Worked Examples for Category 5 Intertripping Service

National Grid's industry consultations on the procurement[1] and utilisation[2] of category 5 intertripping service outline the proposed criteria which National Grid will use in the selection, and subsequent arming, of suitable Generating Units. These criteria are summarised in Appendices A (Procurement Guidelines) and B (Balancing Principles Statement).

This note provides the following three numerical examples showing how the proposed criteria will be applied:

Example 1: Selection of Generating Units with pre-existing commercial intertrips

Example 2: Selection of Generating Units without pre-existing commercial intertrips

Example 3: Arming of Generating Units

[1] This consultation outlines the proposed changes to the Procurement Guidelines.
[2] This consultation outlines the proposed changes to the Balancing Principles Statement.
Both consultations can be found on http://www.nationalgrid.com/uk/Electricity/Balancing/consultations/.

Example 1: Selection of Generating Units with pre-existing commercial intertrips

This example is designed to show how National Grid would select the most appropriate Generating Units in a scenario where some stations already have commercial intertrip schemes installed.

For simplicity, the example shows just seven stations of different size and type: in reality, all stations would be considered.

The results are displayed in Table 1.

Points to Note:

In Example 1, intertrips are pre-existing at a coal station, a gas station and a nuclear station (stations A, C and D). Power stations with pre-existing intertrips have a lower Effective Cost than those for which intertrip equipment would need to be installed by the Transmission Owner. The example assumes a £200k cost[3] by the Transmission Owner to connect stations to an intertrip scheme.

The Effective Cost takes account of the cost of new intertrip equipment and the standard annual capability fee payable to the generator (this fee covers generator installation costs as described in the CAP076 Final Amendment Report). The Effective Cost reduces with increasing plant size and load factor.

Following the assessment of Effective Cost, a further assessment is made on the likely firm trippable generation. These calculations show how the load factors (dependent on type of plant) and BMU planned outages (assuming that one BMU may be on a planned outage at any given time) reduce the likely intertrippable volume. Negative numbers mean that, after taking into account the load factors and BMU outages, certain Generating Units may not have the capability to provide firm trippable volume.

[3] It is assumed that these assets would become part of the Transmission Owner's asset base and recovered via TNUoS charges.

The example shows the selection of 1425MW of firm trippable generation (station A and D) which is greater than the maximum allowed intertrip capability of 1320MW. Of the two stations chosen, Station A has the highest effective cost. Each generating unit at station A is rated at 350MW. Deducting 350MW from the 1425MW firm trippable generation level identified above results in a firm trippable generation less than 1320MW. As a result all generating units at stations A and D will be required to have CAT5 intertrip capability.

Other factors, such as the Minimum Zero Time post-trip, are also considered. In example 1 these factors do not change the outcome.

As a result, a coal station (A) and the nuclear station (D), both of which have existing intertrip schemes installed, are chosen to satisfy the derogated boundary intertrip requirement.

Table 1- Derogated Boundary with Pre-existing Commercial Intertrips

Required Capability (2009/10):	4000	Maximum Allowed Intertrip Capability:	**1320**
Actual Capability (2009/10):	2200	Total Available Intertrip Capability:	4050
Difference:	1800		

POWER STATION	**A**	**B**	**C**	**D**	**E**	**F**	**G**
	4 x 350 MW **coal fired** power station, **existing commercial intertrip**	4 x 500 MW **coal fired** power station	1 x 800 MW **CCGT** power station, **existing commercial intertrip**	4 x 650 MW **nuclear** power station, **existing commercial intertrip**	4 x 200 MW **hydro** power station	150 MW **wind** farm	100 MW **wind** farm
a) Total Station Output Capable of Being Intertripped	1400	2400	250	2600	800	150	50
b) The cost of connecting a Generating Unit to the System-to-Generator Scheme	£0.00	£200,000.00	£0.00	£0.00	£200,000.00	£200,000.00	£200,000.00
c) Payments associated with a category 5 service provider	£30,000.00	£30,000.00	£30,000.00	£30,000.00	£30,000.00	£30,000.00	£30,000.00
d) Trippable size of individual Generating Unit	350	600	250	650	200	150	50
e) Load factor	0.625	0.625	0.632	0.596	0.161	0.26	0.26
f) BMU Output x Load Factor (d*e)	219	375	158	387	32	39	13
g) Total Station x Load Factor (a*e)	875	1,500	158	1,550	129	39	13
h) (1) Effective Cost per Generating Unit (£/MWh) (b+c)/(f)	**£137.14**	**£613.33**	**£189.87**	**£77.44**	**£7,142.86**	**£5,897.44**	**£17,692.31**
h) (2) Effective Cost for Power Station (£/MWh) (b+c)/(g)	**£34.29**	**£153.33**	**£189.87**	**£19.36**	**£1,785.71**	**£5,897.44**	**£17,692.31**
i) Firm trippable Generation: Total Station x Load Factor - BMU Outage (g-d)	**525**	900	-92	**900**	-71	-111	-37
Other factors to consider							
j) Anticipated time to return to commercial load following an intertrip;	6 hours	6 hours	10 hours	999 min (max allowed)	999 min (max allowed)	Up to 1 hour	Up to 30 min
k) Technical characteristics of a Generating Unit;							
l) For a boundary which requires 1320 MW on intertrip, how much volume of intertrip should be available?	Diversity is required to ensure intertrip capability exists during generating unit outages and a range of energy market conditions.The capability to trip up to 1320 MW must continue to exist, taking account of station load factors and the need for planned BMU outages. Using the firm trippable generation levels above, power stations A and D would be chosen to provide Category 5 intertrips. The total volume of intertrip availability would be 4000 MW, being the combined station output of A and D.						
Power Stations selected for Category 5 Intertrip:	**X (All Units)**			**X (All Units)**			

a) For Station C, 250 MW represents 1 x GT. BMU has 2 x 250 MW GTs and 1 x 300 MW ST). Assumes CCGT has demonstrated contractual obligation to deliver steam, hence can only trip 1 GT (0 GTs during GT outages)

b) £200,000 assumed for installation of new intertrip equipment
c) Standard annual capability fee as per CUSC
e) Based on publicly available data from DECC/BERR (Dukes)
g) Need to maintain 1320 MW intertrip capability during outage of one BMU per station
i) Initial selection shown with BOLD border
j) MZT data from BMRS (www.bmreports.com)

Example 2: Selection of Generating Units without pre-existing commercial intertrips

This example is identical to Example 1, except that none of the stations have pre-existing commercial intertripping arrangements in place.

The results are displayed in Table 2.

Points to Note:

In example 2, there are no stations with pre-existing intertrips. Therefore, the Effective Cost is influenced by plant size and load factor. Taking this into account along with an assessment of likely firm trippable generation, stations A and B are selected.

Following the assessment of Effective Cost, other factors, such as the technical characteristics of the station, are also considered. In this example, with no pre-existing intertrip at the nuclear station (Station D) it is recognised (and demonstrated during early discussions) that there will be a need for the station to submit a formal safety case change. The likely timescales associated with making changes to the safety case count against it in terms of selection as, over the expected lifetime of the GBSQSS boundary derogation, other alternatives are likely to be more attractive (i.e. the delay whilst awaiting a safety case change would mean needing to use more expensive constraint management tools).

In this example, the anticipated time to return to commercial load following an intertrip is considered but not the key factor. Since the occurrence of tripping should be a rare event, this factor would only be expected to influence if the effective cost of two stations were similar.

In example 2, the two coal stations (A and B) are chosen to satisfy the derogated boundary intertrip requirement.

Table 2 - Derogated Boundary with No Pre-existing Commercial Intertrips

Required Capability (2009/10):	4000	Maximum Allowed Intertrip Capability:	**1320**
Actual Capability (2009/10):	2200	Total Available Intertrip Capability:	4050
Difference:	1800		

POWER STATION	A	B	C	D	E	F	G
	4 x 350 MW **coal fired** power station	4 x 500 MW **coal fired** power station	1 x 800 MW **CCGT** power station	4 x 650 MW **nuclear** power station	4 x 200 MW **hydro** power station	150 MW **wind** farm	100 MW **wind** farm
a) Total Station Output Capable of Being Intertripped	1400	2400	250	2600	800	150	50
b) The cost of connecting a Generating Unit to the System-to-Generator Scheme	£200,000.00	£200,000.00	£200,000.00	£200,000.00	£200,000.00	£200,000.00	£200,000.00
c) Payments associated with a category 5 service provider	£30,000.00	£30,000.00	£30,000.00	£30,000.00	£30,000.00	£30,000.00	£30,000.00
d) Trippable size of individual Generating Unit	350	600	250	650	200	150	50
e) Load factor	0.625	0.625	0.632	0.596	0.161	0.26	0.26
f) BMU Output x Load Factor (d*e)	219	375	158	387	32	39	13
g) Total Station x Load Factor (a*e)	875	1,500	158	1,550	129	39	13
h) (1) Effective Cost per Generating Unit (£/MWh) (b+c)/(f)	**£1,051.43**	**£613.33**	**£1,455.70**	**£593.70**	**£7,142.86**	**£5,897.44**	**£17,692.31**
h) (2) Effective Cost for Power Station (£/MWh) (b+c)/(g)	**£262.86**	**£153.33**	**£1,455.70**	**£148.43**	**£1,785.71**	**£5,897.44**	**£17,692.31**
i) Firm trippable Generation: Total Station x Load Factor - BMU Outage (g-d)	525	**900**	-92	**900**	-71	-111	-37
Other factors to consider							
j) Anticipated time to return to commercial load following an intertrip;	6 hours	6 hours	10 hours	999 min (max allowed)	999 min (max allowed)	Up to 1 hour	Up to 30 min
k) Technical characteristics of a Generating Unit;	With no pre-existing commercial intertrips, the effectiveness of nuclear plant remains high, although the likely timescales associated with making changes to the Safety Case count against it in terms of selection as, over the lifetime of the derogation, other alternatives are likely to be more attractive.						
l) For a boundary which requires 1320 MW on intertrip, how much volume of intertrip should be available?	Diversity is required to ensure intertrip capability exists during generating unit outages and a range of energy market conditions.The capability to trip up to 1320 MW must continue to exist, taking account of station load factors and the need for planned BMU outages. Using the effectiveness and the firm trippable generation levels above, power stations A and B would be chosen to provide Category 5 intertrips. The total volume of intertrip availability would be 3800 MW, being the combined station output of A and B.						
Power Stations selected for Category 5 Intertrip:	**X (All Units)**	**X (All Units)**					

a) For Station C, 250 MW represents 1 x GT. BMU has 2 x 250 MW GTs and 1 x 300 MW ST). Assumes CCGT has demonstrated contractual obligation to deliver steam, hence can only trip 1 GT (0 GTs during GT outages)

b) £200,000 assumed for installation of new intertrip equipment
c) Standard annual capability fee as per CUSC
e) Based on publicly available data from DECC/BERR (Dukes)
g) Need to maintain 1320 MW intertrip capability during outage of one BMU per station
i) Initial selection shown with BOLD border
j) MZT data from BMRS (www.bmreports.com)

Example 3: Arming of suitable Generating Units

This example shows how National Grid will arm the most appropriate Generating Units.

The results are displayed in Table 3.

Points to Note:

Example 3 considers a scenario where there are four power stations with intertrip schemes installed. There is a requirement for 400 MW of generation to be selected to intertrip. Each station's effectiveness for reducing overloads is different, one of the units is required post-fault to provide voltage support, and one of the units has a long Minimum Zero Time post-trip.

Table 3 shows that the criteria 'a' to 'd' are sufficient to identify the most suitable generating units for arming, and that criterion 'e' regarding 'equitable treatment' (where there is no way of differentiating between the generating units) is not needed. National Grid envisages that this will be the case in most cases (as demonstrated in example 3) and that criterion 'e' will only be used on rare occasions.

In example 3, unit B is selected to intertrip based on the factors discussed.

Table 3 - Arming

	A	B	C	D
a) The output of category 5 providers' generating units;	300	500	600	400
b) The effectiveness of intertripping a specific unit in relieving the constraint with respect to the conditions at that time;	increases limit by: 250MW	increases limit by: 400MW	increases limit by: 400MW	increases limit by: 300MW
c) Any disproportionately detrimental effect to the system in the event of a specific generating unit or combination of units being intertripped when compared to the benefit of arming that generating unit or units (e.g. impact of loss of MVAr reserves, local constraint issues);	Unit providing voltage support for next credible fault	None specific	Long time to resync (Minimum Zero Time) following trip	None specific
(d) where practicable, only arming sufficient intertrip volume on generating units to enable the discrepancy between the present derogated transmission boundary capability and that capability that would be required to satisfy compliance with the GB SQSS; and	300MW benefit required: 250MW delivered by arming this unit	400MW benefit required: 400MW benefit delivered by arming this unit	400MW benefit required: 400MW benefit delivered by arming this unit	400MW benefit required: 300MW benefit delivered by arming this unit
(e) Equitable treatment of generating units where more than one generating unit can provide the required intertrip volume and where, after taking into consideration the above criteria, there is no way of differentiating between the generating units.	Not relevant in this example			
Summary	under provides, and required for volts	**satisfactorily provides: no specific detriment**	**satisfactorily provides but long MZT if tripped**	under provides

Therefore, in this example, most suitable candidates for arming are Units B and C, with preference to arm B owing to long NDZ for unit C.

APPENDIX A

Criteria for selection of suitable Generating Units

(extracted from the proposed changes to the Procurement Guidelines)

1. For category 5 Intertripping Scheme, this service covers intertrips that are capable of being armed with respect to a derogated non-compliant transmission boundary (as defined in the CUSC), subject to an Authority approved derogation to the Security and Quality of Supply Standards. The selection of an appropriate service provider for category 5 Intertripping Scheme will be based on, but not limited to, the following criteria:

a) Technical characteristics of a Generating Unit;
b) The cost of connecting a Generating Unit to the System-to-Generator Scheme;
c) Payments associated with a category 5 service provider;
d) Size of load;
e) Load factor and the likelihood of a Generating Unit running during constraint periods;
f) Anticipated time to return to commercial load following an intertrip
g) Diversity of generation necessary to allow effective management of constraints if, for example, plant with intertrip capability is not generating or if it is required to generate at a certain output to manage local issues.

APPENDIX B

Criteria for arming of suitable Generating Units

(extracted from the proposed changes to the Balancing Principles Statement)

A key operational decision in utilising the category 5 intertrip service is the selection of suitable generating units that could meet the required intertrip volume on a derogated non-compliant transmission boundary. Such a decision is likely to be based on the system conditions at the time, taking into account factors such as:

- the output of category 5 providers' generating units;
- the effectiveness of intertripping a specific unit in relieving the constraint with respect to the conditions at that time;
- any disproportionately detrimental effect to the system in the event of a specific generating unit or combination of units being intertripped when compared to the benefit of arming that generating unit or units (e.g. impact of loss of MVAr reserves, local constraint issues);
- where practicable, only arming sufficient intertrip volume on generating units to enable the discrepancy between the present derogated transmission boundary capability and that capability that would be required to satisfy compliance with the GB SQSS; and
- equitable treatment of generating units where more than one generating unit can provide the required intertrip volume and where, after taking into consideration the above criteria, there is no way of differentiating between the generating units.