DS3:
Model Development & Studies Workstream (2014-2015)

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.

Key inputs into the Model Development and Studies workstream will be results from the Performance Monitoring and Renewable Data workstreams.

The Model Development and Studies (MDS) workstream will provide inputs into the Frequency Control and Voltage Control workstreams. It will also interact closely with the WSAT Development plan.

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 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
- Historic Analysis of System Frequency Events
- Analysis of Ramping Requirements for System Services

WORK COMPLETED IN 2013

In 2013, the following pilot studies were completed for the Voltage Control and Frequency Control workstreams:

- Pilot Voltage Dip-Induced Frequency Dip Study
- Pilot PV Analysis of the Donegal area
- Short-term System Frequency Response Study

Additionally, the testing of the new TSAT dynamic generic wind farm models from Powertech has been completed. The new models include voltage control modes, emulated inertia, governor droop characteristic, reactive response in fault ride-through mode and slow active power recovery following a fault.

FOCUS AREAS FOR 2013-2015

There will be a focus on getting the study processes automated, which will allow more time to be spent on analysis of results. There will also be a continuing focus on studies for the voltage control and frequency control workstreams.

Other System Studies that will be a major focus of the workstream are:

- All-Island Minimum Generation Study
- Frequency Regulation Study

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 wind farm 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	RESPONSIBLE	ORIGINAL DUE DATE	DUE DATE
Model Development and Validation					
MDS.1.1	Develop all-island model for PSS/E / WSAT	WSAT	TSOs	Q2 2012	Complete
MDS.1.2	Develop process for Exciter validation	Performance Monitoring	TSOs	Q2 2012	Complete
MDS.1.3	Develop process for validating all–island model against system events	Performance Monitoring / WSAT	TSOs	Q3 2012	Complete
Enhanced Modelling Capability					
MDS.2.1	Develop generic tuneable wind farm models that can represent behaviours set out in the wind farm Grid Code modifications	Grid Code	TSOs / Powertech	Q3 2013	Complete
MDS.2.2	Investigate and decide on settings for generic tuneable wind farm models		TSOs	New task	Q1 2014
MDS.2.3	Include new generic tuneable wind farm models in on-going high wind studies	WSAT	TSOs	New task	Q1 2014
MDS.2.4.1	Pilot version of automated approach to large-scale dynamic studies using Plexos		TSOs	New task	Q2 2014
MDS.2.4.2	Full version of automated approach to large-scale dynamic studies using Plexos		TSOs	New task	Q4 2014
MDS.2.4.3	Scope operational studies using automated Plexos approach based on existing and proposed operational policies		TSOs	New task	Q4 2014
Frequency Control Studies					
MDS.3.1	Frequency Response following a large disturbance	Frequency Control	TSOs	Q2 2012	Complete
MDS.3.2	Loss of Largest In-feed Study	Frequency Control	TSOs	Q1 2012	Complete
MDS.3.4.1	Study of Ramping Requirements	System Services	TSOs	Q2 2012	Complete
MDS.3.4.2	Agree terms of full Ramping Policy Study		TSOs	New task	Q4 2014
MDS.3.4.3	Ramping Policy Study		TSOs	New task	Q2 2015
MDS.3.5.1	Pilot study to investigate voltage dip-induced frequency dip	Frequency Control	TSOs	Q1 2013	Complete
MDS.3.5.2	Full study to investigate voltage dip-induced frequency dip	Frequency Control	TSOs	Q1 2013	Q3 2014
MDS.3.5.3	Study to assess the need for STATCOMs due to voltage dip-induced frequency dips	Voltage Control	TSOs	New Task	Q4 2014
MDS.3.6.1	Pilot FFR/POR/SOR study based on existing operational practices		TSOs	New task	Q1 2015
MDS.3.6.2	Agree terms of full FFR/POR/SOR study to meet 2020 requirements		TSOs	New task	Q2 2015

MDS.3.7	Over-frequency generation shedding settings schedule study	Frequency Control	TSOs	New task	Q1 2014
Voltage Control Studies					
MDS.4.1.1	Distributed Voltage Control and Dynamic Voltage Support Study Scoping	Voltage Control	TSOs	Q2 2013	Q2 2013
MDS.4.1.2	Distributed Voltage Control and Dynamic Voltage Support Study Analysis	Voltage Control	TSOs	Q4 2013	Q4 2013
MDS.4.2.1	Pilot PV study with existing operational practice to determine the level of dynamic reactive power compensation required on the power system	Voltage Control	TSOs	New Task	Q4 2013
MDS.4.2.2	Full version of PV study with existing operational practices and sensitivity of new ones	Voltage Control	TSOs	New Task	Q3 2014
MDS.4.3	Analysis for pilot nodal voltage control project on a wind farms cluster	Voltage Control	TSOs	New Task	Q1 2014
MDS.4.4	Voltage Trajectory Study	Voltage Control	TSOs	New Task	Q3 2014
Other System Studies					
MDS.5.1	All-Island Minimum Generation Study	None	TSOs	Q3 2013	Q1 2014
MDS.5.2	Analysis of wind farm locational stability and system short-circuit strength	Various	TSOs	Q4 2013	Q4 2014
MDS.5.3	Metrics for assessing system security and stability	None	TSOs	Q4 2013	Q2 2014
MDS.5.4	Other potential studies: FOR 2 - Consolidation of Renewables (CoR)	Various / Grid Code	TSOs	2014/2015	2015/2016