High Penetration of DER on a FERC Jurisdictional Distribution Circuit

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Abstract:

Princeton Municipal Light Department (PMLD) has proposed a 3-MW distributed wind project. The town is supplied by one of National Grid's 13.8-kV distribution circuits. It is a 12 mile long overhead line and serves about 2,000 residential customers including the entire town of Princeton, MA. The same feeder also serves a 5 MW 'winter only' spot load at the Mt. Wachusett ski area. Large snowmaking compressors and pumps have been the subject of prior flicker and voltage studies by the utility. The circuit already has high penetration of DER (distributed energy resource) with 7.2 MW of land-fill gas (LFG) generation interconnected. Beginning in 2007, National Grid undertook line re-conductoring to increase thermal ratings, additional relaying, and substation equipment to accommodate reverse flows from the LFG. This LFG project came under FERC jurisdiction (Schedule 23-SGIP Small Generator Interconnect Procedure) because the distribution line already served in a wholesale transaction with sales to the town of Princeton.

Flicker and power quality were of special concern, given the existence of flicker-producing loads at the ski resort. The wind turbines are 8.5 circuit miles from the substation on a radial line. Wind turbine power quality data in IEC Std. 61400-21 format was requested from the vendor, but these tests are expensive and complete results are not always available. Based on the vendor's test report, the PMLD wind turbines are not expected to produce continuous flicker problems from turbine shadowing, blade pitching, wind variability, etc. However, switching flicker data was not available for turbine start-up and shut-down. For many turbines, the switching flicker is more severe than continuous flicker. Similar sized turbine types with available flicker data showed they could produce switching flicker levels above the IEEE Std. 1453 planning limits. Power quality monitoring was required to verify whether a flicker problem actually exists for this installation.

The LFG is interconnected through a wye/delta transformer that provides a ground source and thereby limits temporary overvoltage (TOV) during backfeed conditions, but the wind turbines will not provide a ground source. To address these issues, National Grid required a 59N (GV3) trip function that is sensitive to voltage unbalance at the wind turbines. IEEE Std. 1547 only requires under/overvoltage and under/overfrequency trip functions, which are not adequate for this application.

With a feeder load rating of about 10.5 MW and a projected total DER of 10.2 MW interconnected, the penetration level will be nearly 100% at peak load. During light load, up to 9 MW may flow back into the transmission system. National Grid required real-time monitoring of the wind turbine output, using a remote terminal unit (RTU) integrated into the Energy Management System (EMS) for utility dispatch system operations. The same requirements were imposed on the LFG project. With a large amount of generation on this feeder, sudden changes in power output may cause the voltage to change by more than 5%. However, this can be mitigated by operating the generators at leading power factor, to absorb reactive power.

James G. Cleary (S 1985, M 1986) is Lead Senior Engineer at National Grid USA with 24 years of Distribution Planning and Engineering experience in Massachusetts. His experience spans project management and estimating, capacity planning, reliability, on-call operations, and complex customer interconnections. The past 5 years have been largely spent on distributed resource interconnection of wind, hydro, solar PV, flywheels, co-generation and landfill gas installations. He has a strong interest in power quality, voltage impacts/ flicker and dynamic var support for large DER installations. Jim is active in the IEEE Central Massachusetts Chapter, the IEEE Std. 1547.6 and .7 working groups, and the IEEE Power System Planning and Implementation Committee. He has a BSEE and MBA from Worcester Polytechnic Institute and is a Registered Professional Engineer in Massachusetts.