DS3:
Model Development & Studies Workstream (2013)

CONTEXT

The Facilitation of Renewables (FOR) study was a detailed and wide-ranging study that covered many different aspects of power system stability and power system operation with high levels of wind. The purpose of the DS3 programme is to implement the necessary actions arising from the FOR study results: introduce changes to operational policies where necessary; develop mitigation strategies; change or improve the standards via Grid Code and Performance Monitoring; incentivise system services via the System Services review; and develop our existing dynamic models and run new studies and simulations where necessary. The Model Development and Studies Plan (MDSP) will provide inputs into the Frequency Control and Voltage Control workstreams. It will also interact closely with the WSAT development plan. Key inputs into the Model Development and Studies Plan will be Performance Monitoring data, and Renewable data.

OBJECTIVES

The main aim of this workstream is to inform future operational policies related to the integration of large amounts of wind onto the Ireland and Northern Ireland system. In order to do this a range of technical studies and analysis is to be performed. This analysis includes steady-state load-flow, quasi steady-state PV load-flow, short-circuit, dynamic stability, transient stability and frequency response analysis. A significant factor in this is to develop and validate the dynamic model of the Ireland and Northern Ireland system so that the TSOs or any impartial observer would have confidence in the results of the studies carried out using those models. Another aim is to streamline and automate the studies process, so that extensive studies on different aspects of power system operation can be carried out more quickly. This may involve using scripting tools to provide a control layer above the actual simulation tools, into which information on dispatches, sensitivities, and key outputs can be fed.

WORK COMPLETED IN 2012

In 2012, work commenced on establishing a model of the network that could be used for 2020 studies. This model has been completed: PSS/E cases together with dynamic data are available for the year 2020. There was also significant work carried out on TSO processes necessary to validate different types of model such as exciters and governors.
Several studies were also carried out during 2012, including:

- Loss of Largest Infeed Study
- Frequency Regulation Study
- Historic Analysis of System Frequency Events
- Analysis of Ramping Requirements for System Services

Focus in 2013

The focus in 2013 will be on studies for the voltage control workstream, including PV analysis and distributed voltage control, as well as the voltage dip-induced frequency dip study. There will also be a focus on getting the study processes automated, which should allow more time to be spent on analysis of results.

The following sections set out the original workstream plan as published in December 2011

Model Development and Validation

EirGrid and SONI use a number of different packages including PSS/E, DSA Tools (PSAT, VSAT, TSAT, WSAT), and PowerFactory. PSS/E is used extensively in planning studies in both EirGrid and SONI. The DSA Tools software suite is more geared towards online studies, but is also used for operational studies (WSAT is part of the DSA Tools suite). PowerFactory is used for in-depth three-phase fault analysis, harmonic studies, and electromagnetic transient studies.

Model development has been ongoing for many years, but mainly on a jurisdictional basis. One aim of this workstream is to produce a functioning all-island model for PSS/E and DSA Tools that has been cross-validated. It will also incorporate special protection schemes and windfarm interface protection schemes, as well as load-shedding schemes and static reserve.

Model validation is ongoing in both EirGrid and SONI. For example, formal processes have been developed to compare system frequency events against the performance of TSAT (Transient Stability Assessment Tool). Processes will also need to be developed to validate/verify the performance of other dynamic models (excitation systems / machine parameters).

Main Studies Required

As well as developing network models, another objective of this workstream is to carry out studies supporting other DS3 workstreams for example voltage and frequency control. Some examples of the areas of investigation identified in the FOR studies will be looked at in more detail on a case by case basis and are listed below.

Frequency-related:

1. Loss of largest in-feed study: Quantifying the limit on generator/windfarm size, by looking at effect on frequency and constraint costs
2. Minimum conventional generation study: Determining if there is a minimum number of conventional generators that must always by online to maintain voltage stability and transient stability of the power system. *(Update: This needs to be re-studied using an all-island dynamic model.)*
3. Voltage-induced frequency dip study: Looking at the effect of transmission system faults on the outputs of windfarms. Quantifying the resulting energy imbalance and the effect on frequency and ROCOF, and transient stability of the system.

4. Frequency regulation study: Quantifying the frequency regulation issue with high wind penetrations. How much will the frequency fluctuate, and what actions does the TSO need to take to mandate additional sources of frequency regulation.
5. Wind Governing and Emulated Inertia Study: Looking at the effect of wind governing and emulated inertia (fast-acting response) from windfarms on system frequency and reserve. Determination of appropriate settings and consequences for curtailment levels. It may also be necessary to consider high frequency effects on the system for high wind and exporting dispatch scenarios.
6. Ramping requirements study: Looking at historical statistics on ramping requirements and extrapolating these results for high wind penetrations. What ramping services will the system require and how best to provide these services.
7. New DSO RoCoF settings: Study the effect of potential changes to loss-of-mains RoCoF and Vector Shift settings, and the impact that this has on the SNSP policy etc.

Voltage-related:

8. Distributed voltage control study and windfarm voltage co-ordination: How best to manage the reactive power resources from DSO and TSO connected windfarms, given the various control modes that they can operate under.
9. PV analysis of system / Overcompensation study: Carry out full Power-Voltage analysis of the power system to determine likelihood of voltage collapse, and determine if system is overcompensated i.e. if the system has too much shunt capacitance relative to the capacity of the transmission network.
10. Synchronous Condensers / Dynamic Reactive Power study: Consider the impact of synchronous condensers and other dynamic reactive power sources on the transient stability of the power system.

Network-related:

11. Short-circuit levels and wind farm clusters: Investigate potential instability related to large windfarms connecting to weak parts of the network, and how short-circuit contributions of nearby windfarms should be treated.

General:

12. SNSP / Metrics / Quantifying Synchronous Torque Study: General analysis of the best metrics to use for determining system stability with high wind penetrations, and quantifying the reduction in synchronizing power at high winds.

There will also be a requirement to re-run the FoR analysis for a more wide-ranging set of dispatches and sensitivities at some point in the future. This will be contingent upon developing procedures for a streamlined approach to these very extensive studies, as mentioned above. Such studies may be based on half-hourly dispatches for a whole year, with a variety of sensitivities, such as operational policy changes. As such, they could not be carried out manually, but would need to be fully automated, and the analysis of the studies would also need to be automated.

Key Outcomes

- Create a working all-island model in PSS/E and DSA Tools / WSAT that has been validated against several system events. This model will be the basis of the rest of the studies.
- Results to be fed into Frequency Control and Voltage Control workstreams.
- Generate recommendations on each of the studies listed, along with recommendations for changes to operational policy, or recommendations for further study
- Establish processes for validating governor and excitation models, and for comparing major system events against simulations.
- Create a streamlined study process that can use scripting capabilities inherent in DSA tools / PSS/E for in-depth studies with multiple sensitivities and dispatches.

Assumptions and Risks

This workstream will create base case models for studies, the input assumptions covering variables such as dispatch, portfolio, wind penetration levels and demand will be defined at the study planning stage.

The majority of the studies will require a working all-island model that includes dynamic models for wind governing response and emulated inertia response. This may involve the use of consultants for model development in PSSE or TSAT. There also will be a requirement for work by Powertech Inc. who develop WSAT, and the dynamic models that are used in it.

The scope of this workstream may change depending on the requirements of the frequency control and voltage control workstreams. It will also depend on the outcomes from the Grid Code workstream and the decisions by industry and regulators on the RoCoF issue.

High-Level Plan

TASK NO.	DELIVERABLES / TASKS	DEPENDENCIES ON DS3 WORKSTREAMS	RESPONSIBILITY	ORIGINAL DUE DATE	DUE DATE
Model Development and Validation					
MDV.1.1	Develop all-island model for PSS/E / WSAT	WSAT	TSOs	Q2 2012	Complete
MDV.1.2	Develop process for Exciter Validation	Performance Monitoring	TSOs	Q2 2012	Complete
MDV.1.3	Develop process for validating all–island model against system events	Performance Monitoring / WSAT	TSOs	Q3 2012	→WSAT Workstream
MDV.1.4	Develop streamlined process for carrying out large system studies	WSAT	TSOs	Q4 2012	Q2 2013 Appears Below
MDV.1.5	Implement Exciter / PSS / System Event Model Validation using PMU outputs	None	TSOs	New task	Q3 2013
MDV.1.6	Develop generic tuneable wind farm models that can represent behaviours set out in the windfarm grid code modifications	Grid Code	TSOs / Powertech	New task	Q3 2013
System Studies					
MDV.2.01	Frequency Response following a large disturbance	Frequency Control	TSOs	Q2 2012	Complete
MDV.2.02	Loss of Largest In-feed Study	Frequency Control	TSOs	Q1 2012	Complete
MDV.2.03	Frequency Regulation Study	Frequency Control	TSOs	Q2 2012	Q1 2013
MDV.2.04	Study of Ramping Requirements	System Services / Grid Code	TSOs	Q2 2012	Complete
MDV.2.05.1	Develop streamlined approach to studies: Pilot version	None	TSOs	Q4 2012	Q2 2013
MDV.2.05.2	Develop streamlined approach to studies: Full version	None	TSOs	New task	Q4 2013
MDV.2.06.1	Investigate voltage dip induced frequency dip in the short-term	Frequency Control	TSOs	Q1 2013	Q2 2013

MDV.2.06.2	Investigate voltage dip induced frequency dip out to 2020	Frequency Control	TSOs	Q1 2013	Q3 2013
MDV.2.07.1	Distributed Voltage Control and Dynamic Voltage Support Study Scoping	Voltage Control / Grid Code	TSOs	2013	Q2 2013
MDV.2.07.2	Distributed Voltage Control and Dynamic Voltage Support Study Analysis	Voltage Control / Grid Code	TSOs	New task	Q4 2013
MDV.2.08	PV Analysis and Overcompensation Study	Voltage Control	TSOs	2013	Q3 2013
MDV.2.09	Follow-up analysis based on DSO RoCoF Report	RoCoF	TSOs	New task	Q2 2013
MDV.2.10	All-Island Minimum Generation Study	None	TSOs	New task	Q3 2013
MDV.2.11	Follow-up analysis of ramping requirements based on system services workstream output	System Services	TSOs	New task	Q3 2013
MDV.2.12	Analysis of wind farm locational stability and system short-circuit strength	Various	TSOs	New task	Q4 2013
MDV.2.13	Metrics for assessing system security and stability	None	TSOs	New task	Q4 2013
MDV.2.14	Other potential studies: FOR 2 - Consolidation of Renewables (CoR)	Various / Grid Code	TSOs	New task	2014/2015