Grid Code Subgroup

Recommendations for the application of Grid Code technical requirements to Offshore Electricity Transmission Networks

1.0 SUMMARY

1.1 This paper sets out the policy recommendations of the Grid Code subgroup regarding the application of Grid Code requirements to offshore electricity transmission networks and generators. The paper also identifies any consequential changes to the STC, and some of the issues which require consideration by other working groups. The methodology, sensitivities and results of studies used to validate these recommendations and any alternative options considered are discussed.

1.2 As an initial starting point it was assumed that existing Grid Code requirements applied onshore would be extended offshore unless there is good reason not to do so.

1.3 The main Grid Code policy changes recommended by the group are detailed below:

- With regards to the application of Grid Code requirements, the group proposes that two new classes of generator are defined; Small Offshore Power Station and Large Offshore Power Station, utilising the 10MW threshold currently defined onshore for the SHETL transmission area. Large Offshore Power Stations will be subject to the full requirements of the Grid Code, whereas Small Offshore Power Stations would need to meet the applicable sections of the Grid Code but would be exempt from the requirements of CC.6.3.

- The group propose that there should be provision for a number of 'strings' of wind turbines to be aggregated into one Offshore PPM and hence treated as a single BMU. This would be possible where a number of 'strings', belonging to a single owner, are connected to a single electrically inseparable point. This proposal would also allow any Grid Code requirements to be applied on an aggregated scale and hence provide economy of scale benefits for developers.

- The group propose that the current requirements of CC.6.3.2 specifying reactive power capability should be met by the Offshore TO at the Onshore Grid Entry Point. The group also recommend that for Offshore Generators with an LV Offshore GEP an additional requirement should be introduced stating that the Offshore Generator should have a steady state power factor capability of unity at the Offshore GEP. For Offshore Generators with a HV Offshore GEP an additional requirement should be introduced that is equivalent to providing unity power factor at the LV point but is adjusted to take into account transformer losses. For connections at all voltage levels an enhanced capability in excess of the default requirement can be agreed between the Offshore Generator, Offshore TO and GBSO provided that this can be fully utilised.

- With regards to voltage control requirements, the group's final proposal is that a requirement should be placed on the Offshore TO (specified within the STC) to; operate to a slope characteristic, return to this slope within 5 seconds in the event of a deviation from the slope and provide a transient response within 1 second. The group also propose that a requirement is placed on the Offshore Generator to return to the required power factor within 3 minutes unless otherwise agreed between the Offshore Generator, Offshore TO and GBSO.

- The group proposed that the voltage limits specified in CC.6.1.4 should be unchanged for Offshore Networks.

- The group propose that two alternative fault ride through criteria should be specified for Offshore Generators:

  (i) Compliance with the existing onshore requirements.
  (ii) Generic requirements specified at the LV point on the offshore platform. These will be based on plant capability. This criteria will provide at least the same level of security to the transmission system as (i), and may provide advantages in demonstrating compliance.

  An Offshore Generator will be compliant if it meets either of these requirements. This requirement is unaffected by the connection voltage level chosen by the Offshore Generator.

- The group propose that frequency response requirements specified in CC.6.3.7 should apply to all Offshore Generators, with an additional obligation placed in the STC for Offshore TO's using DC links to facilitate the provision of frequency response from an Offshore Generator.

2.0 INTRODUCTION

2.1 The Ofgem scoping document "Offshore Electricity Transmission" published in April 2006 identified the issues that require further consideration in implementing an offshore electricity transmission regime. One of the identified work-streams was the need to review the technical rules with respect to Offshore Transmission.

2.2 A review of security standards has already been carried out by the GB SQSS subgroup. The subsequent phase of work was therefore to consider the amendments and additions required for the Grid Code and to identify relevant consequential changes to the System Operator Transmission Owner Code (STC). The Grid Code subgroup was formed in order to assist Ofgem and the DTI in their decisions relating to the Grid Code requirements for Offshore Electricity Transmission.

2.3 The purpose of the subgroup is to complete a review of the current Grid Code for application to offshore transmission networks and generators and consequently:

- Consider if existing Grid Code obligations relevant to Power Park Modules and HVDC Interconnectors (obligations in respect of NGET, Network Operators and Generators) are appropriate to apply offshore.
- Develop proposals to change the Grid Code to incorporate new offshore electricity transmission arrangements.
- Consider consequential obligations that must be included in the STC as a result of any Grid Code recommendations.

2.4 This work was carried out taking due consideration of the recommendations for offshore security standards made by the GB SQSS subgroup, some of which are included in section 4: Assumptions.

3. OBJECTIVES

3.1 The specific objectives of the subgroup are as follows:

- To review the requirements of the current Grid Code relevant to Power Park Modules and HVDC Interconnectors and assess if the onshore arrangements are appropriate to apply offshore (to NGET, generators and offshore TOs). As an initial starting point the Grid Code requirements that apply onshore will be extended offshore unless there is good reason not to do so. For the avoidance of doubt it should be noted that this review work will not take account of any interim changes made to the Grid Code, with the exception of the G/06 recommendations which are currently under consultation.

- To identify consequential changes to the STC for consideration by a separate work- stream.
- The Grid Code subgroup will recommend any changes to the Grid Code and STC that are considered necessary to accommodate the new offshore transmission arrangements.

4. ASSUMPTIONS

4.1 A number of assumptions were agreed by the subgroup in order to facilitate the work being carried out. Several of these were carried over directly from the GB SQSS in order to ensure consistency, however certain assumptions were specific to the Grid Code and STC work. The key assumptions agreed by the Grid Code subgroup are listed below:

- Offshore transmission circuits are classified as 132kV and above.
- Offshore transmission networks will be considered as radial networks connected to a single onshore grid connection entry point. Should the nodes be parallel to the onshore network they would become part of the MITS and therefore be subject to onshore security standards.
- Generation circuits are defined in the introduction to paper number **Offshore SQSS 1**
- Any consideration of distribution network standards is outside the scope of this sub group.
- An Offshore Network is defined as the network from the Offshore Grid Entry Point up to the first substation the circuit(s) reaches onshore.
- Commercial frameworks will be developed as appropriate, and in accordance with the optimum design solution.
- The Grid Code review work will need to take account of the default scope of offshore transmission systems assumed by the GB SQSS review sub group.
- The Grid Code subgroup will not be responsible for the formulation of technical standards with regard to offshore transmission equipment.
- The recommendations made by the Grid Code subgroup will be applicable to all forms of offshore generator technology, although they are based on networks designed by the GB SQSS working group considering the intermittent nature of wind power.

In line with the GB SQSS subgroup the group initially assumed that the Offshore Grid Entry Point would be at the disconnector on the busbar side of the circuit breaker on the LV (likely to be 33kV) busbar on the outgoing windfarm circuits on the offshore platform. However following discussion within the group it was agreed that Offshore Generators should have the option to connect to an Offshore TO at a voltage level of their choosing (e.g. 33kV, 132kV 220kV). Therefore it is important that any recommendations made by the group are applicable to generator connections at various voltage levels.

5. WORKING GROUP DISCUSSIONS

5.1 The group agreed that a full review of the Grid Code was required in order to assess its suitability for application to offshore electricity transmission networks. In particular the following areas are impacted.

- Connection Conditions
- Planning Code
- Glossary and Definitions
- Data Registration Code
- Operating Codes
- Balancing Codes

A full clause by clause review of the Connection Conditions, Planning Code, Glossary and Definitions and Data Registration Code was carried out and the results of this work are shown in Appendix 1.

5.2 **Connection Conditions: Applicability of Grid Code Requirements**

5.2.1 The group noted that the extent to which current Grid Code requirements are applied to onshore Generators is based on registered MW capacity. The group examined whether this arrangement is appropriate to be applied offshore.

5.2.2 The group noted that an offshore wind farm will take the form of a number of 'strings' of turbines connected to the Offshore Grid Entry Point (GEP). For LV Offshore Grid Entry Point connections, under the current definition of a Power Park Module (PPM), each of these strings would be classified as an individual PPM and therefore subject to individual Grid Code requirements based on their registered capacity. This scenario is due to the Offshore GEP being situated on the LV side of the disconnector between the Offshore Generator and the Offshore TO, and will therefore mean that each string connected to the Offshore TO network has a separate connection point. Based on proposed developments it is assumed that these strings will have a generation capacity in the order of 20 – 50MW. Under current Grid Code arrangements in England and Wales they would be classed as Small Power Stations and would not be subject to the full requirements of the Grid Code. Additionally each string would be registered as an individual BMU. This could lead to cumulatively large wind farm developments (>100MW) which do not have to meet the same requirements as a large Onshore Generator. This situation is not desirable as it will reduce the ability of the GBSO to securely operate the transmission system as further offshore developments connect. In cases where an Offshore Generator chooses an HV Offshore GEP the PPM is likely to comprise a number of strings and have a registered capacity in excess of 100MW and therefore will likely be subject to the full requirements of the Grid Code.

5.2.3 The issues referred to in 5.2.2 relate to Offshore Generators with a LV connection, the group discussions focused on the applicability of the requirements to such connections. National Grid believes that the resulting proposals can be applied generically to connections at all voltage levels.

5.2.4 National Grid initially proposed that all Offshore Generators would be subject to the full requirements of the Grid Code regardless of their installed capacity. Provision would also be made for strings with common ownership and connected to the same electrically inseparable point to be aggregated into one Offshore PPM and treated as one BMU, allowing aggregation of the Grid Code requirements and greater economy in meeting them.

5.2.5 The group also discussed the aggregation of strings regardless of connection locations with a view to reducing the administrative burden associated with issuing numerous PNs for an individual windfarm. It was discussed that BMUs be based on the aggregation of a number of Offshore PPMs belonging to a single generator connected behind a single platform and not only those connected to an electrically inseparable point.

5.2.6 The majority of the group agreed that there should be provision for the aggregation of a number of strings into one Offshore PPM as described in 5.2.4. Following discussion it was agreed that it would be necessary to ensure that small prototype generators should be exempt from the provisions of the Grid Code applicable to Medium and Large Generators.

5.2.7 Further to these discussions National Grid proposed the following options for the classification of Offshore Generators.

5.2.8 **Option 1:** All Offshore Generators to be treated in the same way as a Large onshore Power Station irrespective of size and type. This proposal would ensure current levels of system security are maintained, however it was noted by the group that such a proposal represented a more onerous requirement than those applied onshore and could present a barrier for small experimental projects such as wave and tidal generation.

5.2.9 **Option 2:** Extend the definition of Small, Medium and Large Power Stations to the offshore environment with an appropriate review of the thresholds for offshore transmission. This would not impose excessive requirements on small prototype wave and tidal projects. However, National Grid notes that the modular structure of offshore developments may allow for the possibility to register a potentially large volume of generation, each connected to a LV Offshore GEP, as independent Small Power Stations and thus be exempt from CC.6.3. The group noted that this scenario does not occur onshore, however it should be noted that with the option for Distribution connections onshore the incentive for a Small Power Station to be directly connected to the transmission system onshore is significantly reduced. National Grid noted that whilst a directly connected Small Power Station would be exempt from CC.6.3 an embedded Small Power Station would need to comply with the Distribution Code and meet the requirements of G59 and G75

5.2.10 **Option 3:** National Grid is keen to ensure that any plant which connects to an offshore network is treated in a fair and transparent way and requirements are not so onerous such that they place an undue burden on Generators, especially small prototype developments. However, it is important that such requirements do not result in a risk to the safe and secure operation of the transmission system. In considering the above options, it is agreed that option 1 would be too onerous but would offer good network resilience whilst option 2 would be less onerous but could present design and operational issues for the Offshore TO and GBSO. As a result, a combination of the two options may provide a more realistic option. One would be to create a new definition under the Grid Code of a "Prototype Unit". This would include new types of generation technology such as tidal, wave and solar technology and could include new types of wind turbine under development. If this option was carried forward the amended Grid Code would need to provide an exclusion for prototype units. Agreement would be needed on how to define a prototype / experimental unit.

5.2.11 **Option 4:** An alternative approach would be the definition of two new classes; Small and Large Offshore Power Stations. Large Offshore Power Stations would be required to meet the full requirements of the Grid Code. Small Offshore Power Stations would be required to meet the requirements of the Connection Conditions excluding CC.6.3. Discussion within the group suggested that the most appropriate threshold between these two classes would be 10MW, as is applied onshore in the SHETL transmission area. It is believed that this proposal would maintain current system security standards whilst limiting the registration of large volumes of Small Offshore Power Stations. The benefits of this option include:

- Ensuring that the majority of offshore transmission systems and generators contribute to the security and quality of supply of the GB Transmission System.
- It will reduce, to an acceptable level, the likelihood that large volumes of Offshore Generators will be registered as Small Power Stations and therefore be exempt from critical Grid Code requirements.
- It will reduce, to an acceptable level, the likelihood that large numbers of Small Power Stations will have an adverse cumulative effect on the GB Transmission System.
- It will provide a clearly defined class to enable small-scale generation that is unlikely to have an adverse impact on the GB Transmission System to be connected without placing unnecessary requirements and costs on developers. This will also provide a route for the phased development of emerging technologies from small scale research and development projects through to large scale commercial maturity.

5.2.12 **Option 5:** The group also discussed the introduction of a new term, Offshore Power Park Module, to be defined in order to ensure that turbine strings under common ownership are captured as part of the same Power Station. Existing onshore size thresholds would then be adequate to capture offshore generators as either Small, Medium or Large. This option is legally complex.

5.2.13 The group's final proposal is Option 4, i.e. that two new classes of generator are defined; Small Offshore Power Station and Large Offshore Power Station, utilising the 10MW threshold currently defined onshore for the SHETL transmission area.

5.3 Connection Conditions: Reactive Capability Requirement

5.3.1 Current Grid Code requirements state that any Medium or Large PPM must provide a reactive power capability of 0.95 lead / lag at its Grid Entry Point, as specified in CC.6.3.2. The group agreed that it was appropriate to apply this condition offshore. However, it was agreed that consideration must be given to how the requirement would be apportioned between the Offshore Generator and Offshore TO.

Low Voltage Offshore Grid Entry Point Connections

5.3.2 National Grid, in conjunction with Imperial College / DTI, carried out a number of load flow studies in order to formulate a generic requirement for reactive capability. These studies examined a number of offshore network configurations including 0, 200, 500 and 1500MW generators located 25 and 100km offshore. The group agreed that the parameters and topology of the study networks should be in line with those used by the GB SQSS subgroup in order to ensure consistency. The network topologies and parameters used for these studies can be seen in Appendix 2.

5.3.3 As a result of the studies described above National Grid proposed that a minimum steady state power factor capability requirement of unity power factor, with a tolerance of -/+ 5% of rated MW in MVArs, should be placed upon an Offshore Generator with a 33kV Offshore GEP, with the Offshore TO meeting the 0.95 lead / lag requirement at the Onshore GEP. This recommendation was driven by the cable overloads observed in a number of study cases when the full reactive capability requirement was placed at a 33kV Offshore GEP, and the uneconomic use of compensation to offset the required capability that would be required.

5.3.4 The group agreed that a generic provision is required in order to provide clarity and certainty regarding requirements for developers and to ensure consistency between schemes. However the group believed that the unity power factor requirement at the 33kV Offshore GEP should represent a default requirement and that the Grid Code should allow Offshore Generators to liaise with an Offshore TO to provide a greater reactive capability than the default unity requirement, thus assisting the Offshore TO in meeting its obligation. National Grid agreed that an Offshore Generator may offer an Offshore TO a greater capability than unity power factor provided that this capability is fully usable.

High Voltage Offshore Grid Entry Point Connections

5.3.5 The group then discussed three options for a reactive power capability requirement for Offshore Generators with a HV Offshore GEP connection.

5.3.6 **Option 1:** Apply the same requirement as that specified for LV connected Offshore Generators, i.e. a generic default capability of unity power factor with the option for an Offshore Generator and Offshore TO to agree an alternative capability. This option represented the simplest requirements for Offshore Generators but would mean that an HV connected Offshore Generator would have to provide additional capacitive capability compared with LV connected plant to offset greater transformer losses.

Studies carried out by National Grid also indicated that a unity power factor requirement at a HV Offshore GEP may result in an Offshore TO having to install additional shunt reactance in order to prevent cable overload. The group agreed that this is clearly an uneconomic solution.

5.3.7 **Option 2:** Adjust the capability requirement at the HV Offshore GEP in order to represent an equivalent requirement to providing unity power factor at an LV Offshore GEP. The adjustment would be based on typical transformer parameters so that a generic requirement could be included in the Grid Code. This approach is similar to that used for onshore power park modules, where a different reactive power capability is required to synchronous plant to allow for the fact that the requirements are specified at different points. As discussed previously the option for an Offshore Generator and Offshore TO to agree an alternative capability would still be available.

5.3.8 **Option 3:** Specify the requirement at the LV point regardless of whether the Offshore GEP is at the HV side of the transformer. This would ensure consistency with the requirements for an LV connected Offshore Generator. However, this requirement would remove the benefit for Offshore Generators of aggregating the requirements at the HV side of the transformer and would introduce inconsistencies as to whether requirements are specified at the Offshore GEP or within the generator's network. The option to agree an alternative capability would be maintained.

Proposal

5.3.9 The group's final proposal is that the current requirements of CC.6.3.2 should be met by the Offshore TO at the Onshore GEP; this obligation will need to be specified in the STC. The group also recommend that an additional requirement should be introduced stating that an Offshore Generator with an LV Offshore GEP should have a steady state power factor capability of unity at the Offshore GEP. For Offshore Generators with an HV Offshore GEP an alternative requirement, adjusted to take into account transformer losses, representing an equivalent to providing unity at the LV point should be specified (Option 2). In both cases an alternative capability can be agreed between the Offshore Generator, Offshore TO and GBSO provided that this can be fully utilised.

5.4 Connection Conditions: Voltage Control

5.4.1 National Grid proposed that the existing onshore requirements, that are placed in Bilateral Agreements and are currently subject to an industry wide consultation (G/06), be applied offshore in order to maintain system security levels. The existing requirements consist of: steady operation according to a slope characteristic, maintenance of this slope across a five second time period, and a transient response within one second. These requirements would be placed on the Offshore TO in the STC. As per the group's reactive power capability proposal, an Offshore Generator would also require a continuously acting control scheme to maintain a specified power factor with varying output power and following any fault ride through response. In line with current requirements National Grid proposed that the generator should return to unity power factor within 5 seconds[1].

5.4.2 Following discussion within the group it was agreed that, given the absence of a voltage step change requirement offshore (see 5.5 below), the requirement for the Offshore Generator to return to a specified power factor within 5 seconds may in practice be detrimental to system performance. For example, during prolonged voltage dips if the Offshore Generator's reactive output was constrained back this could result in a further drop in system voltage, and that the requirement would be incompatible with fault ride through performance, particularly for longer duration voltage dips. The Mode B fault ride through requirement specifies a capability for the export of reactive current for up to 3 minutes.

[1] Proposal based on G/06 recommendations.

5.4.3 The group's final proposal is therefore that a requirement should be placed on the Offshore TO within the STC to:

- Operate to a slope characteristic.
- Return to this slope within 5 seconds in the event of a variable slope.
- Provide a transient response within 1 second.

It is also proposed that a requirement is placed on the Offshore Generator in the Grid Code to return to the specified power factor within 3 minutes unless otherwise agreed between the Offshore Generator, Offshore TO and GBSO.

5.4.4 Where the GBSO, Offshore Generator and the Offshore TO agree on a usable reactive capability from the Offshore Generator other than the default requirement, the GBSO will specify the voltage control performance expected.

5.5 Connection Conditions: Voltage Limits

5.5.1 Voltage limits are currently specified in National Grid Electricity Transmission's security standards and are referred to in the Grid Code under CC.6.1.4. These limits are based on ensuring voltage levels are maintained for demand customers. As one of the working assumptions of the group is that no demand will be connected to an offshore network National Grid initially proposed that the voltage limits can be widened to -/+ 10% throughout the offshore electricity transmission network.

5.5.2 The group noted that voltage limits at different voltage levels are currently specified within the Electricity Safety, Quality and Continuity Regulations (ESQCR). The ESQCR states that for voltages greater than or equal to 132kV limits of -/+ 10% should be applied, however for voltages lower than 132kV limits of -/+ 6% are specified. However, the ESQCR, as amended in 2006, states that these limits do not apply Offshore.

5.5.3 National Grid carried out a number of system studies that examined the effect of applying different voltage limits. It was found that applying -/+ 10% at below 132kV could result in unacceptable voltage levels at the generator terminals. Therefore, National Grid propose that the existing limits, as specified in CC.6.1.4, should be retained.

5.5.4 The group also discussed the need to specify voltage step change limits for offshore networks. The group agreed that this issue requires further consideration but that it is out with the scope of this working group. Therefore this issue and the impact, if any, of the voltage limits proposed above should be considered by another section of the technical rules work stream.

5.5.5 The group's final proposal is that CC.6.1.4 should be unchanged for Offshore Networks.

5.6 Connection Conditions: Fault Ride Through

5.6.1 The group agreed that Offshore Generators should be subject to equivalent fault ride through requirements as applied to onshore generators to ensure that system reliability and security levels are maintained.

5.6.2 Current onshore fault ride through requirements are specified at a Generator's GEP in terms of a voltage dip and duration. National Grid initially proposed that due to the presence of the Offshore TO there will need to be some form of modification to the fault ride through requirement in order to apply it at the Offshore GEP.

5.6.3 The group discussed the following proposed solutions for fault ride through requirements for generators connected via an **AC link**.

AC Link

5.6.4 **Option1.** Apply current requirements with no modifications. This approach is non-discriminatory between different technology types and ensures requirements are no more or less onerous than for onshore. However this approach would require full knowledge of the Offshore TO for developer design and compliance testing. Knowledge of the Offshore TO network may not be available at the time a connection application is made by a generator.

5.6.5 **Option 2.** Translate Mode A (140ms fault) and Mode B (longer duration dips) requirements to the Offshore Grid Entry Point. This would ensure that developer design and compliance testing is independent of the Offshore TO network. However it is very difficult to accurately translate the requirements without knowledge of the Offshore TO network. National Grid proposed the following methods for translating the onshore requirement offshore.

- **Option 2a.** Base requirement at Offshore GEP but on known generator capability. This proposal removes any issues associated with development design and compliance testing as factory tests could be carried out. However it is probable that this requirement will be more onerous than that for onshore generators and may require additional investment from developers.
- **Option 2b.** Dynamic studies could be carried out using typical Offshore Generator and Offshore TO network data. This proposal would allow a closer translation of onshore requirements but would require significant assumptions to be made regarding the Offshore TO network and generator data which may lead to more or less onerous requirements. It would also prove difficult to separate the response of the generator from the Offshore GEP voltage leading to further inaccuracies.
- **Option 2c.** Steady state studies could be carried out using typical Offshore Generator and Offshore TO network data. This proposal again allows a closer translation of onshore requirements but would require significant assumptions to be made regarding network and generator data which may lead to more or less onerous requirements. However the process would be simpler than carrying out dynamic studies as no machine response would be observed.

5.6.6 **Option 3.** Leave current onshore requirements unchanged but specify an impedance which should be placed between the Offshore GEP and onshore system. This proposal would provide clarity to Offshore Generators in the absence of Offshore TO network data, is simple to derive and makes the minimum number of assumptions. However as in previous proposals assumptions would need to be made as to the configuration of the Offshore TO network which may lead to inaccuracies.

5.6.7 **Option 4.** Specify a generic requirement at the Offshore GEP for Mode A fault ride through but apply current onshore requirements for any longer duration faults. Although a generic requirement for 140ms faults may be more onerous than onshore requirements a generator may still require further investment in order to meet current Mode B requirements. In this case a generic 140ms fault ride through requirement would not result in the need for greater investment by the Offshore Generator. For Mode B events the Offshore Generator and Offshore TO could co-ordinate design work in order to make use of any response from the Offshore TO network.

5.6.8 **Option 5.** Following discussion within the group a combination of Options 1 and 2a was proposed. This would allow an Offshore Generator to comply with either generic requirements specified at the Offshore GEP or, the existing onshore fault ride through requirements. The latter would require knowledge of the Offshore TO network. This option offers the following benefits:

- Provision is made for compliance using type-tested and approved products.

- The original onshore system based requirements are included. This provides an alternative route to compliance for any generator technologies which do not meet the generic offshore requirements.
- Developers are likely to opt for the simplest route to compliance wherever possible; hence this proposal will simplify the compliance process for the developer, the Offshore TO and the GBSO.

5.6.9 Both options 2a and 5 propose that the Offshore GEP requirements should be based on generator capability. National Grid's discussions with manufacturers indicate that the majority of technologies likely to be used are capable of riding through a voltage drop to 15% at the 33kV for 140ms (as shown in Figure 1), and that they can meet the Mode B requirements currently specified onshore if they are applied directly at the 33kV. Further views on this proposal are expected through the consultation.

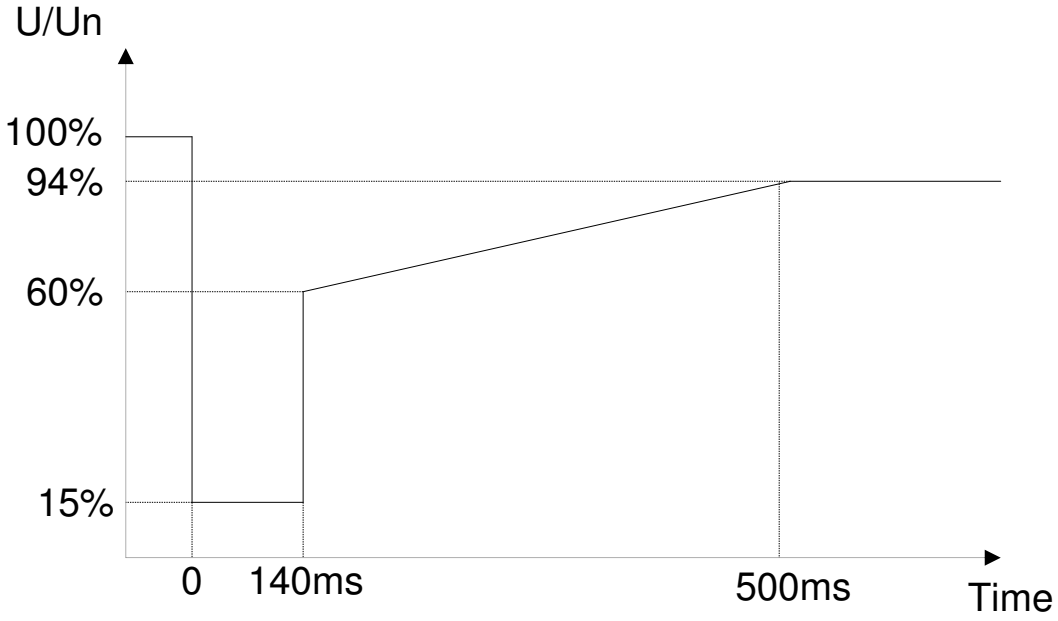


Figure 1

5.6.10 The requirements described in 5.6.9 can be applied directly to generators with a connection at 33kV. National Grid believes that these principles should be maintained for HV connected Offshore Generators. With this view the following two options were discussed by the group for applying options 2a and 5 to HV connections.

5.6.11 **Option 6:** Adjust the generic requirement proposed for LV connected Offshore Generators and apply at the HV Offshore GEP. The HV Offshore GEP will only be electrically separated from the onshore transformers. Under fault condition these will only raise the voltage seen at the HV Offshore GEP by a small level, therefore National Grid proposed that the generic fault ride through requirement for HV connected Offshore Generators should be the same as that applied onshore, i.e. the voltage rise across the Offshore TO network would be neglected. Hence an HV connected Offshore Generator would have to ride through fault conditions resulting in 0V at the HV Offshore GEP. A disadvantage of this option is that requirements are likely to be more onerous than for LV connected Offshore Generators however the requirement would be specified at the GEP which is consistent with existing Grid Code requirements.

5.6.12 **Option 7:** Apply the requirements at 33kV regardless of the voltage level an Offshore Generator connects at. This will provide the same benefits as discussed previously but introduces requirements that are not specified at the Offshore GEP.

5.6.13 National Grid proposed the following solutions for fault ride through requirements for generators connected via a **DC link**.

DC Link

5.6.14 The group acknowledged that for an event on the onshore system an Offshore Generator connected via a DC link may not see the same voltage at the Offshore GEP as a generator connected via an AC link. Therefore a fault ride through requirement based on a voltage dip seen at the Offshore GEP, as proposed in options 2a, 5, 6 and 7 for an AC connection, will not be suitable for DC connected Offshore Generators.

5.6.15 If option 2a, 5, 6 or 7 is adopted for AC connections National Grid proposed that the fault ride through requirement for DC connected Offshore Generators should be based on the load reduction seen by a generator as a result of the DC link being unable to transfer full power to the onshore system during fault conditions. This load rejection would be equivalent to the generic voltage dip specified for AC connected generators (e.g. the load rejection caused by 0.15pu voltage at the Offshore GEP).

Proposal for Both AC and DC Cases

5.6.16 The group's final policy proposal is for Option 5 for LV connections with the modification of Option 7 for HV connections, i.e. that an Offshore Generator should have the choice to comply with either:

(i) a generic fault ride through requirement based on generator capability applied at 33kV. This will comprise of a Mode A requirement as shown in Figure 1 and the current onshore Mode B requirement. For an Offshore Generator connected by an AC link the generic requirement will be based upon a voltage dip and for a DC connected Offshore Generator it will be based on an equivalent load rejection.

(ii) Or, comply with the existing onshore requirements.

5.7 Connection Conditions: Power Output with Falling Frequency

5.7.1 The group agreed that the existing requirement, as specified in CC.6.3.3, should be applied directly to Offshore Generators connected via an AC link. The group discussed whether it is necessary to apply this requirement to Offshore Generators connected via a DC link due to the possibility that the machines may not have visibility of the onshore system frequency. However, the group agreed that in the pursuit of creating generic requirements it is appropriate to apply this requirement to all Offshore generators as some DC links may choose to 'mirror' the onshore system frequency at the Offshore GEP.

5.7.2 The group's final policy proposal is that CC.6.3.3 is applied in its current form to all Offshore Generators.

5.8 Connection Conditions: Frequency Response

5.8.1 The group agreed that Offshore Generators should be subject to the same frequency response requirements as onshore generators, as specified in CC.6.3.7.

5.8.2 The group agreed that the current Grid Code conditions can be applied unchanged to Offshore Generators that are connected via an AC Offshore TO network.

5.8.3 The group noted that Offshore Generators connected via a DC Offshore TO network may not have direct visibility of the onshore system frequency. Therefore, in order to provide frequency response it will be necessary for the Offshore TO to supply information of onshore system conditions to the Offshore Generator. The group

agreed that current frequency response requirements should also be applied to DC connected Offshore Generators but with an additional obligation, specified in the STC, on Offshore TO's using DC links to facilitate the provision of frequency response from Offshore Generators. The wording of the STC will not specify a particular method by which the Offshore TO should facilitate the response in order to allow the Offshore Generator and Offshore TO to agree the optimum solution, taking into account other requirements.

5.8.4 The group's final policy proposal is that C.C.6.3.7 should apply to all Offshore Generators, with an additional obligation placed in the STC for Offshore TO's using DC links to facilitate the provision of frequency response from an Offshore Generator.

5.9 **Connection Conditions: Other Requirements**

5.9.1 The group carried out a full review of the Grid Code connection conditions throughout its discussions. Other than the areas described above the existing conditions are suitable to be applied to the offshore environment. A table detailing the clause by clause review of the connection conditions is shown in Appendix 1A.

5.10 **Planning Code**

5.10.1 The group agreed that the Planning Code will require amendment in order to accommodate offshore electricity transmission networks and to reflect any changes proposed in other areas of the Grid Code.

5.10.2 The group agreed that offshore users will be required to provide the same data as onshore users.

5.10.3 The group agreed that any data requirements to be fulfilled by the Offshore TO will be specified in the STC.

5.10.4 Appendix 1B details the individual changes and amendments that the group propose are required to the Planning Code.

5.11 **Glossary and Definitions**

5.11.1 The group agreed that the Grid Code Glossary and Definitions will require to be updated in line with proposed changes and amendments recommended by the group in other areas of the Grid Code.

5.12 **Data Registration Code**

5.12.1 The group agreed that the Grid Code Data Registration Code will need to be updated in line with proposed changes and amendments recommended by the group in other areas of the Grid Code.

5.12.2 Appendix 1C details the individual changes and amendments that the group propose are required to the Data Registration Code.

5.13 **Operating Codes**

5.13.1 The group agree that the Operating Code will require amending in order to accommodate offshore electricity transmission networks and to reflect any changes proposed in other areas of the Grid Code

5.13.2 The group agree that offshore users will be required to fulfil the same obligations as onshore users.

5.13.3 The group agree that any requirements to be fulfilled by the Offshore TO will be specified in the STC.

5.13.4 Appendix 1D details the individual changes and amendments that the group propose are required to the Operating Code

5.14 Balancing Codes

5.14.1 A string of generators connected at an Offshore Grid Entry Point will constitute a BM Unit.

5.14.2 It will be possible (subject to the conditions of 5.2.3 above) for a number of generator strings to aggregate into a single BM Unit.

5.14.3 The requirements for submitting Physical Notifications will apply to all offshore BM Units regardless of size.

5.14.4 Offshore generators will have the capability to provide Part 1 Ancillary Services for frequency control and be despatched to provide the Services in accordance with BC2.8.

5.14.5 The group's proposal (5.3.5) is that the MVAr output from the Generator at the Offshore Grid Entry Point (or in the case of aggregation**,** the summation of the outputs at the Offshore Grid Entry Point) will be zero in the absence of any agreement with the Offshore TO. If this proposal is adopted the arrangements for the provision of Ancillary Services in relation to reactive power will not apply.

5.14.6 The capability to provide frequency response (BC3.5.1) in accordance with CC6.3.7 will apply to all Offshore Generators regardless of size. However provision will be made for the capability to be provided on an aggregated basis.

5.14.7 All offshore generating units will be expected to operate in **Limited Frequency Mode**.

5.14.8 It was proposed by a member of the subgroup that the criteria for the aggregation of a number of Offshore PPM's into a single BMU is too restrictive and should be extended to allow the aggregation of Offshore PPM's regardless of connection location.

5.15 Emergency Instructions

5.15.1 Current arrangements will be extended to include Generators connected to the offshore transmission networks

5.16 Further Work

5.16.1 With regard to offshore Distribution connected plant, this issue has only recently been raised at the working group and it is felt further work will be required by another work-stream before any proposals can be put forward. National Grid assume that the default position for Offshore Distribution connected generation plant will be that Grid Code requirements will be applied in the same manner as for Offshore Transmission connected generation in a similar manner to the existing LEEMPS arrangements.

5.16.2 The group agreed that the technical standards for offshore networks require consideration but that the issue is out-with the scope of this group and should be examined by another work-stream.

Appendix 1A

Proposals on the Grid Code Connection Conditions in respect of Offshore Electricity Transmission

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
CC.3 – Scope					Requirements will be placed on the offshore TO and Offshore Generator. The requirements on the offshore TO are expected to appear in the STC or equivalent and those on the offshore Generator will appear in the Grid Code. An offshore TO which employs an HVDC scheme will need to have special provisions placed on it within the STC or equivalent in order for the offshore Generators to fulfil certain requirements at the Offshore Grid Entry Point.
CC.5 – Connection issues including items for submission	Submitted under STC or equivalent	Submitted under STC or equivalent	Apply existing Grid Code requirement	Apply existing Grid Code requirement	
CC6.1.3 – Grid Frequency Variations	Apply existing requirement	Apply existing requirement at Grid Entry Point	Apply existing Grid Code requirement	Apply existing Grid Code requirement	
CC.6.1.4 – Grid Voltage Variations	Apply existing requirement	Apply existing requirement	Apply existing requirement	Apply existing requirement	The retention of the existing onshore standards, offshore, would also be compatible with the onshore ESQCR. For Offshore Generators which connect to an Offshore Grid Entry Point of 132 kV or above, the connection point voltage variation will remain within the limits of ±10%. For

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
					Offshore Generators which connect to an Offshore Grid Entry Point of below 132 kV the voltage variation will remain within ±6%.
CC.6.1.5 – Voltage Waveform Quality	Apply existing requirement at Grid Entry Point.	Apply existing requirement	Apply existing Grid Code requirement	Apply existing Grid Code requirement	
CC.6.1.6 – Phase Unbalance	Apply existing requirement	Current Grid Code requirement may be applied although site specific requirements would be specified in the Construction Agreement	Apply existing Grid Code requirement	Apply existing Grid Code requirement	
CC.6.1.7 – Voltage Fluctuations	Apply existing requirement	Apply existing requirement	Not applicable	Not applicable	Specifications for voltage fluctuations and step changes will be passed back for consideration by another section of the technical rules work stream. This will include issues relating to Flicker Severity, which would apply at Offshore Grid Entry Point Voltages of 132 kV or above.
CC6.2 .1 – General Requirements relating to Plant and Apparatus including Substation equipment	Requirements will be covered in the STC or equivalent	Apply existing requirement	Apply existing Grid Code requirement	Consistent requirements to be applied at the Offshore Grid Entry Point with specifications included in the Bilateral Agreement to allow for the HVDC Network.	Requirements on the offshore TO apply at the Grid Entry Point and requirements on the Offshore Generator apply at the Offshore Grid Entry Point

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	**DC Connection**	**AC Connection**	**DC Connection**	
CC.6.2.2 - Requirements at Connection Points that relate to Generators or DC Converter Station Owners	Not applicable	Current Grid Code requirements would be applied and included in the STC or equivalent	Apply existing Grid Code requirement at Offshore Grid Entry Point	Apply existing Grid Code requirement at Offshore Grid Entry Point	Offshore AC Cable Network assumed to have the same protection standards as an onshore Network. Fault Clearance times for 220 kV and 245 kV Offshore Systems would be assumed to have fault clearance times of no faster than 100ms.
CC6.2.3 – Requirements at Connection Points relating to network Operators and Non Embedded Customers	Similar requirements in CC.6.2.3 would be expected to be included in the STC or equivalent	Not applicable – assumed to be covered in DC Converter requirements under CC.6.2.2	Not Applicable	Not Applicable	The STC or equivalent needs to ensure that technical performance requirements for protection are included and consistent with those in the Grid Code. Fault Clearance times for 220 kV and 245 kV Offshore Systems would be assumed to have fault clearance times of no faster than 100ms.
CC6.3.1 – Scope			Offshore Generators will be defined into two groups. Small Offshore Power Stations will be classed as those less than 10 MW. Large Offshore Power Stations will be classed as 10MW or above. Large Offshore Power Stations will be required to meet the full requirements of the Grid Code whilst Small Offshore Power Stations will only need to meet those requirements of the Grid Code as	Offshore Generators will be defined into two groups. Small Offshore Power Stations will be classed as those less than 10 MW. Large Offshore Power Stations will be classed as 10MW or above. Large Offshore Power Stations will be required to meet the full requirements of the Grid Code whilst Small Offshore Power Stations will only need to meet those requirements of the Grid Code as applicable	New terms will be included within the Glossary and Definitions of the Grid Code to include provisions for the Offshore environment. The thresholds will be consistent with the Onshore requirements in SHETL's Transmission Area which is believed to be more reflective of the offshore network.

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
			applicable to Small Onshore Power Stations which would exclude the requirements of CC.6.3.	to Small Onshore Power Stations which would exclude the requirements of CC.6.3.	
CC.6.3.2 – Reactive Range	Existing Grid Code requirement would be required at the Grid Entry Point (0.95 PF lead / lag as per Figure 1 of CC6.3.2) and included within the STC or equivalent	Existing Grid Code requirement would be required at the Grid Entry Point (0.95 PF lead / lag as per Figure 1 of CC6.3.2) and included within the STC or equivalent	Each Offshore Power Park Module should be required to be capable of maintaining : (i) unity power factor for LV connections (ii) a power factor equivalent to unity at the LV for HV connections at the Offshore Grid Entry Point. A tolerance of ± 5% of Rated MW in MVAr would be allowed either side of the specified power factor. The Offshore Generator will have the option to provide a greater reactive capability than the minimum specified under the Grid Code. This will require agreement with the Offshore TO and GBSO.	Each Offshore Power Park Module should be required to be capable of maintaining : (i) unity power factor for LV connections (ii) a power factor equivalent to unity at the LV for HV connections at the Offshore Grid Entry Point. A tolerance of ± 5% of Rated MW in MVAr would be allowed either side of the specified power factor. The Offshore Generator will have the option to provide a greater reactive capability than the minimum specified under the Grid Code. This will require agreement with the Offshore TO and GBSO.	The Grid Code will allow an enhanced reactive capability (beyond the minimum) to be agreed between the Offshore Generator, Offshore TO and GBSO.

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
CC.6.3.3 – Output Power with falling frequency	Not applicable	Existing requirements will apply at the Grid Entry Point	Each Offshore Power Park Module will be required to meet the existing Grid Code requirement for CC.6.3.3 at the Offshore Grid Entry Point.	Each Offshore Power Park Module will be required to meet the existing Grid Code requirement for CC.6.3.3 at the Offshore Grid Entry Point.	
CC.6.3.4 – Active / Reactive power output during system voltage changes within the normal operating range	Apply existing Grid Code requirement	Apply existing Grid Code requirement	Apply existing Grid Code requirement	Apply existing Grid Code requirement	The existing onshore Grid Code requirements applying at 33kV or below will not be applicable to Offshore Generators.
CC.6.3.5 – Black Start	Not applicable	Not applicable	Not applicable	Not applicable	
CC6.3.6 – Capability of plant to provide voltage control and frequency control	Not applicable for frequency control The requirement to control voltage will be specified in the STC or equivalent.	The offshore TO will need to facilitate the provision of frequency control with the Offshore Generator. Existing requirements apply in respect of voltage control and will be specified in the STC or equivalent.	For LV connected Offshore Generators Unity Power Factor will be required at the Offshore GEP. For HV connected Offshore Generators a leading Power Factor will be required at the Offshore GEP, equivalent to providing unity at the LV Offshore GEP. The voltage control requirement will depend on agreement between	For LV connected Offshore Generators Unity Power Factor will be required at the Offshore GEP. For HV connected Offshore Generators a leading Power Factor will be required at the Offshore GEP, equivalent to providing unity at the LV Offshore GEP. The voltage control requirement will depend on agreement between the Offshore TO, Offshore	

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
			the Offshore TO, Offshore Generator and GBSO and the enhanced reactive capability offered by the Offshore Generator under CC.6.3.2. Existing requirements will apply for frequency control.	Generator and GBSO and the enhanced reactive capability offered by the Offshore Generator under CC.6.3.2. Existing requirements will apply for frequency control.	
CC6.3.7 – Frequency Control	Not applicable	Current Grid Code requirement will need to be reflected at the offshore Grid Entry Point. The offshore TO will need to facilitate the provision of frequency control with the Offshore Generator.	Current Grid Code requirement will be applied at the Offshore Grid Entry Point	Current Grid Code requirement will be applied at the Offshore Grid Entry Point. The offshore TO will need to facilitate the provision of frequency control with the Offshore Generator.	
CC6.3.8 – Voltage Control	Voltage control required at Grid Entry Point as per G/06 consultation. Requirements will be specified in the STC or equivalent	Voltage control required at Grid Entry Point as per G/06 consultation. Requirements will be specified in the STC or equivalent	Voltage control characteristics will be agreed between the Offshore Generator, Offshore TO and GBSO if enhanced reactive limits are agreed and offered by the Offshore Generator.	Voltage control characteristics will be agreed between the Offshore Generator, Offshore TO and GBSO if enhanced reactive limits are agreed and offered by the Offshore Generator.	In addition, Offshore Generators will need to meet the fault ride through requirements which may require them to supply MVArs for up to 3 minutes. If offshore Generators agree to provide an enhanced reactive capability in line with CC6.3.2, voltage control would be agreed at the Offshore Grid Entry Point which may be at the HV or LV side of the platform.

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
CC6.3.9 – Steady State load Inaccuracies	Not applicable	Not applicable	Current Grid Code requirement will be applied to Offshore Generators at the Offshore Grid Entry Point.	Current Grid Code requirement will be applied to Offshore Generators at the Offshore Grid Entry Point.	
CC6.3.10 – Negative Sequence Loading	Not applicable	Not applicable	Not applicable unless Synchronous Generation connects directly to an offshore platform (e.g. a stand alone open cycle gas turbine).	Not applicable	Applies only to Synchronous Generating Units.
CC6.3.11 – Neutral Earthing	Existing Grid Code requirement will be specified in the STC or equivalent	Existing Grid Code requirement will be specified in the STC or equivalent	Not applicable unless the Offshore Generator connects to an Offshore GEP at 132 kV or above.	Not applicable unless the Offshore Generator connects to an Offshore GEP at 132 kV or above.	
CC6.3.12 – Frequency Sensitive relays	Not applicable	Current Grid Code requirement will be applied at the Grid Entry Point	Current Grid Code requirement will be applied to Offshore Generators at the Offshore Grid Entry Point	Current Grid Code requirement will be applied to Offshore Generators at the Offshore Grid Entry Point	
CC6.3.13 – Plant protection under extreme frequencies	Not applicable	Current Grid Code requirement will be required and specified in the STC or equivalent	Current Grid Code requirement will be required	Current Grid Code requirement will be required	
CC6.3.14 – Fast Start Capability	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable as the intermittent power source may not be available when required
CC6.3.15 – Fault Ride Through	Not applicable	Current Grid Code requirement will apply at the Grid Entry Point and appropriate provisions included in the STC or	Offshore Generators will have the option to satisfy the fault ride through requirements by either:-	Offshore Generators will have the option to satisfy the fault ride through requirements by either:-	Offshore Generators will have the option to satisfy the fault ride through requirements either based on the requirements at the Onshore Grid Entry Point or a set of requirements at the 33 kV bar (even if the

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	**DC Connection**	**AC Connection**	**DC Connection**	
		equivalent.	**Option 1** Meet the current onshore requirements at the onshore Grid Entry Point. This will require co-ordination with the Offshore TO OR **Option 2** *Mode A – Faults up to 140ms in duration* This will require offshore Generators to ride through faults which result in a retained voltage of 15% at the LV side (typically 33 kV) of the offshore platform for up to 140ms, followed by an instantaneous recovery to 60% voltage, followed by a linear recovery to the minimum steady state voltage of 94% at 33kV or nominal voltage at the LV side of the offshore platform. *Mode B – Voltage dips*	**Option 1** Meet the current onshore requirements at the onshore Grid Entry Point. This will require co-ordination with the Offshore TO OR **Option 2** *Mode A – Faults up to 140ms in duration* This will require offshore Generators to ride through faults which results in a retained voltage of 15% at the LV side (typically 33 kV) of the offshore platform for up to 140ms, followed by an instantaneous recovery to 60% voltage, followed by a linear recovery to the minimum steady state voltage of 94% at 33kV or nominal voltage at the LV side of the offshore platform. Since the Offshore Generator will not see the	Offshore Generator selects to opt for a HV Offshore GEP) which would be based on manufacturer's capability. It is acknowledged that the requirements at the 33 kV bus bar may be more onerous than that at the onshore Grid Entry Point; however an Offshore Generator will always have the option of meeting the onshore requirement. It is believed that this approach would be based on manufacturer capabilities and simplifies the compliance process. The onshore requirements of CC.6.3.15 apply to the GB Transmission System operating at Supergrid voltages (i.e. in excess of 200 kV). The extension of the Supergrid voltage limit of 200 kV would not be applied to the offshore environment.

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
			longer than 140ms For longer duration voltage dips, an Offshore Generator will need to meet the onshore requirements at the LV side (typically 33 kV) of the offshore platform	same voltage depression at the offshore Grid Entry Point, it will be required to reject load and withstand the consequential speed rise that results. *Mode B – Voltage dips longer than 140ms* For longer duration voltage dips, an Offshore Generator will need to meet the onshore requirements at the LV side (typically 33 kV) of the offshore platform	
CC6.3.16 – Additional Damping Control Facilities for DC Converters	Not applicable	Current Grid Code requirement will be applied.	Not applicable	Not applicable	
CC.6.4.2 – Neutral Earthing	Existing Grid Code requirement will be specified in the STC or equivalent	Existing Grid Code requirement will be specified in the STC or equivalent	Not applicable - For Offshore Generators connected at 132 kV or above, the requirements under CC.6.3.11 and CC.6.2.1.1 (b) would apply	Not applicable - For Offshore Generators connected at 132 kV or above, the requirements under CC.6.3.11 and CC.6.2.1.1 (b) would apply	Consideration is being given to having the Offshore Grid Entry Point at 33 kV or 132 kV or above.
CC6.5.6 – Operational Metering	Equivalent Grid Code requirements will apply and be specified in the STC or equivalent	Equivalent Grid Code requirements will apply and be specified in the STC or equivalent	Current Grid Code requirements will apply.	Current Grid Code requirements will apply	

Grid Code Clause	TO Connection Requirements at Offshore / Onshore Grid Entry Point specified in STC or equivalent		Offshore Generator Connection Requirements at Offshore Grid Entry Point specified in Grid Code		Comments
	AC Connection	DC Connection	AC Connection	DC Connection	
CC6.5.10 – Busbar Voltage	Current Grid Code requirement will be applied	Current Grid Code requirement will be applied	Current Grid Code requirement will be applied	Current Grid Code requirement will be applied	Minor changes required to differentiate between offshore and onshore Grid Entry Point.
CC6.6.1 – System Monitoring	Not applicable – Offshore TO is part of the GB Transmission System	As per existing Grid Code requirement and will be specified in the Construction Agreement.	Current Grid Code requirement will be applied to Offshore Generators	As per existing Grid Code requirement and will be specified in the Bilateral Agreement.	
CC.8 – Ancillary Services	Current Grid Code requirements apply in respect of those services to be applied at the Grid Entry Point. Requirement will be specified in the STC or equivalent.	Current Grid Code requirements apply in respect of those services to be applied at the Grid Entry Point. Requirement will be specified in the STC or equivalent.	Current Grid Code requirement will be applied in respect of Offshore Generators.	Current Grid Code requirement will be applied in respect of Offshore Generators.	Ancillary services will apply but will be dependant on Connection Conditions detailed in CC6.3
CC.A.3 - Minimum Frequency Response Requirement profile and operating range	Not applicable	Current Grid Code requirements will be included in the STC or equivalent.	Current Grid Code requirement will be applied in respect of Offshore Generators	Current Grid Code requirement will be applied in respect of Offshore Generators	Existing requirements may be applied although consistency will be required with CC6.3.7
CC.A.4 – Fault Ride Through Requirements					Updates will be included in CC.A.4 to include provisions for Offshore Generators as defined in CC6.3.15.

Appendix 1B

Proposals **on the Grid Code Planning Code in respect of Offshore Electricity Transmission**

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
PC.1 – Introduction			Updates will be required to include Offshore Generators. In particular PC1.1 which makes reference to the STC and Scotland. Similar provisions may also be required under the STC. An Offshore Generator would be classified as a User and an Offshore TO would be classified as a Relevant Transmission Licensee.
PC.2 – Objective		No Change required	
PC.3.1 - Scope	The scope of the data requirements in respect of the Offshore Transmission Network would need to be specified in the STC or equivalent. These would be expected to be broadly similar to those required from a Network Operator.	Amendments required to include Offshore Users	Data requirements specified within the Grid Code would only apply to Offshore Generators and their associated assets. Data requirements relating to the Offshore TO Network would need to be specified in the STC or equivalent.
PC.3.2 – Scope relating to Embedded Power Stations and Embedded DC Converter Stations			Not applicable – An Offshore Generator which connects to a licensed Offshore TO cannot be embedded.
PC.4 – Planning Procedures	Equivalent provisions will be required in the STC or similar	Consequential changes required to include the Offshore arrangements.	

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
PC.5 – Planning Data	Equivalent provisions will be required in the STC or similar.	Changes will be required to include Offshore Generators but no additional data will be required.	
PC.6 – Planning Standards	Equivalent provisions will be required in the STC or similar.		Modifications will be required in respect of Offshore Transmission in particular in relation to PC.6.2. It is possible that a new paragraph PC.6.3 will be required to include Offshore provisions.
PC.A.1 - Introduction	Equivalent provisions will be required in the STC or equivalent.	The Grid Code will need to include provisions for Offshore Generators although no new data over and above that required from onshore Generators would be expected. PC.A.1.10 will need to be changed in respect of Offshore Licensing arrangements as the current arrangements may not be appropriate.	No material change is expected other than the need to include Offshore Generators.
PC.A.2.1 – Users System Data - Introduction	Equivalent provisions will be required in the STC or equivalent	No major change is anticipated in relation to this section other than in respect of ensuring the Grid Code provisions include Offshore Users.	
PC.A.2.2 – Users System Layout	Equivalent provisions will be required in the STC or equivalent which makes reference to the Offshore TO system layout.	Changes will be required to PC.A.2.2.2 to reflect the Offshore regulatory environment.	No major change is anticipated in relation to this section other than in respect of capturing Offshore Users.
PC.A.2.3 – Lumped System Susceptance	Equivalent provisions may be required in the STC in respect of Offshore Networks.	Changes will be required to include Offshore Users.	
PC.A.2.4 – Reactive Compensation Equipment	Equivalent provisions will need to be included in the STC or equivalent and include references to the Offshore TO equipment.	Changes will be required to include Offshore Users.	
PC.A.2.5 – Short Circuit Contribution to GB Transmission System	Fault level infeed data will be required in order to design the necessary equipment at the Onshore Grid Entry Point. Equivalent provisions will therefore be required in the STC or similar.	Minor modifications will be required to accommodate the Offshore transmission arrangements but these changes are only expected in relation to the new terms that would appear within the Glossary and Definitions.	

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
PC.A.2.5.5 – Data from Generators, DC Converter Station owners and from Network Operators in respect of Embedded Medium Power Stations not subject to a Bilateral Agreement and Embedded DC Converter Stations not subject to a Bilateral Agreement and Embedded DC Converter Stations not subject to a Bilateral Agreement within such Network Operators System	Not applicable	Directly connected Offshore Generators would need to supply data that is consistent with that provided by onshore Generators.	Minor modifications will be required to accommodate the Offshore transmission arrangements but these changes are only expected in relation to the Glossary and Definitions.
PC.A.2.5.6 – Data items	Equivalent requirements in respect of the Offshore TO network will need to be placed in the STC or similar which specifies the data to be supplied by the Offshore TO.	Minor modifications will be necessary to accommodate the requirements on Offshore Users but these changes are only expected in relation to the Glossary and Definitions	
PC.A.3.1 – Generating Unit Data - Introduction	Not applicable	Minor modifications will be necessary to accommodate the requirements on Offshore Generators but these changes are only expected in relation to the Glossary and Definitions	
PC.A.3.1.5 – Busbar Arrangements	Not applicable	Minor modifications will be necessary to accommodate the requirements on Offshore Generators but these changes are only expected in relation to the Glossary and Definitions	

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
PC.A.3.2 – Output Data	Not applicable	PC.A.3.2.1 (a) will need to be amended to reflect Offshore Generators; alternatively a new sub-clause could be incorporated.	Minor modifications will be required to capture Offshore Generating Plant connected to an Offshore Transmission Network but these changes are only expected in relation to the Glossary and Definitions. If an Offshore Generator chooses to provide an enhanced reactive capability as agreed with the Offshore TO and GBSO this data will need to be reflected in the Performance Chart as submitted under PC.A.3.2.2 (f).
PC.A.3.3 – Rated Parameters	Not applicable	No major change expected other than to ensure that Offshore Generators submit the required standard planning data in the same way as an Onshore generator.	Minor modifications will be required to capture Offshore generating plant connected to an Offshore transmission network but these changes are only expected in relation to the Glossary and Definitions.
PC.A.3.4 – General Generating Unit Power Park Module and DC Converter Data	Not applicable	No major change expected other than to ensure that Offshore Generators submit required standard planning data in the same way as an Onshore Generator.	Minor modifications will be required to capture Offshore generating plant connected to an Offshore transmission network but these changes are only expected in relation to the Glossary and Definitions.
PC.A.4 – Demand and Active Energy Data	Some provisions will be required within the STC or equivalent to cater for demand within the Offshore network.		Limited applicability. The Offshore TO networks are assumed largely to export power from Offshore Generation. The Offshore TO Networks may have some demand associated with them in terms of auxiliary supplies etc which will need to be captured within the Grid Code.
Part 2			
PC.A.5 – Generating	Not applicable	For Offshore Generators directly connected to an Offshore	No additional data will be required over

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
Unit, Power Park Module and DC Converter Data		TO no material change is expected other than to ensure that the Planning Code is updated to ensure Offshore Generators submit the data currently required (PC.A.5.1.1).	and above that requested from Onshore generators.
PC.A.5.2.2 - Demand	Not applicable	For Offshore Generators directly connected to an Offshore TO no material change is expected other than to ensure that the Planning Code is updated to ensure Offshore Generators submit the currently required demand data as would be expected from an Onshore generator.	
PC.A.5.3 – Synchronous Generating Unit and associated Control System Data	Not applicable	No change expected other than to ensure the data required covers Offshore Generators. No additional data required over and above that requested from Onshore generators.	
PC.A.5.4 – Non Synchronous Generating Unit and Associated Control System data	Not applicable	No change expected other than to ensure the data required covers Offshore Generators. No additional data required over and above that requested from Onshore Generators.	If an Offshore Generator chooses to provide an enhanced reactive and voltage control capability as agreed with the Offshore TO and GBSO, this data will need to be reflected in the data submitted under PC.A.5.4 of the Planning Code.
PC.A.5.4.3 – DC Converter	HVDC Converter data will need to be supplied if such technology is employed by the Offshore TO. These requirements will be included in the STC or equivalent and would be expected to be largely similar to those required in the Grid Code.	Not applicable. For Generating plant (such as a wind turbine employing a full converter), the data will be provided under PC.A.5.4.	No additional data required over and above that requested from Onshore Generators / HVDC Converters.
PC.A.5.5 – Response data for Frequency changes	Not applicable	No change expected other than to ensure the data required covers Offshore Generators. No additional data required over and above that requested from Onshore Generators	.
PC.A.5.6 – Mothballed Generating Unit Mothballed Power Park Module or Mothballed DC	There may be a need to include a clause on mothballed HVDC Converters which form part of an Offshore TO).	No change expected other than to ensure the data required covers Offshore Generators. No additional data required over and above that requested from Onshore Generators.	

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
Converter at a DC Converter Station and Alternative Fuel information			
PC.A.6.1 – Users System Data - Introduction	The Offshore TO will need to submit data to National Grid in respect of the Offshore Transmission Network. The provisions of which shall be included in the STC or equivalent.	Offshore Generators will need to submit network data in relation to any network they own and control for example the low voltage interconnecting network between the Offshore wind turbines and the Offshore Grid Entry Point.	No additional data is required over and above that requested from Onshore Generators.
PC.A.6.2 – Transient Overvoltage Assessment Data	The Offshore TO will need to submit data in order for transient overvoltage assessments to be undertaken. This requirement will be placed in the STC or equivalent.		For Offshore Transmission Networks, transient overvoltage assessment will require careful examination as a result of the high reactive gain of the cables.
PC.A.6.3 – Users Protection Data - Protection	The Offshore TO will need to supply protection data in relation to the Offshore Network. This requirement will need to be incorporated into the STC or equivalent.	Offshore Generators will need to submit protection data in relation to any interconnecting network they own and control, for example, the protection settings between the low voltage interconnecting network and the Offshore Generators circuits connecting the wind turbines to the Offshore Grid Entry Point.	No additional data is required over and above that requested from Onshore Generators or Network Operators. Note - it is important that there is harmonisation and co-ordination between the onshore and offshore protection standards.
PC.A.6.4 – Harmonic Studies	The Offshore TO will need to supply harmonic data in relation to the Offshore Transmission Network. This requirement will need to be incorporated into the STC or equivalent.	Offshore Generators may need to submit harmonic data in relation to any network they own and control for example the low voltage interconnecting network between the Offshore wind turbines and the Offshore Grid Entry Point.	No additional data is required over and above that requested from Onshore Generators or network Operators.
PC.A.6.5 – Voltage Assessment Studies	The Offshore TO will need to supply voltage assessment data in relation to the Offshore Transmission Network. This requirement will need to be incorporated into the STC or equivalent.	Offshore Generators may need to submit voltage assessment data in relation to any network they own and control for example the low voltage interconnecting network between the Offshore wind turbines and the Offshore Grid Entry Point.	No additional data is required over and above that requested from Onshore Generators or Network Operators
PC.A.6.6 – Short Circuit Analysis	The Offshore TO will need to supply short circuit analysis data in relation to the Offshore Transmission Network. This requirement will need to be incorporated into the STC or	Offshore Generators may need to submit short circuit analysis data in relation to any network they own and control for example the low voltage interconnecting network between the Offshore wind turbines and the Offshore Grid Entry Point.	No additional data is required over and above that requested from Onshore Generators or Network Operators

Grid Code Clause	**TO** Data Requirements at the **Offshore** / **Onshore** Grid Entry Point specified in STC or equivalent	**Offshore Generator** Planning Code Requirements at **Offshore** Grid Entry Point specified in Grid Code	Comments
	equivalent.		
PC.A.7 – Additional data for new types of Power Stations DC Converter Stations and Configurations	Not applicable other than in respect of Offshore TO's who employ an HVDC Converter.	No change expected other than to ensure the data required covers Offshore Generators.	
PC.A.8 – Network Data		Updates will be required to ensure that PC.A.8 of the Planning Code incorporates Offshore Users. This will be necessary so Offshore Users can design and operate their Systems effectively.	PC.A.8 lists those items of data which National Grid is required to supply to Users. This will apply to all Users including those offshore but equally there will need to be some provision in the STC or equivalent.

Appendix 1C

High Level Proposals for the Data Registration Code relating to the Regulation of Offshore Electricity Transmission
Discussion Paper

Introduction

1) The Data Registration Code provides a summary of the data required under the Grid Code which Users are required to provide to NGET and reciprocally, data which NGET is required to provide to Users.

2) The changes required to the Data Registration Code to incorporate offshore Transmission will therefore reflect the changes introduced to other sections of the Grid Code.

3) In general terms, changes to the Data Registration Code as a result of the introduction of the offshore transmission arrangements are not anticipated to result in significant changes other than the need for Offshore Generators to supply data that would be required from their onshore counterparts.

4) In addition to the data required from offshore Generators, there will also be a need for the offshore TO to supply data to National Grid in respect of their offshore Network. This will be specified in the STC or equivalent.

Schedule 1

5) Schedule 1 defines the generating unit technical data to be supplied by Generators and is largely a summary of the data required under the Planning Code. In general, the Offshore Transmission arrangements do not present a requirement for the submission of significant volumes of new data, other than the need for the Grid Code to ensure that Offshore Generators (in respect of their offshore Generating Units or offshore Power Park Modules) provide the same type of data as their onshore counterparts. If an Offshore Generator, in agreement with the Offshore TO and GBSO provides and enhanced capability beyond the minimum requirements of the Grid Code, it will need to reflect such capabilities in its data submission.

6) Although outside the scope of Schedule 1, an Offshore TO would be required to supply HVDC data if it used such technology within its network. Such a requirement will need to be included within the STC or equivalent.

Schedule 2

7) Schedule 2 defines the required Generation Planning Parameters. No major changes are expected in relation to Schedule 2 other than in respect of the need to ensure Offshore Generators submit the data required.

9) Schedule 2 only relates to Generators and therefore no consequential changes would be required to the STC or equivalent in respect of the Offshore TO Network.

Schedule 3

10) Schedule 3 relates to “Large Power Station Outage Programmes, Output Useable and Inflexibility Information”. No change is expected to this schedule other than the need to include Offshore Generators.

11) Schedule 3 is only applicable to Generators and therefore there will be no need for any changes to the STC or equivalent.

Schedule 4

12) Schedule 4 relates to "Governor Droop and Response". No change will be required to this schedule apart from the need to include Offshore Generators.

Schedule 5

13) Schedule 5 relates to Users System Data and associated network parameters. Whilst no additional data is required, the Grid Code provisions will need to include the network data that relates to the Offshore Generator's assets.

14) In addition, there will also be a requirement to include similar provisions in the STC or equivalent such that National Grid has knowledge of the Offshore Transmission Network data. This is likely to result in a change to STC Procedure STCP12-1 "Data Exchange Mechanism", the introduction of a new procedure, or equivalent.

Schedule 6

15) Schedule 6 relates to "Users Outage information". Data would need to be supplied by Users Connected to the Offshore TO Network. However it should be noted that no new additional data will be required from Offshore Generators as a result of the offshore provisions.

16) Under the Current STC Procedures, STCP11-1 and STCP11-2 define Outage Planning and Outage Data Exchange data. Equivalent provisions will need to be included in the STC or equivalent to ensure outage data associated with the Offshore Transmission networks can be obtained.

Schedule 7

17) Schedule 7 defines the "Load Characteristics at Grid Supply Points". Demand associated with offshore networks is expected to be low but it is important to ensure a facility exists within the Grid Code to accommodate such data from an offshore User should the need arise. No additional data would be required from an Offshore User over and above that required from an equivalent onshore User.

Schedule 8

18) Schedule 8 defines the "Data to be Supplied by BM Participants". No change is expected to this schedule as the new offshore definitions can be utilised within the existing terms of this Schedule. In addition, no corresponding change would be required to the STC or equivalent.

Schedule 9

19) Schedule 9 defines the "Data to be Supplied by NGET to Users". No major changes are envisaged to this schedule other than to include appropriate provisions for Offshore Users.

Schedule 10

20) Schedule 10 defines "Demand Profiles and Active Energy Data". No major changes are expected to this schedule other than in respect of Offshore Users.

Schedule 11

21) Schedule 11 defines "Connection Point Data". This is mainly aimed at Users Systems with a high volume of demand. Clearly such provisions will not be appropriate to the offshore environment in the initial phase however as networks develop it is possible that demand may become more of an issue.

Schedule 12

22) Schedule 12 defines the data required to be submitted for “Demand Control”. No changes are proposed to this section.

Schedule 13

23) Schedule 13 defines “Fault Infeed” data required from all Users other than Generators. No significant changes are believed to be necessary, as the new definitions required for offshore transmission would fall into the existing terms defined within Schedule 13.

24) There will be a need for the Offshore TO to provide similar data to National Grid at the onshore Grid Entry Point which will be required for design purposes. This data will need to be specified in the STC or equivalent.

Schedule 14

25) Schedule 14 defines the “Fault Infeed” data that should be supplied by Generators. This will need to be updated to ensure that Offshore Generators supply the same type of data as their onshore counterparts. In general, no additional data would be required from offshore Generating Units although it should be noted that this section of the Grid Code is currently being updated through Consultation G/06. It should therefore be noted that Offshore Generators would be required to meet the same proposals as onshore Generators at the appropriate connection point.

Schedule 15

26) Schedule 15 defines the data required in respect of “Mothballed Generating Units, Mothballed Power Park Modules or Mothballed DC Converters at a DC Converter Station”. No change is required to this schedule other than the need to ensure that Offshore Generators are included within these requirements.

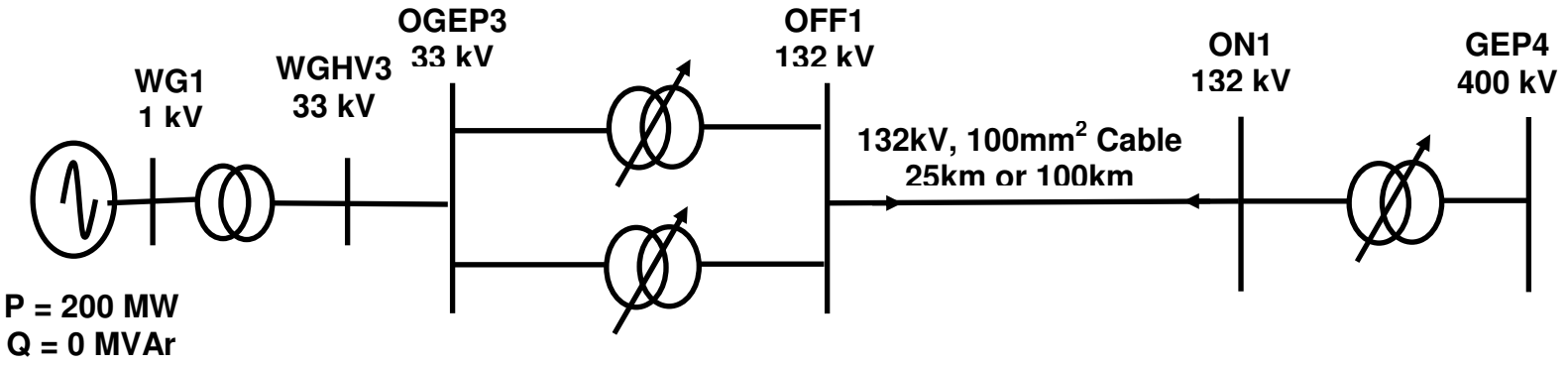
Appendix 1D
Proposed Amendments to the Grid Code Operating Codes

Operating Code	Proposed Amendment	Comments
OC1 Demand Forecasts	Term **Users** as applied in OC 1.3 will be extended to include operators of offshore distribution networks	Operators of offshore distribution networks will be considered as Network Operators in OC1
OC2 Operational Planning and Data Provision	Obligations on power stations directly connected to the onshore transmission system will be extended to include to an offshore transmission network. Generators will provide outage and Output Usable data at the Grid Entry Point level. Owners of offshore transmission networks will provide details of their planned outages to the System Operator	The GBSO's role as co-coordinator of outages for onshore transmission, generation and distribution systems will be extended to include the same offshore. This will facilitate the co-ordination of generation outages with outages on platform apparatus. This will require an amendment to the STC(P)
OC 5 Testing and Monitoring	Will be extended to apply to **Users** (as defined in OC5) of offshore transmission networks	
OC 6 Demand Control	Obligations on **Users** (as defined in OC6) and Non Embedded Customers onshore will apply to the same offshore.	
OC 7 Operational Liaison	Requirements for the exchange of information in relation to an onshore Operation/Event will apply for an Operation/Event offshore GB Transmission System Warnings will be extended to include system conditions and event on offshore network. Procedure for Integral Equipment Tests will apply to users of offshore transmission networks The System Operator will undertake operational switching on offshore transmission networks.	This will require an amendment to the STC(P)
OC8 Safety Co-ordination	Existing OC8a requirements will be placed on Offshore networks which connect to the England and Wales onshore system. Existing OC8b	These proposals are subject to approval.

	requirements will be applied to Offshore Networks which connect to the Scottish onshore system.	
OC9 Contingency Planning	Black Start: Extended to include offshore networks. Offshore TOs will participate in the development of restoration plans but will not invoke the plan of operate the transmission system following implementation. Resynchronisation of Desynchronised Islands: Current Grid Code obligations will apply to offshore transmission networks. A desynchronised island solely comprising of an offshore transmission system and a distribution network dealt with in the same way as a desynchronised island involving an onshore transmission network and distribution system. OC9.5.2.4 which allows the SO to desynchronise generation in a desynchronised island would apply to offshore generation The options for managing transmission connected generation (OC9.5.2), only applicable in Scotland, will apply to all generation connected to an offshore transmission network.	This will require an amendment to the STC(P) This will require an amendment to the STC(P) This will require an amendment to the STC(P)
OC 10 Event Information Supply	Arrangements will apply to **Users** (as defined in OC10) connected to an Offshore Transmission Network	
OC 11 Numbering and Nomenclature of HV Apparatus	Offshore transmission networks will adopt the specification of the onshore TO to which they are directly connected or connected via a distribution network.	This will avoid having to introduce an additional specification into the current TO/DNO geographic areas
OC12 System Tests	Existing arrangements will be extended to include Users (as defined in OC12) of offshore networks.	

Appendix 2
Network Topologies and Parameters

200MW Study Network Topology



200MW Study Network Parameters

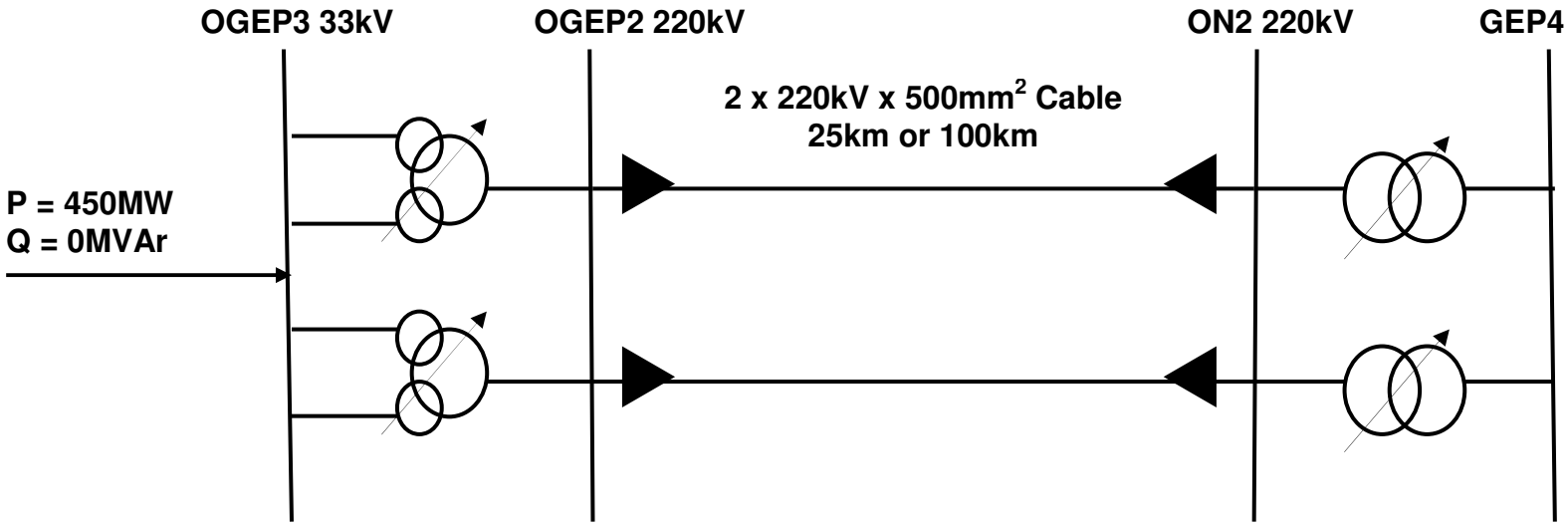
Fixed Ratio Generator Transformer 1 – 33kV			
Rating (MVA)	R (% on 100MVA)	X (% on 100MVA)	Ratio
213	0.0315	0.04274	1

Variable Ratio Transformer 33 – 132kV				
Rating (MVA)	R (% on 100MVA)	X (% on 100MVA)	Ratio Range	Initial Ratio
120	0.0707	1.802	-18% to +12%	1

2 – Winding Transformer 132 – 400kV				
Rating (MVA)	Magnetising Current (%)	X (% on Rating)	Cu Losses (% on Rating)	Tap Ratio
240	0.13208	20	0.38376	-5% to +15%

Offshore TO Cable						
Voltage (kV)	Cross Sectional Area (mm^2)	S Rating (MVA)	I Rating (A)	R (mΩ/km)	X (mH/km)	C (nF/km)
132	1000	217	949	27.5	0.351	238

500MW Study Network Topology



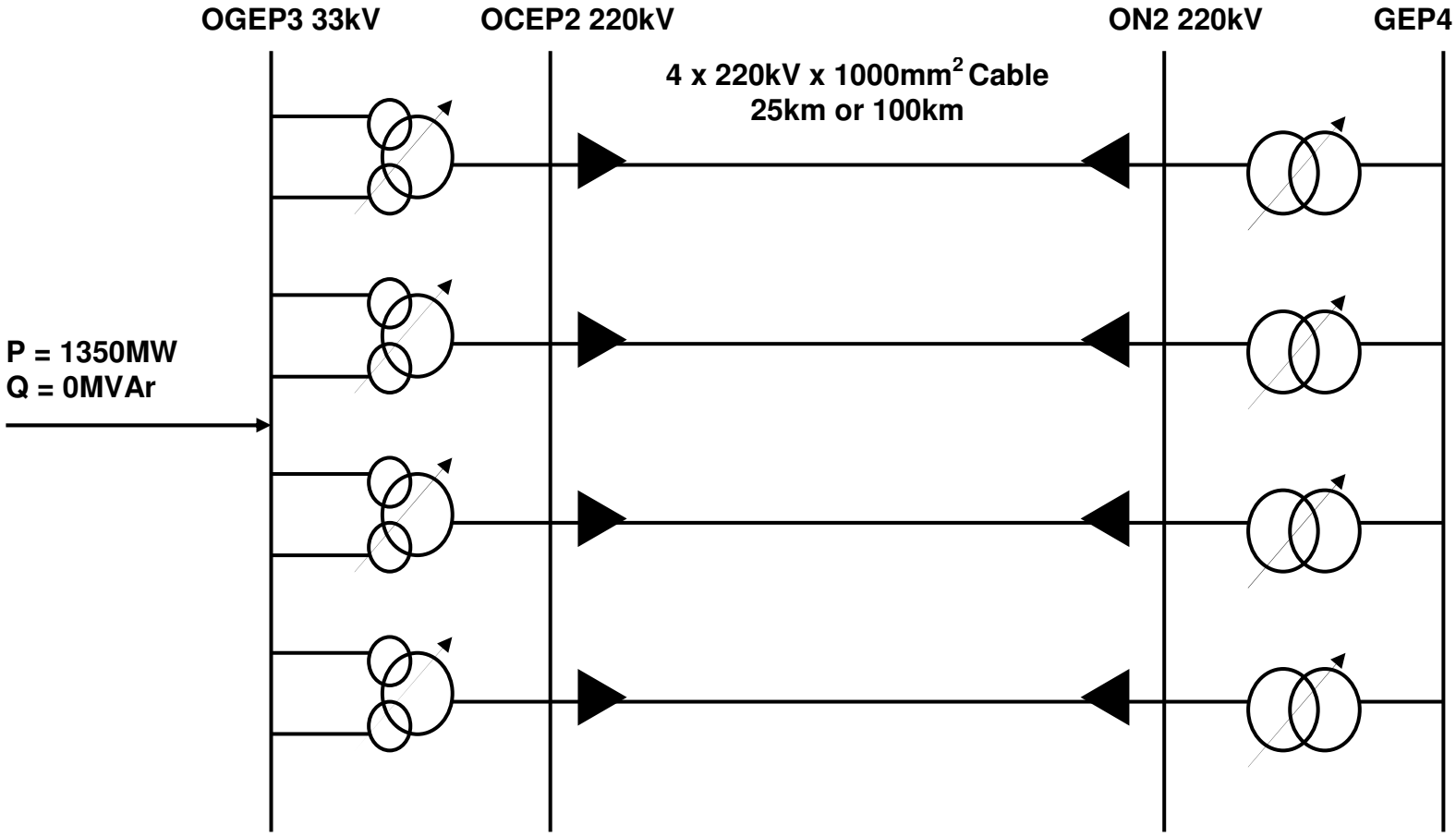
500MW Study Network Parameters

3 – Winding Transformer 33 – 220kV									
Primary Rating (MVA)	Secondary Rating (MVA)	Magnetising Current (%)	X 1-2 (% on Rating)	X 1-3 (% on Rating)	X 2-3 (% on Rating)	Cu Losses 1-2 (% on Rating)	Cu Losses 1-3 (% on Rating)	Cu Losses 2-3 (% on Rating)	Tap Ratio
240	120	0.316	15	15	30	0.15	0.15	0.15	-10% to +10%

2 – Winding Transformer 220 – 400kV			
Rating (MVA)	X (% on Rating)	R (% on Rating)	Tap Ratio
240	15	0.15	-10% to +10%

Offshore TO Cable						
Voltage (kV)	Cross Sectional Area (mm^2)	S Rating (MVA)	I Rating (A)	R (mΩ/km)	X (mH/km)	C (nF/km)
220	500	279	732	48.9	0.437	136

1500MW Study Network Topology



1500MW Study Network Parameters

3 – Winding Transformer 33 – 220kV									
Primary Rating (MVA)	Secondary Rating (MVA)	Magnetising Current (%)	X 1-2 (% on Rating)	X 1-3 (% on Rating)	X 2-3 (% on Rating)	Cu Losses 1-2 (% on Rating)	Cu Losses 1-3 (% on Rating)	Cu Losses 2-3 (% on Rating)	Tap Ratio
360	180	0.475	15	15	30	0.3	0.3	0.4	-10% to +10%

2 – Winding Transformer 220 – 400kV			
Rating (MVA)	X (% on Rating)	R (% on Rating)	Tap Ratio
360	15	0.15	-10% to +10%

Offshore TO Cable						
Voltage (kV)	Cross Sectional Area (mm^2)	S Rating (MVA)	I Rating (A)	R (mΩ/km)	X (mH/km)	C (nF/km)
220	1000	359	942	27	0.386	177