

Rate of Change of Frequency Distribution Code Modifications

Response to the Consultation

1. INTRODUCTION

- 1.1 Following discussions held with the Transmission System Operators (TSOs) in Ireland it was requested that NIE Networks modify the Distribution Code (D-Code) Rate of Change of Frequency (RoCoF) standard from 1Hz/s measured over 500ms to 2Hz/s measured over 500ms.
- 1.2 On the 5th August 2015 NIE Networks presented proposed D-Code RoCoF modifications to the Distribution Code Review Panel (DCRP) and it was agreed to consult on the proposed changes. Subsequently NIE Networks produced the *Distribution Code Amendments Consultation Paper: Rate of Change of Frequency*.
- 1.3 The consultation period ran from 11th September 2015 to 11th December 2015. The associated consultation papers can be found at the following locations:
 - <http://www.nie.co.uk/documents/P-150911-D-Code-Modifications-Consultation-RoCoF>
 - [http://www.nie.co.uk/documents/Attachment-proposed-D-Code-mods-\(RoCoF\)](http://www.nie.co.uk/documents/Attachment-proposed-D-Code-mods-(RoCoF))In total direct contact was made with 386 individual stakeholders to inform them about the consultation.
- 1.4 A total of 11 responses were received. This response document presents an overview of the consultee's comments, responses to those comments and provides recommendations to the Utility Regulator for their consideration.

2. BACKGROUND AND OVERVIEW

- 2.1 The Facilitation of Renewables (FOR) study, published in 2010 by the TSOs, was a detailed technical study that considered levels of non-synchronous generation (wind and HVDC imports) up to 100% of system demand. The study has shown that during times of high wind generation following the loss of the single largest credible contingency, Rate of Change of Frequency (RoCoF) values of greater than 0.5 Hz/s could be experienced on the island power system. If system separation were to occur RoCoF values up to 2 Hz/s measured over a rolling 500ms could be experienced in Northern Ireland. Simulations show that for a voltage dip induced power imbalance in a system with significant volumes of wind farms, RoCoF values in excess of 2Hz/s can occur over short time periods.
- 2.2 Accordingly, the main outcome of the FOR study was that wind levels (Non-Synchronous generation) of up to about 75% of demand could be accommodated, but a series of mitigation measures would have to be carried out. One of these measures was the need to address the issue of RoCoF. This issue is the current binding limitation on operating the power system past a system non-synchronous penetration (SNSP) of 55%.

- 2.3 SONI, in 2012 proposed RoCoF amendments to the Northern Ireland Grid Code¹, which included the following requirement: “...Users must ensure that their Plant and Apparatus remains synchronised to the NI System for a Rate of Change of Frequency up to and including 2 Hz per second as measured over a rolling 500 milliseconds period...” This modification was in relation only to users with an obligation to adhere to the requirements of the Grid Code and therefore did not apply to all independent generating plant². It was therefore requested, by the TSO, that NIE Networks propose a D-Code modification to ensure that all independent generating plant has the capability to remain connected to the electricity system for a RoCoF up to 2Hz/s measured over 500ms.
- 2.4 As stated in section CC 5.2 of the D-Code, the frequency of the distribution system is outwith the control of the DNO, but as set out by the TSO in the Grid Code. It is therefore necessary to ensure that any standard in relation to system frequency enclosed within the D-Code aligns with the Grid Code. It was agreed by the DCRP to consult on proposed RoCoF changes to the Distribution Code to:
- Give the TSO an understanding of the capability of independent generating plant to remain connected to the distribution system and operate for RoCoFs up to 2Hz/s measured over 500ms. This would be achieved through the consultation process associated with the D-Code modification.
 - Ensure harmonisation of the D-Code with the Grid Code.
- 2.5 Presently the Distribution Code requires independent generating plant greater than 100kW to stay connected and operate for RoCoFs up to 1Hz/s over 500ms, unless the generator G59 relay has operated correctly or manual intervention has occurred. The proposed D-Code RoCoF modifications necessitate that all existing and future independent generating plant connected to the NIE Networks’ distribution system must have the capability to stay connected and operate when the distribution system frequency changes at a rate up to 2Hz/s measured over a rolling 500ms, unless the generator G59 relay has operated correctly or manual intervention has occurred. This will allow SNSP levels to be increased beyond 55% whilst maintaining a secure system during system separation.
- 2.6 For the avoidance of doubt this D-Code RoCoF modification does not necessitate a change to the generator G59 or G83 protection. Changes to the G59 and G83 settings are being investigated through a separate workstream which is currently researching the impact that any amendment to G59 and G83 protection may have on the NIE Networks Distribution System. NIE Networks will be writing to generators in due course to inform them of any required protection changes.

¹ “Grid Code Amendments Consultation Paper: Rate of Change of Frequency (RoCoF), APPENDIX: Proposed Grid Code Modifications”. SONI Limited, 20th July 2012.

² A power station which is not subject to central dispatch and is not a controllable WFPS.

3. OVERVIEW OF RESPONSES

3.1 From the 11 responses received during the consultation the following generating technologies declared compliance with the 2Hz/s RoCoF standard, measured over 500ms:

- All GE wind turbines connected to the NIE Networks’ distribution system
- All EWT small scale wind turbines connected to the NIE Networks’ distribution system
- A small scale diesel generator
- A 16kW asynchronous hydro generator

The combined rating of the above generators corresponds to c7% of the total fleet of generators connected to the NIE Networks’ distribution system.

3.2. The table below highlights all of the concerns voiced by the consultees and the associated NIE Networks’ comments.

Consultee Concern	NIE Networks’ Comments
<p>I note from your red-lined text (Connection Conditions 7.12.1) that you intend to apply the proposed changes to Independent Generating Plant which is defined in the Distribution Code as “A Power Station which is not subject to Central Dispatch and is not a Controllable WFPS.” This excludes a significant amount of generators connected to the distribution system. The proposed RoCoF ride through requirements are only useful if the majority of generators have that capability.</p>	<p>All generators connected to the distribution system that are not classified as independent generating plant will be subject to the requirements of the Grid Code. Therefore, all generators connected to the distribution system will either adhere to the RoCoF ride through requirements within the Grid Code or the RoCoF ride through requirements within the D-Code.</p>
<p>I understand that transmission connected generators have been asked to confirm whether or not they can remain connected during rate of change of frequency incidents of up to +/-1Hz/s (up to +/-2Hz/s had been considered in consultation proposals, but SONI’s final proposals to NIAUR and NIAUR’s decision were limited to +/-1Hz/s only). If transmission connected generators will not be required to withstand change of frequency incidents of up to +/-2Hz/s then there is no point in asking distribution connected generators to do so (because transmission connected generation dominates the NI system) and an alternative solution would have to be found in cooperation with the TSO.</p>	<p>In SONI’s report³ to the Utility Regulator they state: “While there are system reasons why there is distinction between jurisdictions SONI believe it appropriate to conduct more analysis on the need for 2Hz/s. This will include commissioning independent consultants DNV Kema to explore the issues for generators operating through high RoCoF. Until this, and any other appropriate study, has been completed SONI will not seek the 2Hz/s for Northern Ireland generators.” Although the 2Hz/s standard for Northern Ireland has been removed until the completion of appropriate studies, NIE Networks believed that it would be prudent to consult on a 2Hz/s D-Code standard, to:</p> <ul style="list-style-type: none"> - Harmonise with the Grid Code, if, following the completion of the relevant studies a

³ “Rate of Change of Frequency Grid Code Modification Report to NIAUR”. SONI Limited, 21st December 2012.

	<p>2Hz/s Grid Code standard is adopted.</p> <ul style="list-style-type: none"> - Give the TSO a better understanding of the capability of independent generating plant to remain connected to the electricity system and operate for RoCoFs up to 2Hz/s measured over 500ms. <p>In any scenario, the D-Code RoCoF modification will be harmonised with the Grid Code RoCoF standard and will not come into force until the Grid Code modification is implemented.</p>
<p>Unless G59/NI RoCoF protection settings are increased to prevent trip for incidents up to +/-2Hz/s then embedded generators using this loss of mains technique will not remain connected for such incidents. Is NIE confident that G59/NI RoCoF protection settings can be increased to +/-2Hz/s 500ms without unacceptably increasing the risk of failure to detect island conditions and the associated increased danger to people and equipment? Requiring a +/-2Hz/s withstand requirement would be premature if the island non-detection risk has not been evaluated and unnecessary if unacceptable risk would ensue from such protection settings.</p>	<p>NIE Networks are currently engaged with Strathclyde University who are completing comprehensive research to quantify the associated risks with the amendment of G59 and G83 settings. Upon successful completion of this study and engagement with the relevant stakeholders NIE Networks will be writing out to generators asking them to amend their G59 settings.</p> <p>However, even if the risks associated with the amendment of G59 and G83 settings are deemed unacceptable the D-Code RoCoF setting will still require amendment, based on the following needs:</p> <ul style="list-style-type: none"> - NIE Networks currently require a total tripping time of 500ms for G59 operation. Consequently, even with a lower G59 setting the generator may be exposed to a 2Hz/s RoCoF measured over 500ms before disconnecting from the system and therefore must have the capability to withstand such an event. - To ensure harmonisation with the Grid Code
<p>RES notes that if the North-South 400kV intertie is developed promptly then the risk of system separation would be mitigated such that generator RoCoF withstand of +/-1Hz/s would be sufficient. Therefore RES urges NIE to expedite this project.</p>	<p>NIE Networks are working with SONI, EirGrid and ESB Networks to deliver this project in a timely manner. SONI as the Transmission System Operator (TSO) is responsible for transmission planning and part of their remit is to obtain consents for the proposed 400kV transmission line and the 400/275kV substation at Turleenan. NIE Networks as the Transmission Asset Owner (TAO) will ensure that once all consents have been obtained, the construction works will be delivered without undue delay.</p>
<p>When the DS3 grid code amendments were being discussed by the all island work group, several wind turbine manufacturers</p>	<p>NIE Networks made direct contact with the</p>

<p>stated that their current products could withstand 1Hz/s (which was the limit under discussion) and some claimed they could withstand 2Hz/s or even 4Hz/s. Wind turbine manufacturers and solar PV inverter manufacturers should be consulted to confirm the capability of their products to ride through RoCoF incidents of up to +/-2Hz/s averaged over 500ms.</p> <p>Has NIE communicated this consultation to all owners of G83 embedded generation? It is not clear how owners of embedded generators which presently comply with G83 would become aware of this proposed requirement and make the necessary verifications or modifications to their equipment. Therefore it is possible that a significant proportion of existing generators of this class may not be compliant. If the proposed change is implemented and RoCoF events exceed present G83 requirements then system resilience would be impaired if the total capacity of such generators is significant.</p>	<p>Northern Ireland Trade Association (NISTA) as well as Northern Ireland Renewables Industry Group (NIRIG) to make them aware of this consultation.</p> <p>To clarify, following the successful completion of the aforementioned Strathclyde University studies, the new settings will only be adopted by new G83 generators connecting to the network, not G83 generators currently connected. On the other hand, G59 setting amendments will apply to all G59 connected generators.</p>
<p>If the present requirements of Engineering Recommendation G83 are not suitable for future RoCoF withstand requirements in Northern Ireland then I recommend that new standards are developed. To incorporate the EU Network Code Requirement for Generators (RfG) with existing GB documentation a number of new Engineering Recommendations are being drafted by the Energy Networks Association. It is recommended that NIE considers how this work could be coordinated with NIE's unique requirements.</p> <ul style="list-style-type: none"> - G98-1 covers the connection procedure and technical requirements for Type Tested Generating Units up to 16 A per phase which are referred to as Micro-generators. (G83/2) - G98-2 covers the connection procedure and technical requirements for multiple Type Tested Microgenerating Plants in a Close Geographic Region and Type Tested Generating Units above 16 A per phase but with a maximum capacity less than 50 kW. (G83/2 and G59/3). - G99 covers the connection procedure and technical requirements for all non-Type Tested Generating Units that G59/3 covers at present. 	<p>NIE Networks are currently progressing this and will have implemented the necessary network code changes within the compliance dates as outlined within the EU Network Codes.</p>
<p>If RoCoF is disabled it is impossible to know exactly what the 'true' RoCoF capability of the generating station is. There are many things to consider the affect a large RoCoF event would have to the generating station i.e. Rotor and gearbox reaction, rotor couplings and also the generator itself. At different wind levels there are considerable differences to the torque applied to the station, therefore capability could be dynamic depending on the output.</p> <p>Currently the Wind turbine controller does not have its own internal RoCoF protection.</p> <p>The current capability of the generating stations is 0.4Hz/s, limited by the G59 relay. It is unknown what the capability would be beyond that. The turbines where not built with high levels of RoCoF in mind and currently there seems to be no industry standard to test RoCoF.</p>	<p>NIE Networks advise that the TSO satisfy themselves that all generating technologies are capable of withstanding a RoCoF in excess of 0.5Hz/s without causing machine damage prior to allowing the maximum permissible system RoCoF to exceed 0.5Hz/s.</p>
<p>I have NIE approval for grid connection for Anaerobic Digester</p>	<p>NIE Networks advise that the TSO satisfy themselves that anaerobic digester technologies</p>

<p>and export of generated power to the network.</p> <p>As this generator is powered by reciprocating internal combustion engine I hereby state that the my expected maximum RoCoF withstand capacity is 0.5Hz/s.</p>	<p>are capable of withstanding a RoCoF in excess of 0.5Hz/s without causing machine damage prior to allow the maximum permissible system RoCoF to exceed 0.5Hz/s.</p>
<p>Our diesel generator should be ok in terms of potential damage to the engine or cooling system. The Generator is set to run at 80% of load capacity so the cooling fan should provide adequate engine cooling even if it is running at a frequency of 48hz for a period of 1hr. Running at 47 hz for 5 minutes should not pose a problem either. There is an overheat cut out facility which will prevent any possible damage but obviously synchronous power generation will cease immediately at that point. As far as our generator service company are aware, the rate of change of frequency is not an issue.</p>	<p>No amendment is proposed to the frequency range within the D-Code; therefore, all independent generating plant greater than 100kW connected to the distribution system should be able to remain connected and operate in accordance with the frequency ranges stipulated in CC 7.12.</p>
<p>NIE are proposing to impose some changes on existing equipment. My existing micro hydro generation system could not incorporate these changes and would incur significant cost to achieve this. I would like to suggest that NIE cannot impose this on existing installations without providing compensation for the cost incurred.</p> <p>These costs are incurred to changeover the control system to enable the level of controls which NIE are requesting. The system I had installed is G59/1 compliant. What NIE are proposing is a set of changes very similar to G59/3 standard. When our installer, Hydro NI, offered to bring systems compliant with G59/3 last year NIE refused these and insisted on the G59/1 standard. NIE cannot move the goalposts now and expect others to pick up the costs of their own incompetence and intransigence.</p> <p>NIE cannot impose these costs retrospectively on people when the systems installed are compliant with the standards they insisted on using at the time. That is just unfair and unreasonable.</p> <p>If NIE, however, are prepared to cover these costs then, technically, what they are proposing is feasible.</p>	<p>The costs which the consultee refers to are associated with G59 protection amendments. As stated within the consultation document this D-Code modification does not require any amendment to G59 or G83 protection settings. The proposed D-Code RoCoF modification necessitates that all existing and future independent generating plant connected to the NIE Networks' distribution system must have the capability to stay connected and operate when the distribution system frequency changes at a rate up to 2Hz/s measured over a rolling 500ms, unless the generator G59 relay has operated correctly or manual intervention has occurred.</p> <p>Engineering Recommendations G59/3 has been adopted by the GB Distribution Network Operators (DNOs) but has not yet been adopted by NIE Networks. The Loss of Mains (LoM) protection settings within G59/3 have been deemed suitable for the GB system but may not be suitable for the Northern Ireland electricity system and, if adopted, may result in unsatisfactory risk to human injury and generator damage. NIE Networks are currently engaged with Strathclyde University who are completing comprehensive research to quantify the associated risks with the amendment of G59 and G83 settings. This piece of work is being progressed through a separate workstream.</p> <p>The current D-Code states that new generator protection settings may need to be agreed if system RoCoF changes: CC 7.13.4 "In relation to any Generator which has agreed the settings with the DNO under these provisions, the DNO shall notify that Generator of any change of which it is aware in the expected rate-of-change-of-</p>

	<p>frequency on the Distribution System which may require new settings to be agreed.” Following the completion of Strathclyde University studies, NIE Networks may require generators to amend their current protection settings. NIE Networks consider that recovery of costs, if/where they may exist, are not deemed to be within the scope of this D-Code modification process and would instead be a matter for consideration by UR and/or the TSO as appropriate.</p>
<p>With regard to consultations on RoCoF on NI Electricity System, we think that these changes should only be applied to new generators and if imposed on existing generators, such as ours then there must be compensation to cover costs,</p>	<p>It is unclear whether these costs are associated with amendments to the machines mechanical structure to ensure that it can withstand a 2Hz/s RoCoF event, amendments to G59 protection settings or both. NIE Networks consider that recovery of costs, if/where they may exist, are not deemed to be within the scope of this D-Code modification process and would instead be a matter for consideration by UR and/or the TSO as appropriate.</p>
<p>7.12.2 As written in 7.12.2(b), the proposed clause states that generators can trip off in the event of a RoCoF in excess of 2.0 Hz/s. To avoid potential confusion with this clause and clause 7.12.2(c), SONI proposes removing clause 7.12.2(c) from 7.12.2 and adding the clauses below to section 7.12.1 as clauses (d) and (e): “(d) continuously where the rate-of-change of Distribution System Frequency up to and including 2 Hz/s as measured over a rolling 500 millisecond period. (e) continuously where voltage dips cause the Distribution System Frequency to change at a rate in excess of 2 Hz/s for periods less than 500 milliseconds” SONI believe that using the term ‘shorter periods’ could be confusing and for clarity suggest that this is changed to ‘periods less than 500 milliseconds’ as per the proposed clause (e) above.</p>	<p>NIE Networks accept SONI’s concern and have amended the Proposed Distribution Code Modifications (Redline) document to reflect this.</p>
<p>7.12.2(c) As written, this proposed addition states that the generator is allowed to disconnect if, ‘in exceptional circumstances voltage dips may cause the Distribution System Frequency to change at a rate in excess of 2 Hz/s for short periods.’ SONI believe that this should be removed as a generator should be required to stay connected even if the RoCoF is in excess of 2.0 Hz/s for a short period of time (within 500 ms) due to a system fault. It should be replaced with the proposed clauses, 7.12.1(d) and (e), as per point 1.</p>	<p>NIE Networks accept SONI’s concern and have amended the Proposed Distribution Code Modifications (Redline) document to reflect this.</p>
<p>7.12.2(d) This existing exemption allows the generator to disconnect if,</p>	<p>NIE Networks define manual intervention as:</p>

'there is manual intervention by the Generator.'

SONIs view is that this could be read that the Generator can set-up its own protection to disconnect for RoCoFs less than 2.0 Hz/s but use this section to justify being exempt from meeting the requirements.

discretionary intervention by the NIE Networks' control engineer in the event of system abnormalities which are serious but not of sufficient magnitude for automatic protection to operate. Therefore, this definition does not allow generators to set-up their own protection to disconnect for RoCoFs less than 2Hz/s. However NIE Networks do accept that this clause may cause confusion and therefore propose that it is modified to the following; "*there is manual intervention*". Moreover, it is proposed that this definition is included within the D-Code Glossary and Definitions section and the term manual intervention used in section 7.12.2 is shown in bold to identify it as a defined term. The Proposed Distribution Code Modifications (Redline) document has been amended to reflect this.

4. NIE NETWORKS' PROPOSAL

- 4.1 NIE Networks were requested by the TSO to propose modifications to the D-Code RoCoF setting to:
- Give the TSO an understanding of the capability of independent generating plant to remain connected to the distribution system and operate for RoCoFs up to 2Hz/s measured over 500ms.
 - Ensure harmonisation of the D-Code with the Grid Code.
- 4.2. The TSO voiced concerns around the wording of the proposed modifications and the definition of manual intervention within the D-Code and as such NIE Networks have amended the proposed modifications to accommodate these concerns. Some generators declared compliance with the 2Hz/s RoCoF standard, one anaerobic digester stated that they are not compliant whilst others stated that they are unaware what RoCoF their machines can remain connected and operate at.
- 4.3. Several consultees voiced concerns around the costs associated with the proposed D-Code modification. It is unclear whether the associated costs are due to generator protection amendments or due to generator electromechanical modifications to accommodate the increased machine stress. NIE Networks consider that recovery of costs, if/where they may exist, are not deemed to be within the scope of this D-Code modification process and would instead be a matter for consideration by UR and/or the TSO as appropriate
- 4.4. If approved the D-Code RoCoF modification should not be implemented until the Grid Code modification is implemented. If, following the completion of the generator studies, a Grid Code RoCoF modification lower than 2Hz/s is implemented then this lower setting should also be adopted within the D-Code.
- 4.5. NIE Networks seek the guidance of the Utility Regulator on the proposed D-Code RoCoF modifications.