DS3:
Rate of Change of Frequency (ROCOF) Workstream

BACKGROUND

Rate of Change of Frequency and the investigation of same is one workstream within the DS3 programme. This, together with the other workstreams provides an integrated solution in terms of the operational integration of renewables.

The "Facilitation of Renewables" report indicated that the key limit to allowing high real time penetrations of wind power plants on the system was the rate of change of frequency (ROCOF). Specifically, the studies identified that with increasing wind power plant the synchronous on-line inertia on the system would reduce. The "Ensuring a Secure, Sustainable Electricity system" report indicated that this would on average reduce by 25% with an assumed portfolio consistent with the renewable policy objectives. This reduced inertia will result in higher ROCOF being experienced for the loss of a single large generation unit.

The current Grid Code in Ireland only requires generators to be able to ride through ROCOF of 0.5 Hz/s. It is not currently clear what standard is required of each distribution generator in Northern Ireland (NI) but it is understood to be in the range of 0.25 to 0.4 Hz/s. From the year 2000 onwards, all transmission connected conventional generation in NI should as part of their connection agreement meet a Minimal Functional Specification ROCOF requirement of 1.5Hz/s From operational experience and analysis, ROCOF in excess of 0.5 Hz/s are likely to be encountered when the system exceeds a 50% system non-synchronous penetration (SNSP) level or the synchronous inertia falls below 25000 MW-seconds. In addition, the loss of mains protection utilised in the distribution network in Ireland and employ ROCOF in excess of 0.6 Hz/s. Operating a power system where a ROCOF of greater than 0.5 Hz/s is likely to occur for a probable event (loss of a single generator) and could lead to the cascade tripping of all remaining generation would not be prudent. Therefore, in order to securely operate a power system with high penetrations of wind power plant there needs to be a reliable level of performance from generators and any associated protection equipment, i.e. that the plant can securely operate with ROCOF well in excess of 0.5 Hz/s or that the inertia on the system with respect to the size of largest in feed remains high (in the order of 25000 MW-seconds for the Ireland and Northern Ireland power system).

The objective of this workstream is to ensure that an operational policy is developed which clearly understands the issues of ROCOF and seeks to systematically address the critical areas in order to be able to operate a power system with respect to ROCOF issues at up to 75% SNSP.

APPROACH

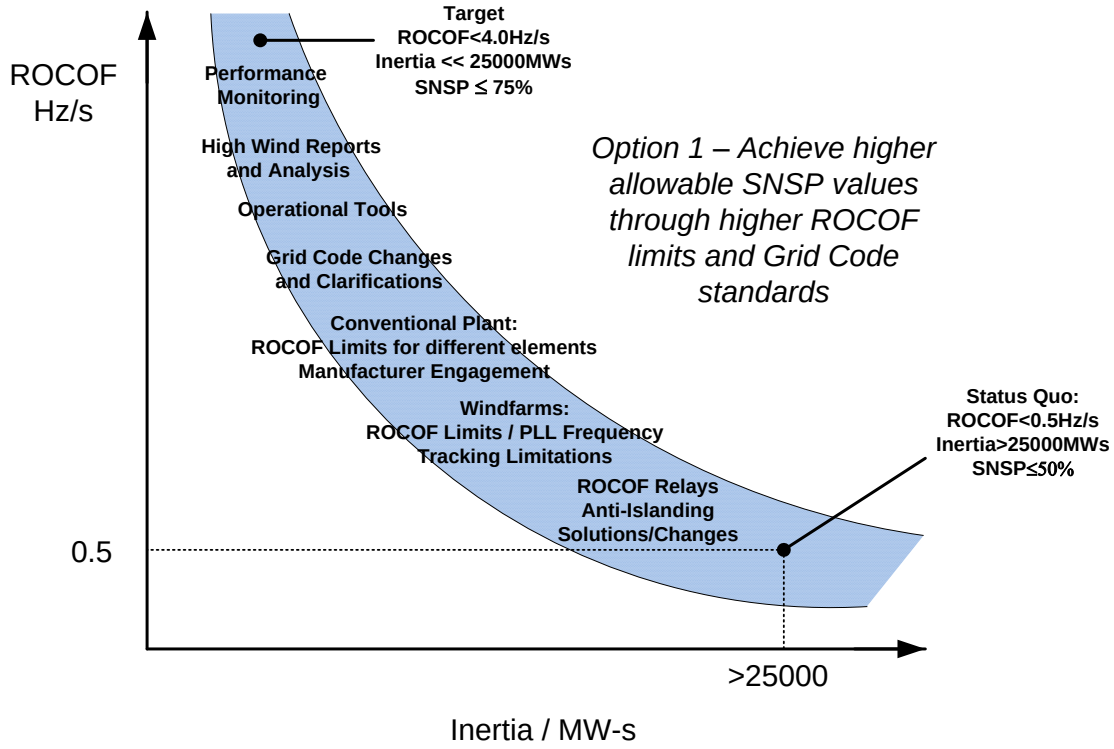
There are different approaches that can be taken to the ROCOF issue, and the final solution is likely to be some combination of these approaches:

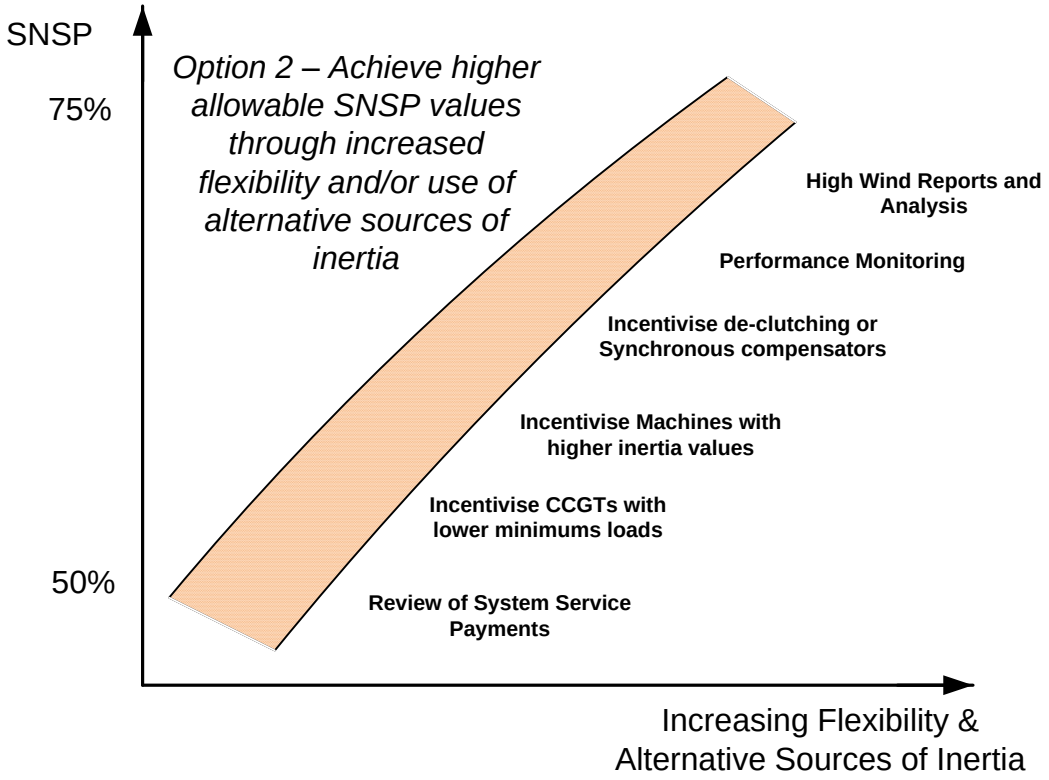
Grid Code Approach which could include the following;

a. All plant to ride-through ROCOF values greater than 0.5 Hz/second, based on discussion with equipment manufacturers and changes to the standards
b. Develop new anti-islanding strategies including a review of the current settings on ROCOF relays

System Services Approach which could include the following;

a. Seek the provision of different forms of inertia, such as flywheels or synchronous compensators, so that high values of ROCOF are not reached
b. Incentivise more flexible plant, such as CCGTs with low minimum loads, or conventional machines with de-clutching action so that they can switch easily to synchronous compensation mode
c. Demand side management such as batteries or compressed air storage





SCOPE

The scope of the ROCOF project plan will be broken into four areas of work. These are:

- Setting appropriate ROCOF standards on all generators (Transmission and Distribution Connected) and appropriate testing
- Ensuring appropriate anti islanding on distribution protection
- On-line tool development and modelling improvement
- Operational Policy review

Setting appropriate ROCOF standards on all generators

This work area will examine how clarified or enhanced standards will be developed and brought in to obligate all generators including wind power plants in Ireland and Northern Ireland, transmission and distribution connected. This will involve Grid and Distribution Code changes. In Northern Ireland, there will need to be an investigation of where these regulations are best placed including connection agreements, grid and distribution codes. The changes need to be driven by a detailed examination of individual plant items that could potentially trip during high values of ROCOF. This work will need co-ordination and co-operation between the TSOs, DSOs, conventional and wind generators, and equipment manufacturers. Initially, this will be through formal compliance statements from all generators to this effect. Over a period of time, performance monitoring data of actual events and testing of new and existing plant will augment these initial compliance statements from generators.

Ensuring appropriate ROCOF on distribution protection

The use of ROCOF for loss of mains protection will be examined with the DSOs in Ireland and Northern Ireland to ascertain if it is possible to increase the settings for the G10 and G59

protection without impacting on the quality of protection employed in the distribution system and which assists in operating a secure power system.

On line tool development and modelling improvement

This work area will leverage developments in real time domain simulations in the WSAT workstream and data collected via the Renewable Data workstream.

In particular, two regular reports will be used, High Wind Event and Actual Event performance reports.

*A **High Wind Event*** report will be produced on a six monthly basis and will simulate a range of contingencies, wind power transfers and disturbances with the time domain model of the system. This report will provide system operators with a review of potential issues with operating the system at consistently higher penetrations of wind.

*An **Actual Event*** report will be produced every six months and will provide a review of large frequency disturbances events on the system against the modelled system. Sub groups for validation and cross validation of generator parameters will be determined. The output of this report will be recommendations for new parameters and model structures to be used in the real time system model used in the real time and for the development of high wind event report.

A key dependency for this work stream is the development of representative models of all types of generators related to voltage control, frequency control, and fault ride through capability which will then be used to develop an all island WSAT model.

Operational Policy review

Operational policy review will be conducted every year. The inputs that will be required are the current status from each of the relevant work areas. Based on a review of the status of ROCOF capabilities of generators and distribution protection and the High wind event and Actual event reports a decision can be made on whether to adjust the operational policy on SNSP, inertia or some other relevant metric. It is likely that this adjustment will be provisional until at least the next formal review. The provisional policy will be formally adopted when there has been sufficient operational experience to indicate that it is prudent to operate the system along these lines and it is deemed prudent to implement said operational policy change by the System Managers.

Outcomes

The results from the ROCOF workstream will feed into several of the other DS3 workstreams, including:

Grid Code: Proposed Grid Code ROCOF modification (the current proposal is 4Hz/s) dependent on the capability of generators and responses from manufacturers that will be elicited by the ROCOF workstream.

Model development and studies: A re-run of a Facilitation of Renewables-type study will be carried out with new assumptions about the values of ROCOF that generators can ride through, and will also consider the impact of new ROCOF relay settings on distribution connected wind farms.

System Services: If the outcome from the ROCOF workstream is that high ROCOF values cannot be countenanced, then alternative approaches to increasing the allowable SNSP will have to be sought. Incentivising different system services such as inertia and flexible generation will be key to that.

Frequency Control: If clarity on the ROCOF capabilities of wind farms and conventional plant is achieved, this will feed into the Frequency Control workstream, especially in relation to loss of largest infeed, spinning reserve, inertial response and ROCOF.

HIGH LEVEL PLAN

Task/Milestone	Stakeholders	Timeline
Setting appropriate ROCOF standards on all generators		
• Bring ROCOF modification to the Grid Code Review Panel meeting	TSOs	Q4 2011
• Identify regulatory mechanism for implementing ROCOF standard in Northern Ireland	SONI TSO	Q4 2011
• Formal response from generators and wind farms to modification	All generators	Q4 2011
• Establish ROCOF DS3/GC working group	TSOs/Industry	Q1 2012
• Working group develops proposals on ROCOF standards for Conventional and Wind Generators	TSOs/Industry	Q2 2012
• Review of Working Group and summary paper	TSOs	Q3 2012
• Modification approval GCRP	TSOs	Q3 2012
• Bring modification to appropriate fora for Northern Ireland	SONI TSO	Q32012
• Approved modification to Grid Code and Distribution Code	CER	Q4 2012
• Approve modification to appropriate regulatory instrument	NIAUR	Q4 2012
• Review and Implementation of new standards	TSOs/DSOs/Industry	Q4 2013
Ensuring appropriate ROCOF on distribution protection		
• Kick off and scope TSO-DSO ROCOF working groups	DSOs/ TSOs	Q4 2011
• Examine safety implications and security impact on changes to G10, G59 protection settings including ROCOF and voltage	DSOs	Q2 2012
• Provide written report on implications for ROCOF setting and loss of mains protection including implementation strategy	DSOs	Q2 2012
• Decision on change to ROCOF protection setting	ESB Networks	Q3 2012
• Decision on change to ROCOF protection settings	NIE	Q3 2012
• Review and Implementation of new standards	TSOs/DSOs/Industry	Q4 2013