## SQSS Modification Proposal Form

# GSR030: Offshore DC Connections

**Overview:** This modification aims to review the restrictions on the loss of power infeed risk allowed for outages of offshore DC converters

### Modification process & timetable

1. **Proposal Form**
   25 October 2022
2. **Workgroup Consultation**
   27 March 2023 – 19 April 2023
3. **Workgroup Report**
   04 July 2023
4. **Code Administrator Consultation**
   17 July 2023 - 11 August 2023
5. **Draft Final Modification Report**
   05 September 2023
6. **Final Modification Report**
   25 September 2023
7. **Implementation**
   In accordance with the Authority timeline

**Status summary:** The Proposer has raised a modification and is seeking a decision from the Panel on the governance route to be taken.

**This modification is expected to have a: High impact**

Generators, Transmission System Operators, Transmission System Owners

| | | |
|---|---|---|
| **Proposer's recommendation of governance route** | Standard Governance modification with assessment by a Workgroup | |
| **Who can I talk to about the change?** | **Proposer:**<br>Bieshoy Awad / Fiona Williams<br>Bieshoy.Awad@nationalgrideso.com<br>Fiona.Williams@nationalgrideso.com<br>07855080359 | **Code Administrator Contact:**<br>Jennifer Groome<br>Jennifer.Groome@nationalgrideso.com<br>07966130854 |

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## What is the issue?

The NETS SQSS restricts the loss of infeed risk associated with any single offshore DC converter, including both monopolar and bipolar configurations, to the normal loss of infeed risk (1320 MW). This restriction, which aims to limit the consumers' exposure to events where frequency drops below 49.5 Hz, could result in additional and potentially sub-optimal investment being required to meet such criteria. It could also result in unintended detrimental impact on the environment due to the increase in the numbers of cables and landing points required.

### Why change?

Increasing the limit of the maximum loss of infeed risk associated with a single DC converter outage and the treatment of bipolar DC links as two independent links allows for better optimisation of offshore transmission network designs. It also facilitates coordination between different offshore projects, maximises the use of planned subsea cable routes, and reduces the environmental impact of offshore wind connections.

## What is the proposer's solution?

The following actions are proposed subject to a satisfactory assessment of the impacts of the proposed change:

- change the reference to the normal loss of infeed risk in clauses 7.7.2.1 and 7.7.12.1 to become a reference to the infrequent loss of infeed risk;
- either revise the wording of 7.7.2.1, 7.7.2.2, 7.7.12.1, and 7.7.12.2 or the definition of a DC converter to allow DC converters using a bipolar configuration with no common mode of failure to be treated as two separate converters;
- if necessary, revise the definition of an offshore transmission circuit and/or clauses 7.8 and 7.11 to ensure that the fact that the two DC conductors and the metallic earth return conductor all form a part of one offshore transmission circuit does not unintentionally restrict the use of DC bipolar configurations with no common mode of failure; and
- if necessary, introduce a restriction on the loss of infeed risk associated with a simultaneous loss of any two subsea cables running close to each other;
- if necessary, revise the N-1-1 restriction on cables forming a part of a DC bipole to ensure that the link automatically restricts its load following a fault on the metallic return cable.

### Treatment of DC Link Bipolar Arrangements

Most of the DC link configurations have at least one common mode of failure. This means that it will be necessary to de-energise the whole link to either isolate a single fault on one of the elements within the link or to facilitate the maintenance of a single piece of equipment within the link.

Some bipolar DC links are designed for each of the two poles to operate such that a fault affecting one pole or a planned outage on that pole would not require the de-energisation of the other pole. This is generally achieved by the provision of one or more metallic return conductors and by ensuring that the control system of each of the two poles allows for fault detection, fault isolation, and planned outages on each of the poles separately.

The NETS SQSS does not currently differentiate between the different DC link configurations. This means that the loss of infeed risk allowed for outages on DC bipoles, including those which could effectively operate as two independent links, is the same as that allowed for outages on monopoles. This imposes an unduly onerous restriction on offshore network designs.

A review of the NETS SQSS to allow different treatment of DC configurations based on whether they have common modes of failure or not will have no material impact on the National Electricity Transmission System provided that:

- the revised legal text is sufficiently robust to mitigate any such impact, and
- any new common modes of failure introduced using such configurations are addressed explicitly.

The review of the legal text will need to cover:

- the definition of a DC Converter and how that works in conjunction with clauses 7.7.2.1, 7.7.2.2, 7.7.12.1, and 7.7.12.2;
- a review of the definition of an Offshore Transmission Circuit and how that interacts with clauses 7.8.1, 7.8.2, 7.11.1, and 7.11.2;
- a potential additional set of clauses to deal with the issue of having cables running in close proximity to each other; and
- a potential review for the N-1-1 conditions in 7.7.2.2, 7.8.2, 7.11.2, and 7.12.2.2 to ensure they are sufficiently robust to ensure that a DC bipole automatically de-loads following an outage on the return cables to a maximum of the infrequent loss of infeed risk.

The initial proposal is to:

- modify the last sentence of the definition of a DC converter so that it becomes “in a bipolar arrangement, where there is a common mode of failure that would cause a fault outage on either of the two poles to affect the other pole or; where there is an operational requirement that would mean that a planned outage on either of the two poles would require the other pole to be unavailable, a DC Converter represents the bipolar configuration. Otherwise, each of the two poles is a separate DC converter;” and
- add to the definition of an offshore transmission circuit “Elements of an offshore DC system within an offshore transmission circuit which can be isolated by means of a control system action in response to a secured event without affecting the rest of the circuit shall be treated as an independent offshore transmission circuit when applying the said secured event.”

This will allow the secured events considered in 7.7.2.1, 7.7.2.2, 7.7.12.1, 7.7.12.2, 7.8.1, 7.8.2, 7.11.1, and 7.11.2 to be applied independently on each of the two poles of a bipolar DC link with no common modes of failures.

The workgroup will need to consider:

- the robustness of the definitions and any potential unintended consequences; and
- alternatives proposals such as a minor change to the wording in 7.7.2.1, 7.7.2.2, 7.7.12.1, 7.7.12.2, 7.8.1, 7.8.2, 7.11.1, and 7.11.2 such that the secured events considered are an outage “on” the converter or the circuit rather than an outage “of” the converter or the circuit.

The treatment of some DC bipoles as two independent DC converters is likely to result in the total power transfer across the link exceeding the infrequent loss of infeed risk. This means that, where the cables are laid too close to each other, a ship anchor dragging across the seabed could affect the entire link. To address this, the initial proposal includes:

- a definition of subsea cables sharing the same route. This definition assumes that these will be within 250m distance from each other for a distance of at least 1km. The 250m is based on analysis done by the GSR013 workgroup. The 1km distance is chosen arbitrarily.
- A requirement to ensure that the loss of infeed risk associated with the simultaneous loss of any subsea cables sharing the same route does not exceed the infrequent loss of infeed risk.

The workgroup will need to consider:

- the materiality of the risk that a ship anchor will cause a simultaneous damage to multiple cables laid too close to each other;
- whether the risk is minimised/mitigated by other codes of practice or not;
- whether the risk is analysis done by the GSR013 workgroup to assess the minimum cable separation requires updating or not; and
- whether the 250m and the 1km values used in the initial proposal are adequate or not.

DC bipoles with metallic return are likely to operate, for the majority of the time, in a balanced mode. This means that the metallic return will not carry any current and will be at the earth potential. As a consequence, damage to the metallic return conductor will not have an immediate impact on the operation of the DC link other than that it will establish a common mode of failure that affects both poles. If such damage is undetected, or if the link continues to operate at its full capacity following such damage, there is a risk that the frequency response dispatched will not be sufficient to secure a subsequent outage on the link.

We note that DC bipoles where the metallic return is via the sheath of the main conductor (provided that these are sized to carry the rated current) will not carry this risk since damage to the sheath is likely to affect the main conductor as well. However, where the metallic return is provided by separate conductors, this risk will be material and is necessary to be addressed.

The current proposal assumes that the N-1-1 criteria in 7.7.2.2, 7.8.2, 7.11.2, and 7.12.2.2 are sufficient to ensure that a DC bipole with metallic return will automatically de-load to ensure that any subsequent secured event affecting the link will not cause a loss of infeed in excess of the infrequent loss of infeed risk. This assumption will need to be assessed by the workgroup.

## The Limit to the Loss of Infeed Risk for Offshore DC Converters

Clauses 7.7.2.1 and 7.12.2.1 restricts the loss of power infeed risk associated with a secured event on a single DC converter to the *normal loss of infeed risk* (1320MW). This restriction was placed due to the lack of reliability data for large DC converters. A further review in 2012 concluded that the likelihood of a DC converter fault is too high to allow a recommendation to increase the loss of infeed risk allowed for such event.

There have been several changes that have taken place since the latest review for these requirements in 2012. These include:

- an increase in the targeted installed capacity of offshore wind generation and a drive to connect these not only in the most economic and efficient way but also in a way that minimises the environmental impact of such connections;
- a change to the frequency control methodology with the discontinuation of having to restrict frequency drop associated with infeed losses below the normal loss of infeed risk to a minimum of 49.5Hz and replacing that with an annual assessment

process that specifies the main parameters of frequency control strategy that would guarantee that frequency excursions below 49.5Hz are limited in both frequency and duration; and
- availability of further reliability data for large DC converters.

Taking all these factors into account, the initial proposal is to revise clause 7.7.2 and 7.12.2 to refer to the *infrequent loss of infeed risk* instead of the *normal loss of infeed risk*. However, the workgroup will need to discuss alternatives including:
- not proposing any change; or
- proposing a change to the level of the *normal loss of infeed risk*.

The impacts that need to be considered are:

1. Cost of frequency response services required to ensure that for all secured events, the system frequency does not drop below 49.2Hz and is restored to above 49.5Hz within 60s.
   With this cost set by the largest loss prevailing in real time, once the 1800MW nuclear units start operating, any 1800MW wind capacity will have a minimal impact on this cost.

2. The potential increase in the number of events per year when the system frequency drops below 49.5Hz.
   This number of events is influenced by the frequency control strategy applicable at the time as set out in the frequency and control report. Assuming these will continue to recommend securing the largest generation loss to 49.2Hz but not set a value on the generation loss that would need to be secured to 49.5Hz, a revision of the requirements in 7.7.2 and 7.12.2 are likely to result in the increase in the number of instances of the frequency dropping below 49.5Hz.

   Analysis to quantify this increase will consider:

- the potential number of faults per converter per year;
- the likelihood of the wind output being at a certain level;
- the likelihood that a specific level of wind output will materialise at a time when system parameters (demand and inertia) are such that the loss of such level would cause the frequency to drop below 49.5Hz; and
- the availability of measures that would reduce the risk of such events having a significant impact on the system frequency. This includes automatic post fault redispatch of flows on the DC offshore system.

   Analysis to support the assessment of this impact will need to consider the relative level of risk arising from increasing the level of generation of an offshore windfarm such that the maximum loss of infeed risk associated with one converter increases from 1320MW to 1800MW.

3. If impact 2 is significant, the increase in the cost of frequency response services required to ensure that for some secured events, the system frequency does not drop below 49.5Hz.

4. The benefits of allowing a larger infeed loss on the system include:
   a. Cost savings: This will be delivered via the implementation of the designs recommended by the holistic network design project.
   b. Civil and environmental savings

Work completed by the Holistic Network Development (HND) team has predicted a £5.5bn reduction in cost due to these considerations.

## Draft legal text

7.7.2.1 *following a planned outage or a fault outage of a single DC converter on the offshore platform, the loss of power infeed shall not exceed the* ~~normal~~ infrequent *infeed loss risk*". This will include providing clear definition and requirements for bipole circuits.

7.12.2.1 following a planned outage or a fault outage of a single DC converter at the onshore DC conversion facilities, the loss of power infeed shall not exceed the ~~normal~~ infrequent infeed loss risk.

7.8.2 following a *fault outage* of a single cable *offshore transmission circuit* during a planned outage of another cable offshore transmission circuit the further loss of power infeed shall not exceed the infrequent infeed loss risk.

7.8.3 following the concurrent fault outage of any two cable *offshore transmission circuits sharing the same route*, the loss of power infeed shall not exceed the infrequent infeed loss risk;

**Definitions section:**

DC converter:

Any apparatus used as part of the national electricity transmission system to convert alternating current electricity to direct current electricity, or vice-versa. A DC Converter is a standalone operative configuration at a single site comprising one or more converter bridges, together with one or more converter transformers, converter control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion. In a bipolar arrangement, where there is a common mode of failure that would cause a fault outage on either of the two poles to affect the other pole or where there are operational requirements that would mean that a planned outage on either of the two poles would require the other pole to be unavailable, a DC Converter represents the bipolar configuration. Otherwise, each of the two poles is a separate DC converter.

Offshore Transmission Circuit:

Part of an offshore transmission system between two or more circuit-breakers which includes, for example, transformers, reactors, cables, overhead lines and DC converters but excludes busbars and onshore transmission circuits. Elements of an offshore DC system within an *offshore transmission circuit* which can be isolated by means of a control system action in response to a *secured event* without affecting the rest of the circuit shall be treated as an independent *offshore transmission circuit* when applying the said *secured event.*

Offshore Cable Circuits Sharing the Same Route:

Two or more cable *offshore transmission circuits* that run within a distance of 250 meters from each other for a distance of 1000 meters or more.

## What is the impact of this change?

| Proposer's assessment against SQSS Objectives | |
|---|---|
| **Relevant Objective** | **Identified impact** |
| (i) facilitate the planning, development and maintenance of an efficient, coordinated and economical system of electricity transmission, and the operation of that system in an efficient, economic and coordinated manner; | **Positive**<br>The proposed change will facilitate better optimisation of the offshore network assets. |
| (ii) ensure an appropriate level of security and quality of supply and safe operation of the National Electricity Transmission System; | **Neutral**<br>There will be an increased level of frequency excursions however the benefits delivered by optimisation will outweigh that cost. |
| (iii) facilitate effective competition in the generation and supply of electricity, and (so far as consistent therewith) facilitating such competition in the distribution of electricity; and | **Neutral** |
| (iv) facilitate electricity Transmission Licensees to comply with any relevant obligations under EU law | **Neutral** |

| Proposer's assessment of the impact of the modification on the stakeholder / consumer benefit categories | |
|---|---|
| **Stakeholder / consumer benefit categories** | **Identified impact** |
| Improved safety and reliability of the system | **Neutral** |
| Lower bills than would otherwise be the case | **Positive**<br>The facilitation of the implementation of the designs recommended by HND will reduce costs to consumers. |
| Benefits for society as a whole | **Positive** |

| | |
|---|---|
| | Will accelerate progress to net zero targets |
| Reduced environmental damage | **Positive**<br>Reduction in landing points and cable routes will reduce environmental damage |
| Improved quality of service | **Neutral** |

## When will this change take place?

**Implementation date**
May 2023

**Date decision required by**
May 2023

**Implementation approach**
To be discussed by the Workgroup.

**Proposer's justification for governance route**
Governance route: Standard Governance modification with assessment by a Workgroup

This modification will be presented by the Proposer to the Panel on 14 September 2022. The Panel will consider the Proposer's recommendation and determine the appropriate route.

## Interactions

☐Grid Code
☐European Network Codes
☐BSC
☐Other modifications
☐STC
☐Other
☐CUSC

No impact identified.

## Acronyms, key terms and reference material

| Acronym / key term | Meaning |
|---|---|
| BSC | Balancing and Settlement Code |
| CUSC | Connection and Use of System Code |
| STC | System Operator Transmission Owner Code |
| SQSS | Security and Quality of Supply Standards |
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**Reference material**

- https://www.nationalgrideso.com/document/15076/download