SHOULD THE WIND INDUSTRY SWITCH TO SYNCHRONOUS GENERATION?

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Introduction

Grid integration is already an issue for the wind industry at a time when only 1% of USA electricity is generated by wind energy. It could become a significant barrier to achieving a goal of over 20% of wind generated electricity if traditional wind turbine technology continues to be deployed.

The electricity system in USA and globally has been designed around the use of synchronous generators directly on line, which are the standard generators used in hydro, coal, and other traditional electricity generation technologies. Naturally the grid codes have been designed around the capabilities of these synchronous, synchronised generators (SSGs). The grid codes require, for example, fault ride-through, voltage and frequency control, and reactive power capabilities.

Traditionally, wind turbines have used induction or asynchronous generators which have limited ability to meet grid code regulations without the use of complex and expensive power electronics or expensive and potentially unreliable add-ons such as large dynamic or static VAR compensators.

Two new wind turbine manufacturers (Windflow Technology, DeWind) have made the move to synchronous generators which go directly on line without these add-ons. These can only be used in turbines which can control the torque from the rotor mechanically, requiring a different approach to gearbox design.

This paper will explain the current grid integration issues and offer a technical and economic solution to wind energy contributing over 20% of US electricity demand by using synchronous generators.

Grid Integration Requirements

Around the world, grid codes are starting to require wind turbines/wind farms to fulfill the same requirements as conventional power plants.

In the USA, FERC developed and issued an interconnection rule (Order 2003A) for wind facilities over 20 MW in capacity, with two relevant points.

1. Low Voltage Ride-Through Capability

If needed, a large wind generating facility must remain operational during voltage disturbances on the grid.

- A wind generating plant must have low voltage ride-through capability down to 15 percent of the rated line voltage for 0.625 seconds (see Figure 1);
- A wind generating plant must be able to operate continuously at 90 percent of the rated line voltage, measured at the high voltage side of the wind plant substation transformer(s).

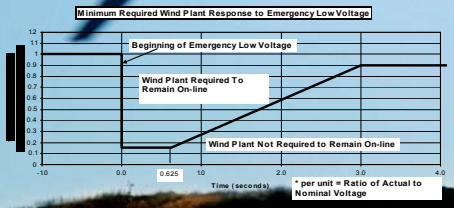

Figure 1 Proposed Low Voltage Ride-through Standard

2. Reactive power control

Large wind plants must, if needed, meet the same technical criteria for providing reactive power to the grid as required of conventional large generating facilities.

- maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection (see USA requirements Figure 2).
- shall not disable power factor equipment while the wind plant is in operation.
- shall be able to provide sufficient dynamic voltage support in lieu of power system stabilizer and automatic voltage regulation at generator excitation system if required.

In order to meet these requirements, wind turbines/farms that use generators other than synchronous, synchronised generators need to use additional electrical converters such as reactors, capacitors, SCs, SVCs or STATCOMs which add additional expense, unwanted harmonics and unreliability to wind farm projects.

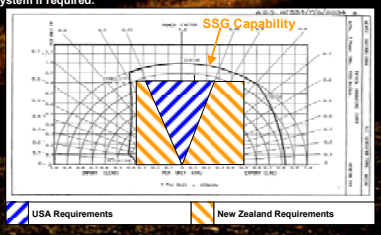

Figure 2 Power Factor Transmission Regulation Requirements Compared to the SSG Capability Curve

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Torque Limiting Gearbox (TLG) allows use of SSG

- The TLG enables the use of a SSG directly online by providing mechanical slip (VS) in above-rated winds thus keeping generator torque constant and within the continuous operating rating of the SSG
- The TLG is typically more compact, economical and robust as it significantly reduces fatigue loads
- The Windflow 500 has successfully deployed this technology combination since 2003 and is now in series production. The 500 kW generator can output 550 kVArs.

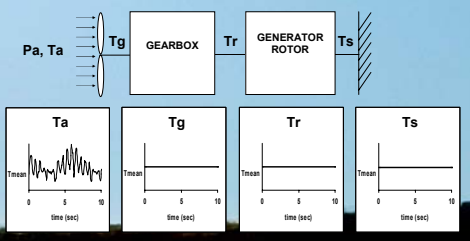

Figure 3 Torque Limiting Gearbox and SSG Combination

Synchronous Generation Benefits the Wind Industry

It should be easier for wind energy to contribute over 20% of US electricity demand if the industry switches to synchronous generation.

Meets Low Voltage Fault Ride-Through Grid Requirements

- SSG's can ride through faults which other WTG's may not be able to
- Loss of synchronism is an issue with prolonged faults (as it is for other WTG's)
- Reactive power control reduces risk of loss of synchronism by supporting local voltage
- If required, control of the TLG can allow "decoupling" of blades from rotor shaft to minimise chance of loss of synchronism

Meets Reactive Power Control Grid Requirements

- by being able to support the grid during voltage excursions by exporting/importing VAr's and remaining on-line. Typically these VAr requirements fall within the capability curve of a SSG (Figure 2, note x- and y-axes are to same scale)

TLG/SSG Combination Offers A Cost-Effective and Robust Wind Technology Solution