nationalgrid

Stage 01: Workgroup Report

National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS)

GSR020: The Modification of Clause 7.8.1.1 to Allow Single Transformer Offshore Substations of Capacity Greater than 90MW

Workgroup Report

What stage is this document at?

01	**Workgroup Report**
02	Industry Consultation
03	Report to the Authority

This proposal seeks to modify the NETS SQSS to clarify the requirements of SQSS which appear to prevent the single transformer installations on offshore installations above a power level of 90MW

This document contains the findings of the Workgroup which was formed April 2015 and concluded September 2015

Published on: **30 October 2015**

The Workgroup recommends:
Requirement can be met with guidance note and side letter without a change to SQSS

High Impact:
None identified.

Medium Impact:
Offshore developers

Low Impact:
National Grid.

Contents

Any Questions?

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About this Document

This document is a Workgroup Report which contains the discussions and recommendations of the GSR020 Workgroup: The Modification of Clause 7.8.1.1 to allow Single Transformer Offshore Substations of Capacity Greater than 90MW

Document Control

Version	Date	Author	Change Reference
0.1	10/09/2015	National Grid	Draft Workgroup Report
1.0	30/10/2015	National Grid	Final Workgroup Report

1 Executive Summary

Open Letter

This summary forms the text for the open letter to industry

1.1 Advances in technology in the offshore industry have made it viable for an offshore substation platform to be mounted on the same standard foundation as a wind turbine. This potentially enables capex savings for example by eliminating the requirement for special heavy lifting vessels chartered specifically for a large platform. The space on the new platforms is, however, limited to the extent that only a single transformer can be mounted on such a platform. Thus, instead of a single platform, two platforms are required to house the necessary transformers and associated equipment.

1.2 Until now, such designs are treated as a design variation, as interpretation of the SQSS deemed the design to be non-compliant to Clause 7.8.1.1. A single transformer platforms design, rather than the traditional single platform with multiple transformers, could result in a reduction of energy delivered by the project over its lifetime. As the project qualifies for subsidy, it is important that the end consumer is not financially disadvantaged. The working group therefore set out to investigate through cost benefit analysis if such schemes provide a net benefit to the end consumer, as well as being in the developers' interest and to decide if the interpretation of the SQSS should be clarified / qualified as necessary.

1.3 The cost benefit analysis showed that for various development configurations and sizes there was an overall saving to the end consumer using the single transformer option. A range of sensitivities was applied and the assumptions feeding the CBA were challenged.

1.4 It was argued that the wording in SQSS already allows for such a design and therefore no change to SQSS was required. The working group agreed that SQSS can be interpreted in this way but that clarification is required. To this end, and with the agreement of the SQSS Review panel, it was proposed that a side letter that makes clear the Transmission Licensee will not require a design variation to be submitted in these circumstances would suffice and this would provide the necessary assurance for developers to progress such projects reducing the project risk that a design variation might entail.

1.5 It was not the intention of the group to preclude existing or future design solutions or to dictate which design is appropriate for a particular project, merely to widen the options available to developers which comply with SQSS without a design variation being required.

1.6 The workgroup was not tasked with finding the most economical solution and did not consider an exhaustive range of possible configurations. Further guidance on the overall efficiency of projects is beyond the scope of this workgroup.

1.7 In conclusion, the working group agreed that the side letter referring to the guidance note prepared by the group and this report is sufficient without an SQSS modification.

2 Purpose & Scope of Workgroup

2.1 At the April 2015 NETS SQSS Review Panel, Nigel Platt presented GSR020 which proposed that a Workgroup was established to investigate Modification of Clause 7.8.1.1 to allow single transformer offshore substations of capacity greater than 90MW. The NETS SQSS Review Panel agreed that this issue required further investigation and approved the Terms of Reference.

Terms of Reference

2.2 A copy of the Terms of Reference can be found in Annex 1.

Timescales

2.3 It was agreed that this Workgroup would report back to the December 2015 NETS SQSS Review Panel. Subsequently the good progress made allowed this to be brought forward and findings and recommendations were discussed at the August 2015 NETS SQSS panel meeting

Timeline

Workgroup Meeting Dates

M1 – 05 June 2015

M2 – 16 July 2015

M3 – 13 August 2015

M4 – 15 October 2015

Why change ?

Progress in technology that wasn't anticipated when SQSS was written is a key driver

Background

3.1 At the start of the project, the modification proposal submitted stated the following information.

3.2 "Siemens along with other manufacturers are developing new systems to provide lower cost export of offshore wind farm power to shore. A common feature of these systems is the simplification of the offshore equipment and in particular a reduction of the number of transformers on each offshore installation. The current NETS SQSS regulations appear to prevent the use of single transformer installations at power levels above 90MW: this is hampering the introduction of the lower cost solutions.

3.3 Siemens has compared a state of the art two transformer offshore substation with an installation using two of the lower cost single transformer modules and can show a positive cost benefit analysis over the lifetime of the wind farm.

3.4 Siemens requested a review of the relevant section of the NETS SQSS to allow the compliant use of the new lower cost solutions.

Description & Background

3.5 The cost of manufacturing the structures that support offshore power transmission equipment and the transport and installation of these structures represent the largest proportion of the capital cost of an offshore substation.

3.6 As wind turbines grow in size their foundations are increasing in size and load bearing capacity. It is now possible to use a wind turbine foundation to support an optimized "mini" substation platform and to use the foundation installation vessel to install the substation module saving the cost of designing and constructing a one off foundation for the substation and also saving the cost of hiring a separate heavy lift vessel.

3.7 To create the "mini" substation, the equipment that would have been put onto one larger platform is broken down and mounted on smaller modules that are placed on their own foundation or share a foundation with a wind turbine. By breaking down the equipment into smaller modules it is possible to save a significant amount of structural steel. To enable the construction of the smaller modules it is necessary to incorporate only one large power transformer per module. This does impact the ability to cross couple circuits to provide redundancy in the event of equipment failure however the lifetime cost of the system can be shown to be lower than conventional offshore substation designs even considering the additional energy that is lost due to potential equipment failure.

3.8 At present Clause 7.8.1.1 of the NETS SQSS states that, in the case of offshore power park module only connections, and where the offshore grid entry point capacity is 90MW or more, following a planned outage or a fault outage of a single AC offshore transformer circuit on the offshore platform, the loss of power infeed shall not exceed the smaller of either: 50% of the offshore grid entry point capacity; or the full normal infeed loss risk. The definition of offshore grid entry point capacity is stated as: the cumulative registered capacity of all offshore power stations connected at a single offshore grid entry point and/or the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system. This is being interpreted to mean that an offshore substation with a capacity of 90MW or greater has to have two transformers. This would prevent the use of low cost “mini” substations containing only one transformer.

Initial Proposed Solution

3.9 That the definition of the offshore grid entry point capacity is clarified to allow the use of multiple single transformer modules so long as the failure of a single module does not reduce the overall system transmission capacity by more than 50%.

3.10 The 90MW limit stated in clause 7.8.1.1 is removed and the clause modified to allow the use of innovative solutions where it can be shown that these solutions offer the lowest overall lifetime cost of power transmission for the wind farm”

3.11 Solutions using more than one transformer per platform were discussed by the working group as possible alternatives to the single transformer per platform solution, however, this was deemed to be out of scope for this working group as multiple transformer platforms are already considered to be compliant to the current SQSS.

4 Workgroup Discussions

4.1 The first Workgroup meeting was held on June 05 2015. As Proposer, Nigel Platt presented the proposal and explained the rationale behind the changes being suggested.

4.2 The Workgroup met four times over the period between June and October 2015

4.3 The Workgroup discussed the changes that have taken place in the offshore industry since the SQSS was introduced and the limitations that the SQSS potentially placed on new developments not envisaged when the original wording was made.

At present Clause 7.8.1.1 of the NETS SQSS states that:

4.4 'in the case of offshore power park module only connections, and where the offshore grid entry point capacity is 90MW or more, following a planned outage or a fault outage of a single AC offshore transformer circuit on the offshore platform, the loss of power infeed shall not exceed the smaller of either: 50% of the offshore grid entry point capacity; or the full normal infeed loss risk.'

4.5 This is one of the core principals of SQSS and is commonly the starting point for the design of any given project. How a project is able to meet this requirement however has been historically restrictive for the designers and although the facility exists to submit a design variation to National Grid this is not always the optimum route for a User because it introduces risk / uncertainty / costs / time. The key point in SQSS that has a significant impact on a User's design options is the interpretation of the definition of 'offshore grid entry point capacity' as shown below;

Offshore Grid Entry Point Capacity (OffGEP Capacity):

4.6 'The cumulative registered capacity of all offshore power stations connected at a single offshore grid entry point and/or the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system.'

4.7 The way the above definition has been interpreted in the past has resulted in designs that are accepted as SQSS compliant without the need for a design variation are always based on having two transformer circuits at each grid entry point and not to treat a given design as an accumulation of offshore grid entry point capacity. By interpreting things in this way it of course allows for the most robust infrastructure for the end customer, however as technology moves forward that can yield further cost benefits to the end user while still complying with SQSS clause 7.8.1.1 it has not always been a clear and easy path to introduce such designs in the knowledge they will be accepted as complying with the SQSS requirements.

Cost Benefit analysis

4.8 The Working Group agreed that a cost benefit analysis (CBA) should be carried out to ascertain that the cost savings of the proposed designs were greater than the cost of any energy lost as subsidised by the end consumer - i.e. there is a net benefit to the UK consumer. It was also determined that the CBA should illustrate the situation for various sizes of offshore wind farm development and various configurations and a range of sensitivities studied.

4.9 The cost benefit analysis spreadsheet is included as an appendix to this report.

4.10 Use of an interlink between platforms

4.10.1 Capital cost savings are achieved when using the single transformer modules through the simplification of the equipment on board which leads to a significantly lower size & weight.

4.10.2 In addition, the lifting vessel used to install the wind turbine foundations can be used to install the single transformer modules - leading to significant cost savings

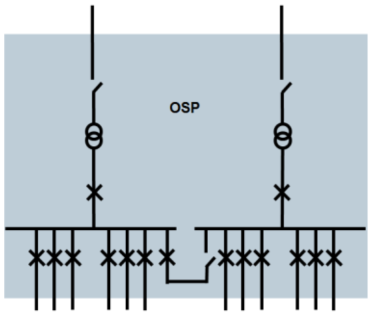
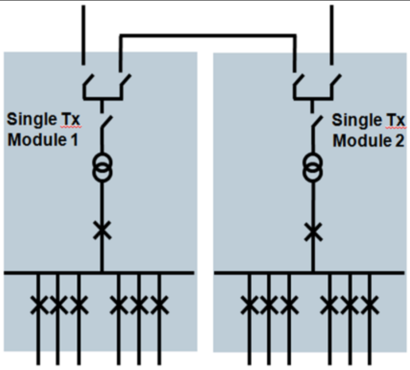
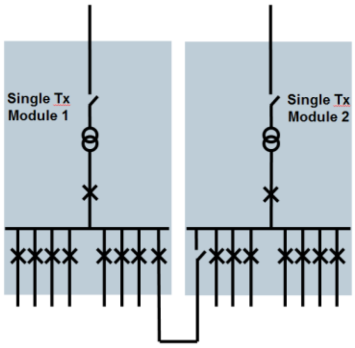
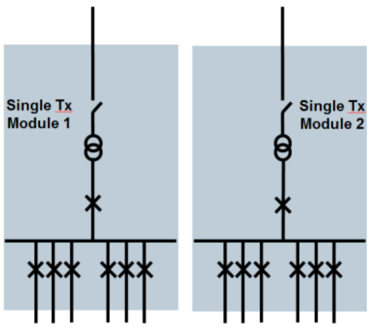
4.10.3 However the fact that the transformers are installed on separated platforms can lead to a reduction in the system redundancy.

In the event that an export cable or the transformer or HV switchgear on one single transformer module fails, the power from part of the wind farm cannot be exported unless interlinks are provided between the faulty module and the remaining module(s). This allows the affected turbines to export their power via the other module(s).

4.10.4 Note that on a single platform with multiple transformers, there is no SQSS requirement to interlink the transformer circuits.

4.11 Single Line Diagrams (see figs 1-4)

Outline single line diagrams for the four systems being compared are shown below.

	Fig. 1 Showing a single platform with two transformers. The two MV circuits connected to the transformers have a (normally open) interconnection.
	Fig 2 Typical diagram for a system using two single transformer modules (platforms) where a HV interconnector between the modules is provided.
	Fig. 3 Showing two single transformer modules (platforms) where a MV interconnector between the modules is provided.
	Fig. 4 Showing a two single transformer modules (platforms) where no interlink is provided between the modules.

4.12 The purpose of the Cost Benefit Analysis is to allow comparison of the overall cost of four different solutions for exporting power from an offshore wind farm:

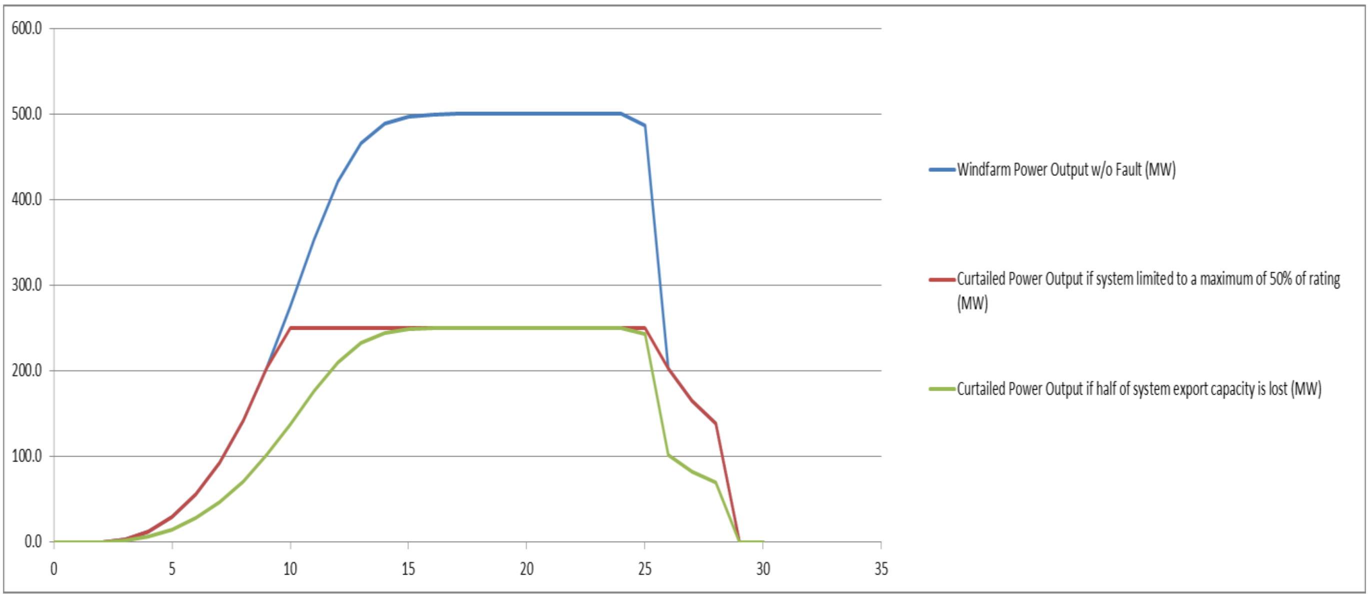
4.12.1 A system using a traditional Offshore Platform (OSP) based substation with two transformers connected to two high voltage export cables. The platform has two medium voltage switchboards connected to the incoming wind turbine (WTG) arrays. The medium voltage switchboards are interconnected via a normally open connection. (Fig 1)

4.12.2 A system using two single transformer modules. Each module has a single transformer connected to a high voltage export cable. The module has high voltage switchgear and a cable cross connection to the other single transformer module rated to 25% of the wind farm capacity. (Fig 2)

4.12.3 A system using two single transformer modules. Each module has a single transformer connected to a high voltage export cable. The medium voltage switchboards on the two single transformer modules are connected by a cable cross connection rated to 25% of the wind farm capacity. (Fig 3)

4.12.4 A system using two single transformer modules. Each module has a single transformer connected to a high voltage export cable. There are no interconnections between the modules. (Fig 4)

4.12.5 The graph below shows an example of Wind Farm Output vs Wind Speed when there is no fault, when the system output is limited to 50% export capacity by a fault and when half of the export capacity is lost due to a fault. The data is based on a 500MW power transmission system. The power export capacity of the Windfarm's Power Transmission system will determine how much generated energy is prevented from reaching the onshore Grid under fault conditions.



4.13 Guidance to the spreadsheet

4.14 The cost benefit analysis performed is embedded in this document electronically and is also filed alongside this report. The notes below refer to this CBA spreadsheet.

4.15 Assumptions Table

Failure rates, mean time to repair (MTTR) for equipment and connection cables and financial data are stated in the assumption table at the top of the spreadsheet. Values shaded in blue can be changed to allow recalculation of the results.

4.16 Calculation of the effect of limitations of system capacity on the energy exported from the power transmission systems:

In the scenarios considered the failure of equipment in the systems under consideration has two major effects:

a) The maximum output of the wind farm can be limited to 50% of its rating with all WTGs connected to the remaining export system.

Or

b) One half of the wind farm is isolated from the export system while the other half can export power as normal.

4.16.1 In order to calculate the total energy lost due to equipment failure for the three system designs it is necessary to calculate the average loss of power for cases a) and b). These "power loss" values are later multiplied by the duration of the outages to obtain an energy loss value.

4.16.2 A series of output characteristics for a typical wind farm development have been averaged to create a reference wind farm output characteristic. The individual output characteristics were obtained from modelling of the wind farm output using meteorological data for the wind farm site and the analysis took account of the effects of wakes from turbines to produce the most realistic wind farm output prediction possible. Six different scenarios involving different turbines and total capacity were used. The reference wind farm output characteristic is shown in the first three columns of the table.

4.16.3 The table then contains the predicted output power characteristic for the cases where there are no equipment failures, where there is an equipment failure that restricts the maximum output of the wind farm to 50% of its rating and where there is an equipment failure that causes one half of the wind farm to be disconnected from the power export system.

4.16.4 The power outputs at each wind speed are multiplied by the number of hours spent at that wind speed per year to obtain an energy output per year at that wind speed for each of the operating scenarios.

4.16.5 Finally the totals of the energy generated each year for the different operating scenarios are used to calculate the average loss of power output for scenarios a) and b) above by dividing the energy loss if the fault were present all year (in MWh) by the total number of hours in a year.

4.16.6 Only equipment failures that produce a different level of performance between the different system designs have been considered. Equipment failures that have the same effect on all systems are not considered.

4.17 Calculation of Outage durations and energy lost due to Transformer, Switchgear or Cable Failure

4.17.1 The first rows of the table show data transferred down from the assumptions table and calculations of mean outage durations using the failure rates and data such as cable lengths (where failure rates are expressed in events/km/year).

4.17.2 The outage durations are summed for each system design and grouped together in the table against the level of energy output reduction that occurs for each failure type.

4.17.3 Outage durations are then multiplied by mean power lost for each type of failure to obtain the average energy lost per year for each system design.

4.17.4 This average energy loss is converted to an average revenue loss using the values of energy generated during and after the contracted period.

4.18 Calculation of Commercial Impact

4.18.1 Using the capital cost saving information from the assumptions table and the cost of energy loss information from the calculations in previous sections, the relative lifetime costs of the different scenarios are evaluated using the Spackman method. Here capital cost differences are converted to a change in annual expenditure by calculating the financing cost for the capital expenditure differences. Any cost savings through lower cost of finance is offset against higher costs of energy lost due to reduced redundancy where appropriate.

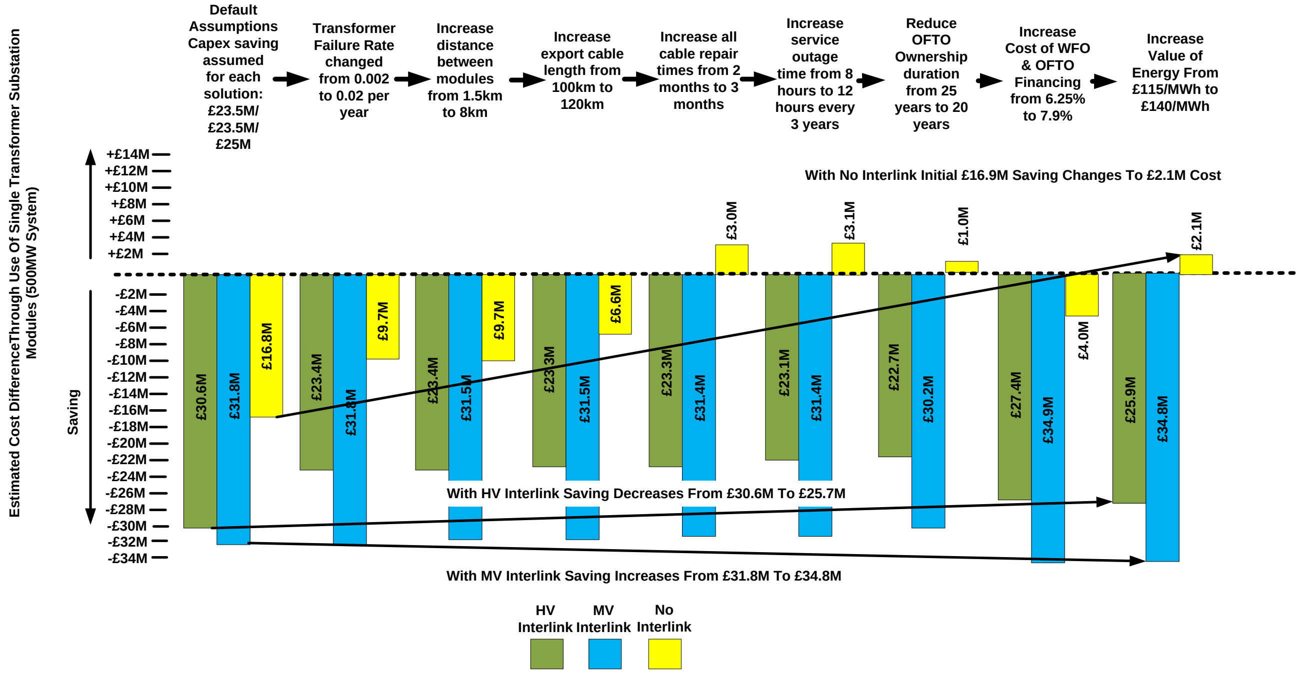
4.18.2 The overall effect on the system cost is calculated for each year of construction and operation.

4.18.3 In the first three years the power export system is being constructed and it is assumed that the capital expenditure is spread evenly over this period.

4.18.4 The annual overall system cost difference figures are then multiplied by a Net Present Value factor to convert future expenditure to today's value and the total cost difference over the lifetime of the system is summed together.

4.19 Illustrative result of CBA - Effect on cost saving through use of single transformer modules as assumptions are changed from default to worst case.

The diagram below illustrates selected scenarios derived from the CBA spreadsheet. By compounding the "worst cases" it can be seen that in all cases, there is a positive benefit to the single transformer platforms when an interconnection between modules is present, and that there is a positive saving for non-interconnected designs for the default and certain other cases. In extreme scenarios with no interconnector, there can be a net cost.



4.20 Reactive Compensation

4.20.1 When setting the objectives for the GSR020 working group there was discussion regarding offshore reactive compensation and its influence on the evaluation of single transformer offshore substation modules vs traditional multi-transformer modules.

4.20.2 After open discussions it was decided that the comparison of single vs multiple transformer offshore substation modules would not include any consideration of offshore reactive compensation.

The rationale has been included as Annex 3

4.21 Conclusion of Cost Benefit Analysis: Calculation of Commercial Impact

For the cases considered, the following lifetime cost savings were calculated for a 500MW system when using the default parameters in the Cost Benefit Analysis:

4.21.1 - Single Transformer Platform based System with HV interlink saving of £30.6M

4.21.2 Single Transformer Platform based System with MV interlink - saving of £31.8M

4.21.3 Single Transformer Platform based System with No interlink - saving of £16.8M

4.22 Analysis was also performed for 250MW, 750MW and 1000MW systems.

4.23 The conclusion is that across the range of sensitivities the work group have considered significant savings can be made using the designs considered.

4.24 Challenges to assumptions

The working group considered the assumptions used in the CBA and developed a range of outcomes based on these sensitivities.

5 Impact & Assessment

Impact on the NETS SQSS

The Workgroup recommends that no modification on the SQSS is required. The proposal will be addressed through “open letter” and WG’s guidance note which is included as Annex 5 of this report.

5.1 The aim of the guidance note is to clarify the definition of Offshore Grid Entry Point Capacity and to highlight some high level design opportunities that will allow more flexibility for Developers to use single transformer platforms without the need for a design variation.

Impact on the National Electricity Transmission System (NETS)

5.2 The proposed changes will not impact adversely on the NETS

Impact on NETS SQSS Users

5.3 The proposed guidance will clarify SQSS clause 7.8.1.1 that such designs will be accepted as complying with the SQSS requirements..

5.4 This should provide assurance to developers and their associates that a design variation is not required to comply with SQSS in these circumstances.

5.5 It is not considered that there are wider impacts on SQSS as a result of this piece of work.

Impact on Greenhouse Gas Emissions

5.6 The proposed guidance will reduce Greenhouse Gas Emissions due to the reduction in steelwork required in construction.

Assessment against NETS SQSS Objectives

5.7 The Workgroup considers that the proposed amendments would better facilitate the NETS SQSS objectives:

5.7.1 *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;*

The clarification will permit the use of economic designs as outlined in this report and the guidance note without the requirement for a design variation being submitted.

5.7.2 *ensure an appropriate level of security and quality of supply and safe operation of the National Electricity Transmission System;*

The proposal has a neutral impact on this objective.

5.7.3 *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*

The proposal has a neutral impact on this objective.

5.7.4 *facilitate electricity Transmission Licensees to comply with their obligations under EU law.*

The proposal has a neutral impact on this objective.

Impact on Core Industry Documents

5.8 The proposed guidance does not impact on any core industry documents.

Impact on Other Industry Documents

5.9 The proposed guidance does not impact on any other industry documents.

Implementation

5.10 The Workgroup proposes that this report and the accompanying open letter are published and that transmission companies can take account of these in future projects.

6 Workgroup Recommendations

6.1 The findings of the workgroup are that transmission systems based on single transformer modules are an economic solution to export power from offshore wind farms and therefore should be allowed to be used without the need for a design variation.

6.2 This does not preclude the use of offshore installations using multiple transformer platform solutions.

6.3 The existing SQSS standard document already allows for the use of multiple single transformer platforms based on the second definition of the offshore grid entry capacity. The Workgroup concludes that designs submitted based on the OffGEP definition – '*the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system'* will no longer automatically require a design variation.

6.4 Transmission Companies will accept that project designs that use this definition of OffGEP are a valid approach as long as the design complies with the core requirements of SQSS clause 7.8.1.1.

6.5 As further clarification it should be noted that clause 7.8.1.1 clearly refers to the offshore capacity as a fixed registered park size (e.g. 500MW) and does not mandate that a given design must be able to export 50% of available power at any one time during a fault or outage. For example, if there are two single transformer platforms with an interconnector and one of the export cables failed then the design would still be compliant regardless of whether the interconnector was rated for export loads or just life support.

6.6 The Workgroup recommends:

(a) No change required to SQSS

(b) Publication of the open letter accepting interpretation of the SQSS as described by this working group

Annex 1 - Terms of Reference

National Electricity Transmission System Security and Quality of Supply Standards Modification of Clause 7.8.1.1 to Allow Single Transformer Offshore Substations of Capacity Greater Than 90MW
TERMS OF REFERENCE

Governance

The Modification of Clause 7.8.1.1 to Allow Single Transformer Offshore Substations of Capacity Greater Than 90MW Workgroup was established by the National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS) Review Panel at the April 2015 NETS SQSS Review Panel Meeting.

The Workgroup shall formally report to the NETS SQSS Review Panel.

Membership

The Workgroup shall comprise a suitable and appropriate cross-section of experience and expertise from across the industry, which shall include: **[see following annex for workgroup members]**

Meeting Administration

The frequency of Workgroup Meetings shall be defined as necessary by the Workgroup chair to meet the scope and objectives of the work being undertaken at that time. National Grid shall provide technical secretary resource to the Workgroup and handle administrative arrangements such as venue, agenda and minutes. The Workgroup will have a dedicated section on the National Grid website to enable information such as minutes, papers and presentations to be available to a wider audience.

Scope

The Workgroup shall consider and report on the following:

The Offshore Grid Entry Point Capacity (OffGEP) definition.

Whether the current clauses 7.8.1.1 and 7.13.1.1 should be modified to ensure that the most economic and efficient solutions for the connection of all offshore wind-farm connections can be facilitated by allowing the use of single transformer offshore substation modules/platforms.

The scope of the Workgroup shall not include:

Anything beyond the scope outlined above.

Deliverables

The Workgroup shall provide updates and a Workgroup Report to the NETS SQSS Review Panel which will:

Detail the findings of the Workgroup;

Draft, prioritise and recommend changes to the NETS SQSS and any associated documents in order to implement the findings of the Workgroup; and

Highlight any consequential changes which are or may be required.

Timescales

It is anticipated that this Workgroup shall provide an update to each NETS SQSS Review Panel Meeting and present a Workgroup Report to the December 2015 NETS SQSS Review Panel Meeting.

If for any reason the Workgroup is in existence for more than one year, there is a responsibility for the Workgroup to produce a yearly update report, including but not limited to; current progress, reasons for any delays, next steps and likely conclusion dates.

John West
NETS SQSS Review Panel Chair
john.west@nationalgrid.com
07768 577940

20 October 2015

Dear Industry Participants,

Re: GSR020: The Modification of Clause 7.8.1.1 to Allow Single Transformer Offshore Substations of Capacity Greater than 90MW.

Introduction:

In April 2015, the NETS SQSS Review Panel initiated a Workgroup to consider Clause 7.8.1.1 and the definition of Offshore Grid Entry Point Capacity (OffGEP) within the NETS SQSS (Modification GSR020). This was intended to clarify the use of single transformer offshore platforms for generation connections to offshore transmission systems.

NETS SQSS Panel View:

The findings of the GSR020 Workgroup are that offshore transmission systems using single transformer offshore platforms are an economic solution to export power from offshore installations and that these should be allowed under the NETS SQSS without the need for a design variation. (Variations to Connection Designs are described in Clauses 7.21 through to 7.24. of the NETS SQSS.) Having reviewed these findings, the NETS SQSS Review Panel has concluded that no modification of the NETS SQSS is required.

In line with the Workgroup view, the NETS SQSS Review Panel considers that the existing NETS SQSS already allows for the use of multiple single transformer platforms. The second part of the current OffGEP definition '*the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system*' allows for the capacity considered in Clause 7.8.1.1 to be aggregated across a number of platforms in the same offshore transmission system. Designs based on this definition of OffGEP should be acceptable to Transmission Licensees without the need for a design variation if the design meets the other requirements of the NETS SQSS.

Through the publication of this open letter and the GDR020 Workgroup report, the NETS SQSS Review Panel confirms that Transmission Licensees do not require a design variation to be submitted in these circumstances. This should also provide the necessary assurance for developers to progress designs utilising single transformer offshore platforms.

This interpretation does not preclude the use existing or future offshore designs, merely increases the options available to developers which comply with SQSS.

Further information to support the NETS SQSS Panel view is provided is the summary paragraphs below and in the Workgroup report which is published alongside this letter.

Background:

Advances in technology in the offshore industry have made it viable for an offshore substation platform to be mounted on the same standard foundation as a wind turbine. Previously, larger offshore platforms were provided to support the offshore substation. Where the capacity of the offshore installation was 90MW or more, more than one transformer would be installed on these larger platforms to satisfy the requirements of Clause 7.8.1.1.

Mounting the substation platform on the same foundation type as would be used for a wind turbine potentially enables potentially enables significant capital cost savings, for example by eliminating the requirement for special heavy lifting vessels chartered specifically for a larger platform. The space and weight restrictions on these new platforms are however limited to the extent that only a single transformer is mounted on such a platform. Thus, instead of a single larger platform, at least two platforms are used for the necessary transformers and associated equipment. In cases where such a design has been proposed before now, it has been interpreted as not meeting the requirements of Clause 7.8.1.1. Each platform has been considered to be a separate Offshore Grid Entry Point and a design variation has been required for the design to be taken forward.

Workgroup Assessment:

The GSR020 Workgroup assessed whether a single transformer platform design, rather than the traditional single platform with multiple transformers could result in an overall benefit by comparing the benefit of reduced capital costs against the costs of any reduction of energy delivered by the project design over its expected lifetime. The Workgroup set out to investigate through cost benefit analysis (CBA) if such schemes provide a net benefit to the end consumer, as well as being in the developers' interest and to decide if the NETS SQSS should be revised or clarified as necessary.

The cost benefit analysis showed that for various offshore power station configurations and sizes, there was an overall saving to the end consumer through using the single transformer offshore platform option. A range of sensitivities was applied and the assumptions underlying the CBA were investigated.

The Workgroup consider that the NETS SQSS already allows for such designs (subject to the ratings of the transformers -) and therefore no change to the NETS SQSS is required.

Annex 3 - Rationale For Decision To Exclude Offshore Reactive Compensation From Evaluation Of Single Transformer Offshore Substation Modules (GSR020)

6.7 Introduction

When setting the objectives for the GSR020 working group there was discussion regarding offshore reactive compensation and its influence on the evaluation of single transformer offshore substation modules vs traditional multi-transformer modules.

After open discussions it was decided that the comparison of single vs multiple transformer offshore substation modules would not include any consideration of offshore reactive compensation.

This section

Written by Nigel Platt, Siemens.

6.8 Rationale

6.8.1 Compensation of the (capacitive) reactive power generated by high voltage AC cable connections to offshore wind farms is needed to ensure that the connection to the onshore grid transmits the real power generated by the wind turbines but limits the reactive power delivered to the onshore grid to within that specified in the relevant codes.

6.8.2 A number of compensation strategies are available and include the compensation of the high voltage export cables at one end, at both ends and part way along the export cable route.

6.8.3 For long export cables, reactive compensation at the offshore end can be used to reduce the reactive power flow in the export cables and allow more real power to be transmitted via a given cable cross section or allow a smaller cable cross section to be used for a given real power transfer.

6.8.4 Offshore compensation can be provided by using fixed reactors, by using the reactive power capabilities of modern wind turbine generators containing AC/AC converters or by a combination of both.

6.8.5 The decision on which compensation strategy to use will largely be an economic one – determined by which strategy gives the lowest lifetime cost for the wind farm and grid connection as a whole.

6.8.6 For relatively close to shore (say 50km export cable length) grid connections the economic analysis currently points towards all reactive compensation being located onshore whereas for further from shore (say 100km export cable length) grid connections compensation provided onshore and offshore appears to be the most economical solution. However it should be noted that this is a generalised statement and every project needs to be evaluated separately.

6.8.7 The GSR020 application to modify the SQSS was submitted to allow the use of single transformer offshore substation modules as opposed to traditional multi-transformer modules without the need to use the SQSS Design Variation clause. The reason for requesting that single transformer modules be allowed to be used without project by project evaluation is that through analysis of a range of conditions they appear to offer a saving in the lifetime cost of grid connections for offshore wind farms – although they have reduced redundancy, the value of any additional energy lost due to equipment failure is more than compensated for by their saving in capital cost.

6.8.8 The issue of how to compensate the capacitive reactive power generated by the high voltage export cables to an offshore wind farm is equally applicable to grid connections built with single transformer substation modules or multi-transformer substation modules.

6.8.9 Designs for single transformer substation modules fitted with fixed reactors have been created (by DONG Energy) so it is clear that if it is deemed the most economical solution to use fixed reactors offshore to provide reactive power compensation then it is technically possible to incorporate these into single transformer substation modules.

6.8.10 From the information we have, the addition of fixed reactors to single transformer offshore substation modules would add no more cost to a grid connection solution designed using single transformer substation modules than it would to a solution designed using multi-transformer substation modules. An important consideration would be if the addition of the fixed reactor pushed the weight of single transformer module solution above the limit at which it could be lifted by the wind-turbine foundation installation vessel. The use of this vessel rather than one specially hired to lift the substation and its foundation is a significant advantage for single transformer substation modules - if this weight limit were exceeded then the use of a single transformer module based solution may be excluded if other benefits were insufficient.

6.8.11 There are a number of wind farm projects currently considering the use of single transformer module based grid connection designs, some are planning to use reactive compensation onshore only and some are considering on and offshore compensation.

6.9 Conclusion

6.9.1 As the method of reactive power compensation does not appear to erode the economic benefits of using single transformer substation modules and all technical solutions for reactive compensation available to multi-transformer substations are available to systems using single transformer modules, it was agreed that the evaluation of single transformer substation modules would not include consideration of reactive power compensation equipment.

Annex 3: Assumptions used in Cost Benefit Analysis

Parameter		Baseline Assumption		Notes		Worst Case Assumption (where different from Baseline)		Notes
Probability of an offshore transformer fault		0.002	events/transformer /year	Transformer Supplier Figure		0.02	events/transformer /year	Higher estimate taken from CIGRE TB537 - Transformer Fire Safety Practices Section 3.11 Table 1 - 1983 survey
Mean Time To Repair Offshore Transformer		4	months	Service Organisation Estimate				
Probability of Failure of HV GIS Bay (disconnector)		0.0011	events/bay/year	Supplier HV Switchgear Group Figure				
Mean Time To Repair HV GIS Bay		10	days	Service Organisation Estimate				
Probability of Failure of MV GIS Bay		0.0011	events/bay/year	MV Switchgear Supplier Group Figure				
Mean Time To Repair MV GIS Bay		10	days	Service Organisation Estimate				
Failure Rate of MV Cable Interlink		0.0008	failures/km/year	Carbon Trust 33/66kV Array Cable Comparison "Best Case"				
Length of MV Interlink Cable		3	km	Typical Layout (2 cables per interlink)		16	km	Based on an actual layout believed to be an extreme case
Mean Time To Repair MV Cable Link		2	months	Estimate from cable supplier/installer		3	months	Based on practical experience
Failure Rate of HV Cable Interlink		0.0008	failures/km/year	Use same rate as MV cable - Cable supplier estimate actually 0.0002				
Length of HV Interlink Cable		1.5	km	Typical Layout		8	km	Based on an actual layout believed to be an extreme case
Mean Time To Repair HV Cable Link		2	months	Estimate from cable supplier/installer		3	months	Based on practical experience
Failure Rate of HV Export Cables		0.0008	failures/km/year	Use same rate as MV cable - Cable supplier estimate actually 0.0002				
Length of HV Export Cables		200	km	Total export cable length for a typical layout		240	km	Increased to cover projects expected to use AC connection solution

Mean Time To Repair HV Export Cable		2	months	Estimate from cable supplier/installer		3	months	Based on practical experience
Capacity of HV Interlink		25	%	Assuming even generation across the windfarm and that each export circuit is rated to 50% of the windfarm capacity this is the maximum amount of power that can be transferred from one circuit to other before the remaining circuit reaches its capacity				
Capacity of MV Interlink		25	%	Assuming even generation across the windfarm and that each export circuit is rated to 50% of the windfarm capacity this is the maximum amount of power that can be transferred from one circuit to other before the remaining circuit reaches its capacity				
Average service duration for offshore transformer & HV GIS		2.7	hours/year	Based on 8 hour shift once every 3 years - visual inspection when in service in-between		4	hours/year	Increased outage time to 12 hours to include time for De-energisation & Re-energisation safety process
Value of energy during contracted period		115	£/MWh	Latest CFD winning bid value		140	£/MWh	Highest value from current project under development
Value of energy after contracted period		75	£/MWh	Future estimate from Developer				
Capital Cost Difference between single transformer module based system & multiple transformer based system (HV Interlink)		23.5	£M	Supplier Estimate				
Capital Cost Difference between single transformer module based system & multiple transformer based system (MV Interlink)		23.5	£M	Supplier Estimate				

Capital Cost Difference between single transformer module based system & multiple transformer based system (No Interlink)		25	£M	Supplier Estimate				
Wind Farm Owner Cost of Finance		6.25	%	As per GSR014 Review		7.9	%	Upper value advised by OFTO
OFTO Cost of Finance		6.25	%	Same rate of finance as Wind Farm Owner		7.9	%	Upper value advised by OFTO
Social Time Preference Rate (STPR)		3.5	%					
Lifetime of OFTO Assets		25	years			20	years	Potential shortened lifetime

Annex 4 - Workgroup Members

David Phillips	**Chair**	
Anis Yaakob	**Technical Secretary**	
Biljana Stojkovska	**National Grid Representative**	National Grid
Nick Martin	**National Grid Representative**	National Grid
Nigel Platt	**Industry Representative**	Siemens
Ander Madariaga	**Industry Representative**	Catapult Offshore Renewable Energy
Charles Balderston	**Industry Representative**	EDF Energy Renewables
Predrag Djapic	**Industry Representative**	Imperial College London
Peter McGarley	**Industry Representative**	DONG Energy
Allan Kelly	**Industry Representative**	Mainstream Renewable Power Ltd
Martin Brown	**Industry Representative**	Blue Transmission
Ana Rodriguez Lizana	**Industry Representative**	Scottish Power
Mick Chowns	**Industry Representative**	RWE Innogy UK Ltd
Roger Carter	**Industry Representative**	SSE
Sheriff Ilesanmi	**National Grid Representative**	National Grid

Annex 5 - GUIDANCE NOTE

GUIDANCE NOTE:

USE OF SINGLE TRANSFORMER OFFSHORE PLATFORMS FOR OFFSHORE GENERATION CONNECTIONS GREATER THAN 90MW

SQSS definition of offshore grid entry point capacity

Author(s): Charles Balderston (EDF-ER), on behalf of NGET GSR020 Working Group

This note provides guidance on interpretation of SQSS to parties intending to submit an application in relation to an offshore generation connection for a capacity greater than 90MW.

For information related to a specific connection, please contact transmissionconnections@nationalgrid.com

For additional information related to the contents of this guidance note please contact BOX.SQSS@nationalgrid.com

INDUSTRY GUIDANCE NOTE Produced by SQSS working panel					
Document number:		SQSS GSR020 – GN01			
Document title:		Use of single transformer offshore substations greater than 90MW			
Issue. No	**Date [DD-MMM-YY]**	**Description**	**Prepared**	**Checked**	**Approved**
1.0	16-JUL-15	ISSUED FOR COMMENT	CB	NP	BS
2.0	31-JUL-15	ISSUED FOR TO SQSS PANEL	CB	NP	BS

Scope:

This note provides basic guidance to parties intending to submit a connection/design application in relation to an offshore generation connection. It explains the concept of offshore grid entry capacity, how it is defined and the changes to the design variation requirements. It provides a methodology a potential connectee may use to assess the impacts of design solutions that arise from using single transformer platforms and examples for the application of this methodology. It highlights the potential commercial and contractual benefits of these designs and the potential to avoid the need for a SQSS design variation (see CBA appendices).

Please note:

- The CBA data provided in this note is indicative. Its use within NGET has been limited to high level cost benefit analysis. The examples provided are for illustrative purpose only.
- Actual generation data will vary from site to site and from year to year due to factors such as technology, weather, fuel prices, and changes of operational regimes. This may affect the level of restriction for a specific site. The results of any analysis are indicative only.
- The CBA methodology provided is suitable for connections where the User is comparing a traditional OHVS (offshore high voltage substation) platform with a minimum of two transformer circuits against two separate single transformer platforms.
- Ultimately, whilst the option for Users to submit single transformer designs via a SQSS Design Variation has been available for a long time there has always been an associated cost, time delay and a level of uncertainty / risk in said application. This document aims to clarify means whereby the User can utilise said designs without the need for a design variation while still remaining SQSS compliant.

Introduction:

At present Clause 7.8.1.1 of the NETS SQSS states that:

'in the case of offshore power park module only connections, and where the offshore grid entry point capacity is 90MW or more, following a planned outage or a fault outage of a single AC offshore transformer circuit on the offshore platform, the loss of power infeed shall not exceed the smaller of either: 50% of the offshore grid entry point capacity; or the full normal infeed loss risk.'

This is one of the core principals of SQSS and is commonly the starting point for the design of any given project. How a project is able to meet this requirement however has been historically restrictive for the designers and although the facility exists to submit a design variation to National Grid this is not always the optimum route for a User because it introduces risk / uncertainty / costs / time. The key point in SQSS that has a significant impact on a User's design options is the interpretation of the definition of 'offshore grid entry point capacity' as shown below;

Offshore Grid Entry Point Capacity (OffGEP Capacity):

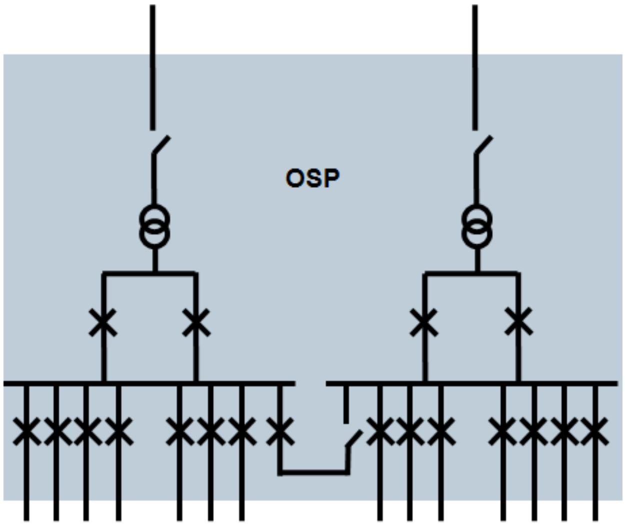
'*The cumulative registered capacity of all offshore power stations connected at a single offshore grid entry point and/or the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system* '.

The way the above definition has been interpreted in the past has resulted in designs that are accepted as SQSS compliant without the need for a design variation but are always based on having two transformer circuits at each grid

entry point and not to treat a given design as an accumulation of offshore grid entry point capacity. By interpreting things in this way it of course allows for the most robust infrastructure for the end customer, however as technology moves forward that can yield further cost benefits to the end user while still complying with SQSS clause 7.8.1.1 it has not always been a clear and easy path to introduce such designs in the knowledge they will be accepted as complying with the SQSS requirements.
The aim of this guidance note is to clarify the definition of Offshore Grid Entry Point Capacity and to highlight some high level design opportunities that will allow more flexibility for Developers to use single transformer platforms without the need for a design variation.

Design:

A common (but not unique) design for an offshore substation at any single grid entry point is shown below:



Offshore platform consists of two transformer circuits in order to meet SQSS security requirements.

Each circuit is connected by a normally open bus bar or possibly cable interconnector rated equal to the export cable; this is not a requirement, only a recommendation

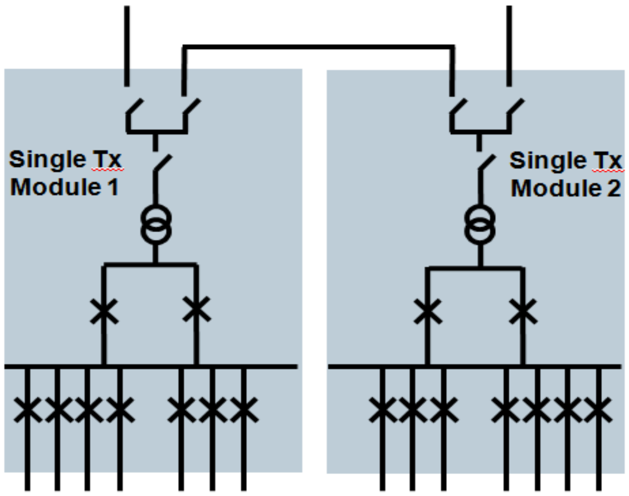
In this example each transformer has two connections to its respective bus bar section, but one connection is acceptable.

Both circuits are contained on a single physical platform

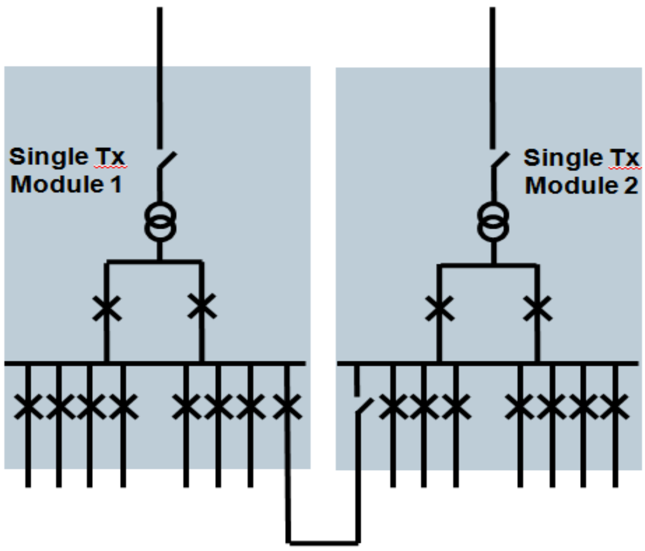
If there is more than one offshore platform it is treated as a separate grid entry point that must be SQSS compliant.

This guidance note offers the opportunity for the industry to explore different designs based around a minimum of two separate single offshore transformer platforms; as of the publication date of this document NGET will no longer expect that designs based on this principal will require a design variation in order to be SQSS compliant.

Some typical examples for design options are shown below but please note these examples are not the only ways to comply with SQSS:



Example 1: two platforms linked by a HV interconnector



Example 2: two platforms linked by a MV Interconnector

- Both examples above comply with the requirement of not losing more than 50% of total registered park size capacity in the event of a transformer fault. In fact even if there was no interconnector of any kind two single platforms would still meet this requirement, subject to equipment and cable ratings.
- When using multiple single transformer platforms connection applications will be accepted based on the definition of the OffGEP, i.e. 'the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system'. This will negate the need for transmission system designs based on a number of single transformer platforms to submit a SQSS design variation.

Summary:

The existing SQSS standard document already allows for the use of multiple single transformer platforms based on the second definition of the offshore grid entry capacity. This guidance note is issued to confirm that designs submitted based on the OffGEP definition – '*the cumulative registered capacity of all offshore power stations connected to all the offshore grid entry points of an offshore transmission system'* will no longer automatically require a design variation. National Grid accepts that project designs that use this definition of OffGEP is a valid approach as long as the design complies with the core requirements of SQSS clause 7.8.1.1.

As further clarification it should be noted that clause 7.8.1.1 clearly refers to the offshore capacity as a fixed registered park size (e.g. 500MW) and does not mandate that a given design must be able to export 50% of available power at any one time during a fault or outage. For example, if there are two single transformer platforms with an interconnector and one of the export cables failed then the design would still be compliant regardless of whether the interconnector was rated for export loads or just life support.

Finally, this note is intended to provide guidance and illustrative examples only. The associated high level cost benefit analysis is not project specific and it is the responsibility of the User to determine the level of security and redundancy that provides the most cost effective solution for their project / plant within the boundaries of SQSS.