NIE Networks' Small Scale Generator Interface Protection Amendment Project

Consultation Report

19/02/18

1. EXECUTIVE SUMMARY

On 4th December 2017 NIE Networks issued a Distribution Code (D-Code) consultation on Generator Interface Protection Amendments. This consultation proposed that the current Generator interface protection settings associated with Small Scale Generation (SSG[1]) connected to the NIE Networks' distribution system should be amended to help facilitate higher levels of SNSP on the electricity system. The proposed consultation allows SSG to follow the same process as that of Large Scale Generation (LSG[2]). The consultation period ran from the 11th of December 2017 to the 22nd of January 2018. Three responses were received.

Taking into consideration the responses to this consultation, and subsequent engagement with stakeholders, NIE Networks is putting forward proposals that make the necessary protection changes at SSGs to help facilitate higher levels of SNSP on the electricity system.

In summary, NIE Networks recommends that the UR approves:

1. Amendments to SSG interface protection settings to 1Hz/s with a 500ms time delay as outlined within Appendix 2 of this document.

2. The proposed D-Code modifications outlined in Appendix 2.

NIE Networks would like to reiterate its commitment to working constructively with all stakeholders to ensure the successful delivery of DS3.

[1] Generation <5MW. Predominantly connected at voltages below 33kV.
[2] Generation ≥5MW. Predominantly connected at 33kV.

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2. CONSULTATION OVERVIEW

2.1 Research Outcome (Small Scale Generation, SSG)

Following a previous NIE Networks consultation, *NIE Networks' Generator Interface Protection Amendment Project*, amendments to interface protection settings at Large Scale Generators (LSG) are now substantially complete. This consultation recommended that no amendments should be made to SSG interface protection settings as the associated risk of fatality and out of phase re-closure for the proposed settings were considerably higher than LSG.

Considering the responses from the previous consultation, engagement with the Single Electricity Market (SEM) Committee, Utility Regulator (UR) and an updated position from System Operator Northern Ireland (SONI) regarding the required interface protection settings, NIE Networks commissioned Strathclyde University to perform additional analysis to quantify the impact of risk mitigation measures. Strathclyde University concluded that the risk mitigation measures studied offered a cumulative reduction in risk when compared to the scenario where no risk mitigation measures were employed.

It is NIE Networks' view that with the prudent approach taken in the derivation of the risk figures, combined with the risk mitigation measures and the apparent financial benefits in amending generator interface protection settings, the proposed settings in Table 1 for SSG should be adopted. However, NIE Networks will continue to investigate measures to reduce the risk of electrocution and out-of-phase reclosure with the view to reduce the risk below the current risk level over time. For the avoidance of doubt, these changes will apply retrospectively to all SSG.

Protection Function	Existing Settings	Proposed Settings	
		Setting	Time Delay
U/V stage 1	0.9pu	0.85pu	3.0s
U/V stage 2	N/A	0.6pu	2.0s
O/V	1.1pu	1.1pu	0.5s
U/F	48Hz	48Hz	0.5s
O/F	50.5Hz	52Hz	1.0s
LoM (RoCoF)	0.125 – 0 .4Hz/s	1.0Hz/s	0.5s
LoM (Vector Shift)	6 – 12deg	N/A	

Table 1

The impact of the risk mitigation measures on risk of electrocution are shown in Figure 1. It can be seen that compliance with a 1Hz/second standard as opposed to a 2Hz/second standard offers a risk reduction moving the risk closer to the current risk level.

The risk mitigation measures also offer a small risk reduction with regards to the out-of-phase re-closure; this is shown in Table 2.

It was also identified that if generators employing Vector Shift protection transferred to RoCoF protection the impact on risk would be negligible.

It should however be noted that an additional risk of out-of-phase re-closure[3] exists which will have an associated risk of fatality if the generator suffers catastrophic failure. This risk cannot be quantified as it is dependent on generator technology and geographic location. However, NIE Networks has requested that these SSG perform their own risk assessment to determine if the risk of out-of-phase re-closure is acceptable. This is an important issue that is the responsibility of the generators to complete.

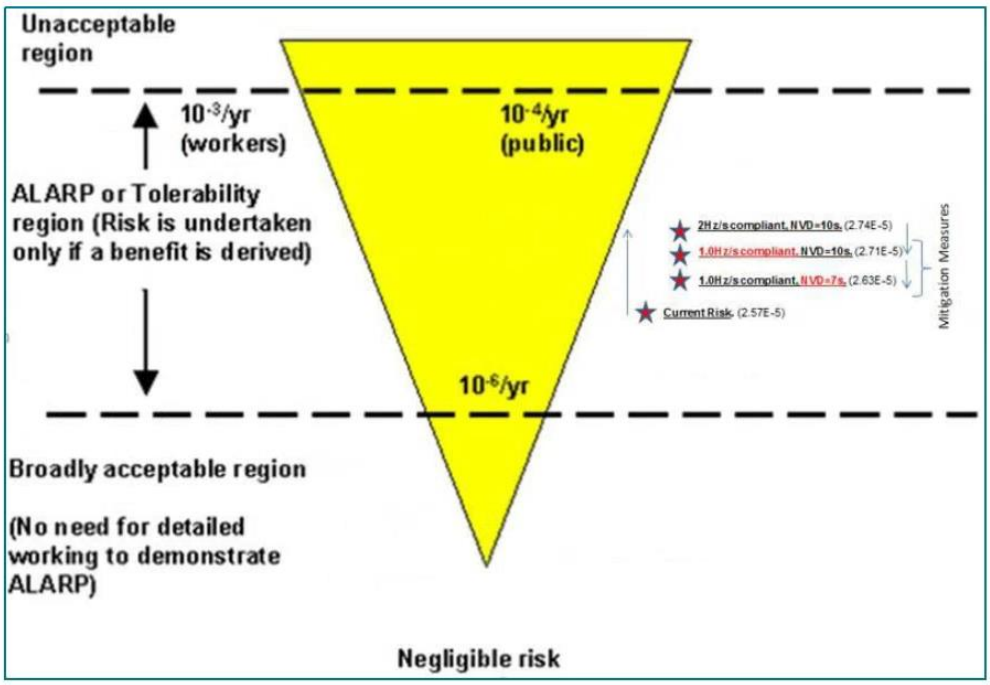


FIGURE 1 - SSG RISK OF FATALITY

Settings	Current Settings, 10s NVD operating time	2Hz/s Compliant, 10s NVD operating time	1Hz/s Compliant, 10s NVD operating time	7s NVD operating time
Out of phase reclosures/annum	4.09E-2	4.36E-2	4.31E-2	4.30E-2

TABLE 2

[3] Out-of-Phase reclosure for LSG = 2.16E-3

3. OVERVIEW OF RESPONSES

3.1 The consultation can be found at the following location: http://www.nienetworks.co.uk/About-us/Distribution-code/DC-review-panel.

3.2 The three respondents (from various industry sectors) are listed below:

Company Name
Renewable Energy Systems Limited (RES)
Northern Ireland Renewable Industrial Group (NIRIG)
SONI

3.3 All of the respondents stated that they were supportive of NIE Networks' proposal to amend the interface protection settings associated with SSG and requested that this is progressed urgently. NIE Networks would comment that they are committed to ensure that all SSG have amended their interface protection settings by the required date, subject to regulatory approval and SSG sites making the necessary arrangements to perform the amendment. Detailed commentary around all the responses is provided in Appendix 1.

3.4 Points for further discussion with SONI

NIE Networks will discuss the following points firstly with SONI and then we will discuss them with UR:

- Withstand capability
- Quantum of SSG in scope
- Implementation timeline
- Short-term frequency response
- 2Hz/sec standard
- Vector Shift
- Self-certification assurance
- Alternative RoCoF programme

4. RECOMMENDATIONS

Having reviewed the responses to the consultation, NIE Networks recommends that the UR approves:

1. Amendments to Small Scale Generator (SSG) interface protection settings to 1Hz/s with a 500ms time delay as outlined within Appendix 2 of this document.

2. The proposed D-Code modifications outlined in Appendix 2 for SSG.

NIE Networks have previously indicated that implementing the changes for SSG will require regulatory support including the potential for disconnecting generators that do not comply with a

modified D-Code[4]. Given that there are significantly more SSG sites than LSG sites and no financial benefit for SSG to make this proposed RoCoF change, then the delivery of a plan similar to the LSG is unlikely to be successful

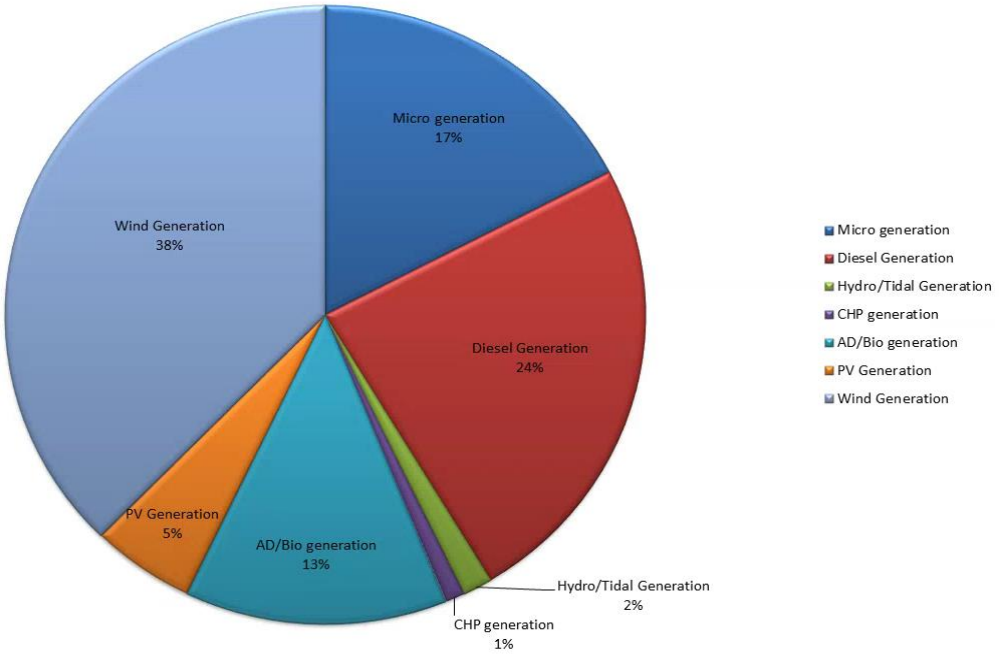
There are issues to be resolved concerning the technical implementation and a SSG cost recovery mechanism. A comprehensive implementation plan is essential so as to ensure the completion of the required SSG settings changes within the necessary timeframe. NIE Networks will write to UR separately on this.

[4] Non compliance is covered in paragraph 4.4.2 of D-Code OC10 where in the event that the non-compliance is not rectified, the matter will be referred to the authority (UR).

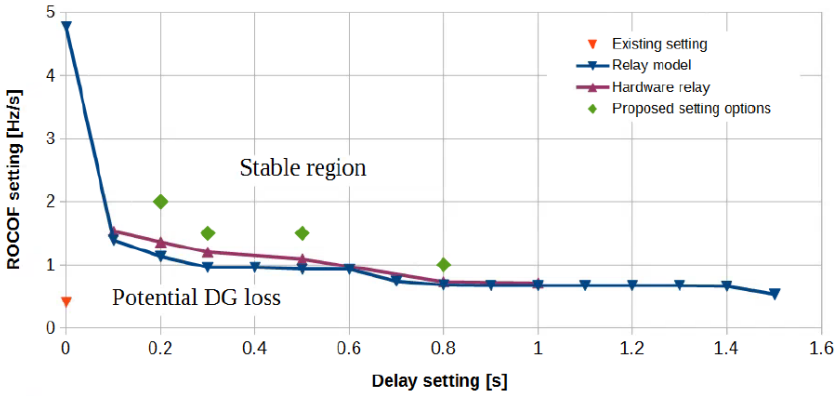
APPENDIX 1 – DETAILED CONSULTATION RESPONSES

The table below gives an overview of the respondent's feedback to the consultation and the corresponding NIE Networks' comments.

Consultee	
RES	**Consultee Comment:** RES agree with proposals outlined in this consultation document and are satisfied that this addresses the concerns expressed in their previous response dated 15th August 2017 to the NIE Networks Consultation on Distribution Code Changes on Generator Interface Protection published on 17th July 2017 **NIE Networks' Response:** NIE Networks welcome this positive response from a company who understands the issues associated with generator interface protection settings.
NIRIG	**Consultee Comment:** NIRIG were supportive of the proposal contained in the consultation which gives 18 months for existing generators (as at 1st March 2018) to implement the new settings, test and return the required certification to NIE Networks. They were keen to see these proposals implemented comprehensively and asked for further details on how NIE Networks will ensure compliance within the proposed timeframe. **NIE Networks' Response:** NIE Networks welcome this positive response from NIRIG and their views on the proposed implementation timeframe. NIE Networks are currently developing its plans for how the changes will be implemented and as part of this will consult with SONI and UR.
SONI	**Consultee Comment:** SONI supports NIE Networks' proposal to retrospectively apply increased RoCoF settings of 1.0Hz/s to Small Scale Generation (SSG) and highlights how this will assist the delivery of public policy objectives in Northern Ireland and Ireland. They also recognise the importance of appropriate protection philosophy and practice to maintain public safety in operating transmission and distribution networks, and welcome the commitment to continue investigation into measures to reduce any safety risk. **NIE Networks' Response:** NIE Networks welcome this positive support from SONI and their recognition of the importance of appropriate protection philosophy and practice to maintain public safety. We will continue to engage with SONI as the work to implement the required protection changes progresses.
SONI	**Consultee Comment:** SONI note that some generation is rarely run so the risk of tripping is lower; however, NIE Networks have not quantified the risk. **NIE Networks' Response:** NIE Networks has since 2012, provided SONI with a detailed breakdown of the volumes of generation <5MW. More recently, following a request from SONI, NIE Networks provided a further analysis of this generation including actual load profiles from the different generation types. NIE Networks agree that some of this generation is rarely run but due to the highly intermittent nature of renewable generation it was not possible to incorporate this into the studies. A significant portion of this generation is of a standby conventional type, contracted with AGU's and under dispatch by SONI. We will discuss this further with SONI.

SONI	**Consultee Comment:** SONI understands that approximately 420MW of SSG is connected in Northern Ireland which is currently not compliant with the 1Hz/s over 500ms standard, with this figure rising from approximately 150MW in October 2013. **NIE Networks' Response:** NIE Networks agree with the figures quoted by SONI, an estimated breakdown of this generation is shown below. We believe that it should be possible to prioritise the settings changes by generation type. We will investigate this matter further with SONI. 
SONI	**Consultee Comment:** It should be reiterated that until changes are made to the settings for Small Scale Generation the following impacts are expected: • Operational SNSP limit cannot increase above 65% • Operational RoCoF limit cannot increase from current 0.5Hz/s limit • Minimum number of large sets (conventional generators on the system at any given time) required to operate the system cannot be reduced from its current level • Minimum inertia levels on the system cannot be reduced. Progress on the DS3 RoCoF project was expected to facilitate the transitional implementation of the new operational RoCoF standard beginning in Q1 2018. This implementation will not be possible due to delays in the application of the new settings, including the roll out of settings to SSG in Northern Ireland. **NIE Networks' Response:** In order to better understand this impact, NIE Networks requested the analysis on which these conclusions were based. SONI provided NIE Networks their analysis, completed in 2014 and referred to earlier in their consultation response. This analysis concluded that even at low levels of secondary tripping (40MW) the impact of the trip subsequent to the initial imbalance could lead to a frequency nadir which would trigger under frequency load shedding. NIE Networks have reviewed the report provided and will engage further with SONI to better understand the conclusions and recommendations.

SONI	**Consultee Comment:** Progress on the DS3 RoCoF project was expected to facilitate the transitional implementation of the new operational RoCoF standard beginning in Q1 2018. This implementation will not be possible due to delays in the application of the new settings, including the roll out of settings to SSG in Northern Ireland. **NIE Networks' Response:** The delay including the roll out of settings to SSG is a contributing factor to the start of the transition to the new RoCoF standard, however NIE Networks would point out that this also requires conventional generator RoCoF programme to be complete. The most recent 6 monthly report on the conventional RoCoF project in NI indicates that there are significant delays with this programme. Furthermore, NIE Networks were only made aware of the importance of SSG RoCoF changes in June 17.
SONI	**Consultee Comment:** NIE Networks proposes that for SSG connected to the system prior to 1st March 2018 the new settings should be applied by 30th September 2019. SONI views this as an unacceptable timescale as it will cause significant additional delay to the delivery of the DS3 Programme and could result in Northern Ireland not meeting 2020 public policy objectives. We would encourage a shorter timescale for implementation, which will ensure that the delay to implementation of the new operational RoCoF standard and meeting of public policy objectives is as minimal as possible. In light of this, SONI proposes the implementation of the new RoCoF standard should be delayed by 1 year, beginning Q1 2019. We would therefore strongly advocate the application of settings in timelines supportive of this implementation date. **NIE Networks' Response:** NIE Networks are currently assessing various options for the implementation of the new SSG Interface protection settings. These options will be presented separately to UR, it should be noted however that there are issues to be resolved concerning the technical implementation and a SSG cost recovery mechanism. A comprehensive implementation plan is essential so as to ensure the completion of the required SSG settings changes within the necessary timeframe. The implementation plan will require input and the agreement of NIE Networks, SONI and UR.
SONI	**Consultee Comment:** To this end, the proposed mechanism of self-certification outlined by NIE Networks will in SONI's view provide insufficient certainty with respect to the successful change of the settings in the timelines required. Lack of assurance in the change to settings increases the risk of system security during a high RoCoF event when operating to the higher standard. Therefore acting prudently the TSO may determine the change in operational RoCoF policy cannot be made. As such the proposed mechanism should be revised to increase oversight by NIE Networks. It is our opinion that a process similar to that used for the large conventional units would be suitable i.e. regulatory process with TSO and DSO responsibilities and oversite. **NIE Networks' Response:** During the LSG settings change implementation programme and in line with our obligations under ER G59/1/NI, NIE Networks' personnel witnessed the testing of the new interface protection settings at all LSG sites. In their consultation response SONI appear to be suggesting that unless a similar process is applied to the SSG changes then it may not have the necessary assurance to begin moving the RoCoF standard. In line with the requirements of ER G59/1/NI NIE Networks do not witness the testing of interface protection settings at LV connected generation sites. Given the number of SSG sites in scope (c1200), NIE Networks do not believe this is a feasible approach in the timescales required by the TSO. NIE Networks will address this issue as part of further discussions with UR and SONI on the SSG implementation plan.

SONI	**Consultee Comment:** It is important to note that the analysis completed by Strathclyde University for NIE has shown that a 1Hz/s with a 500ms delay relay setting remains stable for a 2Hz/s measured over 500ms RoCoF event. Based on this and without pre-empting the outcome of the generator studies process or any UR decisions, SONI is of the opinion that a setting of 1Hz/s with a 500ms delay is acceptable for SSG in NI. This view aligns with the standard required for Large Scale Generation in both Northern Ireland and Ireland. **NIE Networks' Response:** The analysis completed by Strathclyde University has shown that a 1Hz/s with a 500ms delay relay setting can remain stable for approximately 1.9Hz/s measured over 500ms and is not 2Hz/s measured over 500ms. Looking closely at the figure below it can be seen that at 1.5Hz/s the "hardware relay" is tripping slightly after the "relay model". From this it can be estimated that the 1Hz/s relay will remain stable up to about 1.9Hz/s measured over 500ms. 
SONI	**Consultee Comment:** NIE Networks' consultation proposed that Vector Shift protection shall no longer be allowed and RoCoF must be used, acknowledging that this change has a negligible impact on the results. The proposal indicates that this change is due to the TSOs preference only. SONI would like to highlight that this removal of Vector Shift protection is in line with NIE Networks proposed settings for Large Scale Generation as outlined in NIE Networks' previous consultation, and that in this consultation it was highlighted that this change had a negligible impact on safety. **NIE Networks' Response:** NIE Networks would note that, as the use of Vector Shift as a LoM technique has negligible impact on the risk of islanding, then we have no preference as to whether it is disallowed. SONI previously indicated that their preference is to disallow Vector Shift, NIE Networks are happy to accommodate this. We will discuss further with SONI.

APPENDIX 2 – PROPOSED DISTRIBUTION CODE MODIFICATIONS (REDLINE)

Connection Conditions

7.1 Suitable **Protection** arrangements and settings will depend upon the particular **Generator**'s installation and the requirements of the **Distribution System**. These individual requirements must be ascertained in discussions with the **DNO**. To achieve the objectives above, the **Protection** must include the detection of:

a. Over Voltage (O/V)
b. Under Voltage (U/V)
c. Over **Frequency** (O/F)
d. Under **Frequency** (U/F)
e. Loss of Mains (LoM)

Protection Function	All Power Stations >16Amps/phase ~~≥5MW~~	
	Setting	Time Delay
U/V stage 1	0.85pu$	3.0s
U/V stage 2	0.6pu$	2.0s
O/V	1.1pu$	0.5s
U/F	48Hz	0.5s
O/F	52Hz#	1.0s
LoM(RoCoF)¥	1.0Hz/s	0.5s∝

Note: ∝ The required protection requirement is expressed in Hertz per second (Hz/s). The time delay should begin when the measured rate exceeds the threshold expressed in Hz/s and be reset if it falls below that threshold. The relay must not trip unless the measured rate remains above the threshold expressed in Hz/s continuously for 500ms. Setting the number of cycles on the relay used to calculate the RoCoF is not an acceptable implementation of the time delay since the relay would trip in less than 500ms if the rate was significantly higher than the threshold.

¥ RoCoF – Rate of Change of Frequency

$ Base unit is defined as the nominal voltage at the **Connection Point.** This applies to phase-phase and phase-neutral voltages.

A default setting of 52Hz will apply unless a lower setting is requested by the **DNO**.

7.1.1 For each of the protection functions, the CB opening should occur with no inherent time delay following a protection trip operation from the relay.

7.1.2 All **Power Stations** with an output ≥5MW and connected to the **System** on or after 1st October 2017 must apply **Protection** settings as per paragraph CC7.11. For the avoidance of doubt, **Power Stations** with an output ≥5MW and connected on or after 1st October 2017 shall not employ vector shift as a LoM technique.

~~7.1.3 All **Power Stations** ≥16Amps/phase and <5MW connected to the **System** shall maintain the protection settings as outlined in their **Connection Agreement.**~~

All **Power Stations** with an output >16Amps/phase and <5MW and connected to the **System** on or after 1st March 2018 must apply **Protection** settings as per paragraph CC7.11. For the avoidance of doubt, **Power Stations** with an output >16Amps/phase and <5MW and connected on or after 1st March 2018 shall not employ vector shift as a LoM technique.

7.1.4 **All Power Stations** ≥5MW connected to the system prior to 1st October 2017 shall ensure that the **Protection** settings as per paragraph CC7.11 are applied by 31st December 2017. For the avoidance of doubt, Power Stations with an output ≥5MW and connected to the **System** prior to 1st October 2017 shall not employ vector shift as a LoM technique.

7.1.5 **All Power Stations** >16Amps/phase and <5MW connected to the system prior to 1st March 2018 shall ensure that the **Protection** settings as per paragraph CC7.11 are applied by 30th September 2019. For the avoidance of doubt, Power Stations with an output >16Amps/phase and <5MW and connected to the **System** prior to 1st March 2018 shall not employ vector shift as a LoM technique

7.1.6 For the avoidance of doubt, the requirements of paragraph CC7.11 shall take precedence in any conflict arising between this **Distribution Code** and Engineering Recommendation G59/1/NI

7.1.7 In line with HSENI recommendations, all **Generators** should review and update relevant risk assessments to take account of the risks associated with islanding, with particular emphasis on out of phase re-closure, when adhering to the requirements of paragraph CC7.11. Further information on this is included in Appendix 4.

GUIDANCE ON RISK ASSESSMENT WHEN USING ROCOF LOM PROTECTION

1 This procedure aims to provide guidance on assessing the risks to a **Generator's Plant** and equipment where a **Power Station** is considering the effect of applying higher interface **Protection** settings. Information provided by the **DNO** in relation to this appendix 4 may be at the expense of the **Generator.**

1.1 The guidance in this appendix 4 relates to a new activity. Early experience may suggest there are more efficient or effective ways of assessing the risk. The **DNO** and **Generators** will be free to adapt this procedure to achieve the **Generators'** ends.

1.2 When a **Generator** wishes to carry out a risk assessment the **DNO** will be able to provide an estimate of the net (i.e. taking into account as appropriate other Generation on that part of the network) potential trapped load. This can be in the form of a yearly profile, and possibly in the form of a load duration curve. It is possible that an island may form at more than one automatic switching point on the **DNO's** network and the **DNO** will be able to provide a profile or estimate of a profile for each. This will enable a quick assessment to be made as to the whether the mismatch between load and generation is so gross as to obviate further study. It is for the **Generator** to determine what a gross mismatch is depending on the **Generating Unit's** response to a change in real or reactive power. The **Generator** should be aware that the trapped load on a network can change over time, due to the connection or disconnection of load and or Generation and network topology changes; hence the trapped load assessment may need to be carried out periodically.

1.3 **DNOs** will also be able to provide indicative fault rates for their network that lead to the tripping of the automatic switching points in paragraph 1.2 above.

1.4 **DNOs** will also be able to provide the automatic switching times employed by any auto-reclose switchgear employed at switching points identified in paragraph 1.2.

1.5 **DNOs** will provide the information above and any other relevant information reasonably required within a reasonable time when requested by the **Generator**.

1.6 A key influence on the stability of any power island will be the short term, i.e. second by second, variation of the trapped load. The **DNO** will be able to provide either a generic variability of the load with typically 1s resolution data points, or at the **Generator's** expense will be able to measure actual load variability for the network in question for some representative operating conditions.

1.7 Armed with the above information the **Generator** will be able to commission appropriate modelling to simulate the stability of the **Generator's Plant** when subject to an islanding condition and hence assess the risks associated with an out-of-phase re-closure incident. Where the Generator considers these risks to be too high, sensitivity analysis should enable them to identify the effectiveness of various remedial actions.