each hold 175 MW of Capacity Credits for the 2026-27 Capacity Year.
- MERREDIN_ESR1: New battery at Merredin Terminal, holds 94.5 MW of Capacity Credits for the 2026-27 Capacity Year.
- TESLA_PICTON_G1, TESLA_NORTHAM_G1, and PRK_AG: These Facilities do not hold Capacity Credits for the 2026-27 Capacity Year, hence are not obliged to make their Capacity available to relieve congestion with an Intervention Event.
- MUJA_G6: 194 MW coal Facility, scheduled to be retired on 1st April 2025.
- Tender 2 of the Capacity Investment Scheme[35] (CIS) seeks to deliver 500 MW of battery projects across the WEM. The tender is currently under assessment; the successful projects are expected to be announced in March 2025.

8.3 Changes to Load

The 2024 WEM Electricity Statement of Opportunities (WEM ESOO) has forecast a significant growth in peak demand over the next few years, from 4,304 MW in the 2023-24 Capacity Year to 4,772 MW in the 2028-29 Capacity Year. The higher peak loads are likely to contribute to Network congestion, particularly in the South Region on lines such as APJ-PNJ 81, PIC-MRR 81, and KEM-MRR 81.

The 2024 RCM Limit Advice[36] identifies new loads associated with the new Morley-Ellenbrook train line (Beckenham, Edgewater, Whiteman Park, and Bunning Lake) and increases to various block loads (Bridgetown, Marriot Road, Yanchep, and Karara). This is not expected to have significant impact on Network congestion.

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[35] https://www.dcceew.gov.au/energy/renewable/capacity-investment-scheme

[36] See 2024 RCM Limit Advice