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**Assigned by DCUSA Secretariat*

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Nature of Issue

A defect has become apparent in the drafting of the Power Factor clauses within the National Terms of Connection. This specifically applies to clause 13 of Section 3 of the National Terms of Connection, although some consideration in respect of Section 2 of the National Terms of Connection may also be required in light of the growth of power electronics and micro-generation that may cause a premises to export Reactive Energy.

The Existing wording of Clause 13 of Section 3 of the National Terms of Connection and an indicative alteration are set out on the following pages for initial discussion. The wording has been crafted to avoid the use of the words Leading or Lagging and in their place refer to the Import of Reactive Energy and the Export of Reactive Energy to better align with the BSC metering requirements and metering quantity identifiers (RI and RE) as utilised in metering data.

The National Terms of Connection, Section 3 Clause 13 currently requires a customer to not operate a leading power factor and to operate a lagging power factor and as close as unity power factor as possible but not worse than 0.95 lagging power factor. These terms derive from an era focussed on almost exclusively serving demand customers and therefore the phrasing of "no leading power factor", pointing to a capacitive mode of consuming operation, as opposed to "shall not export Reactive Energy", was appropriate at the time. A customer exporting Reactive Energy at the same time as exporting Active Energy is conventionally treated as a lagging power factor.

Furthermore the written prohibition on leading power factors (of consumption) was intended to refer to capacitive load because of the damaging and potential catastrophic failures arising in the opening operation of switchgear and circuit breakers that had large quantities of capacitance connected downstream. The same problems occur with energy production with a capacitive component.

The power quadrant diagram approach to describing "power factor", as noted in BSC Metering Codes of Practice is that an export of Active Energy that is simultaneously exporting Reactive Energy is described as "Lagging".

Flow of Active Energy	Power Factor	Flow of Reactive Energy	Additional Information
Import	Lagging	Import	Associated with Active Import
Import	Leading	Export	Associated with Active Import
Import	Unity	Zero	n/a
Export	Lagging	Export	Associated with Active Export
Export	Leading	Import	Associated with Active Export
Export	Unity	Zero	n/a

It is the particular use of the term "Lagging Power Factor" when describing the use of a Connection Point in a generating mode that presents a problem in terms of the application of the National Terms of Connection's current wording which refers only to "Leading Power Factor".

On the one hand the DNO will strive to technically minimise the existence of capacitance upon its system and separately will strive to prohibit export of Reactive Energy by customers generating power at a "Lagging" Power Factor or by customers consuming power at a "Leading" Power Factor to avoid excessive voltage rise.

The DNO needs to be able to correctly manage the usage of power, including Reactive Energy, by its customers and therefore for its own purposes alone will require a correction at the very least to Clause 13 of Section 3 of the National Terms of Connection.

More broadly the proposal will also help in the context of requirements DNOs have to manage and coordinate voltage levels with the National Electricity Transmission System Operator and to prevent undesirable effects upon the transmission system. It is a distribution licence requirement to comply with both the CUSC and the Grid Code. It is important to emphasize that in part a change in the nature of power flows on a DNO system that causes a problem on the transmission system is by causation a DNO problem with a responsibility upon the DNO to organise its affairs to compliantly co-ordinate with the electricity transmission system operator/owners. As highlighted in the System Operability Framework (SOF)[1], issued by National Grid in September 2014, there is currently a rapidly emerging issue around falling Reactive Energy Import from Distribution Systems leading to high voltage levels on the National Electricity Transmission System operated by National Grid under low load conditions. In some cases the Reactive Energy Export from the distribution systems to the transmission system has occurred, particularly at times of low night time load in major conurbations. The following two diagrams, extracted from National Grid's SOF, show the decline in Reactive Energy Import into distribution systems and the number of Grid Supply Points now having Reactive Energy Export from distribution systems.

[1] System Operability Framework 2014 (http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=37976)

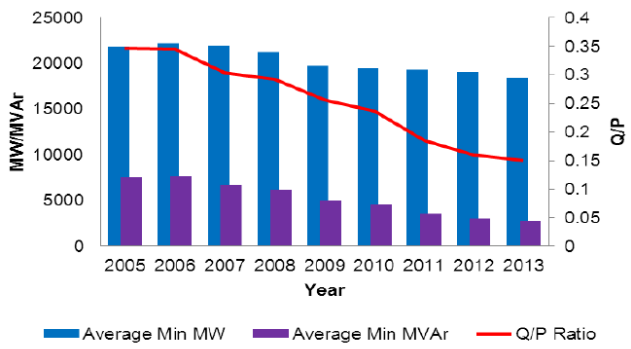

Figure 23 Historic Q/P Ratio Trend

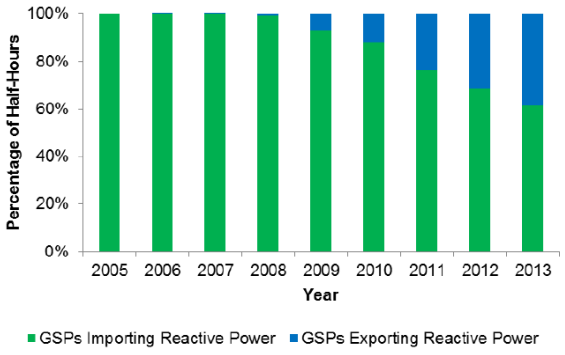

Figure 24 Historic GSP Reactive Power Exchange

The reduction in distribution system Reactive Energy Import alters the reactive energy balance in the regional transmission system and causes generation equipment, generally transmission connected generation, in the region to have to operate at a different active/reactive energy operating point and this risks causing such generation to be less stable and be more susceptible to over-voltage wear and tear or damage. Factors stated by National Grid in the SOF, impacting on transmission system assets as well as connected generation, are Flashover risks, Asset overstressing and insulation breakdown, Wound equipment over-fluxing, Risk of circuit breaker re-strike during de-energisation, Increased risk of asset catastrophic failure.

To compensate for changed conditions arising from power flows from and to distribution systems National Grid are installing reactor banks to act as compensating Reactive Energy Import. This expediently rebalances power flows across regions of the transmission system and helps to maintain transmission system voltage with statutory limits. However correctly managing user behaviour and in the case of DNO's managing consuming and generating customer behaviour with clear contractual requirements is important to enable the fulfilment of any transmission related obligations upon the DNO.

The SOF issue flagged by National Grid relates primarily to sustained trends in reactive energy usage. Whilst National Grid do have existing CUSC requirements on Licensed and relevant License Exempt generation to operate in constant voltage mode this is as a direct requirement on generators to be stable through transient system events rather than to deliver more broad transmission system remedial effects such as sustained Reactive Energy consumption. It seems quite clear that the emerging matter of sustained reductions in Reactive Energy Import (use) identified in the System Operability Framework publication is a quite separate matter to existing stability requirements within the Grid Code.

It seemed appropriate however, in light of the emerging issues, to review the distributor's commercial controls on the power factor usage by both demand and generation customers, namely Active Energy consumers or Active Energy producers.

The DNO needs its terms of connection to be correct for the mixed network use now occurring in respect of Distribution Systems. Although National Grid's operational requirements in respect of DNO demand and generation users are not yet fully formed to address the emerging and sustained transmission system impacts, the corrections identified in this proposal would, if implemented, better support any consequential future CUSC or Grid Code requirements upon the DNO to manage the behaviour of the DNO connection consuming and producing customers.

EXISTING WORDING IN CLAUSE 13 OF SECTION 3 OF THE NATIONAL TERMS OF CONNECTION.

"13. POWER FACTOR AND PHASE BALANCE

13.1 Unless otherwise agreed, the Customer shall at all times ensure that the Power Factor of any import of electricity from, or export of electricity to, the Distribution System through the Connection Point is maintained:

13.1.1 (unless otherwise required by the Company for operational reasons) so that there is never a leading Power Factor; and

13.1.2 (subject to Clause 13.1.1) at or as near to unity as practicable, but in any case no less than 0.95 lagging.

13.2 The Customer shall not allow the Power Factor at the Connection Point to vary such as to cause damage or disturbance to the Distribution System.

13.3 Where connection at the Connection Point is provided through two or more phases, the Customer shall ensure (insofar as is reasonably practicable) that the flow of electricity through the Connection Point is at all times balanced between the phases.

13.4 If the Customer fails to comply with Clause 13.1, 13.2 or 13.3 the Company may in its reasonable discretion and having given such notice as it considers reasonable in the circumstances De-energise the Connection Point until the causes of the failure are remedied. If the Customer is unable to remedy the situation within a reasonable time, the Company may require a Modification to be made to the Company's Equipment and/or the Customer's Installation."

Solution Overview – if known	
Solution description:	A starting suggestion on drafting, for discussion purposes only, ahead of more detailed debate during a formal change proposal is set out below. **"13. POWER FACTOR AND PHASE BALANCE** 13.1 Unless otherwise agreed, the Customer shall at all times ensure that the Power Factor of any import of electricity from, or export of electricity to, the Distribution System through the Connection Point is maintained: 13.1.1 (unless otherwise required by the Company for operational reasons including any requirements placed upon it pursuant to the CUSC or the Grid Code) so that; A) during any flow of Active Energy Import from the Distribution System to the Customer's Installation there is never a Reactive Energy Export to the Distribution System and that the flow of electricity through the Connection Point is only with a Reactive Energy Import from the Distribution System and is at or as near to unity power factor as practicable, but in any case no less than 0.95 power factor and B) during any flow of Active Energy Export from the Customer's Installation to the Distribution System there is never a Reactive Energy Export to the Distribution System and that the flow of electricity through the Connection Point is only with a Reactive Energy Import from the Distribution System and is at or as near to unity power factor as practicable, but in any case no less than 0.95 power factor. 13.2 The Customer shall not allow the Power Factor at the Connection Point to vary such as to cause damage or disturbance to the Distribution System. 13.3 Where connection at the Connection Point is provided through two or more phases, the Customer shall ensure (insofar as is reasonably practicable) that the flow of electricity through the Connection Point is at all times balanced between the phases. 13.4 If the Customer fails to comply with Clause 13.1, 13.2 or 13.3 the Company may in its reasonable discretion and having given such notice as it considers reasonable in the circumstances De-energise the Connection Point until the causes of the failure are remedied. If the Customer is unable to remedy the situation within a reasonable time, the Company may require a Modification to be made to the Company's Equipment and/or the Customer's Installation." Active Energy Import, Active Energy Export, Reactive Energy Import and Reactive Energy Export would be required to be defined.
Lead time for Implementation:	The implementation lead time would be subject only to appropriate consultation pursuant to a DCUSA change process and broader consultation in respect of amending the National Terms of Connection.