ASIA-PACIFIC SOLAR RESEARCH CONFERENCE

# Wind Farm Grid Connection Studies and Field Testing Solutions in UNSW

Ke Meng[1], Joe Dong[1], Wang Zhang[1], and Yuan Qiao[2]

[1]*School of Electrical Engineering and Telecommunications, University of New South Wales, Kensington, NSW 2052, Australia*
[2]*Xinjiang GoldWind Science & Technology Co., Ltd., Beijing, 100176, China*
*E-mail: ke.meng@unsw.edu.au*

## Background

With increasing levels of weather-dependent energy resources added to the features of Australia's grid, i.e. long distances over an island grid, the fossil fuel-dominated Australian power system faces a number of unique challenges. Large-scale wind generation is being connected in areas with good resources, e.g. South Australia and Tasmania, which tends to be the weaker parts of the grid, primarily designed to supply local loads. Whilst geographical and technological diversity smooths the impact of intermittency, due to the current inter-regional transmission constraints and the low power system inertia conditions, the Australian power grid is becoming more susceptible to prevalent disturbances than ever before. Secure and reliable operation of the power grid becomes now one of the basic needs for national security. To achieve a smooth grid connection, wind farm developers need to assess and comply with a range of regulatory requirements specified in the "Grid Code". Therefore, it is important to understand the ISO's requirements on connecting new wind power plants, grid's ability to accommodate new wind generation, as well as its potential impacts on system stability.

## Grid Connection Studies

The Renewable Energy Integration Team (REIT) in UNSW provides a wide range of services to assess system-wide impact of increased penetration level of wind energy, allowing TNSPs and DNSPs to integrate renewables without harming network reliability. The REIT has expertise on technical and financial feasibility analysis, including wind resource assessment, wind data generation, wind turbine selection, micrositing optimization, electrical layout optimization and wind farm energy estimates for the business case. The team has years' experience in modelling of various wind generators (DFIG, PMSG, etc) necessary for the grid connection studies. Equipped with a range of state-of-the-art simulation software, full grid integration studies and system studies are performed, in compliance with the relevant national grid codes and standards. The service covers all aspects of grid reliability when integrating renewables from pre-test simulations, GPS compliance assessment, to R2 model validation. Specifically,

- steady-state analysis/power flow analysis
- short-circuit and protection coordination effects
- transient stability analysis/dynamic simulations
- market operations and grid congestion
- electromagnetic transient impacts.

## Filed Testing Facilities (Goldwind-UNSW Joint Research Lab)

Except for electrical feasibility studies, grid codes and compliance assessments, a smooth process and risk mitigation is ensured through on-site measurements and testing. In order to ensure the stable and reliable operation of the grid-connected wind farms, fault ride through capabilities are required in the national grid code. Low voltage ride through capability (LVRT) – ability of the wind turbines to withstand credible fault conditions, and support to network voltage recovery by injecting reactive current [1]; high voltage ride through capability (HVRT) – wind turbines should have the ability to operate at high voltage condition and stay connected for a certain period.

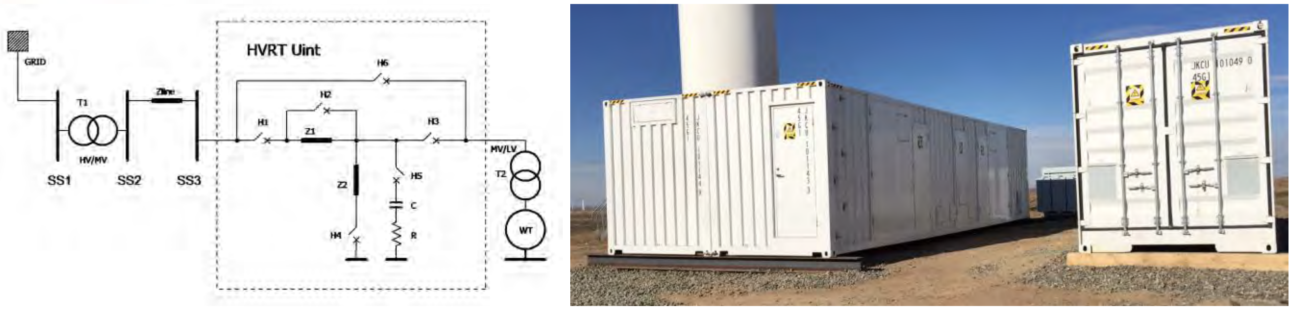


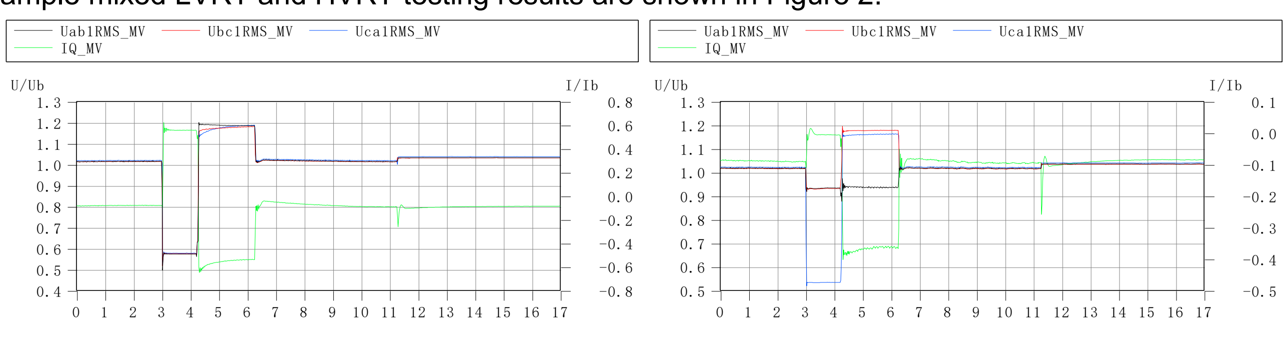

**Figure 1. Overall view of testing equipment**

Together with Goldwind, the largest PMSG wind turbine manufacturer, a LVRT/HVRT testing facility has been developed. The Figure 1 shows a simplified view of the test equipment. The testing equipment consists of a series-connected impedance $Z_1$ capable of limiting the short-circuit current, a parallel-connected impedance $Z_2$ capable of reducing the voltage level of the turbine side, and a capacitor C for raising the voltage. The impedances $Z_1$ and $Z_2$ consist of several coils each. By changing the ratio $Z_1$ to $Z_2$ the depth of the voltage dip can be configured. Depending on the respective grid code, different depths of voltage dips and rises can be simulated, ranging from 0% to 140% with a step of 2% of the rated voltage. The duration of the dip depends on the depth and ranges from 1000 milliseconds to 3000 milliseconds. Different grid faults can be simulated, including line to line (L-L), double line to ground (LL-G), and line to line to line (L-L-L). It can test generating plants up to 8 MVA in grids up to 35 kV in either 50 Hz or 60 Hz system.

**Table I. Field testing equipment specifications**

| | |
|---|---|
| **Rated capacity** | 8 MVA |
| **Rated voltage** | 35 kV |
| **Frequency** | 50 or 60 Hz |
| **Fault type** | line to line (L-L)<br>double line to ground (LL-G)<br>line to line to line (L-L-L) |
| **Voltage range** | from 0% to140% p.u. with 2% step |
| **Size** | 3 standard containers (12.00 m * 2.50 m *2.90 m) |

Sample mixed LVRT and HVRT testing results are shown in Figure 2.




(a) (b)

**Figure 2. 0.5 p.u. LVRT and 1.2 p.u. HVRT field testing results (a) Symmetrical, (b) Unbalanced fault**

**References**

[1] AEMO, "wind turbine plant capabilities report," Australian Energy Market Operator2013.