Appendix I Limit equations

This appendix lists the Queensland intra-regional limit equations, derived by Powerlink, valid at the time of publication. The Australian Energy Market Operator (AEMO) defines other limit equations for the Queensland region of the National Electricity Market in its market dispatch systems.

Limit equations are continually under review to consider changing market and network conditions.

Interested parties should contact Powerlink via NetworkAssessments@powerlink.com.au to confirm the latest form of the relevant limit equation if required.

Table I.1 Far North Queensland grid section voltage stability equation

Measured variable	Coefficient
Constant term (intercept)	597
Total MW generation at Mt Emerald Wind Farm	-0.55
Total MW generation at Kaban Wind Farm	-0.64
Total MW generation at Kareeya Power Station	-0.57
Total MW generation in Ross zone (1)	0.06
Total nominal MVAr of 132kV shunt capacitors online within nominated Cairns area (2)	0.38
Total nominal MVAr of 275kV shunt reactors online within nominated Cairns area (3)	-0.38
Total nominal MVAr of 132kV shunt reactors online within nominated Chalumbin area (4)	-0.36
Total nominal MVAr of 275kV shunt reactors online within nominated Chalumbin area (5)	-0.46
AEMO Constraint ID	Q^NIL_FNQ_8905

Notes:

(1) Ross generation term refers to summated active power generation at Mt Stuart, Townsville, Ross River Solar Farm, Sun Metals Solar Farm, Kidston Solar Farm, Hughenden Solar Farm, Clare Solar Farm, Haughton Solar Farm and Invicta Mill.

(2) The shunt capacitor bank locations, nominal sizes and quantities for the Cairns 132kV area comprise the following:

Innisfail 132kV	1 x 10MVAr
Edmonton 132kV	1 x 13MVAr
Woree 132kV	2 x 54MVAr

(3) The shunt reactor location, nominal sizes and quantities for the Cairns 275kV area comprise the following:

Woree 275kV	2 x 20.2MVAr, 1 x 42MVAr

(4) The shunt reactor location, nominal size and quantities for the Chalumbin 132kV and below area comprise the following:

Chalumbin tertiary	1 x 20.2MVAr

(5) The shunt reactor location, nominal sizes and quantities for the Chalumbin 275kV area comprise the following:

Chalumbin 275kV	2 x 29.4MVAr, 1 x 30MVAr

Table I.2 Central to North Queensland grid section voltage stability equations

Measured variable	Coefficient	
	Equation 1	Equation 2
	Feeder contingency	Townsville contingency
Constant term (intercept)	1,500	1,650
Total MW generation at Barron Gorge, Kareeya and Koombooloomba	0.321	–
Total MW generation at Townsville	0.172	-1.000
Total MW generation at Mt Stuart	-0.092	-0.136
Number of Mt Stuart units online [0 to 3]	22.447	14.513
Total MW northern VRE (1)	-1.00	-1.00
Total nominal MVAr shunt capacitors online within nominated Ross area locations (2)	0.453	0.440
Total nominal MVAr shunt reactors online within nominated Ross area locations (3)	-0.453	-0.440
Total nominal MVAr shunt capacitors online within nominated Strathmore area locations (4)	0.388	0.431
Total nominal MVAr shunt reactors online within nominated Strathmore area locations (5)	-0.388	-0.431
Total nominal MVAr shunt capacitors on line within nominated Nebo area locations (6)	0.296	0.470
Total nominal MVAr shunt reactors on line within nominated Nebo area locations (7)	-0.296	-0.470
Total nominal MVAr shunt capacitors available to the Nebo Q optimiser (8)	0.296	0.470
Total nominal MVAr shunt capacitors on line but not available to the Nebo Q optimiser	0.296	0.470
AEMO Constraint ID	Q^NIL_CN_FDR	Q^NIL_CN_GT

Notes:

(1) Northern VRE includes all solar farms and wind farms in the Far North, Ross and North zones.

(2) The shunt capacitor bank locations, nominal sizes and quantities for the Ross area comprise the following:

Ross 132kV	1 x 50MVAr
Townsville South 132kV	2 x 50MVAr
Dan Gleeson 66kV	2 x 24MVAr
Garbutt 66kV	2 x 15MVAr

(3) The shunt reactor bank locations, nominal sizes and quantities for the Ross area comprise the following:

Ross 275kV	2 x 84MVAr, 2 x 29.4MVAr

(4) The shunt capacitor bank locations, nominal sizes and quantities for the Strathmore area comprise the following:

Newlands 132kV	1 x 25MVAr
Clare South 132kV	1 x 20MVAr
Collinsville North 132kV	1 x 20MVAr

(5) The shunt reactor bank locations, nominal sizes and quantities for the Strathmore area comprise the following:

Strathmore 275kV	1 x 84MVAr

(6) The shunt capacitor bank locations, nominal sizes and quantities for the Nebo area comprise the following:

Moranbah 132kV	1 x 52MVAr
Pioneer Valley 132kV	1 x 30MVAr
Kemmis 132kV	1 x 30MVAr
Dysart 132kV	2 x 25MVAr
Alligator Creek 132kV	1 x 20MVAr
Mackay 33kV	2 x 15MVAr

(7) The shunt reactor bank locations, nominal sizes and quantities for the Nebo area comprise the following:

Nebo 275kV	1 x 84MVAr, 1 x 30MVAr, 1 x 20.2MVAr

(8) The shunt capacitor bank which may be available to the Nebo Q optimiser comprise the following:

Nebo 275kV	2 x 120MVAr

The following table describes limit equations for the Inverter-based Resources (IBRs) in north Queensland. The Boolean AND operation is applied to the system conditions across a row, if the expression yields a True value then the maximum capacity quoted for the farm in question becomes an argument to a MAX function, if False then zero (0) becomes the argument to the MAX function. The maximum capacity is the result of the MAX function.

Table I.3 North Queensland system strength equations

System conditions								Maximum capacity (%)	
Number of Stanwell units online	Number of Stanwell + Callide (1) units online	Number of CQ units online (2)	Clarke Creek Synchronous Condenser	Number of Kareeya units online	Total of Haughton Synchronous Condenser + Townsville GT	NQ Load	Ross + FNQ Load	Haughton Solar Farm	Other NQ plants
≥ 2	≥ 3	≥ 7	≥ 0	≥ 0	≥ 1	> 250	> 100	100% (if Haughton SC ON) 50% (if Haughton SC OFF)	100%
≥ 2	≥ 3	≥ 7	≥ 0	≥ 2	≥ 0	> 350	> 150	100% (if Haughton SC ON) 50% (if Haughton SC OFF)	100%
≥ 1	≥ 4	≥ 6	≥ 0	≥ 2	≥ 1	> 350	> 150	100% (if Haughton SC ON) 50% (if Haughton SC OFF)	100%
≥ 1	≥ 4	≥ 6	≥ 0	≥ 0	≥ 2	> 250	> 100	100%	100%
≥ 1	≥ 4	≥ 6	1	≥ 2	≥ 0	> 350	> 150	100% (if Haughton SC ON) 50% (if Haughton SC OFF)	100%
≥ 2	≥ 3	≥ 7	≥ 0	≥ 0	≥ 1	> 50	> 0	100% (if Haughton SC ON) 10% (if Haughton SC OFF)	70%
≥ 2	≥ 3	≥ 7	≥ 0	≥ 2	≥ 0	> 50	> 0	100% (if Haughton SC ON) 10% (if Haughton SC OFF)	60%
≥ 1	≥ 4	≥ 6	≥ 0	≥ 2	≥ 1	> 50	> 0	100% (if Haughton SC ON) 10% (if Haughton SC OFF)	60%
≥ 1	≥ 4	≥ 6	≥ 0	≥ 0	≥ 2	> 50	> 0	100%	70%
≥ 1	≥ 4	≥ 6	1	≥ 2	≥ 0	> 50	> 0	100% (if Haughton SC ON) 10% (if Haughton SC OFF)	60%
AEMO Constraint ID								Q_NIL_STRGTH_HAUSF	Various (3)

Notes:

(1) Refers to the total number of Callide B and Callide C units online.

(2) Refers to the number of Gladstone, Stanwell and Callide units online.

(3) Q_NIL_STRGTH_CKWF, Q_NIL_STRGTH_CLRSF, Q_NIL_STRGTH_COLSF, Q_NIL_STRGTH_DAYSF, Q_NIL_STRGTH_HAMSF, Q_NIL_STRGTH_HAYSF, Q_NIL_STRGTH_KBWF, Q_NIL_STRGTH_KEP, Q_NIL_STRGTH_KIDSF, Q_NIL_STRGTH_MEWF, Q_NIL_STRGTH_RRSF, Q_NIL_STRGTH_RUGSF, Q_NIL_STRGTH_SMSF, Q_NIL_STRGTH_WHTSF.

Table I.4 Central to South Queensland grid section voltage stability equations

Measured variable	Coefficient
Constant term (intercept)	1,015
Total MW generation at Gladstone 275kV and 132kV	0.1407
Number of Gladstone 275kV units on line [2 to 4]	57.5992
Number of Gladstone 132kV units on line [1 to 2]	89.2898
Total MW generation at Callide B and Callide C	0.0901
Number of Callide B units on line [0 to 2]	29.8537
Number of Callide C units on line [0 to 2]	63.4098
Total MW generation in southern Queensland (1)	-0.0650
Number of 90MVAr capacitor banks available at Boyne Island [0 to 2]	51.1534
Number of 50MVAr capacitor banks available at Boyne Island [0 to 1]	25.5767
Number of 120MVAr capacitor banks available at Wurdong [0 to 3]	52.2609
Number of 50MVAr capacitor banks available at Gin Gin [0 to 1]	31.5525
Number of 120MVAr capacitor banks available at Woolooga [0 to 1]	47.7050
Number of 50MVAr capacitor banks available at Woolooga [0 to 2]	22.9875
Number of 120MVAr capacitor banks available at Palmwoods [0 to 1]	30.7759
Number of 50MVAr capacitor banks available at Palmwoods [0 to 4]	14.2253
Number of 120MVAr capacitor banks available at South Pine [0 to 4]	9.0315
Number of 50MVAr capacitor banks available at South Pine [0 to 4]	3.2522
Equation lower limit	**1,550**
Equation upper limit	**2,100 (2)**
AEMO Constraint ID	**Q^^NIL_CS, Q:NIL_CS**

Notes:

(1) Southern Queensland generation term refers to summated active power generation for generators in the Wide Bay, Moreton, South West, Bulli and Surat zones and Terranora Interconnector and Queensland - New South Wales Interconnector (QNI) transfers (positive transfer denotes northerly flow).

(2) The upper limit is due to a transient stability limitation between Central and Southern Queensland areas.

Table I.5 Tarong grid section voltage stability equations

Measured variable	Coefficient	
	Equation 1	Equation 2
	Calvale-Halys contingency	Tarong-Blackwall contingency
Constant term (intercept) (1)	740	1,124
Total MW generation at Callide B and Callide C	0.0346	0.0797
Total MW generation at Gladstone 275kV and 132kV	0.0134	–
Total MW in Surat, Bulli and South West and QNI transfer (2)	0.8625	0.7945
Surat/Braemar demand	-0.8625	-0.7945
Total MW generation in Moreton	-0.0517	-0.0687
Active power transfer (MW) across Terranora Interconnector	-0.0808	-0.1287
Number of 200MVAr capacitor banks available (3)	7.6683	16.7396
Number of 120MVAr capacitor banks available (4)	4.6010	10.0438
Number of 50MVAr capacitor banks available (5)	1.9171	4.1849
Reactive to active demand percentage (6) (7)	-2.9964	-5.7927
Equation lower limit	3,200	3,200
AEMO Constraint ID	Q^^NIL_TR_CLHA	Q^^NIL_TR_TRBK

Notes:

(1) Equations 1 and 2 are offset by 100MW and 150MW respectively when the Middle Ridge to Abermain 110kV loop is run closed.

(2) Surat, Bulli and South West generation term refers to summated active power generation for all generators listed in Table H.3 in Appendix H in the Surat, Bulli and South West zones and Queensland New South Wales Interconnnector (QNI) transfers (positive transfer denotes northerly flow).

(3) There are currently three capacitor banks of nominal size 200MVAr which may be available within this area.

(4) There are currently 18 capacitor banks of nominal size 120MVAr which may be available within this area.

(5) There are currently 37 capacitor banks of nominal size 50MVAr which may be available within this area.

(6) Reactive to active demand percentage = $\frac{\text{Zone reactive demand}}{\text{Zone Active demand}} \times 100$

Zone reactive demand (MVAr) = Reactive power transfers into the 110kV measured at the 132/110kV transformers at Palmwoods and 275/110kV transformers inclusive of south of South Pine and east of Abermain + reactive power generation from 50MVAr shunt capacitor banks within this zone + reactive power transfer across Terranora Interconnector.

Zone active demand (MW) = Active power transfers into the 110kV measured at the 132/110kV transformers at Palmwoods and the 275/110kV transformers inclusive of south of South Pine and east of Abermain + active power transfer on Terranora Interconnector.

(7) The reactive to active demand percentage is bounded between 10 and 35.

Table I.6 Gold Coast Grid Section Voltage Stability Equation

Measured Variable	Coefficient
Constant term (intercept)	1,351
Moreton to Gold Coast demand ratio (1) (2)	-137.50
Number of Wivenhoe units on line [0 to 2]	17.7695
Number of Swanbank E units on line [0 to 1]	-20.00
Active power transfer (MW) across Terranora Interconnector (3)	-0.9029
Reactive power transfer (MVAr) across Terranora Interconnector (3)	0.1126
Number of 200MVAr capacitor banks available (4)	14.3339
Number of 120MVAr capacitor banks available (5)	10.3989
Number of 50MVAr capacitor banks available (6)	4.9412
AEMO Constraint ID	Q^NIL_GC

Notes:

(1) Moreton to Gold Coast demand ratio = x 100

(2) The Moreton to Gold Coast demand ratio is bounded between 4.7 and 6.0.

(3) Positive transfer denotes northerly flow.

(4) There are currently three capacitor banks of nominal size 200MVAr which may be available within this area.

(5) There are currently 16 capacitor banks of nominal size 120MVAr which may be available within this area.

(6) There are currently 33 capacitor banks of nominal size 50MVAr which may be available within this area.