Low Inertia Workshop Summary

Philosophically
It is more than inertia that is being lost. Something fundamental to the power system is disappearing with the removal of synchronous machines. It can be characterised by declining levels of fault current, reactive power, inertia, ramping capability, etc., but we are moving from a system based on electromechanical generation devices (which have an inherent response to a disturbance) to a system based on semiconductor generation devices (whose response is almost completely defined by control logic). This movement from a system driven by physical laws to a system defined by the control of inverters is uncharted territory.

A converter-based power system is getting to the heart of power system assumptions. We are moving from a world in which generation is controllable, and load that is predictable to the opposite.

Regulatory
With TSO only having the power to set up the rules and frameworks – rather than own assets to control the power system, TSO have little control of the driving forces behind the change in the power system. They can only anticipate and adapt.

There is no standard behavior of a converter – it is up to the manufacturer. This is again unlike synchronous machines (which have been standardised many years ago). Grid codes will need to cater for this future convert-based world, prudently and agnostically.

Technically
One potential issue in a 100% converter-based generation world is that converters have hard energy limits, i.e. unlike synchronous machines, converter-based generation do not have a significant overload capability. Thus, if there is not sufficient headroom between the output of a wind/PV farm and the converter limit, then such units may not be able to inject as much power as the system desires.

Modelling of the future power system will require more detailed models. Positive sequence time domain simulations may not reveal all the issues associated with a converter-based power system, this was highlighted by the differing responses from current or voltage source representations of converter-based generation in stability simulations.

Mathematical Sciences Collaboration in Energy Systems Integration

Workshop Summary

From the workshop the first result that claimed attention was that integrating energy systems, including electricity networks, gas networks, and water treatment systems can be seen as a complex problem, and mathematical sciences can be used as a tool to solve several aspects of such a complex problem.

The workshop included several examples detailing how mathematical sciences can be applied to solve present problems in energy system integration. Simon Wilson from trinity college explained how fault-tree analysis can be applied for reliability analysis and risk assessment of complex systems. Muireann Lynch presented a piece of their work in ESRI on the development of three distinct mathematical models that can be used to determine the optimal time to invest on a new technology, to define optimal feed-in tariffs for renewables, and to design an optimal bidding strategy for private generating companies. Paula Carroll from UCD defined unit commitment problem for the Irish power system. She then applied mixed integer linear programming, stochastic programming and robust optimization to handle the uncertainty of variables involved in the problem. Next, Amy Wilson from Durham University introduced an energy system simulator, and presented an approach implemented in the simulator to quantify different uncertainties, including parametric, structural, and functional uncertainties involved in energy system problems. Finally, James Glyn from Environmental Research Institute based in UCC presented the past and anticipated future shares of various energy sources in the Irish energy systems.

The general conclusion from the discussion was that the advent of energy system integration has increased the complexity of the problems in each of electricity, gas and water sectors, and it is the time for engineers of these sectors to collaborate with mathematicians to solve their problems.