07

Network capability and performance

This chapter discusses the evolving generation mix and demand profiles and how these changes impact the power flows across the transmission network.

Key highlights

- Generation commitments since the 2022 Transmission Annual Planning Report (TAPR) add 399MW to Queensland's semi-scheduled variable renewable energy (VRE) generation capacity taking the total existing and committed semi-scheduled VRE generation capacity to 5,334MW.
- Storage commitments since the 2022 TPAR include the 100MW 2 hour Chinchilla Battery energy storage system (BESS).
- Record maximum and record minimum transmission delivered demands were experienced in Wide Bay, South West and Gold Coast zones during 2022/23. All three regions had a reduction in transmission delivered energy.
- Record minimum transmission delivered demands were also recorded in Far North, Ross and Moreton zones during 2022/23.
- The transmission network has performed reliably during 2022/23, with Queensland grid sections largely unconstrained.

7.1 Introduction

This chapter on network capability and performance provides:

- an outline of existing and committed generation capacity over the next three years
- a summary of network control facilities configured to disconnect load as a consequence of non-credible events
- single line diagrams of the existing high voltage (HV) network configuration
- background on factors that influence network capability
- zonal energy transfers for the two most recent years
- historical constraint times and power flow duration curves at key sections of Powerlink Queensland's transmission network
- a qualitative explanation of factors affecting power transfer capability at key sections of Powerlink's transmission network
- historical constraint times and load duration curves at key zones of Powerlink's transmission network
- double circuit transmission lines categorised as vulnerable by the Australian Energy Market Operator (AEMO).

The capability of Powerlink's transmission network to meet forecast demand is dependent on a number of factors. Queensland's transmission network is predominantly utilised more during summer than winter. During higher summer temperatures transmission plant has lower power carrying capability which is also when demand is higher as shown in Figure 3.14.

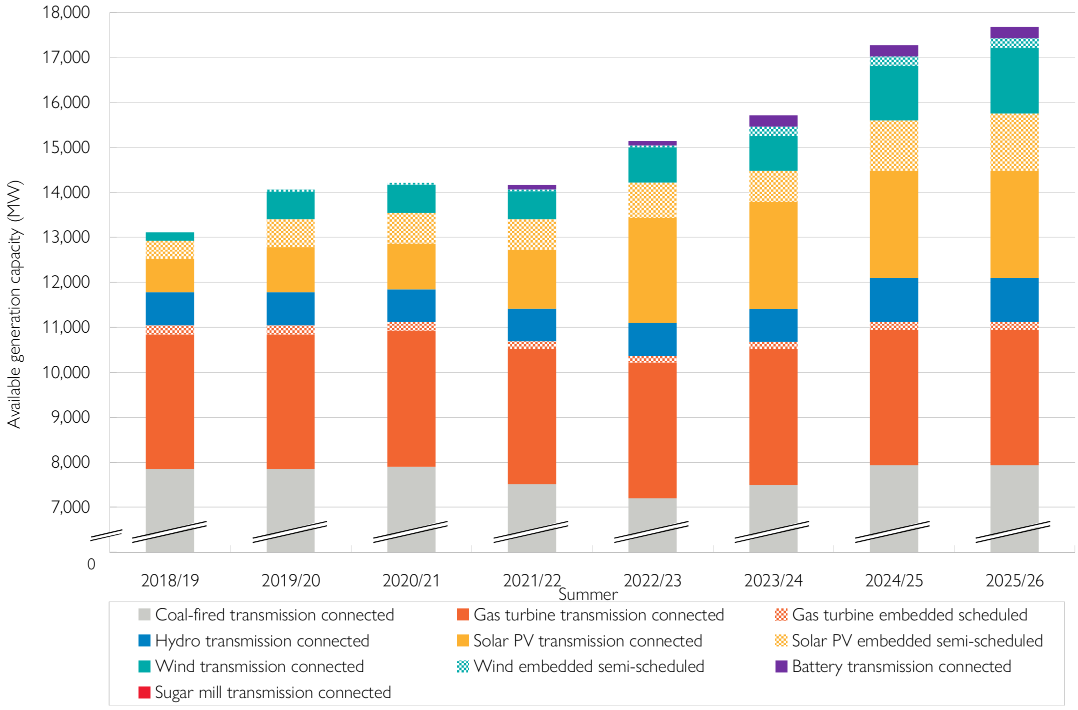
The location and pattern of generation dispatch influences power flows across the Queensland network. Future generation dispatch patterns and interconnector flows are uncertain in the deregulated electricity market and will vary substantially due to output of VRE generation and because of planned or unplanned outages of generation plant. Power flows can also vary substantially with planned or unplanned outages of transmission network elements. Power flows may also be higher at times of local area or zone maximum demands (refer to Table 3.17) and/or when embedded generation output is lower.

7.2 Available generation capacity

Scheduled generation in Queensland is predominantly a combination of coal-fired, gas turbine and hydro-electric generators with an increasing share coming from battery and pumped hydro energy storage systems. Semi-scheduled generation in Queensland is a combination of wind and solar generation.

AEMO's definition of 'committed' from the System Strength Impact Assessment Guidelines[1] (effective 6 June 2023) has been adopted for the purposes of this year's TAPR. During 2022/23, commitments have added 399MW of semi-scheduled VRE capacity, taking Queensland's semi-scheduled VRE generation capacity to 5,334MW. Figure 7.1 illustrates the expected changes to available and committed large-scale generation capacity in Queensland from summer 2018/19 to summer 2025/26.

Figure 7.1 Summer available generation capacity by energy source



7.2.1 Existing and committed transmission connected and direct connect embedded generation

Table 7.1 summarises the available generation capacity of power stations connected, or committed to be connected to Powerlink's transmission network (including the non-scheduled generators at Yarwun, Invicta and Koombooloomba) or to Powerlink's direct connect customers.

Semi-scheduled transmission connected Wambo Wind Farm has reached committed status since the 2022 TAPR.

Scheduled transmission connected Chinchilla BESS has reached committed status since the 2022 TAPR.

Information in this Table has been provided to AEMO by the owners of the generators. Details of registration and generator capacities can be found on AEMO's website. In accordance with Clause 5.18A of the National Electricity Rules (NER), Powerlink's Register of Large Generator Connections with information on generators connected to Powerlink's network can be found on Powerlink's website.

[1] AEMO, System Strength Impact Assessment Guidelines, June 2023.

Table 7.1 Available generation capacity – existing and committed generators connected to the Powerlink transmission network or direct connect customers

Generator	Location	Available capacity MW generated (1) Summer 2023/24	Winter 2024	Summer 2024/25	Winter 2025	Summer 2025/26	Winter 2026
Coal-fired							
Stanwell	Stanwell	1,460	1,460	1,460	1,460	1,460	1,460
Gladstone	Calliope River	1,680	1,680	1,680	1,680	1,680	1,680
Callide B	Calvale	700	700	700	700	700	700
Callide Power Plant	Calvale	434	932	868	932	868	932
Tarong North	Tarong	443	443	443	443	443	443
Tarong	Tarong	1,400	1,400	1,400	1,400	1,400	1,400
Kogan Creek	Kogan Creek PS	710	750	710	750	710	750
Millmerran	Millmerran PS	670	852	670	852	670	852
Total coal-fired		7,497	8,217	7,931	8,217	7,931	8,217
Gas turbine							
Townsville 132kV	Townsville GT PS	150	165	150	165	150	165
Mt Stuart	Townsville South	387	400	387	400	387	400
Yarwun (2)	Yarwun	160	155	160	155	160	155
Condamine (3)	Columboola	139	144	139	144	139	144
Braemar 1	Braemar	501	543	501	543	501	543
Braemar 2	Braemar	480	519	480	519	480	519
Darling Downs	Braemar	563	630	563	630	563	630
Oakey (4)	Tangkam	288	346	288	346	288	346
Swanbank E	Swanbank E PS	350	365	350	365	350	365
Total gas turbine		3,018	3,267	3,018	3,267	3,018	3,267
Hydro-electric							
Barron Gorge	Kamerunga	66	66	66	66	66	66
Kareeya (including Koombooloomba) (5)	Chalumbin	93	93	93	93	93	93
Wivenhoe (6)	Mt. England	570	570	570	570	570	570
Kidston Pumped Hydro Storage (6)	Kidston			250	250	250	250
Total hydro-electric		729	729	979	979	979	979
Solar PV (7)							
Ross River	Ross	116	116	116	116	116	116
Sun Metals (3)	Townsville Zinc	121	121	121	121	121	121
Haughton	Haughton River	100	100	100	100	100	100
Clare	Clare South	100	100	100	100	100	100
Whitsunday	Strathmore	57	57	57	57	57	57
Hamilton	Strathmore	57	57	57	57	57	57
Daydream	Strathmore	150	150	150	150	150	150
Hayman	Strathmore	50	50	50	50	50	50
Rugby Run	Moranbah	65	65	65	65	65	65

Table 7.1 Available generation capacity – existing and committed generators connected to the Powerlink transmission network or direct connect customers *(continued)*

Generator	Location	Available capacity MW generated (1) Summer 2023/24	Winter 2024	Summer 2024/25	Winter 2025	Summer 2025/26	Winter 2026
Lilyvale	Lilyvale	100	100	100	100	100	100
Moura	Moura	82	82	82	82	82	82
Woolooga Energy Park	Woolooga	176	176	176	176	176	176
Blue grass	Chinchilla	148	148	148	148	148	148
Columboola	Columboola	162	162	162	162	162	162
Gangarri	Wandoan South	120	120	120	120	120	120
Wandoan	Wandoan South	125	125	125	125	125	125
Edenvale Solar Park	Orana	146	146	146	146	146	146
Western Downs Green Power Hub	Western Downs	400	400	400	400	400	400
Darling Downs	Braemar	108	108	108	108	108	108
Total solar PV		2,383	2,383	2,383	2,383	2,383	2,383
Wind (7)							
Mt Emerald	Walkamin	180	180	180	180	180	180
Kaban	Tumoulin	152	152	152	152	152	152
Clarke Creek	Broadsound			440	440	440	440
Wambo	Halys					245	245
Coopers Gap	Coopers Gap	440	440	440	440	440	440
Total wind		772	772	1,212	1,212	1,457	1,457
Battery (7)							
Bouldercombe 2h BESS	Bouldercombe	50	50	50	50	50	50
Wandoan 1.5h BESS	Wandoan South	100	100	100	100	100	100
Chinchilla 2h BESS	Western Downs	100	100	100	100	100	100
Total battery		250	250	250	250	250	250
Sugar mill							
Invicta (5)	Invicta Mill	0	34	0	34	0	34
Total sugar mill		0	34	0	34	0	34
Total all stations		14,649	15,652	15,773	16,342	16,018	16,587

Notes:

(1) Synchronous generator capacities shown are at the generator terminals and are therefore greater than Power Station (PS) net sent out nominal capacity due to station auxiliary loads and step-up transformer losses. The capacities are nominal as the generator rating depends on ambient conditions. Some additional overload capacity is available at some power stations depending on ambient conditions.

(2) Yarwun is a non-scheduled generator, but is required to comply with some of the obligations of a scheduled generator.

(3) Condamine and Sun Metals are direct connected embedded generators.

(4) Oakey PS is an open-cycle, dual-fuel, gas-fired PS. The generated capacity quoted is based on gas fuel operation.

(5) Koombooloomba and Invicta are transmission connected non-scheduled generators.

(6) Wivenhoe and Kidston Pumped Hydro Storage are shown at full capacity. However, output can be limited depending on water storage levels.

(7) VRE generators and batteries are shown at maximum capacity at the point of connection. The capacities are nominal as the generator rating depends on ambient conditions.

(8) Generators undergoing commissioning are shown at full capacity from the anticipated start of commissioning activities. Actual available generating capacity will vary over the course of the commissioning program.

7.2.2 Existing and committed scheduled and semi-scheduled distribution connected embedded generation

Table 7.2 summarises the available generation capacity of embedded scheduled and semi-scheduled power stations connected, or committed to be connected to Queensland's distribution network.

Semi-scheduled embedded Gunsynd Solar Farm and Banksia Solar Farm have reached committed status since the 2022 TAPR.

Information in this Table has been provided to AEMO by the owners of the generators. Details of registration and generator capacities can be found on AEMO's website.

Table 7.2 Available generation capacity – existing and committed scheduled or semi-scheduled generators connected to the Ergon Energy and Energex (part of the Energy Queensland Group) distribution networks

Generator	Location	Available capacity MW generated (1)					
		Summer 2023/24	Winter 2024	Summer 2024/25	Winter 2025	Summer 2025/26	Winter 2026
Gas turbine (1)							
Townsville 66kV	Townsville GT PS	78	82	78	82	78	82
Barcaldine	Barcaldine	32	37	32	37	32	37
Roma	Roma	54	68	54	68	54	68
Total gas turbine		164	187	164	187	164	187
Solar PV (2)							
Kidston	Kidston	50	50	50	50	50	50
Kennedy Energy Park	Hughenden	15	15	15	15	15	15
Collinsville	Collinsville North	42	42	42	42	42	42
Clermont	Clermont	75	75	75	75	75	75
Middlemount	Lilyvale	26	26	26	26	26	26
Emerald	Emerald	72	72	72	72	72	72
Bundaberg	Gin Gin		78	78	78	78	78
Bullyard	Gin Gin				97	97	97
Banksia	Isis					60	60
Aramara	Aramara			104	104	104	104
Susan River	Maryborough	75	75	75	75	75	75
Childers	Isis	56	56	56	56	56	56
Munna Creek	Kilkivan		120	120	120	120	120
Kingaroy	Kingaroy		40	40	40	40	40
Maryrorough	Yarranlea	27	27	27	27	27	27
Yarranlea	Yarranlea	103	103	103	103	103	103
Oakey 1	Oakey	25	25	25	25	25	25
Oakey 2	Oakey	55	55	55	55	55	55
Warwick	Warwick	64	64	64	64	64	64
Gunsynd	Waggamba			94	94	94	94
Total solar PV		685	923	1,121	1,218	1,278	1,278
Wind (2)							
Kennedy Energy Park	Hughenden	43	43	43	43	43	43
Dulacca	Roma	173	173	173	173	173	173
Total wind		216	216	216	216	216	216
Total all stations		1,065	1,326	1,501	1,621	1,658	1,681

Notes:

(1) Synchronous generator capacities shown are at the generator terminals and are therefore greater than PS net sent out nominal capacity due to station auxiliary loads and step-up transformer losses. The capacities are nominal as the generator rating depends on ambient conditions. Some additional overload capacity is available at some power stations depending on ambient conditions.

(2) VRE generators shown at maximum capacity at the point of connection. The capacities are nominal as the generator rating depends on ambient conditions.

7.3 Network control facilities

Powerlink participated in the 2023 General Power System Risk Review[2] (GPSRR), published by AEMO in July 2023. The GPSRR replaces and expands on the scope of the previous Power System Frequency Risk Review (PSFRR) which only focussed on power system frequency risks associated with non-credible contingency events, to now include other modes of failure.

AEMO has added the following in relation to Queensland in this review:

- Investigation, and if found viable, design and implementation of a special protection scheme to mitigate the risk of QNI instability and synchronous separation of Queensland following a range of non-credible contingencies.

Work is continuing on the following recommendations from the 2022 PSFRR including:

- Establishment of an Over Frequency Generation Shedding (OFGS) scheme to manage over frequency if QNI separates. AEMO and Powerlink are working on the design of this scheme which is planned for completion at the end of 2023.
- Identification and implementation of measures to restore Under Frequency Load Shedding (UFLS).
- Review and implementation of Wide Area Monitoring, Protection and Control (WAMPAC) for the non-credible loss of both Calvale – Halys 275kV lines and loss of both Columboola – Western Downs 275kV lines.

Associated with high penetration of rooftop photovoltaic (PV) installations, Powerlink is reviewing the transient stability limits for CQ-SQ and QNI. The review includes dynamic load models that include rooftop PV behaviour. Powerlink submitted draft reports to AEMO in March 2023.

Powerlink owns other network control facilities that minimise or reduce the consequences of multiple contingency events. Network control facilities owned by Powerlink which may disconnect load following a multiple non-credible contingency event are listed in Table 7.3.

Table 7.3 Powerlink owned network control facilities configured to disconnect load as a consequence of non-credible events during system normal conditions

Scheme	Purpose
FNQ Under Voltage Load Shed (UVLS) scheme	Minimise risk of voltage collapse in FNQ
North Goonyella Under Frequency Load Shed (UFLS) relay	Raise system frequency
Dysart UVLS	Minimise risk of voltage collapse in Dysart area
Eagle Downs UVLS	Minimise risk of voltage collapse in Eagle Downs area
Boyne Island UFLS relay	Raise system frequency
Queensland UFLS inhibit scheme	Minimise risk of QNI separation for an UFLS event for moderate to high southern transfers on QNI compared to Queensland demand
CQ-SQ N-2 WAMPAC scheme	Minimise risk of CQ-SQ separation for a non-credible loss of the Calvale to Halys 275kV double circuit transmission line
Tarong UFLS relay	Raise system frequency
Middle Ridge UFLS relays	Raise system frequency
Mudgeeraba Emergency Control Scheme (ECS)	Minimise risk of voltage collapse in the Gold Coast zone

2 AEMO, 2023 General Power System Risk Review, July 2023.

7.4 Existing network configuration

Figures 7.2, 7.3, 7.4 and 7.5 illustrate Powerlink's system intact network as of July 2023.

Figure 7.2 Existing HV network July 2023 – North Queensland

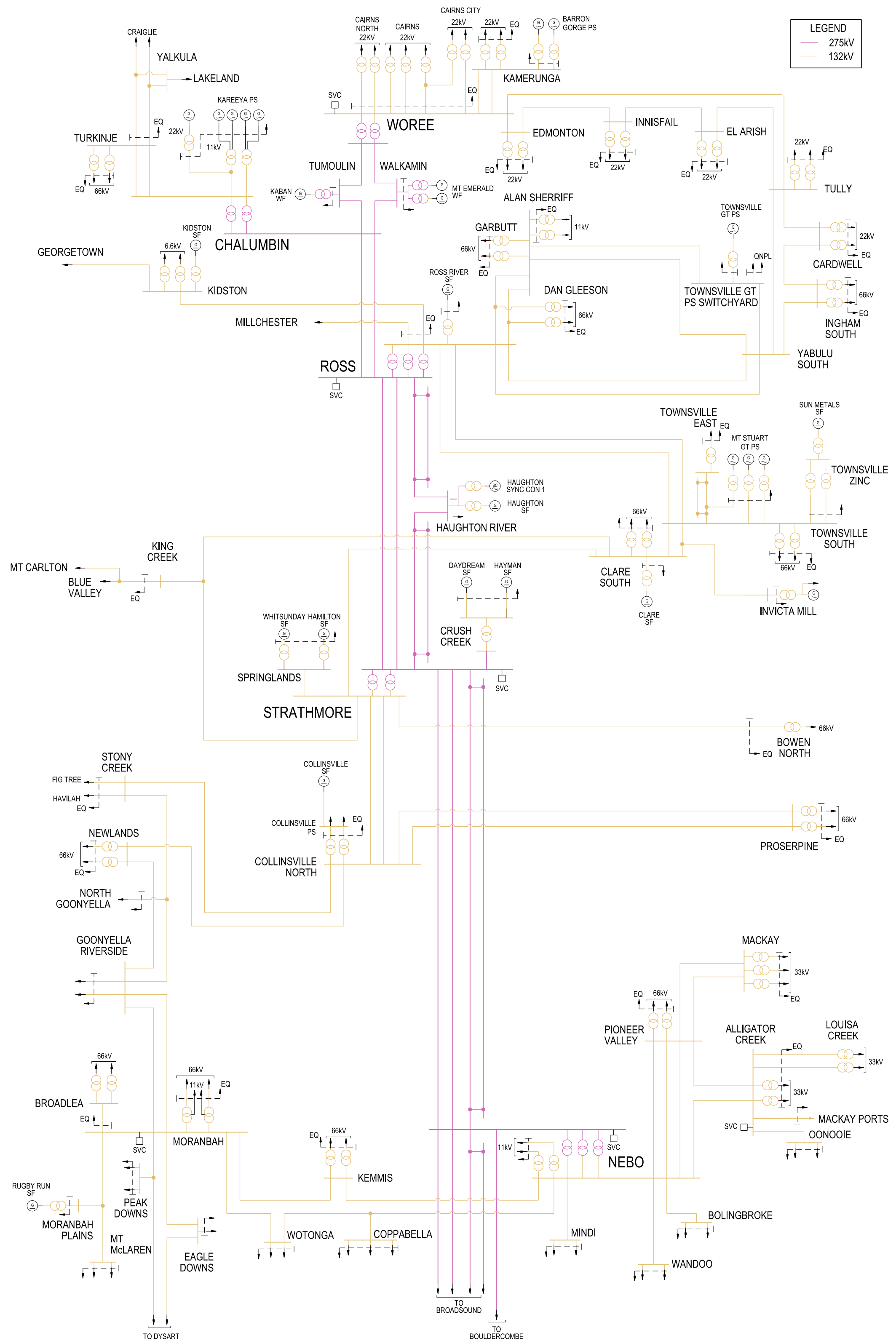


Figure 7.3 Existing HV network July 2023 – Central Queensland

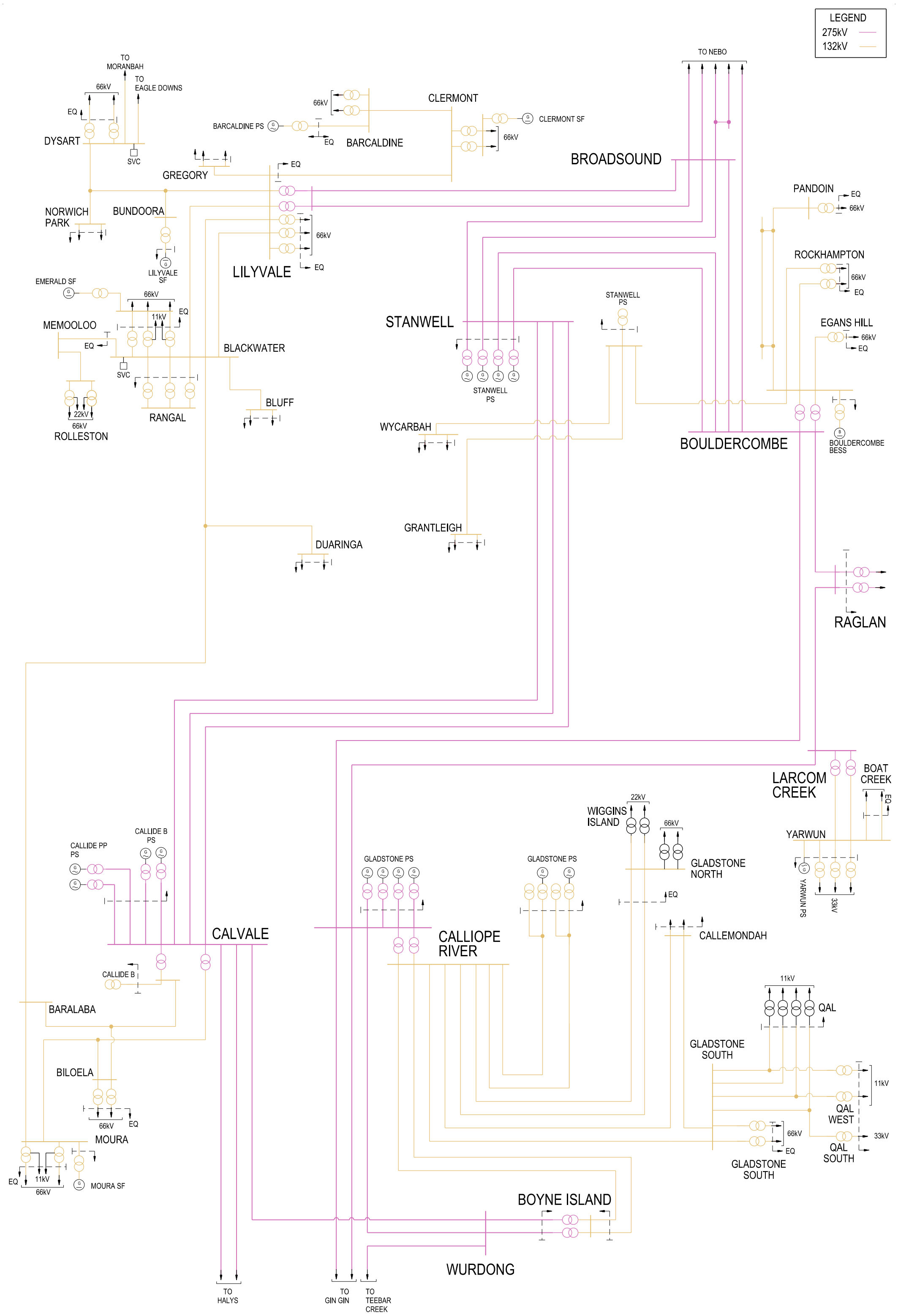


Figure 7.4 Existing HV network July 2023 - South West Queensland

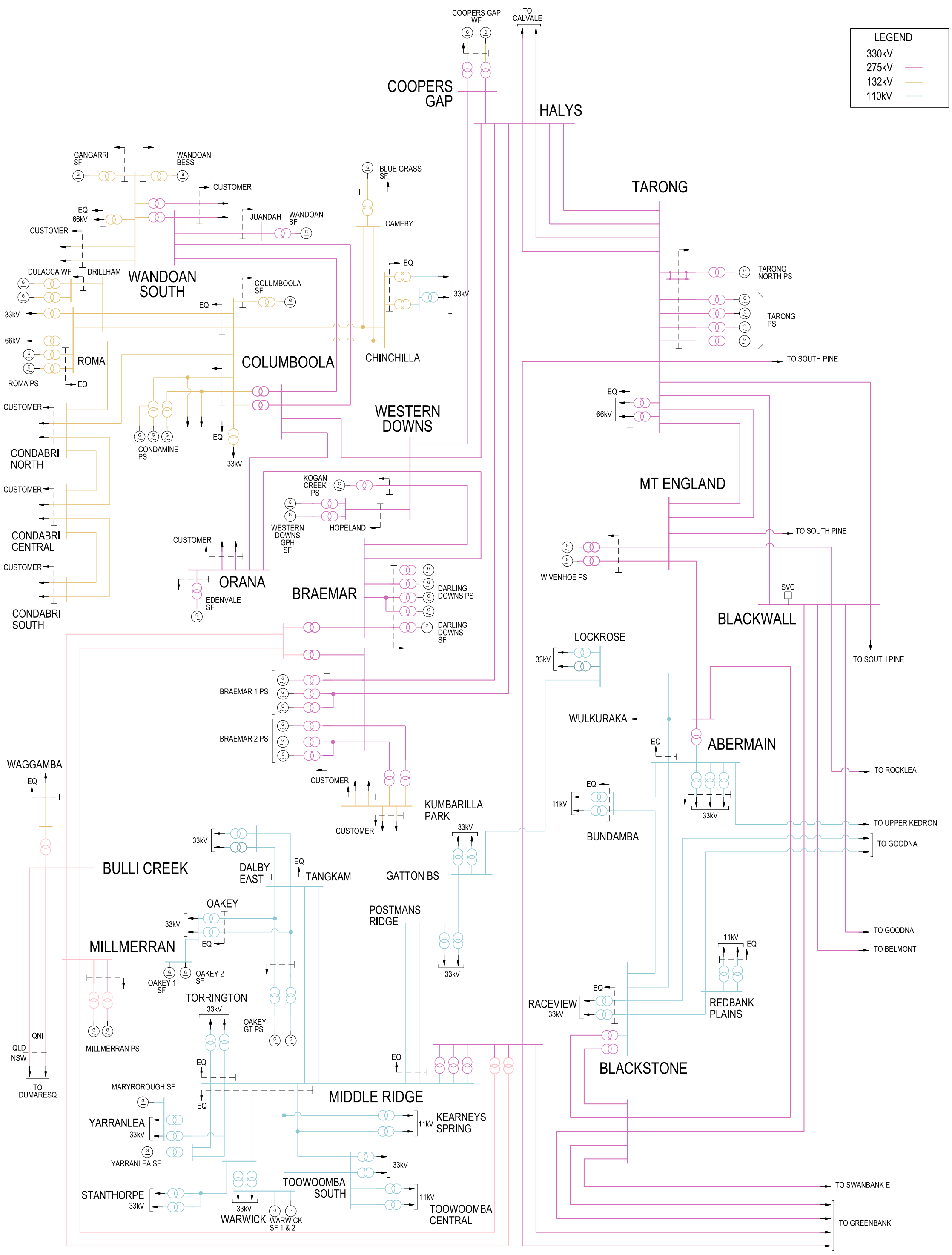
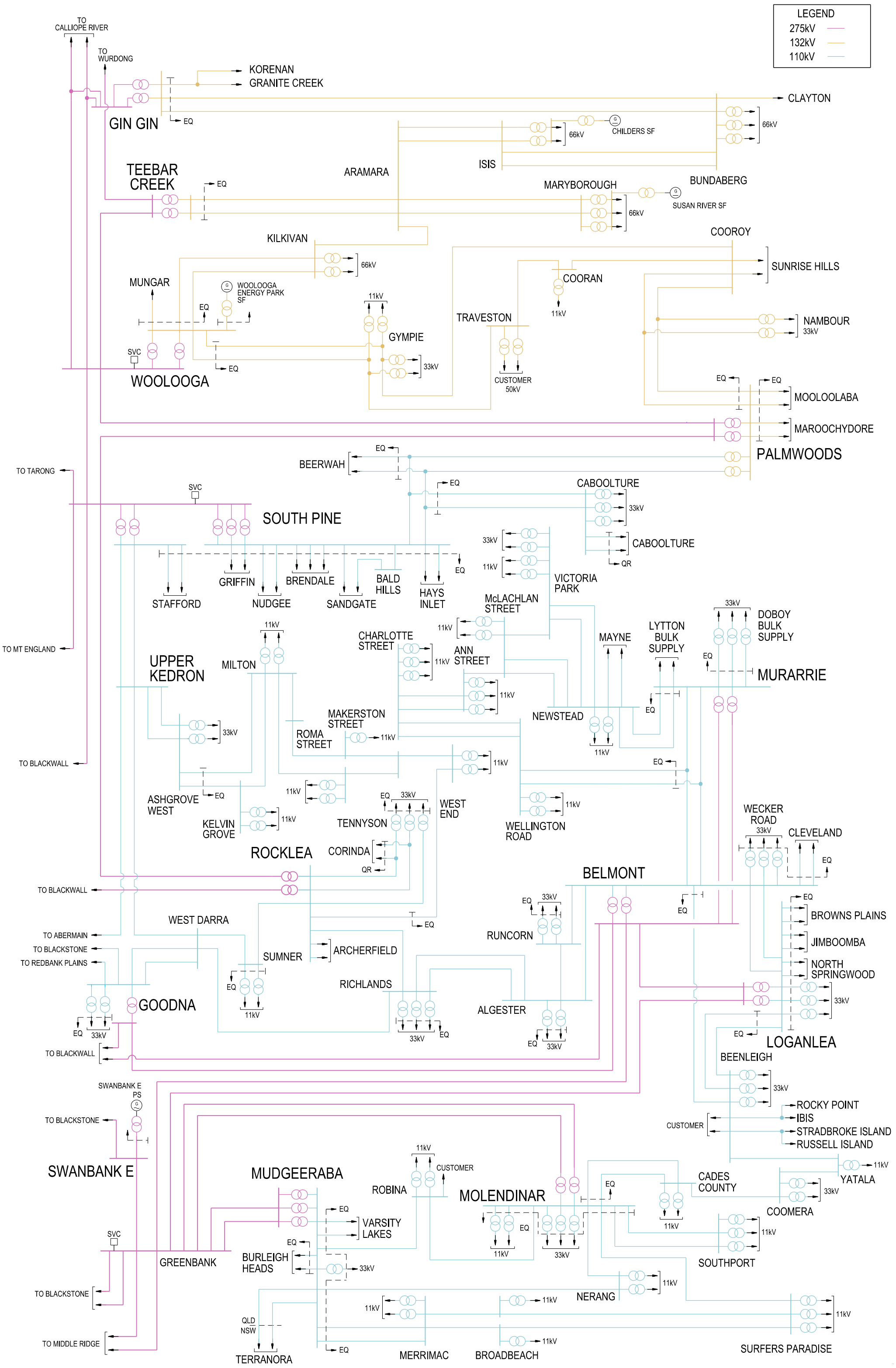


Figure 7.5 Existing HV network July 2023 - South East Queensland



7.5 Transfer capability

7.5.1 Location of grid sections

Powerlink has identified a number of grid sections that allow the assessment of network capability and to forecast limitations in a structured manner. Maximum power transfer capability may be set by transient stability, voltage stability, thermal plant ratings or protection relay load limits. Powerlink develops and maintains limit equations for these grid sections to quantify maximum secure power transfer. AEMO then incorporates these limit equations into constraint equations within the National Electricity Market Dispatch Engine (NEMDE). Table F.2 and Figure F.1 in Appendix F define and illustrate the location of relevant grid sections on the Queensland network.

7.5.2 Determining transfer capability

Transfer capability across each grid section varies with different system operating conditions. Transfer limits in the National Electricity Market (NEM) are not generally amenable to definition by a single number. Instead, TNSPs define the capability of their network using multi-term equations. These equations quantify the relationship between system operating conditions and transfer capability, and are implemented into NEMDE, following AEMO's due diligence, for optimal dispatch of generation. In Queensland the transfer capability is highly dependent on which generators are in-service and their dispatch level. The limit equations maximise transmission capability available to electricity market participants under prevailing system conditions.

Limit equations derived by Powerlink are provided in Appendix G. These limit equations are current at the time of publication of this TAPR but will change over time with demand, generation and network development, and/or network reconfiguration. For example, the commissioning of the third 275kV circuit into Cairns later this year will trigger an update to the FNQ grid section voltage stability equation. Additionally, expected limit improvements for committed works are incorporated in all future planning. Section 7.6 includes a qualitative description of the main system conditions that affect the capability of each grid section.

7.6 Grid section performance

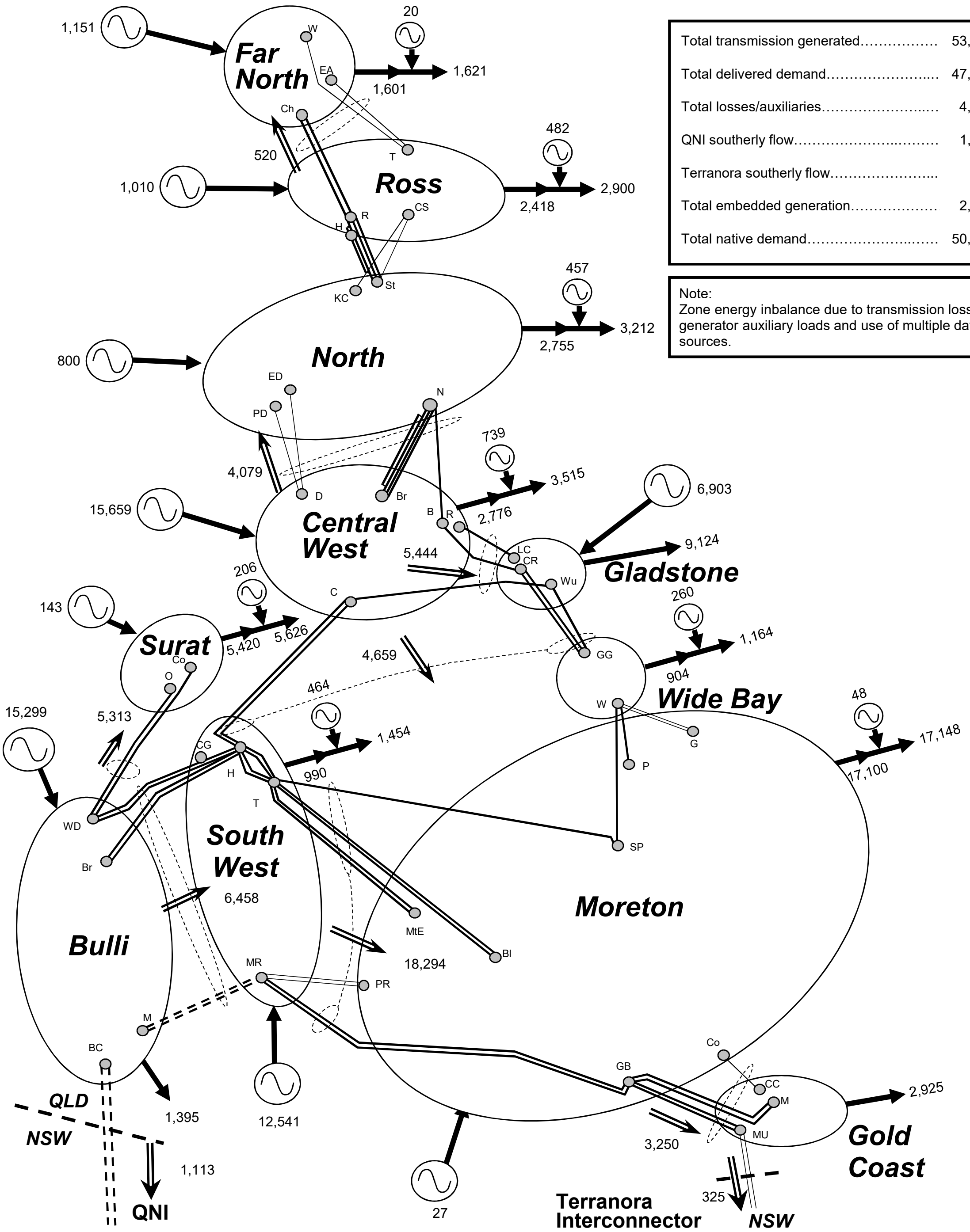
This section is a summary of the changing flows on the key grid sections of the Queensland network and the system conditions with major effects on their transfer capability.

Historical transfer duration curves for the last five years are included for each grid section. Grid section transfers are affected by load, generation and transfers to neighbouring zones. Figures 7.6 and 7.7 provide 2021/22 and 2022/23 zonal energy flows. This includes transmission connected generation, major embedded generators, transmission delivered energy to Distribution Network Service Providers (DNSPs) and direct connect customers as well as energy transfers for each grid section. Figure 7.8 provides the changes in energy transfers from 2021/22 to 2022/23. These figures assist in the explanation of differences between grid section transfer duration curves over the last two years. A breakdown of transmission connected generation by generation type and zone is provided in Table F.3 in Appendix F.

Along with the grid section transfer duration curves, the time that the associated constraint equations have bound over the last 10 years is provided. These are categorised as occurring during intact or outage conditions based on AEMO's constraint description. Constraint times can be associated with a combination of generator unavailability, network outages, unfavourable dispatches and/or high loads. Constraint times do not include occurrences of binding constraints associated with network support agreements. Binding constraints whilst network support is dispatched are not classed as congestion. Although high constraint times may not be indicative of the cost of market impact, they serve as a trigger for the analysis of the economics for overcoming the congestion.

Binding constraint information is sourced from AEMO. Historical binding constraint information is not intended to imply a prediction of constraints in the future.

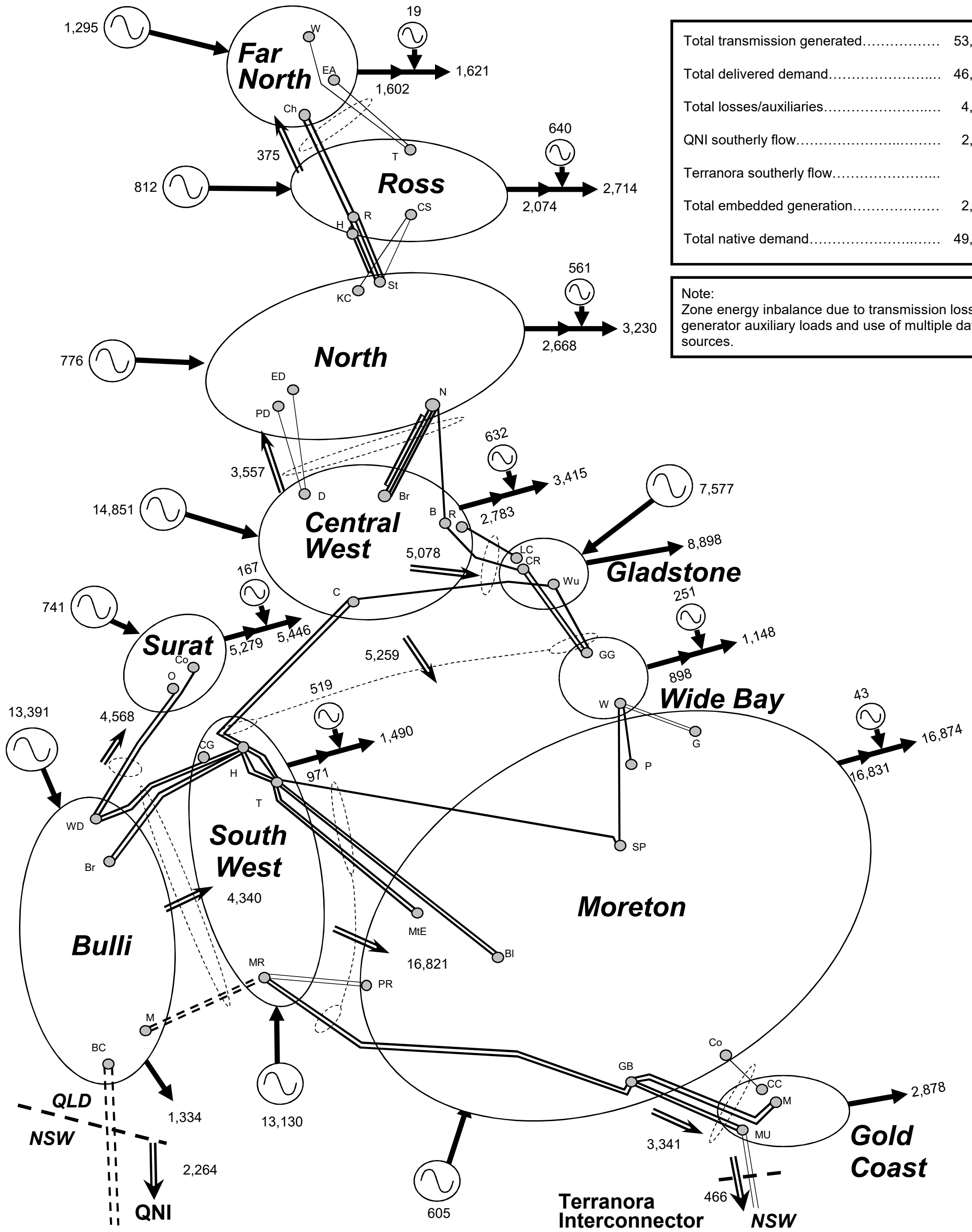
Figure 7.6 2021/22 zonal electrical energy transfers (GWh)



Total transmission generated	53,534 GWh
Total delivered demand	47,409 GWh
Total losses/auxiliaries	4,687 GWh
QNI southerly flow	1,113 GWh
Terranora southerly flow	325 GWh
Total embedded generation	2,676 GWh
Total native demand	50,085 GWh

Note:
Zone energy inbalance due to transmission losses, generator auxiliary loads and use of multiple data sources.

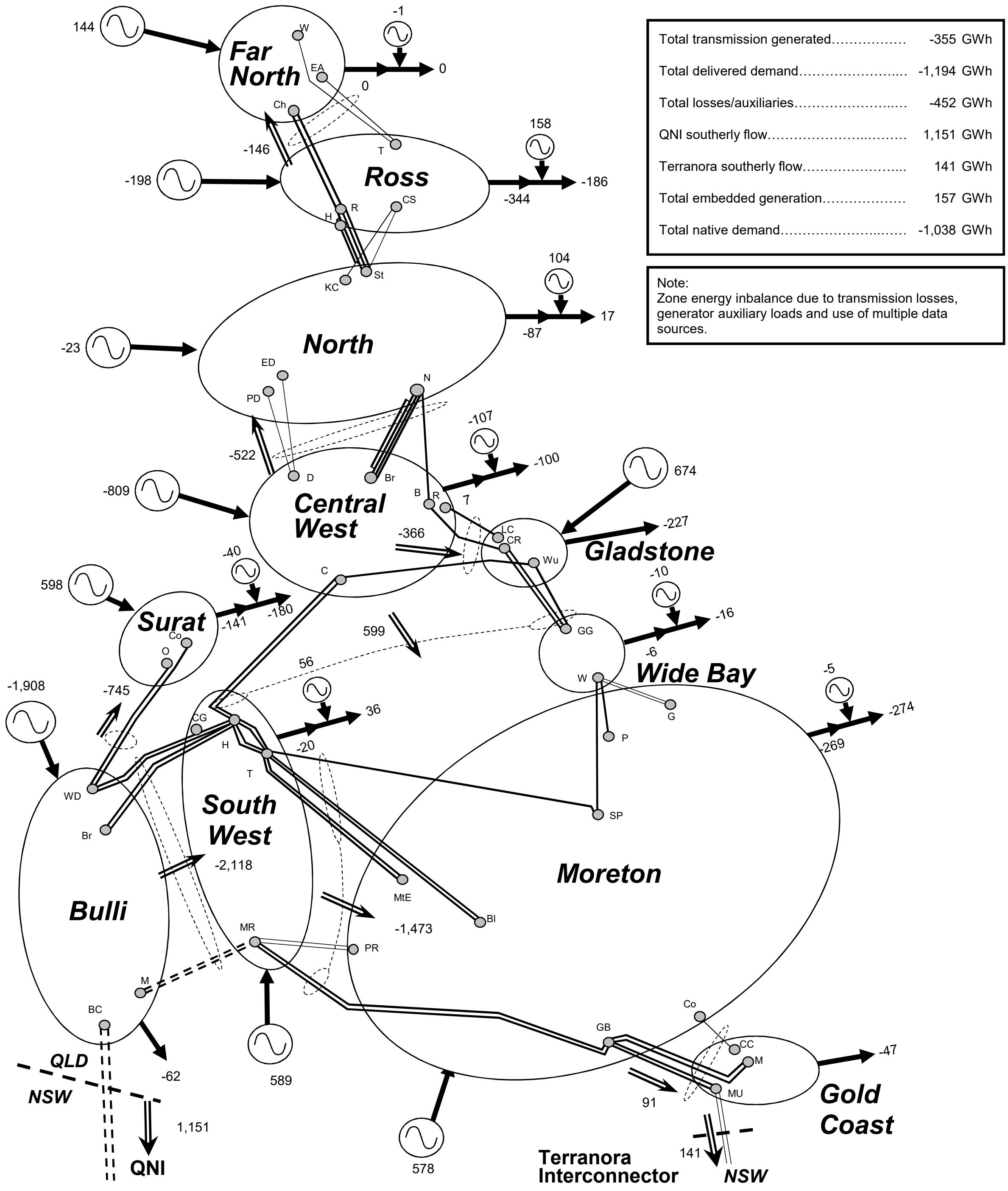
Figure 7.7 2022/23 zonal electrical energy transfers (GWh)



Total transmission generated	53,179 GWh
Total delivered demand	46,214 GWh
Total losses/auxiliaries	4,235 GWh
QNI southerly flow	2,264 GWh
Terranora southerly flow	466 GWh
Total embedded generation	2,833 GWh
Total native demand	49,047 GWh

Note:
Zone energy inbalance due to transmission losses, generator auxiliary loads and use of multiple data sources.

Figure 7.8 Change in zonal electrical energy transfers (GWh)



7.6.1 Far North Queensland grid section

Maximum power transfer across the Far North Queensland (FNQ) grid section is set by voltage stability associated with an outage of the Woree SVC or Mt Emerald Wind Farm.

The limit equation in Table G.1 of Appendix G shows that the following variables have a significant effect on transfer capability:

- Far North zone generation
- Far North zone shunt compensation levels.

Local hydro and wind generation reduces transfer capability but allows more demand to be securely supported in the Far North zone. This is because reactive margins increase with additional local generation, allowing further load to be delivered before reaching minimum allowable reactive margins. However, due to its distributed and reactive nature, increases in delivered demand erode reactive margins at greater rates than they were created by the additional local generation. Limiting power transfers are thereby lower with the increased local generation but a greater load can be delivered.

The FNQ grid section was constrained for approximately one hour during outage conditions in 2022/23. The historical duration of constrained operation for the FNQ grid section is summarised in Figure 7.9.

Figure 7.9 Historical FNQ grid section constraint times

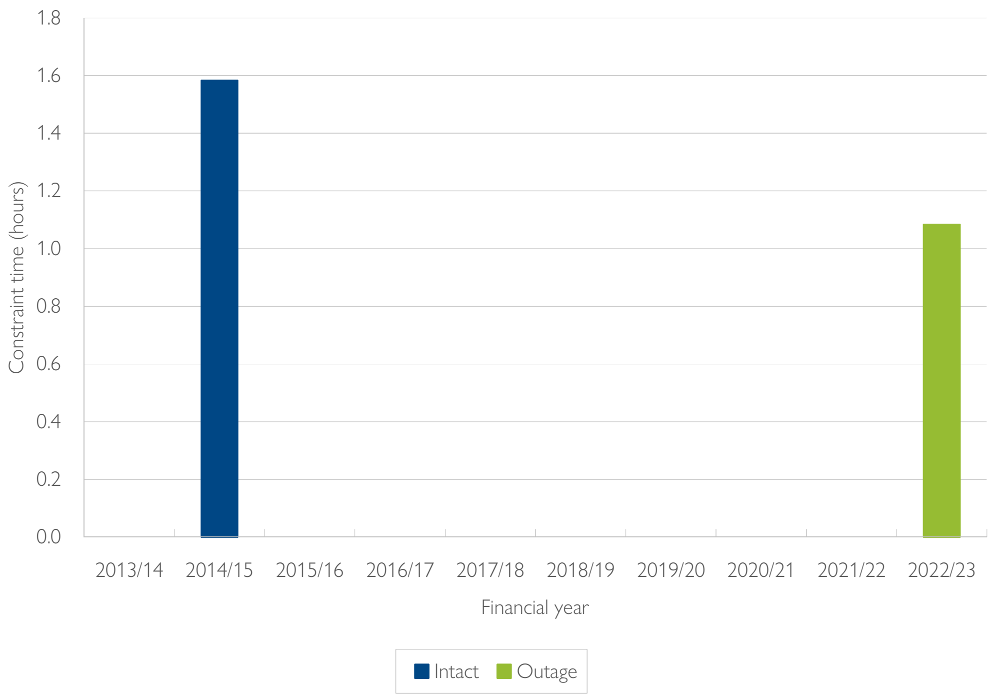
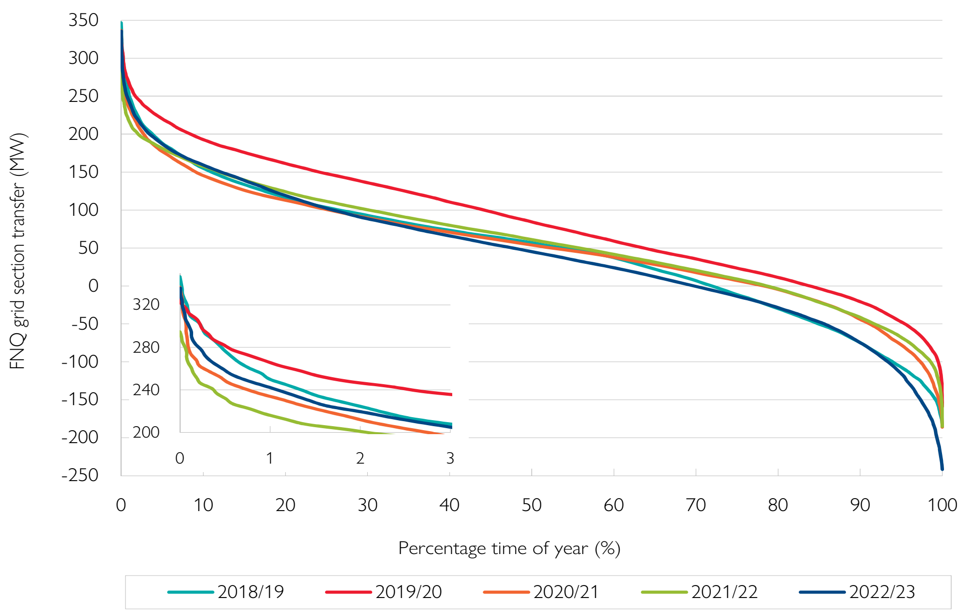


Figure 7.10 provides historical transfer duration curves showing the duration and magnitude of southerly flows have increased between 2021/22 and 2022/23. Historically, changes in peak flow and energy delivered to the Far North zone by the transmission network have been dependant on the Far North zone load and generation from the hydro generating power stations at Barron Gorge and Kareeya and Mt Emerald Wind Farm. This year the energisation of Kaban Wind Farm has further increased the available generation in the Far North zone. This has resulted in a corresponding decrease in northerly delivered energy across the Far North Queensland grid section (refer to figures 7.6, 7.7 and 7.8).

Figure 7.10 Historical FNQ grid section transfer duration curves



In May 2021 it was announced that the Queensland Government would invest transmission line infrastructure in North Queensland to establish a Queensland REZ (QREZ), with Neoen's Kaban Wind Farm identified as the foundational proponent.

The transmission augmentation works involve energising one side of the existing 132kV coastal double circuit transmission line at 275kV. This will result in the establishment of a third 275kV transmission line into Woree substation in Cairns. Work on the third 275kV transmission augmentation is expected to be completed by April 2024 (refer to Table 9.3).

7.6.2 Central Queensland to North Queensland grid section

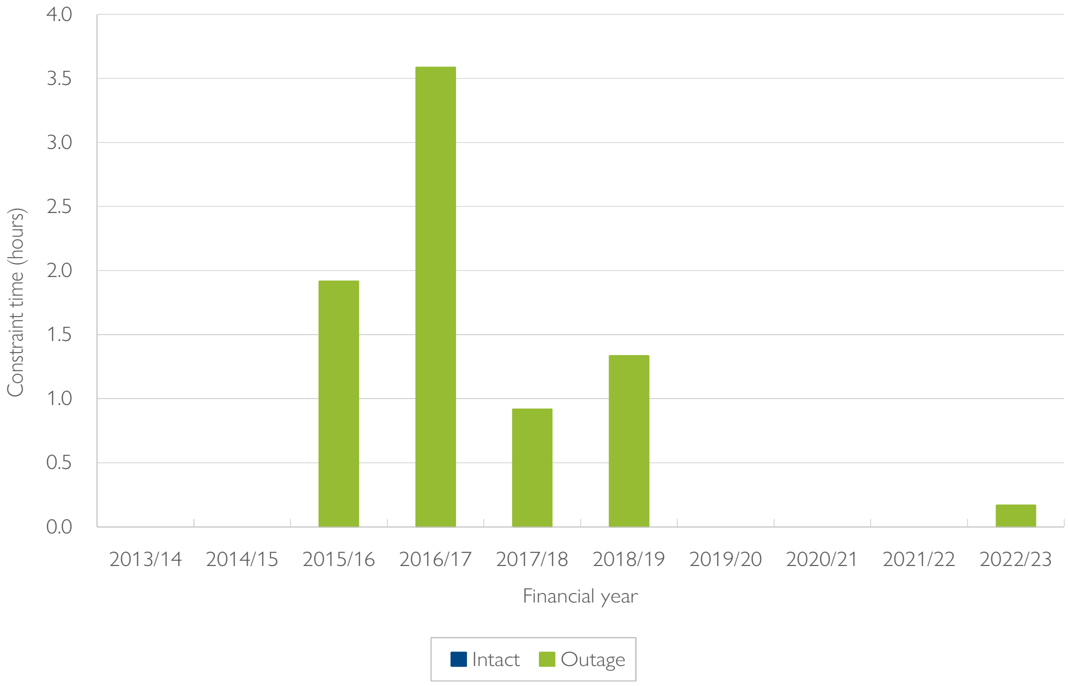
Maximum power transfer across the Central Queensland to North Queensland (CQ-NQ) grid section may be set by thermal ratings associated with an outage of a Stanwell to Broadsound 275kV circuit, under certain prevailing ambient conditions. Power transfers may also be constrained by voltage stability limitations associated with the contingency of the Townsville gas turbine or a Stanwell to Broadsound 275kV circuit.

The limit equations in Table G.2 of Appendix G show that the following variables have a significant effect on transfer capability:

- level of Townsville gas turbine generation
- Ross and North zones shunt compensation levels.

The CQ-NQ grid section was constrained for 10 minutes during outage conditions in 2022/23. The historical duration of constrained operation for the CQ-NQ grid section is summarised in Figure 7.11.

Figure 7.11 Historical CQ-NQ grid section constraint times



The constraint times were associated with thermal constraint equations during planned outages to ensure operation within plant thermal ratings.

Figure 7.12 provides historical transfer duration curves showing decreases in energy transfer over recent years. This decrease is predominantly attributed to the addition of renewable generation in the Far North, Ross and North zones. Despite reductions in total energy transfer, the peak power transfer in 2022/23 is similar to previous years.

Figure 7.12 Historical CQ-NQ grid section transfer duration curves

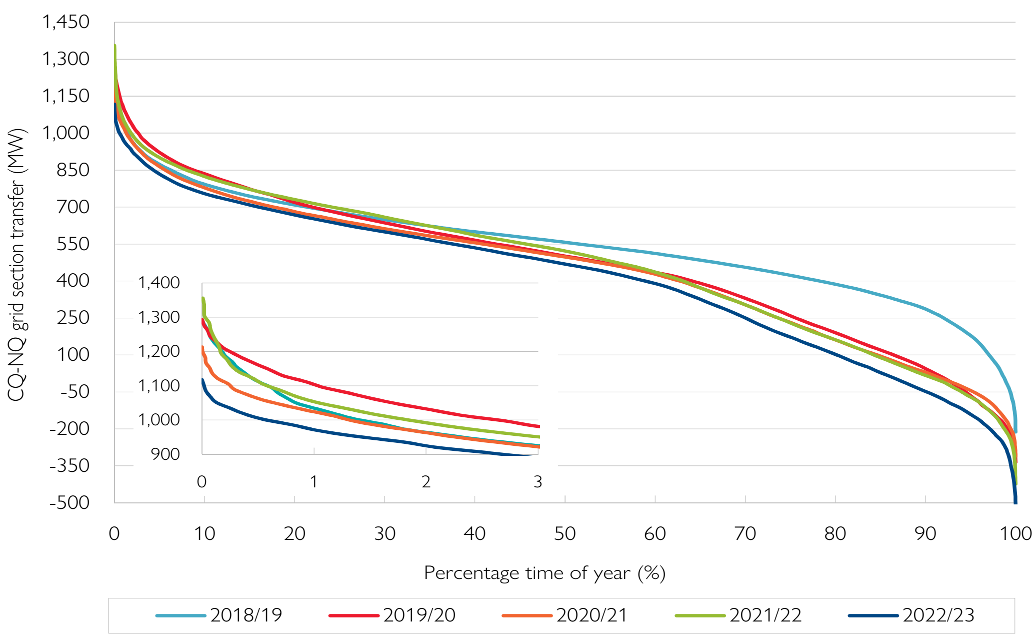
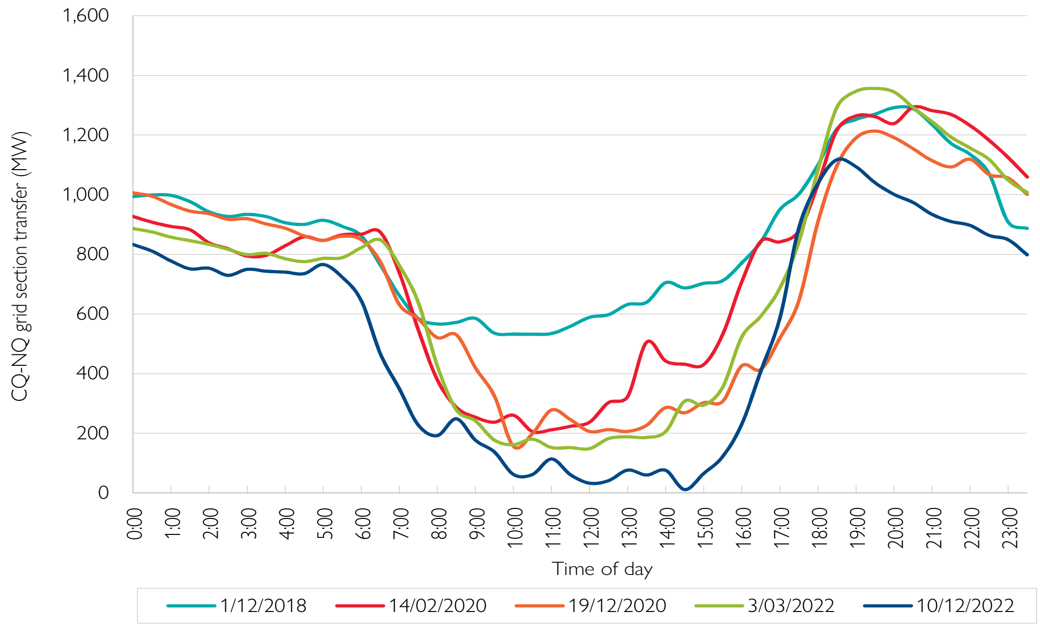


Figure 7.13 provides a different view of the altered power flows experienced over the last years for the day corresponding to the annual peak CQ-NQ transfer. This shows the impact of solar generation in creating minimum demands and network transfers during the middle of the day.

Figure 7.13 Historical CQ-NQ peak grid section transfer daily profile



These midday reductions in transfers are introducing operational challenges in voltage control. Midday transfers are forecast to continue reducing with integration of additional rooftop PV and large-scale VRE in NQ. Correspondingly, voltage control is forecast to become increasingly challenging for longer durations.

In February 2021, Powerlink completed the Project Assessment Conclusions Report (PACR)[3] recommending the establishment of a 150MVAr 300kV bus reactor at Broadsound, which is expected to be commissioned by October 2024.

7.6.3 North Queensland system strength

System strength is a measure of the ability of a power system to remain stable under normal conditions and to return to a steady state condition following a system disturbance. System strength can be considered low in areas with low levels of synchronous generation and deteriorates further with high penetration of inverter-based resources.

Powerlink has determined that the dominant limitation to VRE hosting capacity is the potential for multiple generators, and other transmission-connected dynamic plant, to interact in an unstable manner. These dynamic plant control interactions manifest as an unstable or undamped oscillation in the power system voltage. The frequency of the oscillation is dependent on the participating plants, but is broadly characterised as between 8Hz and 15Hz.

North Queensland (NQ) has been the focus of system strength limitations in Queensland due to the high number of VRE plants and relatively low synchronous fault levels. Electromagnetic Transient-type (EMT) analysis has been performed to determine the system conditions that could result in unstable operation of VRE plant. The limit equations in Table G.3 of Appendix G reflect the output of this analysis. The limit equations show that the following variables have a significant effect on NQ system strength:

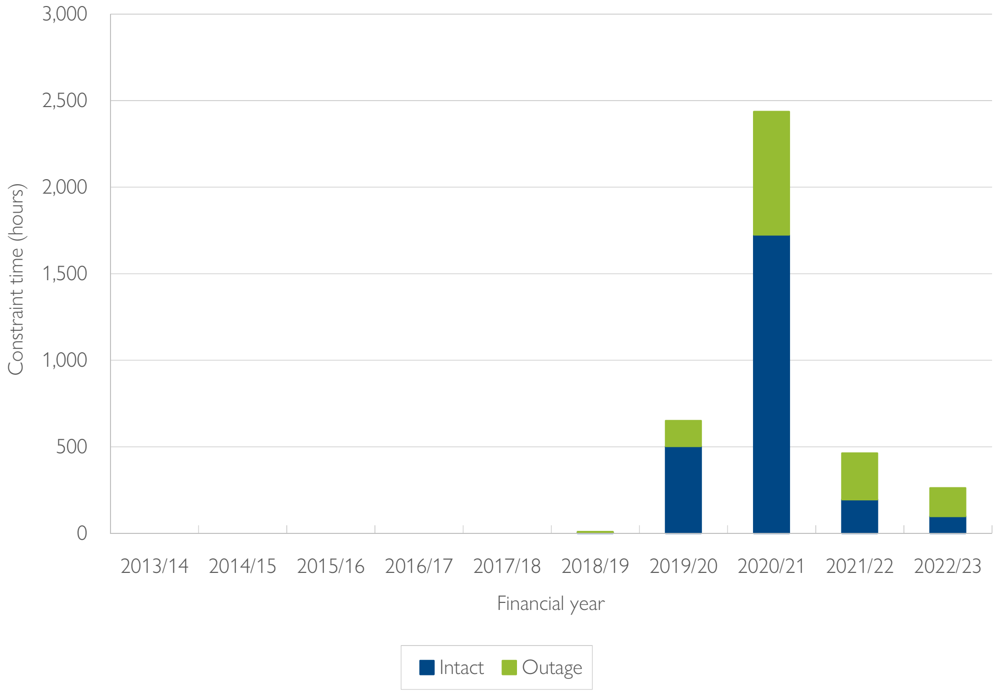
- number of synchronous units online in CQ and NQ
- NQ demand
- status of Haughton Synchronous Condenser.

[3] Powerlink, Project Assessment Conclusions Report - Managing voltage control in Central Queensland, February 2021.

The historical duration of constrained operation for inverter-based resources in NQ is summarised in Figure 7.14. During 2022/23, inverter-based resources in NQ experienced 262 hours of constrained operation, of which 98 hours occurred during intact system conditions.

In December 2021, AEMO declared a fault level shortfall at the Gin Gin node in the Wide Bay zone. Subsequently Powerlink initiated an Expression of interest (EOI) for services to address this fault level shortfall[4]. While the shortfall was declared in the Wide Bay zone, it may be best addressed by a solution elsewhere in the state. Progress on addressing this gap is discussed in Section 6.8.1.

Figure 7.14 Historical NQ system strength constraint times (1)



Note:

(1) AEMO's Infoserver (and therefore the 2021 TAPR) includes bound constraints applying to unavailable VRE (e.g. solar farms during the night). These constraint records are now removed from the calculation. Constraint times for 2020/21 have been revised.

7.6.4 Gladstone grid section

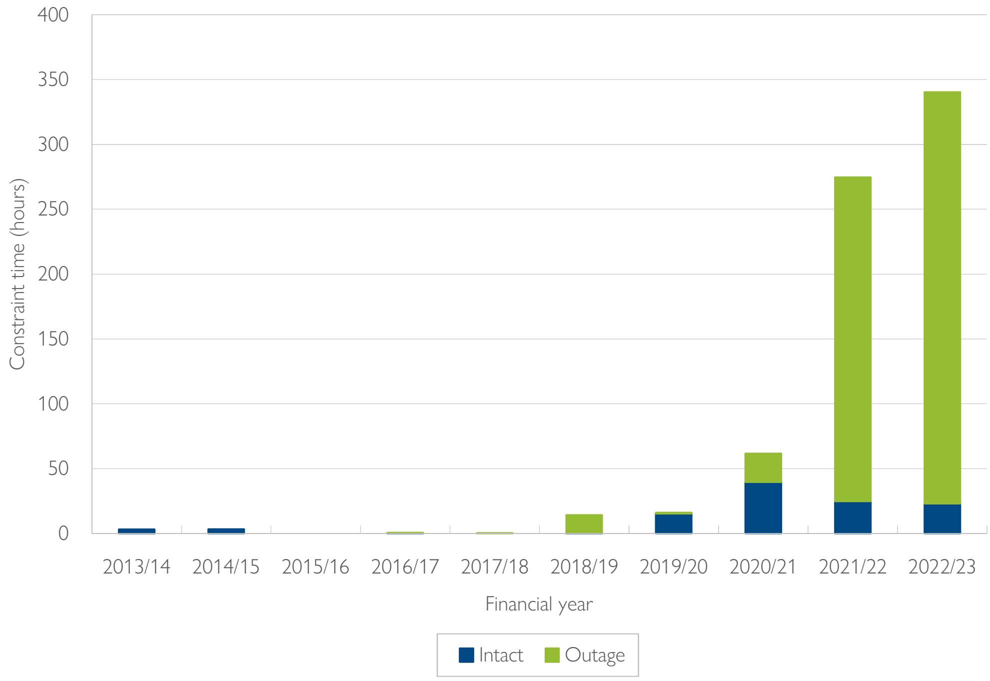
Maximum power transfer across the Gladstone grid section is set by the thermal rating of the Bouldercombe to Raglan, Larcom Creek to Calliope River, Calvale to Wurdong or the Calliope River to Wurdong 275kV circuits.

If the rating would otherwise be exceeded following a critical contingency, generation is constrained to reduce power transfers. Powerlink makes use of dynamic line ratings and rates the relevant circuits to take account of real time prevailing ambient weather conditions to maximise the available capacity of this grid section and, as a result, reduce market impacts. The appropriate ratings are updated in National Electricity Market Dispatch Engine (NEMDE).

The historical duration of constrained operation for the Gladstone grid section is summarised in Figure 7.15. During 2022/23, the Gladstone grid section experienced 340 hours of constrained operation, with 23 hours during intact system conditions due to lower generation in the Gladstone zone coupled with higher flows from central to southern Queensland. The majority of the constrained operation was due to outages associated with planned primary plant replacement work at Bouldercombe substation.

[4] Powerlink, Request for power system security services in central, southern and broader Queensland regions, May 2022.

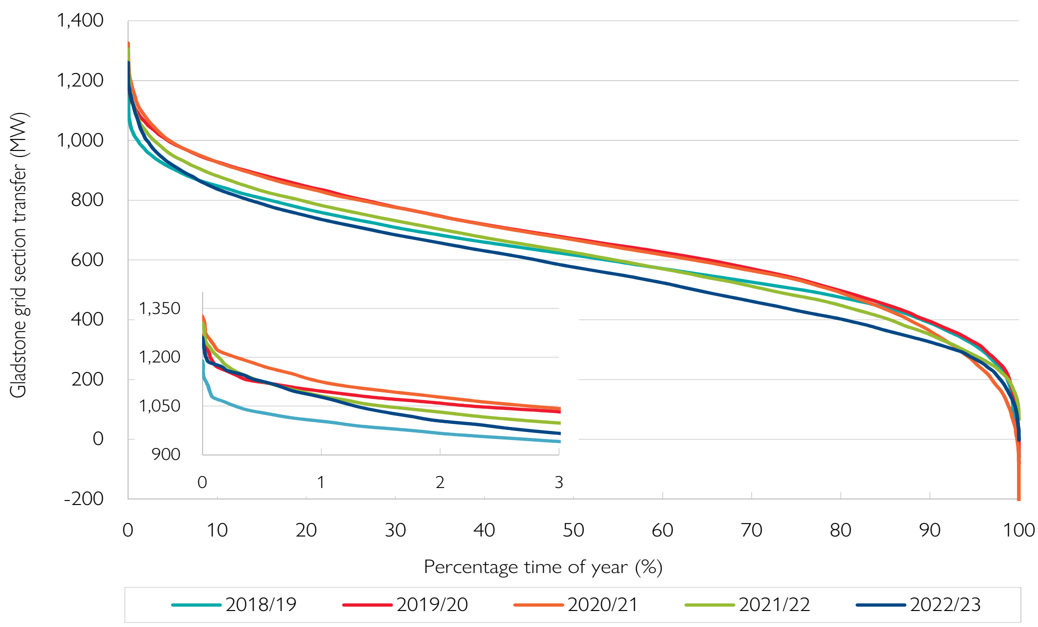
Figure 7.15 Historical Gladstone grid section constraint times



Power flows across this grid section are highly dependent on the balance of generation and demand in Gladstone and transfers to between CQ and SQ. Figure 7.16 provides historical transfer duration curves showing decreased utilisation in 2022/23 compared to 2021/22. Reduced demand in the Gladstone zone is responsible for this change (refer to figures 7.6, 7.7 and 7.8).

Section 8.2.3 discusses the strategy to increase the capacity of the Gladstone grid section should there be a significant shift in the generation and demand balance in the Gladstone zone.

Figure 7.16 Historical Gladstone grid section transfer duration curves



7.6.5 Central Queensland - southern Queensland grid section

Maximum power transfer across the CQ-SQ grid section is set by transient or voltage stability following a Calvale to Halys 275kV circuit contingency.

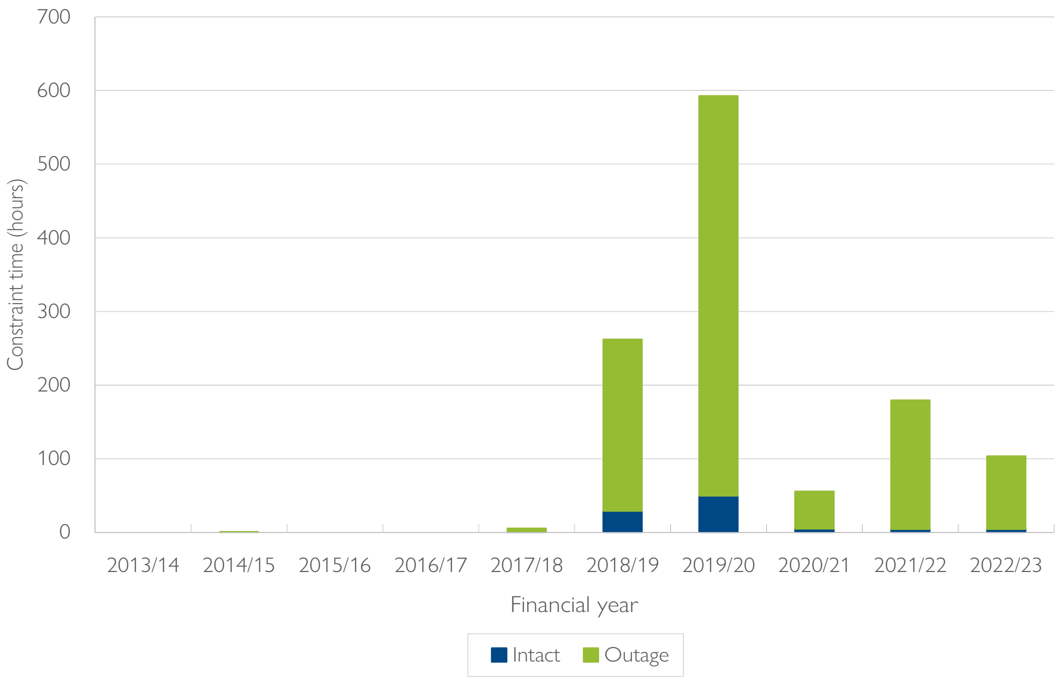
The voltage stability limit is set by insufficient reactive power reserves in the Central West and Gladstone zones following a contingency. More generating units online in these zones increase reactive power support and therefore transfer capability.

The limit equation in Table G.4 of Appendix G shows that the following variables have significant effect on transfer capability:

- number of generating units online in the Central West and Gladstone zones
- level of Gladstone PS generation.

The historical duration of constrained operation for the CQ-SQ grid section is summarised in Figure 7.17. During 2022/23, the CQ-SQ grid section experienced 103 hours of constrained operation. Constrained operation was due to outages associated with planned maintenance activities. Only five hours of constrained operation was during system normal conditions.

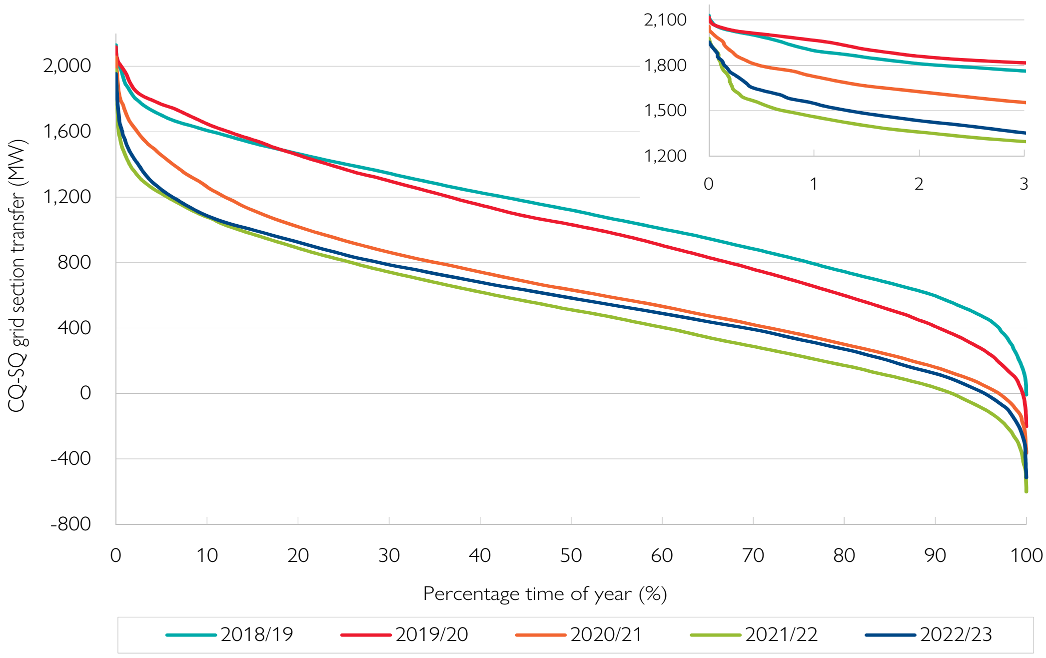
Figure 7.17 Historical CQ-SQ grid section constraint times



Associated with high penetration of rooftop PV installations in southeast Queensland, Powerlink is reviewing the transient stability limit for CQ-SQ. The review includes dynamic load models that include rooftop PV behaviour. Powerlink submitted a draft report to AEMO in March 2023.

Figure 7.18 provides historical transfer duration curves showing utilisation similar to that over the last two years. Over the 2022/23 year there was a decrease in output from generation in central Queensland but this was offset by an increase in output from generation in north Queensland (refer to figures 7.6, 7.7 and 7.8),

Figure 7.18 Historical CQ-SQ grid section transfer duration curves



The eastern single circuit transmission lines of CQ-SQ traverse a variety of environmental conditions that have different rates of corrosion resulting in varied risk levels across the transmission lines. Depending on transmission line location, it is expected that sections of lines will be at end of technical service life from the next five to 10 years.

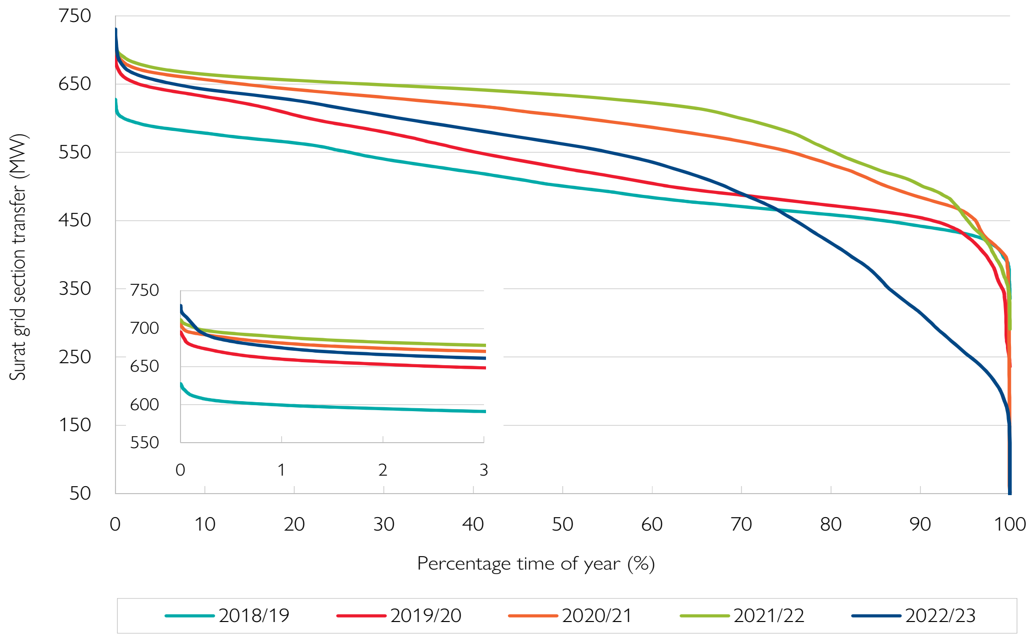
7.6.6 Surat grid section

The maximum power transfer across the Surat grid section is set by voltage stability associated with insufficient reactive power reserves in the Surat zone following an outage of a Western Downs to Orana 275kV circuit[5]. More generating units online in the zone increases reactive power support and therefore transfer capability. Local generation reduces transfer capability but allows more demand to be securely supported in the Surat zone. There have been no constraints recorded over the history of the Surat grid section.

Figure 7.19 provides the transfer duration curves for the last five years. Energy transfers have reduced in the last year due to Blue Grass, Columboola, Gangarri and Edenvale Solar Farms and Dulacca Wind Farm all coming online and at various stages of commissioning.

[5] The Orana Substation is connected to one of the Western Downs to Columboola 275kV transmission lines (refer to Figure 7.4).

Figure 7.19 Historical Surat grid section transfer duration curve



In April 2023 the Tarong to Chinchilla 132kV feeders were removed from service to make way for the development of the Western Downs REZ with Wambo Wind Farm as the foundation project.

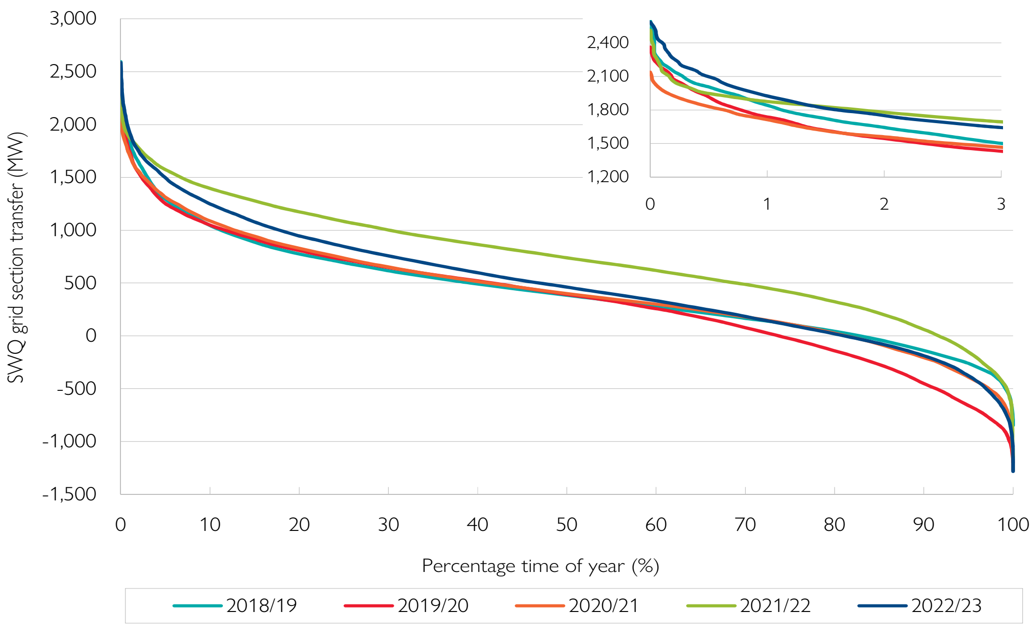
7.6.7 South West Queensland grid section

The South West Queensland (SWQ) grid section defines the capability of the transmission network to transfer power from generating stations located in the Bulli zone and northerly flow on QNI to the rest of Queensland. The thermal rating of the Middle Ridge 330/275kV transformer sets maximum power transfer across the SWQ grid section.

The SWQ grid section did not constrain operation at any time during the last 10 years.

Figure 7.20 provides historical transfer duration curves showing a decrease in energy transfer between 2021/22 and 2022/23. After experiencing higher than normal flows on the SWQ grid section last year, the flows have returned to levels observed in the previous years due to higher CQ-SQ flows and more generation in the Moreton region (refer to figures 7.6, 7.7 and 7.8).

Figure 7.20 Historical SWQ grid section transfer duration curves



AEMO's 2022 Integrated System Plan[6] (ISP) identified stage 1 of the Darling Downs REZ Expansion as a future actionable ISP project. This project involves an upgrade to the transformer capacity at Middle Ridge Substation. Powerlink provided a preparatory activities report for this project to AEMO on 30 June 2023.

7.6.8 Tarong grid section

Maximum power transfer across the Tarong grid section is set by voltage stability associated with the loss of a Calvale to Halys 275kV circuit. The limitation arises from insufficient reactive power reserves in southern Queensland.

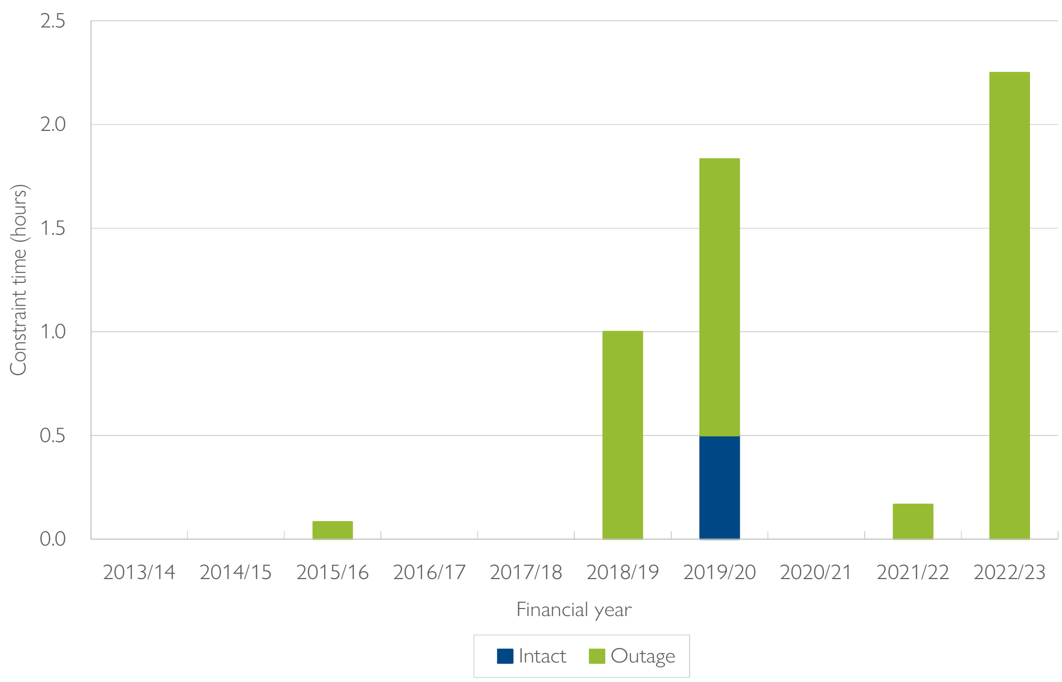
Limit equations in Table G.5 of Appendix G show that the following variables have a significant effect on transfer capability:

- QNI transfer and South West and Bulli zones generation
- level of Moreton zone generation
- Moreton and Gold Coast zones capacitive compensation levels.

Any increase in generation west of this grid section, with a corresponding reduction in generation north of the grid section, reduces the CQ-SQ power flow and increases the Tarong limit. Increasing generation east of the grid section reduces the transfer capability, but increases the overall amount of supportable South East Queensland (SEQ) demand. This is because reactive margins increase with additional local generation, allowing further load to be delivered before reaching minimum allowable reactive margins. However, due to its distributed and reactive nature, increases in delivered demand erode reactive margins at greater rates than they were created by the additional local generation. Limiting power transfers are thereby lower with the increased local generation but a greater load can be delivered.

The Tarong grid section was constrained for two hours in 2022/23. This occurred during planned maintenance work. The historical duration of constrained operation for the Tarong grid section is summarised in Figure 7.21. Constraint times have been minimal over the last 10 years.

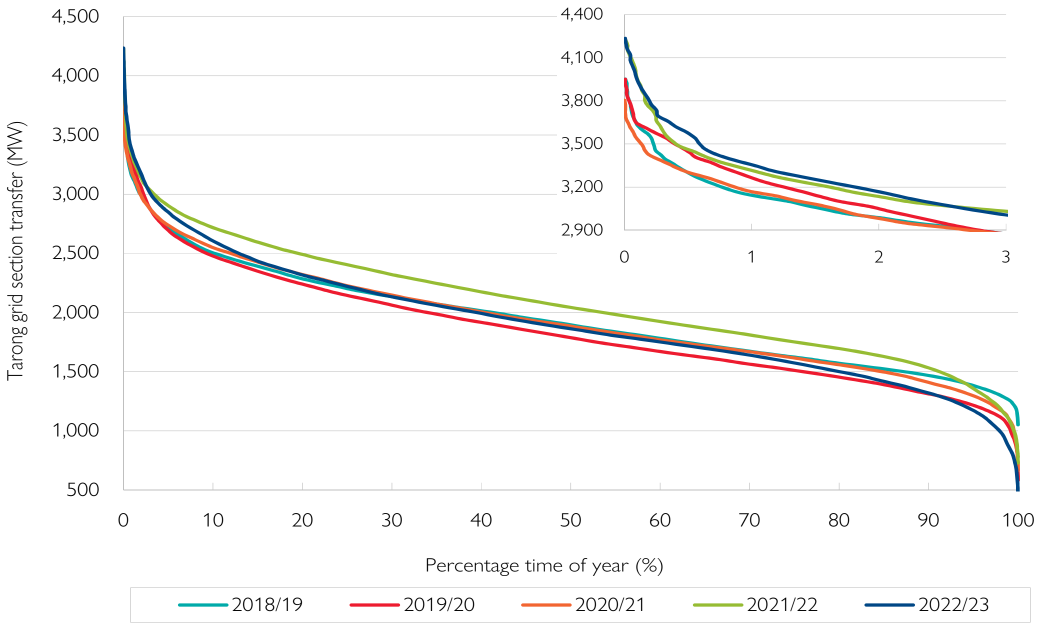
Figure 7.21 Historical Tarong grid section constraint times



6 AEMO, 2022 Integrated System Plan (ISP), June 2022.

Figure 7.22 provides historical transfer duration curves showing a decrease in flows between 2021/22 and 2022/23. After experiencing higher than normal flows on the SWQ grid section last year, predominantly due to an unplanned outage of the Swanbank E generator between December 2021 and September 2022, the transfers have returned to levels observed in the previous years (refer to figures 7.6, 7.7 and 7.8).

Figure 7.22 Historical Tarong grid section transfer duration curves



7.6.9 Gold Coast grid section

Maximum power transfer across the Gold Coast grid section is set by voltage stability associated with the loss of a Greenbank to Molendinar 275kV circuit, or Greenbank to Mudgeeraba 275kV circuit.

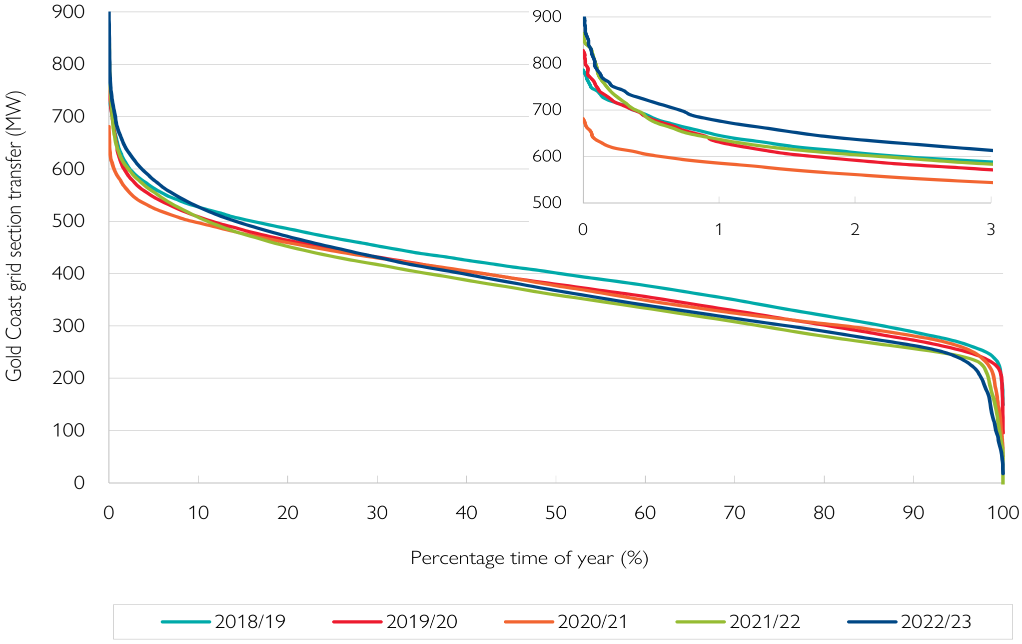
The limit equation in Table G.6 of Appendix G shows that the following variables have a significant effect on transfer capability:

- number of generating units online in Moreton zone
- level of Terranora Interconnector transmission line transfer
- Moreton and Gold Coast zones capacitive compensation levels
- Moreton zone to the Gold Coast zone demand ratio.

Reducing southerly flow on Terranora Interconnector reduces transfer capability, but increases the overall amount of supportable Gold Coast demand. This is because reactive margins increase with reductions in southerly Terranora Interconnector flow, allowing further load to be delivered before reaching minimum allowable reactive margins. However, due to its distributed and reactive nature, increases in delivered demand erode reactive margins at greater rates than they were created by the reduction in Terranora Interconnector southerly transfer. Limiting power transfers are thereby lower with reduced Terranora Interconnector southerly transfer but a greater load can be delivered. There have been no constraints on the Gold Coast grid section over the last 10 years.

Figure 7.23 provides historical transfer duration curves showing changes in grid section transfer demands and energy in line with changes in transfer to northern NSW and changes in Gold Coast loads (refer to figures 7.6, 7.7 and 7.8).

Figure 7.23 Historical Gold Coast grid section transfer duration curves



7.6.10 QNI and Terranora interconnector

The transfer capability across QNI is limited by voltage stability, transient stability, oscillatory stability, and line thermal rating considerations. The capability across QNI at any particular time is dependent on a number of factors, including demand levels, generation dispatch, status and availability of transmission equipment, and operating conditions of the network.

AEMO publish Monthly Constraint Reports which includes a section examining each of the NEM interconnectors, including QNI and Terranora Interconnector. Information pertaining to the historical duration of constrained operation for QNI and Terranora Interconnector is contained in these Monthly Constraint Reports. The Monthly Constraint Report can be found on AEMO's website.

For intact system operation, the southerly transfer capability of QNI is most likely to be set by the following:

- voltage stability associated with a fault on the Sapphire to Armidale 330kV transmission line in NSW
- thermal capacity of the 330kV transmission network between Dumaresq and Liddell in NSW.

For intact system operation, the combined northerly transfer capability of QNI and Terranora Interconnector is most likely to be set by the following:

- transient and voltage stability associated with transmission line faults in NSW
- transient and voltage stability associated with loss of the largest generating unit in Queensland
- thermal capacity of the 330kV and 132kV transmission network within northern NSW.

The QNI Minor project is complete and inter-network testing activities, as required by NER 5.7.7, are progressing.

Associated with high penetration of rooftop PV installations, Powerlink is reviewing the transient stability limit for QNI southerly transfer. The review includes dynamic load models that include rooftop PV behaviour. Powerlink submitted a draft report to AEMO in March 2023.

AEMO's 2022 Integrated System Plan[7] (ISP) considered the QNI Connect project that would increase transfer capacity between Queensland and New South Wales. The ISP identified that QNI Connect may be required as early as 2029/30 (based on the Hydrogen Superpower scenario). Powerlink provided a preparatory activities report for this project to AEMO on 30 June 2023.

7.7 Zone performance

This section presents, where applicable, a summary of:

- the capability of the transmission network to deliver loads
- historical zonal transmission delivered loads
- intra-zonal system normal constraints
- double circuit transmission lines categorised as vulnerable by AEMO[8]
- Powerlink's management of high voltages associated with light load conditions.

Double circuit transmission lines that experience a lightning trip of all phases of both circuits (where its magnitude or degree is not considered an Exceptional Event[9]) are categorised by AEMO as vulnerable. A double circuit transmission line in the vulnerable list is eligible to be reclassified as a credible contingency event during a lightning storm if a cloud to ground lightning strike is detected close to the line. A double circuit transmission line will remain on the vulnerable list until it is demonstrated that the asset characteristics have been improved to make the likelihood of a double circuit lightning trip no longer reasonably likely to occur or until the Lightning Trip Time Window (LTTW) expires from the last double circuit lightning trip. The LTTW is three years for a single double circuit trip event or five years where multiple double circuit trip events have occurred during the LTTW.

Statewide delivered energy has decreased slightly from 2021/22 to 2022/23. Most zones experienced a reduction in total delivered energy as well as the majority of zones setting new record minimum demands (refer to Figure 7.8). The Queensland region's installed rooftop PV capacity continues to increase. As at 30 June 2023 there was 5,583MW of rooftop PV generating capacity in the state[10]. This is an increase of approximately 830MW over the year. The following sections show load duration curves for each zone. See Figure 3.16 for annual transmission delivered demand load duration curves for the Queensland region as a whole.

7.7.1 Far North zone

The Far North zone experienced no load loss for a single network element outage during 2022/23.

The Far North zone includes the non-scheduled embedded generator Lakeland Solar and Storage as defined in Figure 3.9. This embedded generator provided 19GWh during 2022/23.

Figure 7.24 provides historical transmission delivered load duration curves for the Far North zone. There was no material change in energy delivered from the transmission network between 2021/22 and 2022/23. The maximum transmission delivered demand in the zone was 347MW, which is below the highest maximum demand over the last five years of 381MW set in 2018/19. The minimum transmission delivered demand in the zone was 40MW, which is the lowest minimum demand on record.

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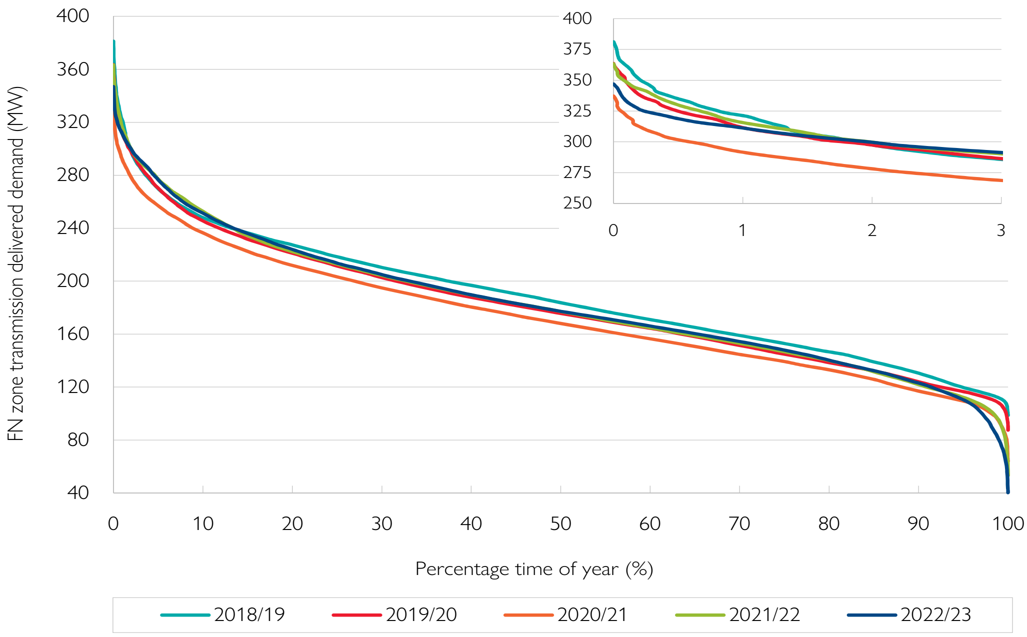
7 AEMO, 2022 Integrated System Plan, June 2022.
8 AEMO, List of Vulnerable Lines, effective May 2023.
9 An Exception Event is defined in AEMO's Power System Security Guidelines (SO_OP_3715) as a simultaneous trip of a double circuit transmission line during a lightning storm caused by an event that is far beyond what is usual in magnitude or degree for what could be reasonably expected to occur during a lightning storm.
10 Clean Energy Regulator, Postcode data for small-scale installations – all data, data as at 31/07/2023, August 2023.

Figure 7.24 Historical Far North zone transmission delivered load duration curves



As a result of double circuit outages associated with lightning strikes, AEMO includes the Chalumbin to Turkinje 132kV double circuit transmission line in the vulnerable list. This double circuit tripped due to lightning in November 2022.

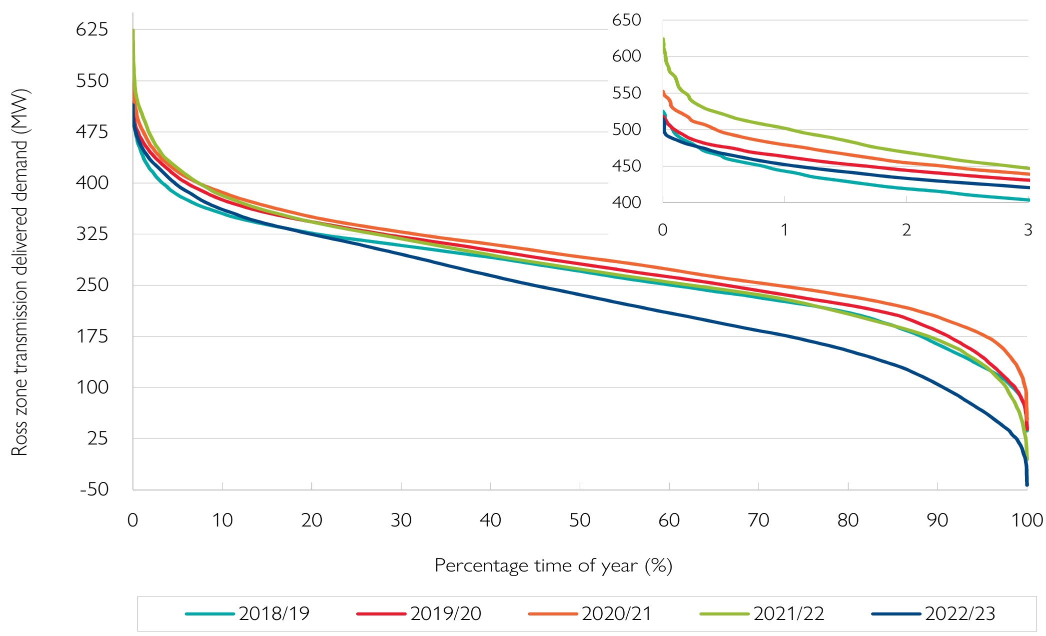
7.7.2 Ross zone

The Ross zone experienced one load loss for a single network element outage during 2022/23. The duration of the outage was approximately 15 hours and approximately 24MWh of energy was lost. The loads impacted by this outage are supplied by a single radial connection under normal system conditions.

The Ross zone includes the scheduled embedded Townsville PS 66kV component (steam turbine component of the CCGT), semi-scheduled distribution connected embedded Kidston Solar Farm, Kennedy Energy Park and direct connected embedded Sun Metals Solar Farm, and the significant non-scheduled embedded generators Hughenden Solar Farm and Pioneer Mill as defined in Figure 3.9. These embedded generators provided 640GWh during 2022/23.

Figure 7.25 provides historical transmission delivered load duration curves for the Ross zone. Energy delivered from the transmission network has reduced by 14.2% between 2021/22 and 2022/23 to the lowest level in the last decade. The reduction in energy delivered is due to the increases in energy from the embedded generators Sun Metals Solar Farm and Kennedy Energy Park Wind Farm accompanied by a reduction in native demand. The peak transmission delivered demand in the zone was 515MW, which is below the highest maximum demand over the last five years of 624MW set in 2021/22. The minimum transmission delivered demand in the zone was -43MW, which is the lowest demand on record.

Figure 7.25 Historical Ross zone transmission delivered load duration curves



High voltages associated with light load conditions are managed with existing reactive sources.

As a result of double circuit outages associated with lightning strikes, AEMO includes the Ross to Chalumbin 275kV double circuit transmission line in the vulnerable list. This double circuit tripped due to lightning in January 2020 and again in November 2022.

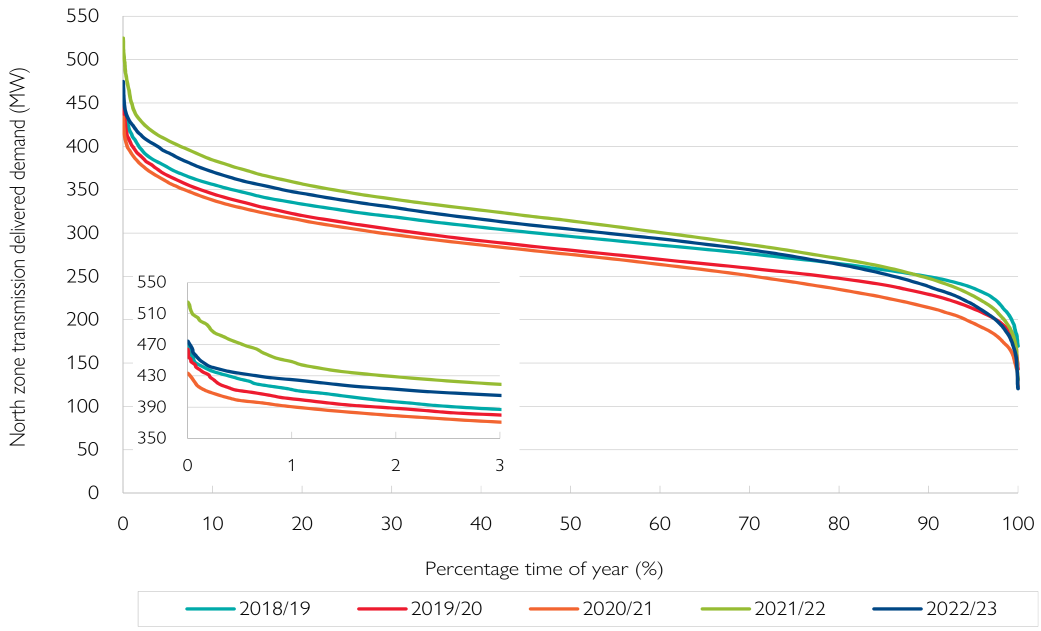
7.7.3 North zone

The North zone experienced one load loss for a single network element outage during 2022/23. The duration of the outage was less than one hour and approximately 6MWh of energy was lost. The loads impacted by this outage are supplied by a single radial connection under normal system conditions.

The North zone includes semi-scheduled embedded generator Collinsville Solar Farm and significant non-scheduled embedded generators Moranbah North, Moranbah and Racecourse Mill as defined in Figure 3.9. These embedded generators provided 561GWh during 2022/23.

Figure 7.26 provides historical transmission delivered load duration curves for the North zone. Energy delivered from the transmission network has decreased by 3.2% between 2021/22 and 2022/23. The peak transmission delivered demand in the zone was 475MW, below the highest maximum demand over the last five years of 525MW set in 2021/22. The minimum transmission delivered demand in the zone was 120MW, which is the lowest minimum demand in the last five years.

Figure 7.26 Historical North zone transmission delivered load duration curves



High voltages associated with light load conditions are currently managed with existing reactive sources. However, midday power transfer levels continue to reduce as additional rooftop PV is installed in NQ. As a result, voltage control is forecast to become increasingly challenging for longer durations. This is discussed in Section 7.6.2.

As a result of double circuit outages associated with lightning strikes, AEMO includes the following double circuits in the North zone in the vulnerable list:

- Collinsville North to Proserpine 132kV double circuit transmission line, last tripped February 2023
- Collinsville North to Stoney Creek and Collinsville North to Newlands lines, last tipped November 2022.

The following double circuit has, this year, been removed from the vulnerable list:

- Strathmore to Clare South and Strathmore to Clare South tee King Creek 132kV double circuit transmission line, last tripped January 2019.

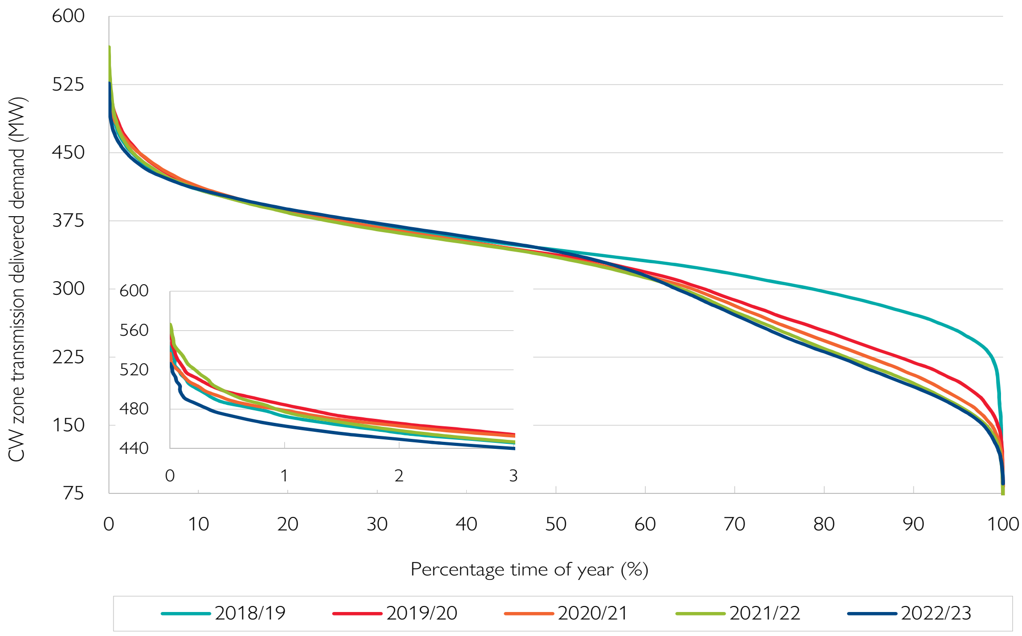
7.7.4 Central West zone

The Central West zone experienced one load loss for a single network element outage during 2022/23. The duration of the outage was less than one hour and approximately 1MWh of energy was lost. The loads impacted by this outage are supplied by a single radial connection under normal system conditions.

The Central West zone includes the scheduled embedded Barcaldine generator, semi-scheduled embedded generators Clermont Solar Farm, Emerald Solar Farm and Middlemount Solar Farm and significant non-scheduled embedded generators Barcaldine Solar Farm, Longreach Solar Farm, German Creek and Oaky Creek as defined in Figure 3.9. These embedded generators provided 632GWh during 2022/23.

Figure 7.27 provides historical transmission delivered load duration curves for the Central West zone. Energy delivered from the transmission network has increased by 0.2% between 2021/22 and 2022/23, close to the historical minimum reached last year. The peak transmission delivered demand in the zone was 526MW, below the highest maximum demand over the last five years of 566MW set in 2021/22. The minimum transmission delivered demand in the zone was 86MW, which is higher than the lowest minimum demand over the last decade, which was 64MW recorded in 2020/21.

Figure 7.27 Historical Central West zone transmission delivered load duration curves



EDL has advised AEMO of its intention to retire Oaky Creek non-scheduled embedded generators in 2025.

There are currently no double circuits in the Central West zone in AEMO's lightning vulnerable transmission line list.

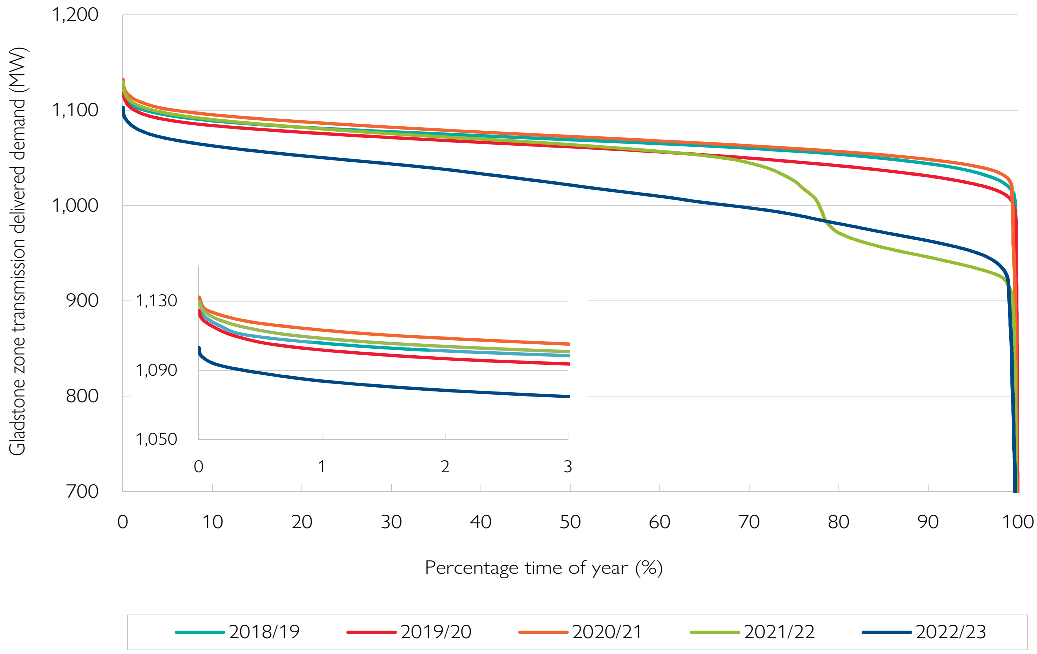
7.7.5 Gladstone zone

The Gladstone zone experienced no load loss for a single network element outage during 2022/23.

The Gladstone zone contains no scheduled, semi-scheduled or significant non-scheduled embedded generators as defined in Figure 3.9.

Figure 7.28 provides historical transmission delivered load duration curves for the Gladstone zone. Energy delivered from the transmission network has reduced by 2.5% between 2021/22 and 2022/23 to the lowest level in the last decade. This decrease was due to reduced demand from Boyne Smelters Limited (BSL). The peak transmission delivered demand in the zone was 1,103MW, which is lower than the highest maximum demand over the last five years of 1,132MW set in 2020/21. Minimum demand coincides with small periods when one or more of potlines at Boyne Smelters Limited (BSL) are out of service. The minimum transmission delivered demand in the zone was 616MW.

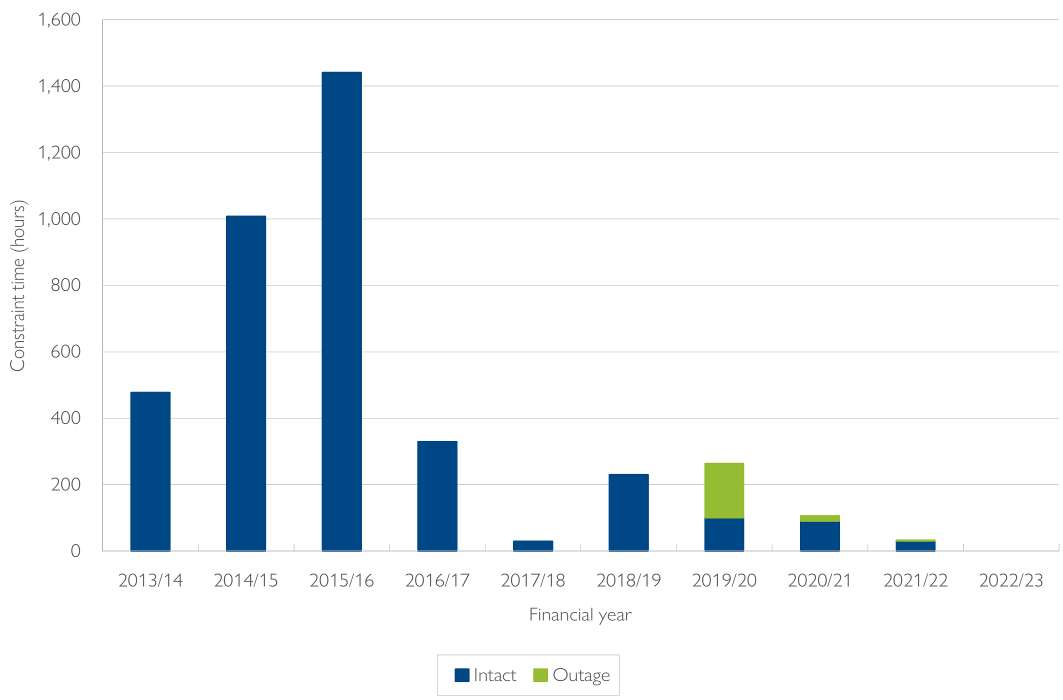
Figure 7.28 Historical Gladstone zone transmission delivered load duration curves



Constraints occur within the Gladstone zone under intact network conditions. These constraints are associated with maintaining power flows within the continuous current rating of a 132kV feeder bushing within BSL's substation. The constraint limits generation from Gladstone PS, mainly from the units connected at 132kV. AEMO identifies the system normal constraint by constraint identifier Q>NIL_BI_FB. This constraint was implemented in AEMO's market system from September 2011.

Information pertaining to the historical duration of constrained operation due to this constraint is summarised in Figure 7.29. This constraint did not constrain operation at any time during 2022/23.

Figure 7.29 Historical Boyne Island feeder bushing constraint times



There are currently no double circuits in the Gladstone zone in AEMO's lightning vulnerable transmission line list.

7.7.6 Wide Bay zone

The Wide Bay zone experienced no load loss for a single network element outage during 2022/23.

The Wide Bay zone includes the semi-scheduled embedded generators Childers Solar Farm and Susan River Solar Farm, and significant non-scheduled embedded generator Isis Central Sugar Mill as defined in Figure 3.9. These embedded generators provided 251GWh during 2022/23.

Figure 7.30 provides historical transmission delivered load duration curves for the Wide Bay zone. Wide Bay zone is one of three zones in Queensland where the delivered demand reaches negative values, meaning that the embedded generation exceeds the native load, the transmission network supplying the zone is often operated at zero and near zero loading, and the embedded generation makes use of the transmission network to supply loads in other zones. Figure 7.31 provides the daily load profile for the minimum transmission delivered days over the last five years. This Figure shows that periods of negative demand correlate with solar generation and the trend is continuing.

While energy has seen significant reductions, the peak demand, which occurs at night, remains at similar levels. Energy delivered from the transmission network reduced by 0.7% between 2021/22 and 2022/23 to the lowest level in the last decade. The peak transmission delivered demand in the zone was 325MW, which is highest maximum demand in the last decade. The minimum transmission delivered demand in the zone was -131MW, which is the lowest demand on record.

Figure 7.30 Historical Wide Bay zone transmission delivered load duration curves

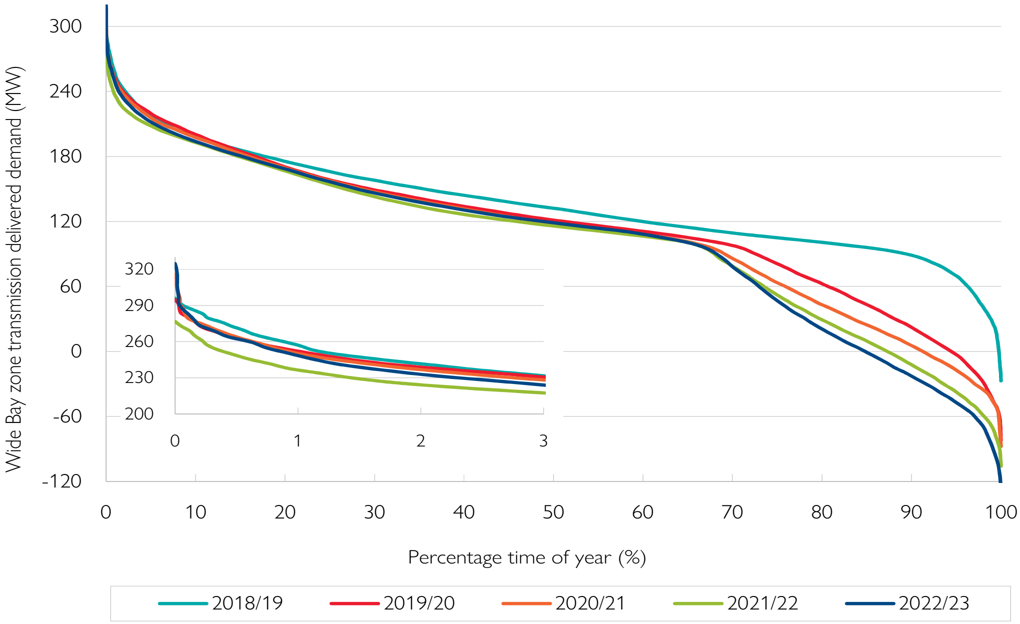
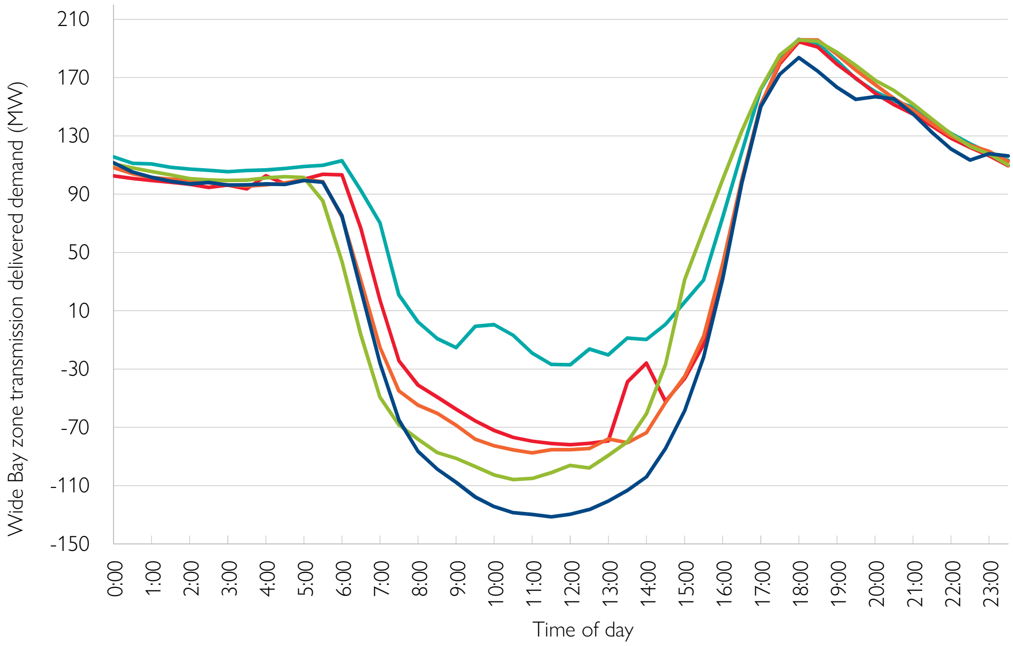


Figure 7.31 Historical Wide Bay zone minimum transmission delivered daily profile



There are currently no double circuits in the Wide Bay zone in AEMO's lightning vulnerable transmission line list.

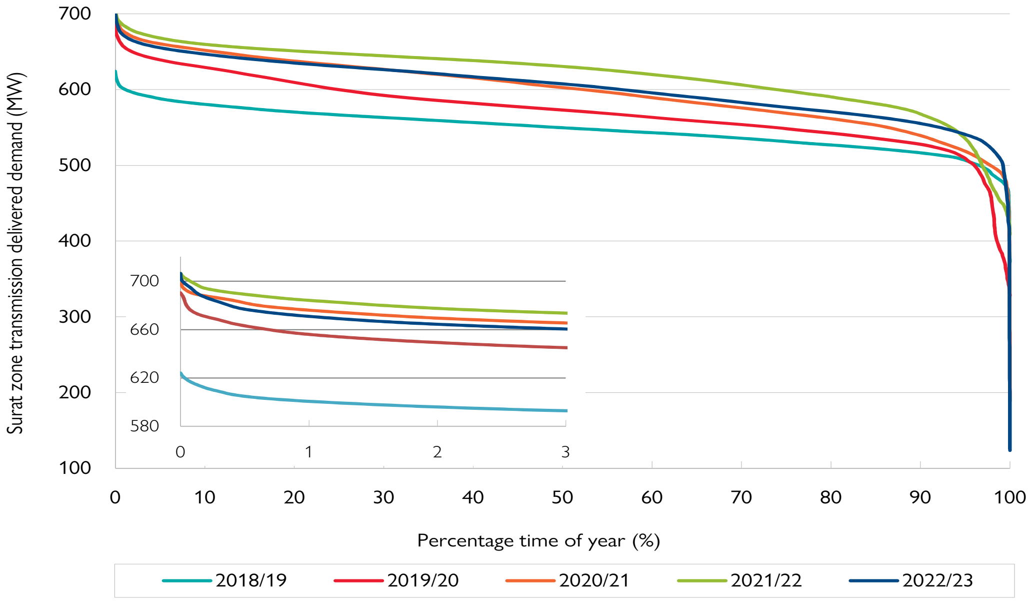
7.7.7 Surat zone

The Surat zone experienced no load loss for a single network element outage during 2022/23.

The Surat zone includes the scheduled embedded Roma and direct connected embedded Condamine generators, semi-scheduled Dulacca Wind Farm and significant non-scheduled embedded generator Baking Board Solar Farm as defined in Figure 3.9. These embedded generators supplied 167GWh during 2022/23.

Figure 7.32 provides historical transmission delivered load duration curves for the Surat zone. Energy delivered from the transmission network has decreased by 2.6% between 2021/22 and 2022/23. The peak transmission delivered demand in the zone was 706MW, which is just under the highest maximum demand of 707MW over the last five years set in 2021/22. The minimum transmission delivered demand in the zone was 124MW. This minimum demand coincides with a network loss of supply incident on 13 February 2023 that was the result of a multiple network element outage caused by a bushfire.

Figure 7.32 Historical Surat zone transmission delivered load duration curves



There are currently no double circuits in the Surat zone in AEMO's lightning vulnerable transmission line list.

The following double circuits have, this year, been removed from the vulnerable list:

- Tarong to Chinchilla 132kV double circuit transmission line, now removed from service
- Condabri North to Condabri Central 132kV double circuit transmission line, last tripped January 2020.

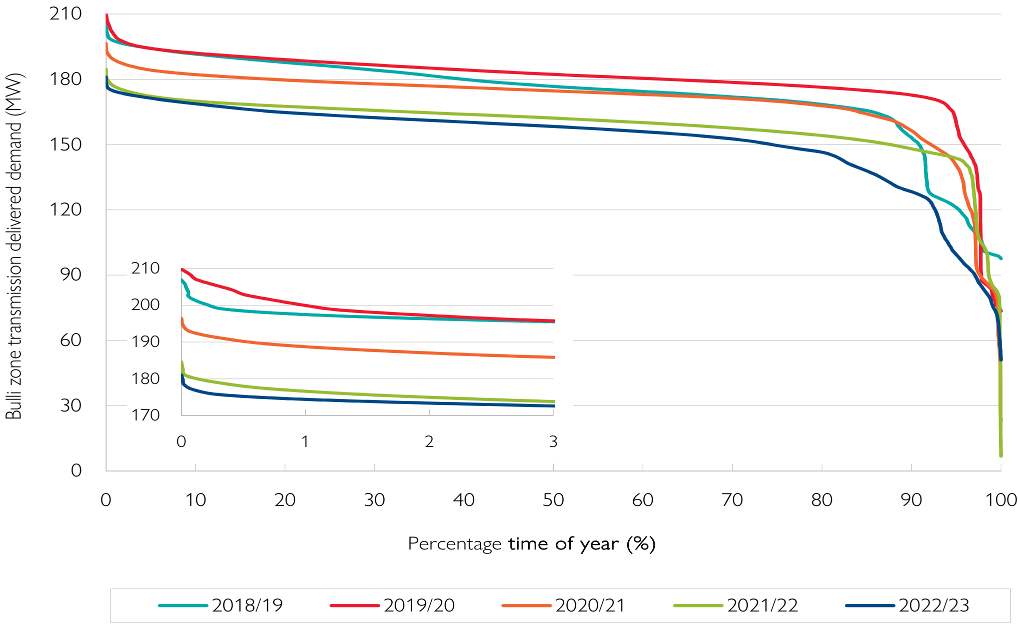
7.7.8 Bulli zone

The Bulli zone experienced no load loss for a single network element outage during 2022/23.

The Bulli zone contains no scheduled, semi-scheduled or significant non-scheduled embedded generators as defined in Figure 3.9.

Figure 7.33 provides historical transmission delivered load duration curves for the Bulli zone. Energy delivered from the transmission network has reduced by 4.4% between 2021/22 and 2022/23. The peak transmission delivered demand in the zone was 181MW which is below the highest maximum demand over the last five years of 210MW set in 2019/20. The minimum transmission delivered demand in the zone was 51MW.

Figure 7.33 Historical Bulli zone transmission delivered load duration curves



There are currently no double circuits in the Bulli zone in AEMO's lightning vulnerable transmission line list.

7.7.9 South West zone

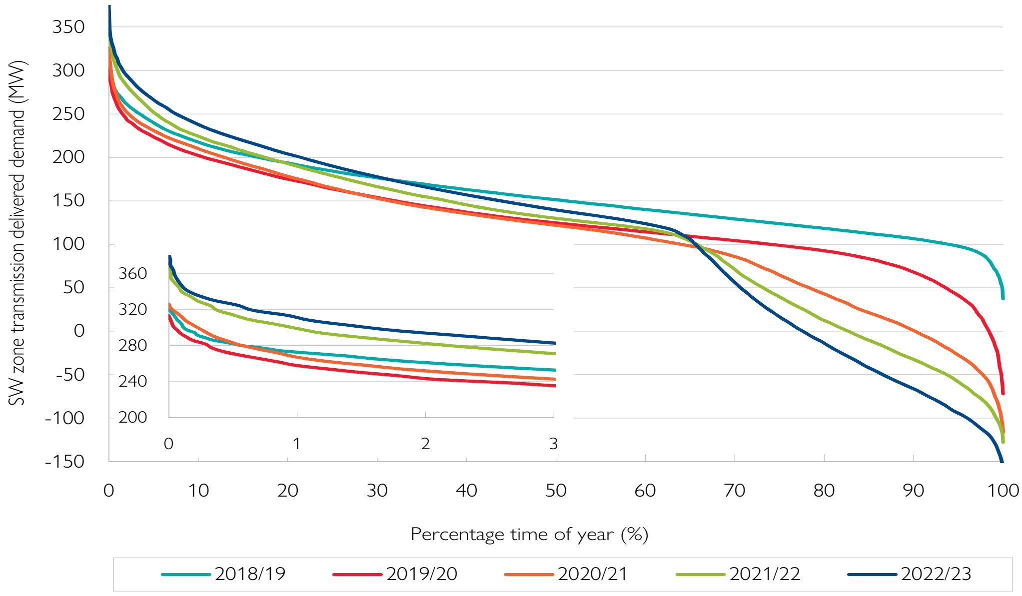
The South West zone experienced no load loss for a single network element outage during 2022/23.

The South West zone includes the semi-scheduled embedded generators Oakey 1 Solar Farm, Oakey 2 Solar Farm, Yarranlea Solar Farm, Maryrorough Solar Farm and Warwick Solar Farm as defined in Figure 3.9. These embedded generators provided 519GWh during 2022/23.

Figure 7.34 provides historical transmission delivered load duration curves for the South West zone. The South West zone is one of three zones in Queensland where the delivered demand reaches negative values, meaning that the embedded generation exceeds the native load, the transmission network supplying the zone is often operated at zero and near zero loading, and the embedded generation makes use of the transmission network to supply loads in other zones.

Energy delivered from the transmission network has reduced by 2.0% between 2021/22 and 2022/23, to the lowest level in the last decade. The peak transmission delivered demand in the zone was 381MW, which is the highest demand on record. The minimum transmission delivered demand in the zone was -170MW, which is the lowest demand on record.

Figure 7.34 Historical South West zone transmission delivered load duration curves



There are currently no double circuits in the South West zone in AEMO's lightning vulnerable transmission line list.

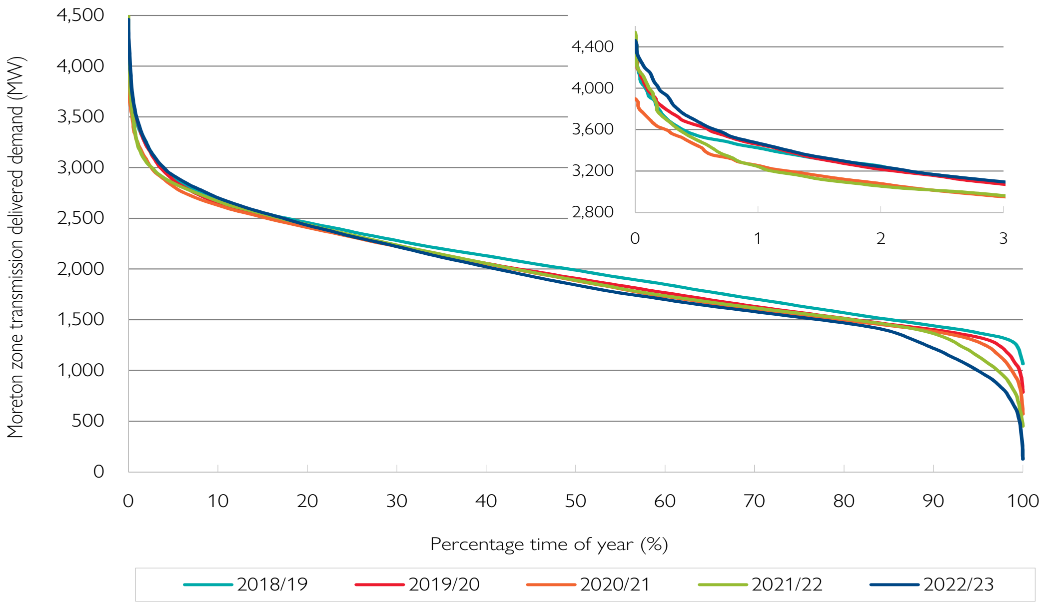
7.7.10 Moreton zone

The Moreton zone experienced no load loss for a single network element outage during 2022/23.

The Moreton zone includes the significant non-scheduled embedded generators Sunshine Coast Solar Farm, Bromelton and Rocky Point as defined in Figure 3.9. These embedded generators provided 43GWh during 2022/23.

Figure 7.35 provides historical transmission delivered load duration curves for the Moreton zone. Energy delivered from the transmission network has decreased by 1.6% between 2021/22 and 2022/23 to the lowest level in the last decade. The peak transmission delivered demand in the zone was 4,460MW, which is lower than the highest maximum demand over the past five years of 4,539MW set in 2021/22. The minimum transmission delivered demand in the zone was 126MW, which is the lowest demand on record.

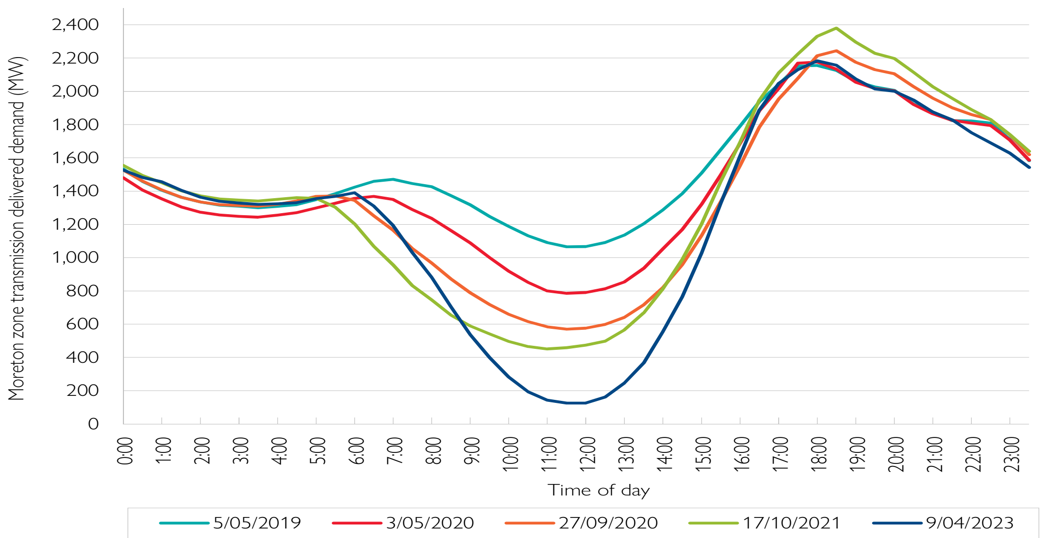
Figure 7.35 Historical Moreton zone transmission delivered load duration curves



High voltages associated with these light load conditions are currently managed with existing reactive sources. However, voltage control within Powerlink's and Energex's network is forecast to become increasingly challenging for longer durations. In 2021, AEMO identified an NSCAS gap of up to 250 MVAr of reactive power absorption in the southern Queensland. Due to this gap, Powerlink initiated an EOI to identify network and non-network options to address this gap. Powerlink has now entered into a Network Support Agreement with CleanCo Queensland to address the immediate gap. In late 2024 a bus reactor will be installed at Belmont Substation to address the long-term requirements. More detail on this process is provided in Section 6.8.1.

Figure 7.36 provides the daily load profile for the minimum transmission delivered days for the Moreton zone over the last five years. This Figure highlights the steady decrease in minimum demands but also shows the minimum demands days are shifting to shoulder periods, as the impact of greater rooftop PV yield outweighs the impact of higher native loads in the warmer weather. This is a trend observed across several zones with high levels of rooftop PV generation. The figure also highlights the increasing gap between minimum and maximum demand on these days.

Figure 7.36 Historical Moreton zone minimum transmission delivered daily profile



There are currently no double circuits in the Moreton zone in AEMO's lightning vulnerable transmission line list.

7.7.11 Gold Coast zone

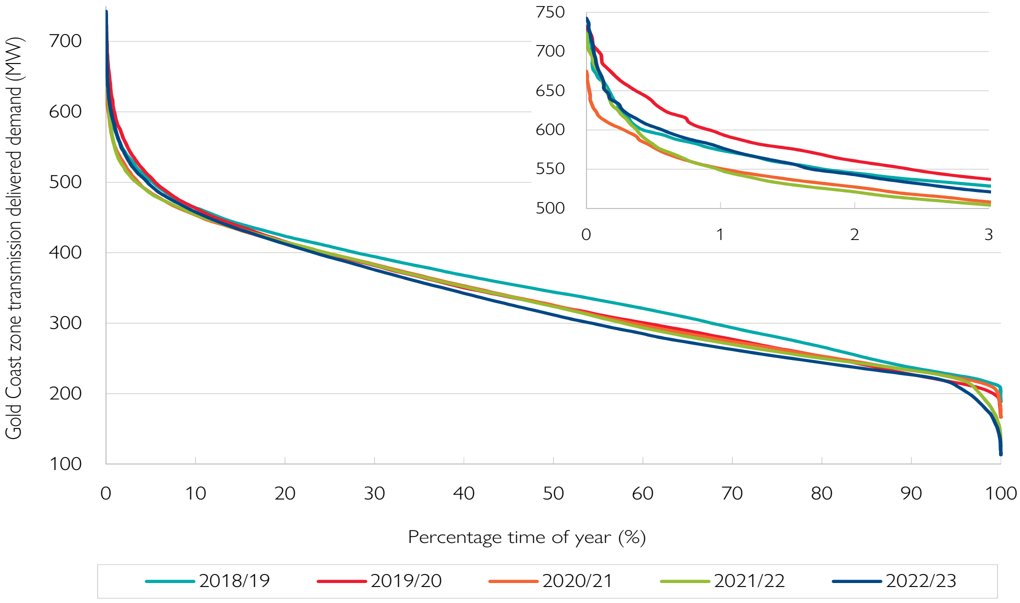
The Gold Coast zone experienced no load loss for a single network element outage during 2022/23.

The Gold Coast zone contains no scheduled, semi-scheduled or significant non-scheduled embedded generators as defined in Figure 3.9.

Due to condition drivers, Powerlink has retired one of the 275/110kV transformers at Mudgeeraba Substation.

Figure 7.37 provides historical transmission delivered load duration curves for the Gold Coast zone. Energy delivered from the transmission network has reduced by 1.6% between 2021/22 and 2022/23, to the lowest level in the last decade. The peak transmission delivered demand in the zone was 742MW, which is the highest maximum demand over the last five. The minimum transmission delivered demand in the zone was 113MW which is the lowest demand on record.

Figure 7.37 Historical Gold Coast zone transmission delivered load duration curves



There are currently no double circuits in the Gold Coast zone in AEMO's lightning vulnerable transmission line list.