Generator Forecasting Compliance Procedure

Final Procedure following consultation

PowerWater

Purpose of procedure

This procedure specifies the process the *System Controller* will use to detect and respond to any non-compliance with clause 3.3.5.17 – Capacity Forecasting of the Network Technical Code. The procedure also describes the process applied to assess the generator's compliance with dispatch instructions as described in clause 3.3.5.14 – "Active Power Control" of the Network Technical Code.

Scope

The procedure applies to the Northern Territory regulated power systems.

The procedure is prepared under the authority of clause 3.3.5.17 (f) of the Network Technical Code that requires that the *System Controller* must publish a procedure that specifies the process that will be used to detect and respond to non-compliance with this clause. This procedure addresses that obligation.

Note that the procedure describes capacity forecasting compliance requirements and does not make any reference to energy forecasting. These two terms should not be confused when developing systems to meet the compliance requirements of this procedure. The capacity forecast (in MW) for any five minute dispatch interval should specify the minimum amount of active power that the generator expects to be able to sustain for the dispatch interval.

The Performance Standard

The Network Technical Code requires all generators greater than 2 MW to have a generator performance standard defining their capacity forecast requirement and active power control requirement. Clauses 3.3.5.17 and 3.3.5.14 define the level of performance required to meet the automatic access standard for each requirement. This procedure describes the compliance assessment process for generator capacity forecasts and active power control. It assumes that generators are designed and operated to meet the automatic access standard. If a generator has successfully applied the processes defined in clauses 3.3.5(a) through (h) of the Network Technical Code to define an agreed negotiated access standard, then the level of performance in the negotiated access standard would apply to that generator when assessing compliance.

The Network Technical Code specifies that a generator meeting the automatic access standard must submit a forecast of its capacity for a rolling 24-hour period. The forecast is expressed in five-minute intervals, is updated every five minutes and contains 288 intervals. The forecast (in MW) is the expectation of the minimum output that can be sustained over each five-minute period.

Clause 3.3.5.17 (b) of the Network Technical Code states that, a forecast meeting the automatic access standard is required to meet the following accuracy requirements:

- *Have an accuracy such that in any rolling 24-hour period, at least 90% of the non-zero forecasts for the intervals commencing from t=5min to t= 30min do not exceed the firm offer for the time for which the forecast was made.*
- *For every forecast assessed in paragraph (2)(ii)* [the clause] *above that exceeds the firm offer, the forecast must not exceed the firm offer by a margin greater than:*
  - *(i) 5% of the generating unit's nameplate rating; or*

(ii) 1 MW,

whichever is the lesser.

- *The firm offer* [$t_0 - t_{5min}$] *must be the capacity of the generating system for that interval and therefore the generating system must follow a dispatch instruction up to the firm offer in accordance with the requirements in clause 3.3.5.14.*
- *The firm offer is considered in developing the dispatch instruction for each 5 minute dispatch interval. Unless responding to a frequency disturbance clause 3.3.5.14(f) requires that the active power output of the generating system be within +/-0.5% of the dispatch instruction subject to the firm offer in clause 3.3.5.17 and plant ramp rates.*

The *System Controller* will rely on the capacity forecasts provided by each generator when undertaking its security functions. It is therefore important that compliance with the standard is continually monitored by all relevant parties.

The forecasting methodology utilised for capacity forecasting is at the discretion of the generator. The generator has the responsibility for meeting the capacity forecasting performance standard and the choice of methodology used to meet that standard is at the discretion of the generator. The response by the *System Controller* to forecasting non compliances is detailed in this procedure.

System Controller Response to Non-compliance

Monitoring of forecast accuracy will be an automated process and any non-compliance will be addressed in either real time or as soon as practicable within normal business hours depending on the severity.

The principle is that for any generator's non-compliant forecast, a constraint will be applied by the *System Controller* to the generator's future output. The constraint level is calculated iteratively until the historic forecasts would have met the accuracy requirements should the constraint have applied.

The constraint is considered a forced outage issued by the *System Controller* and can only be removed following the successful completion of the return to service process. Therefore, the restriction on the plant will continue even though the subsequent 24-hour forecast may have complied. The published "Plant Outage Procedure" provides specific details about return to service process.

After the constraint is applied by the *System Controller*, all future forecasts (including the firm offers) will be de-rated by the *System Controller* by the percentage established when the constraint was applied until such time that the constraint can be removed following the successful completion of the return to service process. The de-rated forecast and de-rated firm offer are referred to below respectively as constraint adjusted forecasts and constraint adjusted firm offer.

If further non-compliances occur whilst the generator constraint is in place, then the constraint will be increased in line with the constraint algorithm.

As part of the forced outage process the *System Controller* may at their discretion impose a more relaxed constraint compared to the automatically applied constraint.

Forecast Constraint Calculation Process

SCADA data is monitored continuously by the *System Controller* against the 24-hour forecasts, if the system identifies a non-compliance, a constraint for the site is calculated iteratively to the extent that the historic forecasts would have achieved compliance.

Performance measures:

- D – in the last 24 hours, what percentage of the non-zero forecasts from 30 min prior to 5 min prior to dispatch exceeded the resulting firm offer.
- K_M, K_P – in the forecasts from 30 min prior to 5 min prior to dispatch, what was the highest overestimate compared to the resulting firm offer, both in absolute terms (K_M) and relative to nameplate rating (K_P).

The capacity forecasting performance requirements must be met even if a generator has responded to a frequency disturbance. Generators that utilise energy storage systems to achieve capacity forecast performance must ensure those systems are not discharged to such an extent in responding to an under-frequency event, that the capacity forecast requirements are unable to be achieved for future dispatch intervals.

A further measure is applied by the *System Controller* to assess how closely the active power produced by the generator across each dispatch interval aligns with the dispatch instruction for that interval considering the firm offer (forecast made at t=0min covering the period to t=5min) and plant ramp rates. If across any 5 minute dispatch interval, the active power deviates from the dispatch instruction by greater than +/- 0.5% (in the absence of any frequency disturbance) the generator will be considered non-compliant, subject to Network Technical Code Clause 3.3.5.14.

<u>Compliance check:</u>

D is not to exceed 10% of forecasts over a rolling 24hour period.

K_M is not to exceed 1 MW or K_P is not to exceed 5% in any 5 minute interval, whichever is the lesser.

In all dispatch intervals where frequency is within the normal operating band, the maximum absolute difference between the actual power output and the dispatch instruction must be less than 0.5% of the dispatch instruction, subject to Network Technical Code Clause 3.3.5.14.

<u>Constraint calculation:</u>

A constraint adjusted forecast is calculated by the *System Controller* as the original forecast less a proportion of that forecast. The calculation iteratively increases the proportion of the forecast capacity in 1% increments (such that the constraint adjusted forecast = actual forecast – percentage of actual forecast) until the compliance check (using the constraint adjusted forecast) is satisfied.

This constraint is then applied to subsequent forecast processing (constraint adjusted forecasts). If further non-compliance occurs whilst the generator constraint is in place, then the constraint will be increased by the *System Controller* in line with the constraint algorithm.

Active power compliance:

The *System Controller* will continuously monitor the alignment of a generator's active power output with its dispatch instructions. The action taken by the *System Controller* in response to detected non-compliance with the performance obligations in a generator's active power control standard may vary depending on the extent of the difference between the dispatch instruction and the active power output and may include:

- applying a constraint on the firm offers and capacity forecasts reflecting the percentage error observed between the active power output and the dispatch instruction;
- instructing a generator to rectify the non-conformance and requiring the generator to remain below a nominated power output until the non-conformance is rectified; and
- instructing a generator to rectify the non-conformance and requiring the generator to disconnect and remain disconnected until the non-conformance is rectified.

Constraint Algorithm – Capacity Forecast Performance

Screen forecast and fill values:

$f_{0,5i}$ =max(0,min(R, $f_{0,5i+}$)), i=1,2,3,…,6	(Forecast is constrained to within a sensible range i.e. no less than zero and not greater than rated capacity)
$f_{0,5i} = f_{-5,5i}$ for any {i|i=1,2,3,…,6}	(Any forecast not submitted in time, or invalid data is set to prior forecast value by the *System Controller*)

Extract forecasts for each dispatch interval that are used in the compliance assessment:

For each dispatch interval, the assessment considers the firm offer for the dispatch interval and the six forecasts (identified by index i, with a range from 1 to 6) for the dispatch interval made over the five minutes periods prior to the dispatch interval:

G_t = *Firm offer* for the dispatch interval commencing at time, *t.*

The dispatch intervals are identified by index, *j*. For the current dispatch interval *j=1*, with the index increasing by 1 for every prior dispatch interval over the past 24 hours. Therefore, *j* has a range from 1 to 288.

The *firm offer* for current dispatch interval in the current trading interval is assumed to be made at time *t=0*.

The following set of forecasts are to be compared by the *System Controller* with the relevant *firm offers:*

$T_{t1,t2} = F_{-(5j-5+5i), -(5j-5)}$ = Forecast $F_{t1,t2}$ made at time *t1* for the dispatch interval starting at time *t2*

Performance measures:

$D = \frac{\sum_{j=288}^{1}\sum_{i=6}^{1}[(G_{-(5j-5)} - F_{-(5j-5+5i),-(5j-5)}) < 0]}{\sum_{j=288}^{1}\sum_{i=6}^{1}[F_{-(5j-5+5i),-(5j-5)} > 0]}$ (previous 24-hour calculation of forecast violations). The calculation is performed from the oldest forecast to the most recent forecast to allow the time at which D exceeded the allowable limit (if it actually did) to be determined.

For each forecast period that exceeds the firm offer the margin needs to be checked.

$K_M = max(F_{-5i,0} - G_0), i = 1,2,3 \dots 6$ (forecast outside 1 MW limit)

$K_P = max\left(\frac{F_{-5i,0} - G_0}{R}\right), i = 1,2,3 \dots 6$ (forecast outside 5% of nameplate rating limit)

Where:

t is time, with *t*=0 being the time when the forecast was made setting the firm offer for the current dispatch interval.

f_{t_1,t_2} is the forecast made at time t_1 for the dispatch interval starting at time t_2.

Where constraints have been to be applied to manage an identified non-compliance, constraint adjusted forecasts are used:

$F_{t_1,t_2} = f_{t_1,t_2} - 0.01(c+q)f_{t_1,t_2}$ is the constraint adjusted forecast made at time t_1 for the dispatch interval starting at time t_2.

$G_{t_1} = f_{t_1,t_1+5} - 0.01(c+q)f_{t_1,t_1+5}$ is the constraint adjusted firm offer made at time t_1.

R is the rated plant capacity

c is an integer used to iteratively set the constraint following non-compliance (c >= 0). It is limited to a maximum value which will always allow an output from the generator of 5% of nameplate rating or 1 MW whichever is the lesser. The maximum value of c is calculated as follows:

If R $\leq$ 20, max(c) = 95; If R > 20, max(c) = 100 - Int(100/R).

q is an integer which can be used by the *System Controller* to apply a manual negative variation to relax the constraint. For example the *System Controller* may choose to manually relax an applied constraint during testing of an updated forecasting methodology by the generator.

Compliance check:

$$Compliance = (D \leq 10\%)\ , and\ the\ lesser\ of\ (K_M \leq 1\ MW)\ \ or\ (K_P \leq 5\%)$$

A worked example of the above calculation is provided at Attachment A. An example calculation spreadsheet can be accessed on the Market Operator website.

Manual constraint notes:

Under extenuating circumstances, constraints may take another form than specified above if manually applied by the *System Controller*. In that case, such manually applied constraints apply until a subsequent non-compliance occurs, then this automatic procedure supersedes (starting at *c* = 0 and q= 0). Allowable alternate forms of manual constraint (which may not result in a more onerous constraint than the automatic constraint) are:

$F_{t1,t2}$ = min($f_{t1,t2}$,*r*), where *r* is a cap representing reduced plant capacity constraint, and must not be less than (1-0.01·*c*)·*R;* or

$F_{t1,t2}$ = $a \cdot f_{t1,t2}$, where *a* is a constant proportional constraint, and must not be greater than (1-0.01·*c*).

Notification Process

The generator is responsible for the performance of its capacity forecasting system and the active power control system. As such, if a generator becomes aware that either its capacity forecasting system or active power control system will be or has been unable to meet its performance standard than it must make the *System Controller* aware of the potential non-compliance by submitting a Generator Outage and Testing Request (GOTR) as soon as practicable.

The *System Controller* will monitor compliance and will notify the generator of a constraint application due to non-compliance of the capacity forecast or to address non-compliance with dispatch instructions. The constraint will be applied as soon as possible, in most cases immediately after the non-compliance has been detected. Subsequent to notification, the generator will then be required to submit a GOTR as soon as practicable.

The GOTR will identify the cause of the non-compliance, which will include two categories:

- Type 1 non-compliance – Asset Failure
- Type 2 non-compliance – Forecasting Algorithm Failure

The process for returning to service is different for the two categories and is outlined below. The requirement for a separate process is due to the complex nature of rectifying and testing a Type 2 non-compliance. Under this process the *System Controller* will require additional information on the remedial actions prior to commencing online testing.

Unless a specific exemption is documented in the relevant Operating Protocol, the generator must notify the *System Controller* of any intended changes to the forecasting algorithm via a GOTR. The *System Controller* will need to approve, in writing, the GOTR prior to the generator making the change.

Type 1 Non-compliance - Asset Failure – for example a non-compliance caused by an inverter or communications failure

Non-compliance identified	GOTR submitted by generator	Risk Notice issued	Return to Service
Non-compliance notification issued by System Controller to Generator	GOTR outlines: - cause of non-compliance - action already taken or to be taken to rectify issue*	Risk notice issued, identifying: - constraint to be applied and arrangements in place until remedial action complete (only required if remedial action not complete) - online testing requirements, including impact on other system participants to ensure system security during testing.	To be submitted by generator and will be assessed by the System Controller.

The online testing requirements required for an asset failure will be consistent with the standard online testing requirements for a standard (non-forecast related) forced outage.

Type 2 Non-compliance – Algorithm failure – for example a non-compliance caused by an insolation forecast error or a battery storage calculation error

Non-compliance identified	GOTR submitted by generator	Risk Notice issued	GOTR submitted by generator	Risk Notice issued	Return to Service
Non-compliance notification issued by System Controller to Generator	GOTR outlines: - cause of non-compliance, identifying that it relates to a Type 2 non-compliance.	Risk notice issued, identifying: - constraint to be applied and arrangements in place until remedial action complete.	GOTR (updated) outline: - action that was taken to rectify issue, including appropriate evidence, which could include a simulation of the incident with updated algorithm to demonstrate its effectiveness. - Proposed approach to demonstrating compliance during online testing.	Risk notice updated, identifying: - online testing requirements, including impact on other system participants to ensure system security during testing.	To be submitted by generator and will be assessed by the System Controller.

The generator's proposed approach to demonstrating compliance during online testing is only an example of one possible approach. The adoption of the generator's proposed approach will be at the *System Controller*'s discretion.

The approach to online testing required by the *System Controller* will vary according to the underlying cause and size of the non-compliance. For example, it may include a staged reduction of the constraint, testing under specific weather events or a full removal of the constraint.

Review

This document is to be reviewed in accordance with changes to the System Control Technical Code and/or the Network Technical Code.

Document History

Date of Issue	Version	Prepared By	Description of Changes
16 April 2020	V1.0	Jodi Triggs	Initial Version
13 July 2020	V1.1	Jodi Triggs	Procedure published following consultation

Worked Example

This example shows the calculations performed over the last two successive dispatch intervals (adding to the compliance assessment performed over a full 24 hour period) in which non-compliance is detected with respect to the firm forecast shown in yellow in the Forecast Value column, compliant forecasts are shown in green. The example is a simplified view of errors that might occur where the timing of the impact of cloud cover events were incorrectly forecast. Forecast accuracy improved as the time before dispatch reduced. Over the previous 24 hours (up to 11:25am) 77 non-zero forecasts exceeded the firm offer with all occurring over the previous three hours, none of which exceeded K_M or K_P. In the example t=0 is 11:35 am.

In this example the generator's rated capacity is 30MW (R=30MW), the firm offer is shown in the orange column and the forecast is shown in the green column. The number of forecasts >0 over 24 hours has been assumed as 864[1] as a solar generator is forecast to produce some output during one half of the total of 1728 forecasts made across the 24 hours, that are used in assessing capacity forecast compliance.

D is calculated at <10%, hence this example would be a compliant forecast against the 90% threshold but would not meet other requirements as K_M (2MW and 6MW for the two dispatch periods exceed 1MW) and K_P (6.7% and 20% during those two dispatch periods exceeding 5%) exceed limits.

Actual Time at start of dispatch interval	Indices		Time Firm Offer was made	Forecast made at time	Time forecast applies	Firm Offer Value G(t)	Forecast Value F(t1,t2)	$G_t - F_{t1,t2}$	D - over 24 hour period	K_M	K_P	D Numerator	Calculation	D Denominator	Calculation
	j	i	t=-(5j-5)	t1= -(5j–5+5i)	t2=-(5j-5)	MW	MW	MW	%	MW	%	No of times forecast > firm offer over 24hrs	formula	Forecasts > 0 over 24 hours	Formula
11:35	1	1	0	-5	0	20	5	0	9.8%	2	6.7%	85	$G_0 - F_{(-5,0)} <0$	864	$F_{(-5,0)} > 0$
11:35	1	2	0	-10	0	20	5	0	9.8%			85	$G_0 - F_{(-10,0)} <0$	864	$F_{(-10,0)} > 0$
11:35	1	3	0	-15	0	20	5	0	9.8%			85	$G_0 - F_{(-15,0)} <0$	864	$F_{(-15,0)} > 0$
11:35	1	4	0	-20	0	20	21	-1	9.8%			85	$G_0 - F_{(-20,0)} <0$	864	$F_{(-20,0)} > 0$
11:35	1	5	0	-25	0	20	21	-1	9.7%			84	$G_0 - F_{(-25,0)} <0$	864	$F_{(-25,0)} > 0$
11:35	1	6	0	-30	0	20	22	-2	9.6%			83	$G_0 - F_{(-30,0)} <0$	864	$F_{(-30,0)} > 0$
11:30	2	1	-5	-10	-5	20	20		9.5%	6	20.0%	82	$G_{-5} - F_{(-10,-5)} <0$	864	$F_{(-10,-5)} > 0$
11:30	2	2	-5	-15	-5	20	21	-1	9.5%			82	$G_{-5} - F_{(-15,-5)} <0$	864	$F_{(-15,-5)} > 0$
11:30	2	3	-5	-20	-5	20	21	-1	9.4%			81	$G_{-5} - F_{(-20,-5)} <0$	864	$F_{(-20,-5)} > 0$
11:30	2	4	-5	-25	-5	20	21	-1	9.3%			80	$G_{-5} - F_{(-25,-5)} <0$	864	$F_{(-25,-5)} > 0$
11:30	2	5	-5	-30	-5	20	22	-2	9.1%			79	$G_{-5} - F_{(-30,-5)} <0$	864	$F_{(-30,-5)} > 0$
11:30	2	6	-5	-35	-5	20	26	-6	9.0%			78	$G_{-5} - F_{(-35,-5)} <0$	864	$F_{(-35,-5)} > 0$

[1] 864 = no of dispatch intervals in 12 hours*number of forecasts for each dispatch interval = 144*6

In the example the maximum K_M for any dispatch interval in the 24 hours was 6 MW and the maximum value of K_P is 20% of R. Given the nameplate rating is 30 MW, a K_P of 5% is 1.5 MW. K_M (1MW) is less than K_P, so, as a result, taking the lesser of the two, a 1 MW compliance requirement applies. (Note this is true for generators with a nameplate rating of 20MW and above, for generators below 20MW the $K_P \leq 5\%$ compliance check will always apply.)

To achieve compliance would require applying a constraint constant to reduce the forecasts to a level which would not have caused the non-compliance. In this example the percentage that the forecasts would have to be reduced by to be equal to the firm offer would be ((26-21)/26) = 19.2%. This could be achieved by iteratively increasing the constraint constant c (an integer) to a value of 20. This would apply a 20% reduction to all future forecasts. Any further constraint adjusted forecast that exceeds the firm offer would trigger further iterations which would increase the constraint constant. Each iteration would increase the level of the constraint applied to the forecasts by 1%. The constant would continue to increase iteratively until such time that the forecasts being examined are made compliant with the accuracy requirements.

The generator would be notified of the compliance breech and that a constraint had been applied. The generator is then expected to complete a GOTR identifying the cause of the non-compliance. Following successful remediation, the constraint would be lifted by the *System Controller*.