PROGRESS REPORT: ER G5

1 BACKGROUND

GC0036 is tasked with reviewing and revising ENA Engineering Recommendation (ER) G5, which is the harmonic voltage distortion standard and, which is referred to in Grid Code CC6.1.5 (a). GC0036 is due to close and ENA has taken over as the administrator of the review of the document.

The document is split into the following sections:

i. General text: definition and common materials.

ii. Review of planning and compatibility levels.

iii. General connection process.

iv. Stage 1: connection at LV (up to 415 V).

v. Stage 2: connection <33 kV.

vi. Stage 3: connection >33 kV.

It has been agreed in the main workgroup that when applicable, the document is aligned with relevant IEC standard such as IEC61000-3-6 and IEEE 519 as much as possible. It has also been noted that not in all areas this may be possible due to differences in the nature of the standards as ER G5 is applied to a specific power system such as GB network and other international standards, by default, should consider a wide range of diversity.

2 MAIN AND SUB WORKGROUP

The main workgroup consists of all members, list of which is provided in Appendix A.

In order to ensure a focused approach, it was decided by the main workgroup to divide technical works in different areas into several sub-workgroups, reporting back to the main workgroup.

The following sub-workgroups were setup:

i. Sub-workgroup: Harmonics above 50^{th} order.

ii. Sub-workgroup: Stage 1 and 2 assessment

iii. Sub-workgroup: Magnification of background harmonic levels at LV and up to 22 kV.

iv. Sub-workgroup: Stage 3 assessment.

The main workgroup met on 9/11/2017 in ENA office, London. All sub-workgroups presented their work and submitted their proposal for approval by the main workgroup. It was requested that all members submit their comments by 24/11/2017.

3 GENERAL TEXT, DEFINITIONS AND COMMON MATERIALS

This section consists of definitions and general document text. The conditions and voltage levels where the standard is applicable are defined.

Guideline on voltage notches and relevant limits have been reviewed, discussed and amended as necessary. There are no significant changes compared to ER G5/4-1 in this section, which is awaiting final approval by the main workgroup.

One section that has been agreed to be included is guidelines for situations where the network background harmonic levels are above the planning and/or compatibility levels. This has been found to be an issue in practice which may delay other network user's connection. This is a new item in the revised document.

Aggregation of network background harmonic levels and those emitted by a new connectee and other sources of pollution, also known as aggregation rule, has been debated thoroughly and agreement has been reached. The adopted aggregation rule deviates from the existing guideline in G5/4-1 and is aligned with IEC 61000-3-6 standard.

The general text has been prepared and discussed in the main workgroup and consensus has been reached. It is awaiting final approval by the main workgroup.

4 REVIEW OF PLANNING AND COMPATIBILITY LEVELS

Comparison between planning and compatibility levels contained in ER G5/4-1 and other relevant international standards were made. Some differences in these levels between different standards were noted. It has been agreed that, in absence of thorough and detailed scientific research and work publically available, the highest planning and compatibility levels amongst those in different standards are adopted. It has also been agreed that the limits for voltage total harmonic distortion is kept at that given in G5/4-1, which allows, for some harmonic orders, more relaxed levels than those in ER G5/4-1 while ensuring that the total thermal effect to remain unchanged. It is envisaged that this will facilitate more cost effective connection, in particular at medium and high voltage levels, without jeopardising security and quality of supply.

ER G5/4-1 provides planning and compatibility levels for harmonic orders up to the 50th. The main workgroup discussed the necessity to consider the same for harmonics above the 50th. This debate was initiated because of recent changes in technologies, such as voltage source converters used in high voltage direct current, wind farms, solar energy and domestic consumptions such as energy saving bulbs and power supplies, and increase in the volume of polluting equipment connecting to the public supply system.

A sub-workgroup was set up to focus on the harmonics above 50th. This, if approved, will be a new section in ER G5. The sub-workgroup has met four times and has finalised their recommendation to the main workgroup. The terms of reference for the sub-workgroup work includes, the existence of higher than 50th order harmonics in the system, practicality of measurement and accuracy of modelling and assessment.

In the meeting of 9/11/2017, the sub-workgroup presented their report. It was suggested that Planning and probably compatibility levels for harmonics above 50th are included in the documents as indicative levels with a period to allow utilities and network users to adjust and prepare. The sub-workgroup will submit the final text. The main workgroup members were requested to provide their comments.

The list of participants in the sub-workgroup is given in Appendix B.

5 GENERAL CONNECTION PROCESS

It has been agreed that, in general, the same approach as ER G5/4-1 to be adopted. The connection process would consist of three main stages.

Some of the issues encountered in using G5/4-1 were identified and are being addressed. Self-assessment for small equipment complying with international product standards is allowed and conforming network users would still be able to connect to supply system with no or little interference from the network owner.

One of the main obstacles in the present process was identified to be exchange of data between connectees and network owners that may lead to prolong assessment and thus connection. It was decided that the revised ER G5 should, as much as possible, try to shorten the process time and reliance on availability and amount of data that is needed to carry out assessments, without affecting fairness of the process, with respect to all connectees, and affecting the security and quality of supply.

6 STAGE 1 AND 2 ASSESSMENT

A sub-workgroup was set up to focus on Stage 1 and Stage 2 processes. The list of members of the sub-workgroup is given in Appendix C.

The concept and approaches adopted in Stage 1 and Stage 2 have been already presented to the main workgroup in the previous meeting. The work of this sub-workgroup is complete and final text has been drafted, which will be presented to the next meeting of the main workgroup for final approval.

The main difference in the presentation of the processes compared to that in G5/4-1 is the distinct flowchart for each sub-stage with the clear connection to the previous and next sub-stages. The failure and pass conditions and data requirements for each sub-section will clearly be illustrated.

The Stage 1 and Stage 2 connection processes were presented to the main workgroup on 9/11/2017. It was mentioned that the changes compared to G5/4-1 are more towards clarity of the process. The main workgroup was invited to submit their comments by 24/11/2017.

6.1 Stage 1

Stage 1 is designed for connection at LV. It is designed in a linear process such that assessments are applied in stages and sub-stages. If a sub-stage is passed the customer can connect, if the sub-stage is failed the next sub-stage of assessment is undertaken. In total there are four sub-stages in Stage1.

The sub-stages are designed such that earlier sub-stages require less data from the network user but use conservative assumptions. As the connectee progresses through the sub-stages more data is required but by having more data the pass criteria can be relaxed in terms of conservative assumptions made in the process.

Stage 1 also allows for self-certification. If a customer connects equipment compliant with the relevant international product standards and for the reference impedance, defined in the document, they may connect with no assessment and referral to the network owner.

The benefits of this approach are that it will allow easier connection for network users as there are fewer requirements on them to provide data, which may be difficult for smaller parties. The revised standard has also been written in more accessible way such that the process of connection should be more understandable for those with limited experience in using standards.

6.2 Stage 2

Stage 2 is designed for connection between 6.6 kV and 22 kV and those that have failed Stage 1. It is also designed in a linear process such that assessments are applied in sub-stages.

Stage 2 includes three sub-stages and follows the same concept and has the same benefits as Stage 1. Those connections which failed Stage 1 may be connected under one of the three sub-stages in Stage 2, as more data from the connectee and network will be progressively required through the sub-stages. If a connection fails in Stage 2, the assessment under Stage 3 will be carried out.

6.3 Magnification of background harmonic levels

A sub-workgroup was set up and commissioned to propose a method to assess the impact of power factor correction capacitor and long cables on the magnification of network background harmonic levels. This is a new entry in the revised ER G5 compared to the present version, G5/4-1.

The sub-workgroup investigated the phenomena and proposes methods to limit the amplification of network background harmonic levels by capacitor banks or long cables to ensure that other users' equipment will not be adversely affected.

The sub-workgroup has completed its work. A text has been produced and presented to the main workgroup members. It was suggested during the discussion that this is included in the document as a guideline and not a connection condition under Stage 1 and Stage 2.

The list of participants of this sub-workgroup is given in Appendix D.

7 STAGE 3 ASSESSMENT

Stage 3 assessment applies to connection of equipment that fails Stage 2 and those connecting to voltage levels of 33 kV and above. This is the same as present ER G5/4-1.

The main workgroup identified, amongst others, two main areas that required particular attention when applying Stage 3 assessment.

i. Concurrency of connections:

   While the number of polluting equipment in the supply system are increasing it is very likely that two or more network users apply for connection to the same node or electrically near each other, in a short period of time. This imposes the need for a versatile process which allows the harmonic limits for each connection to be obtained fairly, in a timely manner and possibly independent of each other.

   Under current G5/4-1 if two connectees are connecting in close electrical proximity the second cannot complete their harmonic studies until the first has finished theirs. This could lead to a delay in the project. The ER G5 workgroup is attempting to improve the situation however this requires a method to allow the design of both parties to run in parallel and managing the resultant risk. There is no a credible international recommendation for this so requires a novel approach.

ii. Data requirement and exchange between connectee and Network Owner

   Currently the assessment for the first connectee should be completed before the process for the second begins. Usually the full data for harmonic assessment is available at later stages of connection process which in turn introduces delays in the assessment of subsequent connectees. Amount of data that is needed to begin the harmonic assessment and reduction of the dependency of assessment on the data have been the subject of debate.

A sub-workgroup was set up to delve in Stage 3 process and explore other possibilities to alleviate the above mentioned issues. The sub-workgroup has met five times to date. The list of members of this sub-workgroup is given in Appendix E.

Under current standard the amount of the harmonic headroom each customer can have is allocated on a first come-first served basis. The sub-workgroup has concluded that this approach does not help with the above concurrency and data requirement issues and is potentially disadvantaging some customers. Alternatives have been considered and a list of options, including first come-first served, has been prepared, which will be presented to the main workgroup.

The procedure for Stage 3 assessment and data requirement as well as the assessment output were presented in the meeting. The allocation of right is based on the apportionment of harmonic headroom and method of apportionment was presented in the meeting. Due to differences in the nature of networks above 132 kV voltage level and those below and also the size of equipment connecting to the system, it is proposed that similar approaches but with slightly different parameters for voltage level above 132 kV are used. The sub-workgroup proposal was presented in the meeting and members were invited to submit their comments by 24/11/2017.

8 PROJECT TIMELINE

i. Comments from the main workgroup on proposals from all sub-workgroup are to be received by 24/11/2017.

ii. The proposed text for all sections of the document are made available by 15/12/2017

iii. The first draft of full document is made available by mid-February 2018.

9 APPENDICES

9.1 Appendix A

List of members:

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9.2 Appendix B

Members of harmonics above 50th sub-workgroup:

Frank Griffiths	ABB
Andrew Oliver	TNEI
Liam Mcsweeney	WPD
Ahmed Shafiu	Siemens

9.3 Appendix C

Members and observers of Stage 1 and Stage 2 sub-workgroup:

Members

Frank Griffiths	ABB
Andrew Oliver	TNEI
Simon Scarbro	WPD
Ahmed Shafiu	Siemens

Observers

Ben Gomersall	National Grid (SO)
Forooz Ghassemi	National Grid (TO)

9.4 Appendix D

Members of magnification of background harmonic levels sub-workgroup:

Davor Vujatovic	VandA Consultants
Forooz Ghassemi	National Grid (TO)

9.5 Appendix E

Members of Stage 3 assessment sub-workgroup

Steve Mould	UKPN
Davor Vujatovic	VandA Consultants
Simon Scarbro	WPD
Ben Gomersall	National Grid (SO)
Forooz Ghassemi	National Grid (TO)