Methodology for Determining System Operator and Non-Marginal Flags

Version 1.0

11th September 2018

EIRGRID SONI

1 OVERVIEW

This document is published in accordance with Appendix N paragraph 4 of the Trading and Settlement Code Part B (TSC), which states:

The System Operators shall publish a "Methodology for determining System Operator and Non-Marginal Flags" including detailed information on how System Operator Flags and Non-Marginal Flags are determined for each Operational Constraint and Unit Constraint in accordance with paragraphs 1-3, including the process for determining whether an Operational Constraint is binding and the process for determining whether a Generator Unit is bound by a Unit Constraint or a binding Operational Constraint.

This document should be read in conjunction with the Trading and Settlement Code, the Grid Codes and the Balancing Market Principles Statement.

The Grid Codes set out the obligations on the TSOs with respect to the scheduling and dispatch of the system. These processes form the basis on which this methodology is applied. The Balancing Market Principles Statement provides further information on these processes. This provides important context as the determination of flags is based on information that comes from the scheduling processes described in the Balancing Market Principles Statement.

The Trading and Settlement Code includes the rules for Imbalance Pricing including the requirement for the System Operators to determine System Operator, Non-marginal and System Service flags and the broader rules that apply these flags in the calculation of the Imbalance Price.

Of particular relevance to this paper is Section 4 of the Balancing Market Principles Statement "The Scheduling and Dispatch Process", which sets out, "the general and specific processes and methodologies that determine scheduling and dispatch decisions, and the balancing actions taken by the TSOs". This methodology is built around these scheduling and dispatch processes and it determines the relevant flags based on their outputs.

1.1 INDICATIVE OPERATIONS SCHEDULE & OPERATIONAL CONSTRAINTS

The Indicative Operations Schedule is determined based on requirements set out in the Grid Codes and the process for determining it is discussed further in the Balancing Market Principles Statement. Operational Constraints are also discussed in the Balancing Market Principles statement and represent limitations on the operation of the power system arising for reasons of system security. When considering dispatch decisions, the System Operator is tasked with operating the system in an economically efficient manner while ensuring that it remains at all times within these operational security limits. These constraints are published in the Operational Constraint Updates on the EirGrid website (www.eirgridgroup.com).

1.2 High-Level Methodology

In order to assess whether a Generator Unit[1], u, is bound by an Operational Constraint, it is necessary to test (a) whether the Operational Constraint is binding and (b) whether the Generator Unit is bound by this constraint.

The reason for this is that some Operational Constraints can be binding but the Generator Unit may not be bound by the constraint e.g. a Generator Unit contributes to inertia by being scheduled on; however, it is only bound by the inertia constraint when it is at its Lower Operating Limit (i.e. it is being run at the lowest possible output level to satisfy the constraint).The reason for this is that inertia *does not* change for changes in output level, only changes in commitment status. If the unit is required only to provide inertia, it would be doing so at the minimum cost i.e. at the Lower Operating Limit. If it was operating above this level, there must be another reason for the unit to be scheduled at this level, which may be that it is required for energy balancing. As such, it would not be flagged.

1.3 Tests To Calculate Flags

Figure 1 shows an example of a basic reserve characteristic for a Generator Unit. The unit has to be on at Min Stable Generation to provide operating reserve. The unit can provide its max operating reserve (green section) up to the level where the headroom starts to decrease for every increase in unit output (sloping red section).

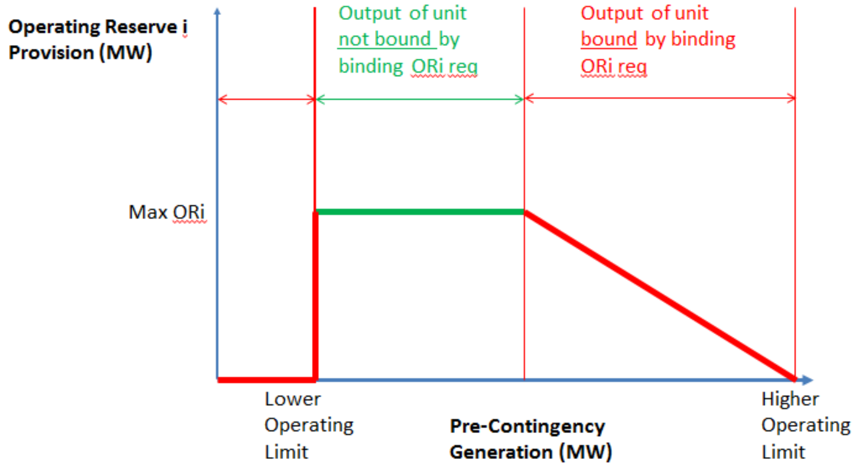

Figure 1 - If ORi constraint is binding, unit is only bound if the change in MW output changes the ORi provision

In order to test whether this unit is bound by the operating reserve constraint, we first check to see if the scheduled operating reserve from all relevant Generator Units is equal to the requirement. If this test is true

[1] The Trading and Settlement Code refers to Generator Unit which includes Interconnector Residual Capacity Units and Interconnector Error Units. While these are distinct from Interconnectors under the Trading and Settlement Code, they are represented in the Indicative Operation Schedule as Interconnectors and therefore the test that apply to Generator Units are also applied to Interconnectors.

(i.e. the operating reserve is binding) then the second test is only true if the schedule places the unit in the area indicated by the red line. In this area, the unit cannot change its output in both directions without causing a reserve shortfall (as the reserve constraint is binding).

The concept that the unit has to be able to move in both directions is important for the flagging process and the unit is considered to be bound by a constraint if it cannot move in both directions. A binding requirement arises from two competing imperatives – on one side we have the economic imperative and on the other we have the imperative of the Operational Constraint, which must be satisfied.

In the above diagram, if the economic imperative suggested that the Generator Unit should run at just below its higher operating limit but the Operational Constraint indicated that it was needed for its max operating reserve, the Generator Unit would be scheduled in the Indicative Operations Schedule to a point where the green line becomes red sloping downwards. At this point, the economic imperative is pushing for greater output from the Generator Unit to just below its higher operating limit and the reserve requirement is pushing for lower output downwards to get max operational reserve. The influence of the reserve requirement ceases at the point where the curve goes green because it gets no additional reserve by reducing the output of the Generator Unit. In this example, the unit is bound by the reserve constraint at this point. In the absence of the constraint, the unit would operate economically at a different level of output. If there was an increase in the system demand, this Generator Unit would not be able to meet it without introducing a reserve shortfall.

On the other hand, if the economic optimal level of the Generator Unit was somewhere along the green line in Figure 1, even if the operating reserve was binding, the Generator Unit would not be bound by this constraint. The reason for this is that this generator could increase or decrease its output without violating the reserve constraint (as its contribution to the reserve constraint remains constant). This means that the reserve constraint is exerting no influence on the Generator Unit's schedule when it is in this range. In the absence of any other binding constraints, this Generator Unit would be the marginal energy action. If there were cheaper actions available, this Generator Unit's output would be reduced in favour of the cheaper actions until the Generator Unit reaches its Minimum Stable Generation, at which point it would become bound by the reserve constraint.

In this way, we can identify Generator Units that are scheduled in order to satisfy Operational Constraints, Unit Constraints and System Service Constraints. These units are flagged and cannot set the Imbalance Price set out in Chapter E of the TSC.

The following sections set out the flagging tests for each Operational Constraint category featured in the Operational Constraints Update. In most cases, these tests reflect the exact treatment of the Operational Constraints in the scheduling systems; however, in some cases, e.g. in the case of reserve constraints, the implementation of the rules will be more complex reflecting the specific reserve characteristic of each Generator Unit.

2 FLAGGING METHODOLOGY AND TESTS

2.1 SYSTEM OPERATOR FLAGS

Paragraph 1 of Appendix N of the Trading and Settlement Code states:

For each Imbalance Pricing Period, φ, the System Operators shall use information from the most recent Indicative Operations Schedule to identify whether a Generator Unit's scheduled output is bound by the presence of an Operational Constraint and where they determine that the Generator Unit is so bound, shall set the System Operator Flag ($FSO_{u\varphi}$) for that Generator Unit, u, equal to zero for that Imbalance Pricing Period, φ. Otherwise, the System Operators shall set the System Operator Flag ($FSO_{u\varphi}$) for that Generator Unit, u, equal to one for that Imbalance Pricing Period, φ.

Throughout this document, the term 'SO Flagging' will be used to refer to the setting of the System Operator Flag ($FSO_{u\varphi}$) for that Generator Unit, u, equal to zero for that Imbalance Pricing Period, φ.

In general, as per requirements, a unit should only be SO Flagged if it is bound by an Operational Constraint i.e. it cannot increase or decrease its output without breaching a binding Operational Constraint (all other things being equal). There are a number of corollaries that follow from this set out below:

- Corollary A: a Generator Unit should not be SO Flagged for an Operational Constraint if it is not bound by that Operational Constraint i.e. both an increase and a decrease[2] in its output would not result in a breach of the binding Operational Constraint (all other things being equal).

- Corollary B: a Generator Unit should not be SO Flagged for an Operational Constraint if a marginal change in its total contribution to that binding Operational Constraint for both a marginal increase and a marginal decrease in output is zero e.g. where a Generator Unit has a maximum reserve of zero, it should not SO Flagged unit.

- Corollary C: a generator unit should not be SO Flagged for an Operational Constraint if its total contribution to that binding Operational Constraint is invariant for both an increase and a decrease in the Generator Unit's output e.g. where a Generator Unit is providing its Maximum Reserve.

- Corollary D: In the case of a minimum constraint, a Generator Unit should not be SO Flagged for an Operational Constraint if its total contribution to that binding Operational Constraint cannot decrease (including changes to commitment). e.g. where its contribution to reserve is zero.

---

[2]Note: to be considered "not bound", a unit has to (a) be capable of increasing output without breaching the binding Operational Constraint *and* (b) be capable of decreasing output without breaching the binding Operational Constraint.

- Corollary E: In the case of a maximum constraint, a Generator Unit should not be SO Flagged for an Operational Constraint if its total contribution to a binding Operational Constraint cannot increase (including changes to commitment). e.g. where the Generator Unit is operating at its Higher Operating Limit.

As a point of convention, when referring to slopes and breakpoints on a reserve curve, if a criteria relates to the slope of the reserve curve but the unit is at a breakpoint then then the slope test does not apply (as the unit is deemed not to be on that slope).

If a Generator Unit is flagged for any Operational Constraint in the following categories, it is SO Flagged. Finally, where a Generator Unit does not contribute to a constraint, it cannot be flagged for that constraint.

2.1.1 All-Island and Minimum Reserves and Ramping Margins

The tests described in this section apply to the following system services: fast frequency reserve, primary operating reserve, secondary operating reserve, tertiary operating reserve bands 1 and 2, negative reserve, replacement reserve, ramping margin 1, ramping margin 3 and ramping margin 8.

For each system service, for all-island requirements and for minimum requirements for each jurisdiction, if the total system service provision from all applicable Generator Units (and other sources such as interruptible load) is equal to the System Service requirement, the constraint is considered binding and the following tests are carried out for each Generator Unit that contributes to the constraint.

If the System Service is based on a positive percentage of the largest infeed, any Generator Unit who’s output is equal to the largest infeed is considered to be bound by the presence of this operational constraint and is SO Flagged.

Any Generator Unit whose System Service provision would decrease for an increase or decrease in the Generator Unit’s output is SO Flagged.

2.1.2 SNSP and RoCoF Tests

When the SNSP (System Non-Synchronous Penetration) level is equal to the SNSP limit, all wind generator units and interconnectors are SO Flagged.

Any Generator Unit whose output is at its RoCoF (Rate of Change of Frequency) limit is SO Flagged.

2.1.3 Inertia Tests

If the total Inertia provision from Generator Units is equal to the System Inertia requirement, the constraint is considered binding and each Generator Unit that is operating at its Lower Operating Limit is SO Flagged.

2.1.4 Dynamic and Voltage Stability Tests

For all constraints where a minimum number of Generator Units from a set of Generator Units are required to be on, if the number of Generator

Units on is equal to the minimum number, then the constraint is considered binding and each Generator Unit that is operating at its Lower Operating Limit is SO Flagged.

2.1.5 Generator Unit Limit Tests

For all constraints where a MW limit applies to the output of a set of Generator Units, if the output of that set of Generator Units (as weighted by the terms of the constraint) is equal to the limit, then the constraint is considered binding and each Generator Unit in that set is SO Flagged.

For all constraints where a MWR limit applies to the output of a set of Generator Units (i.e. a limit based on the output and reserve provision of a set of Generator Units and the area demand), if the output and reserve of that set of Generator Units (as weighted by the terms of the constraint constraint) is equal to the limit, then the constraint is considered binding and the following applies for each Generator Unit in that set:

Any Generator Unit whose total contribution to the constraint (both in terms of output and reserve provision) would increase for an increase or decrease in the Generator Unit's output is SO Flagged.

2.2 System Service Flags

Paragraph 2 of Appendix N of the Trading and Settlement Code states:

For each Imbalance Pricing Period, φ, the System Operators shall use information from the most recent Indicative Operations Schedule to identify whether a Generator Unit's scheduled output is bound by the presence of an Operational Constraint relating to the provision of Replacement Reserve, and where they determine that the Generator Unit is so bound, shall set the System Service Flag (FSSuφ) for that Generator Unit, u, equal to zero for that Imbalance Pricing Period, φ. Otherwise, the System Operators shall set the System Service Flag (FSSuφ) for that Generator Unit, u, equal to one for that Imbalance Pricing Period, φ.

2.2.1 System Service Flag Tests

Generators Units that are SO Flagged for Replacement Reserves in Northern Ireland or Ireland are also System Service Flagged.

2.3 Non-Marginal Flags

Paragraph 3 of Appendix N of the Trading and Settlement Code states:

For each Imbalance Pricing Period, φ, the System Operators shall use information from the most recent Indicative Operations Schedule to identify whether a Generator Unit's scheduled output is bound by the presence of a Unit Constraint and where they determine that the Generator Unit is so bound, shall set the Non-Marginal Flag ($FNM_{u\varphi}$) for that Generator Unit, u, equal to zero for that Imbalance Pricing Period, φ. Otherwise, the System Operators shall set the Non-Marginal Flag ($FNM_{u\varphi}$) for that Generator Unit, u, equal to one for that Imbalance Pricing Period, φ.

2.3.1 Non-Marginal Flagging Tests

Generator Units that are operating at their minimum stable generation, their availability or are ramp limited are Non-Marginal Flagged.