NETS SQSS Modification Proposal

Operational and Planning Criteria for 220kV Transmission Assets

Panel Paper

5th August 2015

1. Introduction and Requirement for Modification Proposal

With the introduction of 220kV assets on the National Electricity Transmission System (NETS), the planning and operational criteria in the NETS SQSS (referred to herein as SQSS) need to be modified to include this new voltage level. The first 220kV assets will be introduced to the NETS with the commissioning of the Kintyre – Hunterston subsea AC link which consists of two 220kV subsea cables between Crossaig on the Kintyre peninsula and Hunterston in Scotland in 2015. These will connect to the onshore transmission network via two 220/132kV transformers at the Scottish Hydro Electric Transmission's Crossaig end and two 400/220kV supergrid transformers at the ScottishPower Transmission's Hunterston end.

It is envisaged that other 220kV AC projects will be developed on the NETS, especially with the connection of some offshore windfarms. A number of contracted offshore developers/offshore transmission owners (OFTOs) have indicated plans to connect to the onshore transmission system at 220kV. The 220kV nominal voltage is largely dictated by the submarine cable technology currently available. While this modification proposal seeks to include the 220kV nominal voltage in the SQSS, it also recognises that as the technology advances, the voltage ratings of subsea cables are likely to rise. Thus, it is possible that nominal voltages other than those currently in operation on the NETS will likely emerge in the foreseeable future.

Planning and operational voltage limits are specified in Section 6 of the SQSS – 'Voltage Limits in Planning and Operating the Onshore Transmission System' and Section 10 – 'Voltage Limits in Planning and Operating an Offshore Transmission System'. Section 6 voltage limits are applicable to Sections 2, 3, 4[1] and Section 5 while Section 10 voltage limits are applicable to Sections 7, 8, 9 and Section 4[2].

Within the onshore sections of the SQSS, distinction is made between supergrid assets and transmission assets in general. 'Supergrid' is a defined term in the SQSS, referring to the "part of the transmission system operated at a nominal voltage of 275kV and above". As currently defined, the 220kV assets would not be considered as supergrid assets but would be transmission assets on any part of the NETS.

Section 10, which specifies voltage limits for offshore transmission systems, provides voltage limits for all nominal voltages less than 400kV down to 132kV inclusive. Thus, there is no ambiguity with

[1] Voltage criteria of SQSS Section 6 are applicable to the onshore part of the Main Interconnected Transmission System (MITS).

[2] Voltage criteria of SQSS Section 10 are applicable to the offshore part of the MITS.

voltage limits at 220kV on the offshore transmission system in the current version of the SQSS. There is also no reference made to the defined term 'supergrid' in the offshore section of the SQSS.

Pre-fault voltage limits, steady state voltage limits and voltage step limits are specified by explicit transmission voltage level within the onshore criteria meaning that voltage limits are effectively not defined at any transmission voltage that is not explicitly specified on the onshore transmission system. Within Section 6 and the relevant onshore sections, a number of secured events are qualified by the term 'supergrid'. It is important to provide clarity on whether 220kV should be considered as a supergrid voltage or not and to unambiguously specify the applicable voltage limits for the same.

2. Proposal

The proposed modification is to:

i. Adopt the 275kV planning and operational voltage limits for 220kV; and
ii. Modify the defined term 'supergrid' to include 220kV by aligning with the Grid Code definition which considers any voltage above 200kV as a supergrid voltage.

3. Justification for the proposal

3.1 Voltage limits

The proposal to adopt the 275kV voltage limits for 220kV was based on a number of reasons as follows:

a) 220kV is closer to 275kV than the lower transmission voltage of 132kV in Scotland;
b) 275kV and 132kV voltage limits are broadly similar, therefore there is no compelling argument to consider different voltage limits for an intermediate voltage;
c) There are no properly defined low voltage limits at 132kV, i.e. the low voltage limit at 132kV is dictated by the ability to achieve a target voltage of 105% pre-fault voltage or 100% steady state voltage on the LV busbar of a GSP in Scotland;
d) Operationally, 132kV can be relaxed to 120% for no more than 15 minutes following a major system fault. At 275kV, the corresponding relaxation is 115%. Given 220kV is closer to 275kV and that insulation costs increase with voltage, it is preferable to adopt the tighter voltage relaxation criteria i.e. 115% as for 275kV rather that the 120% relaxation for 132kV; and
e) The choice of 220kV nominal voltage is based on the IEC rated voltage (or highest voltage of equipment) of 245kV in the same way that 275kV is based on 300kV. Within IEC, the way 245kV is treated is the same as the way 300kV is treated so adopting the 275kV voltage limits should be straightforward.

Given the above points and the fact that 132kV is not a transmission voltage in England and Wales, the proposal to adopt the 275kV voltage limits for 220kV was arrived at.

3.2 Definition of the term 'supergrid'

The proposal to modify the SQSS definition of the term 'supergrid' was made on the basis that:

a) There are currently no nominal system voltages between 132kV and 275kV on the NETS;
b) Following on from the arguments given for the proposal to adopt the 275kV voltage limits above, it would make sense to ensure that secured events involving 220kV assets are treated similarly to their 275kV counterparts which are currently classified as supergrid assets; and
c) The Grid Code has the term 'supergrid' as a defined term covering all voltages above 200kV. This is a key document for the System Operator, Transmission Owners and Users therefore it is proposed to align the SQSS definition to the Grid Code definition of 'supergrid'.

4. Impact assessment

4.1 Impact on the NETS SQSS

Introducing voltage limits for the new 220kV nominal voltage without changing the limits for all currently specified voltages in the SQSS will have no impact on the SQSS. It is important to ensure that the drafting changes to the SQSS text, to facilitate this modification, do not unduly impact on any other SQSS criteria.

The proposed definition for the term 'supergrid', which covers a wider voltage range, would mean that more assets would now be included when considering secured events involving supergrid assets but the additional assets would only be the assets at the new 220kV nominal voltage at this stage. Modifying the term 'supergrid' in the SQSS to align with the Grid Code definition will therefore have no impact on the SQSS given that there are currently no system nominal voltages between 132kV and 275kV specified in the SQSS.

4.2 Impact on the National Electricity Transmission System (NETS)

No impact identified

4.3 Impact on greenhouse gas emissions

No impact identified

4.4 Impact on relevant computer systems

No impact identified

4.5 Impact on other documents

An impact assessment of the proposed modification was carried out on the Grid Code, Distribution Code and a number of key Engineering Recommendation documents and associated Engineering Technical Reports. The findings are given in Table 1:

Table 1. Impact assessment summary for the proposed 220kV SQSS modification on relevant industry documents

Document	Short Description	Impact Assessment
Grid Code		The Grid Code definition of supergrid is the one proposed to be adopted in the SQSS. Therefore this aspect of the proposed modification does not have any impact on the Grid Code. The Grid Code makes reference to voltage limits at 400kV, 275kV and 132kV in CC.6.1.4. It also makes reference to the same voltage levels in CC.6.2.2.2.2 and CC.6.2.3.1.1 in connection with fault clearance times and CC.6.3.2 in connection with plant performance requirements. The introduction of 220kV in the SQSS does not have an impact on the Grid Code although there may be the need to update the Grid Code to include this voltage level.
D Code	Distribution Code	There are no transmission voltage limits specified in the Distribution Code and there is no reference to the term 'supergrid' either. Therefore the proposed modification does not have an impact on the Distribution Code.
ER P2/6	Security of Supply	The term 'supergrid' is referenced once but it is not defined within the document. This is in connection with security criteria for Group Demand over 300MW and up to 1500MW (Supply Class E). "The provisions of Class E to infeeds to the distribution system but not to systems regarded as part of the interconnected Supergrid to which the provisions of Class F (Group Demand over 1500MW) apply." The definition of the term 'Group Demand' refers to demand submission under the Grid Code. The meaning of supergrid in the context of ER P2/6 is therefore taken to be the same as that in the Grid Code; hence the proposed SQSS modification would have no impact on ER P2/6.
ER G5/4 (and draft ER G5/5)	Planning levels for harmonic voltage distortion	ER G5/4 neither makes specific reference to the term 'supergrid' nor treats voltage levels by range categories. However, ER G5/5, currently in draft form, refers to voltage range categories broadly aligned to IEC 60038 (IEC standard voltages). Voltage categories of interest are High Voltage (>36kV and <= 230kV) and Extra High Voltage (>230kV). Given that the term 'supergrid' is not used in the draft ER G5/5, the proposed modification would have no impact on the draft ER G5/5 in its current form. This however means the supergrid voltages would include some HV voltages as well as some EHV voltages in draft ER G5/5. This is not envisaged to present an issue.
ER G59/3-1 (and draft ER G59/3-2)	Recommendations for the connection of generating plant to the distribution systems of licensed Distribution Network Operators	The term 'supergrid' is used in ER G59/3-1 and draft ER G59/3-2 (with reference to supergrid transformers) but is not defined therein. The Engineering Recommendation is intended to provide guidance to generators and DNOs with mandatory conditions governing connection conditions of distributed generators set out in the Distribution Planning and Connection Code of the Distribution Code and the connection conditions of the Grid Code. Since the Distribution Code does not use the term 'supergrid', it is the Grid Code context of the term that is applicable in ER G59/3-X. Given that the proposal is to align the SQSS definition of the term 'supergrid' with the definition in the Grid Code, no impact is envisaged on ER G59/3-X as a result of this modification proposal.
ER P28	Planning limits for voltage fluctuations	The term supergrid impedance is used in the document relating to consideration of system impedances above 132kV. The proposed SQSS modification would therefore have no impact on ER P28.
ER P29	Planning limits for voltage unbalance	The term supergrid impedance is used in the document relating to consideration of system impedances above 132kV. The proposed SQSS modification would therefore have no impact on ER P29.

Document	Short Description	Impact Assessment
European Codes		There appears to be no visible impact at this time. This is primarily because, similar to 275kV, 220kV conveniently sits in the middle of one of the European voltage ranges (110-300kV).

4.6 Impact on GSR008 Modification Proposal

GSR008 modification proposal covers regional variations and wider issues and is now with the Authority for approval. As the 220kV proposal is introducing a new voltage, the same modifications proposed to the SQSS text would be applicable to the GSR008 SQSS text with no impact identified.

5. SQSS text edits to implement the proposal

5.1 Voltage limits

There are potentially two ways of implementing the proposed modifications to include the 220kV nominal voltage in the voltage limits section of the NETS SQSS Version 2.2, Dated March 5 2012. These are:

a) Inserting an extra row in the SQSS Tables 6.1, 6.3 and 6.5. The row would enter voltage limits for 220kV. In the range of interest, IEC recognises 170kV, 245kV, 300kV, 362kV and 420kV ratings, each of which has a recognised associated nominal voltage for the system. From this perspective, it is desirable to specify voltage limits for 220kV explicitly to avoid confusion and make sure we are always working within the framework of international standardisation. **This is the preferred modification approach**. The proposed SQSS text modifications to reflect this are illustrated in Appendix 1.

b) Replacing the row with the 275kV voltage limits in the SQSS Tables 6.1, 6.3 and 6.5 with a row that specifies voltage limits for a range of voltages that include the new nominal voltage of 220kV. Potentially, this approach offers the benefit that if the technological improvements in subsea cables result in voltages higher then 220kV up to and including 275kV, there would be no modification required in the SQSS. The proposed SQSS text modifications to reflect this are illustrated in Appendix 2.

5.2 Definition of the term 'supergrid'

Current definition:

That part of the National Electricity Transmission System operated at a nominal voltage of 275kV and above.

Proposed definition:

That part of the National Electricity Transmission System operated at a nominal voltage of 200kV and above.

Appendix 1. SQSS text modification option explicitly specifying criteria for 220kV

Table 6.1 Pre-fault planning voltage limits

Nominal voltage	Minimum	Maximum
400kV	390 kV (97.5%)	410 kV (102.5%) Note 1
275kV	261 kV (95%)	289 kV (105%)
220kV	**209 kV (95%)**	**231 kV (105%)**
132kV in SPT's transmission system and SHETL's transmission system.	Note 2	139 kV (105%)
<275kV in NGET's transmission system and <132kV in SPT's transmission system and SHETL's transmission system.	Note 3	105%

Notes… (no notes applicable for 275kV)

Table 6.3 The steady state voltage limits in planning timescales

Nominal voltage	Minimum	Maximum
400kV	380kV (95%) Note 1	410kV (102.5%) Note 2
275kV	248kV (90%)	289kV (105%)
220kV	**198kV (90%)**	**231kV (105%)**
132kV	Note 3	139kV (105%)
<132kV	Note 3	105%

Notes… (no notes applicable for 275kV)

Table 6.5 The steady state voltage limits in operational timescales

Nominal voltage		Transmission System		
		NGET	SPT	SHETL
400kV	Minimum	360kV (90%)	360kV (90%)	360kV (90%)
	Maximum	420kV (105%) Note 1	420kV (105%) Note 2	420kV (105%) Note 2
275kV	Minimum	248kV (90%)	248kV (90%)	248kV (90%)
	Maximum	303kV (110%)	303kV (110%) Note 3	303kV (110%) Note 3
220kV	**Minimum**	**198kV (90%)**	**198kV (90%)**	**198kV (90%)**
	Maximum	**242kV (110%)**	**242kV (110%)** **Note 5**	**242kV (110%)** **Note 5**
132kV	Minimum	119kV (90%)	119kV (90%)	119kV (90%)
	Maximum	145kV (110%)	145kV (110%) Note 4	145kV (110%) Note 4
Less than 132kV	Minimum	94%	95%	94%
	Maximum	106%	105%	106%

Notes

1. May be relaxed to 440kV (110%) for no longer than 15 minutes
2. May be relaxed to 440kV (110%) for no longer than 15 minutes following a major system fault
3. May be relaxed to 316kV (115%) for no longer than 15 minutes following a major system fault
4. May be relaxed to 158kV (120%) for no longer than 15 minutes following a major system fault
5. May be relaxed to 253kV (115%) for no longer than 15 minutes following a major system fault

Appendix 2. SQSS text modification option based on modifying the 220kV limits to cover a range of voltages above and including 200kV up to 275kV

Table 6.1 Pre-fault planning voltage limits

Nominal voltage	Minimum	Maximum
400kV	390 kV (97.5%)	410 kV (102.5%) Note 1
~~275kV~~**>= 200kV but <= 275kV**	~~261 kV (95%)~~**95%**	~~289 kV (105%)~~**105%**
132kV in SPT's transmission system and SHETL's transmission system.	Note 2	139 kV (105%)
<275kV in NGET's transmission system and <132kV in SPT's transmission system and SHETL's transmission system.	Note 3	105%

Notes… (no notes applicable for 275kV)

Table 6.3 The steady state voltage limits in planning timescales

Nominal voltage	Minimum	Maximum
400kV	380kV (95%) Note 1	410kV (102.5%) Note 2
~~275kV~~**>= 200kV but <= 275kV**	~~248kV (90%)~~**90%**	~~289kV (105%)~~**105%**
132kV	Note 3	139kV (105%)
<132kV	Note 3	105%

Notes… (no notes applicable for 275kV)

Table 6.5 The steady state voltage limits in operational timescales

Nominal voltage		Transmission System		
		NGET	SPT	SHETL
400kV	Minimum	360kV (90%)	360kV (90%)	360kV (90%)
	Maximum	420kV (105%) Note 1	420kV (105%) Note 2	420kV (105%) Note 2
~~275kV~~>= 200kV but <= 275kV	**Minimum**	~~248kV (90%)~~ **90%**	~~248kV (90%)~~ **90%**	~~248kV (90%)~~**90%**
	Maximum	~~303kV (110%)~~**110%**	~~303kV (110%)~~**110%** Note 3	~~303kV (110%)~~**110%** Note 3
132kV	Minimum	119kV (90%)	119kV (90%)	119kV (90%)
	Maximum	145kV (110%)	145kV (110%) Note 4	145kV (110%) Note 4
Less than 132kV	Minimum	94%	95%	94%
	Maximum	106%	105%	106%

Notes

1. May be relaxed to 440kV (110%) for no longer than 15 minutes
2. May be relaxed to 440kV (110%) for no longer than 15 minutes following a major system fault
3. May be relaxed to 115% for no longer than 15 minutes following a major system fault
4. May be relaxed to 158kV (120%) for no longer than 15 minutes following a major system fault