

# Generator Forecasting Compliance Procedure



**DRAFT FOR CONSULTATION**  
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## 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.

## 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.

As outlined in clause 3.3.5.17 (b) of the Network Technical Code, 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.

## 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 in business hours depending on the severity. The principle is that for any generator's non-compliant forecast, a constraint will be applied to the generator's future output. The constraint level is calculated iteratively to the extent that is needed such that 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.

After the constraint is applied, all future forecasts (including the firm offers) will be de-rated 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 (i.e. increasing error rate), 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.

## Forecast Constraint Calculation Process

Actual SCADA data is monitored continuously 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 (constraint adjusted) forecasts from 30 min prior to 5 min prior to dispatch exceeded the resulting (constraint adjusted) firm offer.
- $K_M$ ,  $K_P$  – in the (constraint adjusted) forecasts from 30 min prior to 5 min prior to dispatch, what was the highest overestimate compared to the resulting (constraint adjusted) 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 should 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.

In addition to the above measures a further measure is applied 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  $t=0$ min covering the period to  $t=5$ min) and plant ramp rates. If across any 5 minute dispatch interval, the active power deviates from the dispatch instruction by greater than  $\pm 0.5\%$  (in the absence of any frequency disturbance) the generator will be considered non-compliant.

#### Compliance check:

D is not to exceed 10% of forecasts over a rolling 24hour period and  $K_M$  is not to exceed 1 MW, and  $K_P$  is not to exceed 5% in any 5 minute interval.

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

#### Constraint calculation:

A constraint adjusted forecast is calculated 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), until such time as it is manually adjusted by the *System Controller*. Future forecast processing may result in a more onerous constraint, which then carries forward until manual intervention.

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:

$$f_{0,5i} = \max(0, \min(R, f_{0,5i+})) , i=1,2,3,\dots,6 \quad (\text{Clip forecast to within sensible range i.e. no less than zero and not greater than rated capacity})$$

$$f_{0,5i} = f_{-5,5i} \text{ for any } \{i | i=1,2,3,\dots,6\} \quad (\text{Any forecast not submitted in time, or invalid data is set to prior forecast value})$$

#### 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:

$G_t = \text{Firm offer}$  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 need to be compared with the relevant *firm offers*:

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

#### Performance measures:

$$D = \frac{\sum_{j=288}^1 \sum_{i=6}^1 [(G_{-(5j-5)} - F_{-(5j-5+5i), -(5j-5)}) < 0]}{\sum_{j=288}^1 \sum_{i=6}^1 [F_{-(5j-5+5i), -(5j-5)} > 0]} \quad (\text{previous 24 hour calculation of forecast}$$

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.

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

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

Where:

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

$f_{t1,t2}$  is the forecast made at time  $t1$  for the dispatch interval starting at time  $t2$ .

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 ( $c \geq 0$ ).

$q$  is an integer which can be used by the *System Controller* to apply a manual variation to the constraint ( $q$  may be positive for additional constraint or negative to relax a constraint).

#### Compliance check:

$$\text{Compliance} = (D \leq 10\%) , (K_M \leq 1 \text{ MW}), \text{ and } (K_P \leq 5\%)$$

A worked example of the above calculation is provided at Attachment A.

#### Manual constraint notes:

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

$F_{t_1,t_2} = \min(f_{t_1,t_2}, r)$ , where  $r$  is a cap representing reduced plant capacity constraint, and must not be less than  $(1-0.01 \cdot c) \cdot R$ ; or

$F_{t_1,t_2} = a \cdot f_{t_1,t_2}$ , where  $a$  is a constant proportional constraint, and must not be greater than  $(1-0.01 \cdot c)$ .

## 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 should 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. The process will require additional information on the remedial actions prior to commencing online testing. The generator shall not modify the forecasting algorithm at any time

without prior notification being issued to the *System Controller*. The *System Controller* will determine what tests will be required to be performed to assess the forecasting algorithm compliance.

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



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 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 System Controller’s normal processing time for GOTRs is 10 business days. A shorter time period may be arranged under special circumstances, subject to approval by the System Controller.

The generator’s proposed approach to demonstrating compliance during online testing is a suggestion and will be adopted at the System Controller’s discretion.

The approach to online testing 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



**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 by 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<sup>1</sup> 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 $t=-(5j-5)$	Forecast made at time $t1=-(5j-5+5i)$	Time forecast applies $t2=-(5j-5)$	Firm Offer Value $G(t)$ MW	Forecast Value $F(t1,t2)$ MW	$G_t - F_{t1,t2}$ MW	D - over 24 hour period %	$K_M$ MW	$K_P$ %	D Numerator No of times forecast > firm offer over 24hrs	D Calculation formula	D Denominator Forecasts > 0 over 24 hours	D Calculation Formula
	j	i													
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	$F_{(-35,-5)} > 0$

<sup>1</sup> 864 = no of dispatch intervals in 12 hours\*number of forecast for each dispatch interval = 144\*6

## Attachment A

In the example it 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. To achieve compliance would require applying a constraint constant 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  $((26-20)/26) = 23.1\%$ . This could be achieved by iteratively increasing the constraint constant  $c$  (an integer) to a value of 24. This would apply a 24% 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 breach 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*.