PROLONGING THE LIFE OF WIND FARM TRANSFORMERS

Prof. Shesha Jayaram

Transformers are a crucial — and expensive — part of wind farm infrastructure, boosting the low-voltage output from turbine generators to the higher voltage required by the grid. But too often, they fail prematurely. That's because standard transformers aren't designed to handle spikes in high-frequency energy that are common in wind farms, where vacuum circuit breakers and switching devices often create transient voltages. As a result, they can break down the transformer's insulation, putting it out of commission.

WISE researcher Dr. Shesha Jayaram and two of her grad students set out to analyze the problem. Mahdi Khanali began by developing and verifying a scaled model, since working with large power transformers is complex and time-consuming. He also developed a chemical method to detect the impact of partial discharges (PDs) — as directly measuring the PD activities is difficult electromagnetically in windfarm connected transformers.

Using this approach, he confirmed that exposing transformers to hundreds of hours of the distorted, high-frequency voltages produced in wind farms degrades the transformer's insulation far faster than grid-quality electricity.

Fellow student Anurag Devadiga then pinpointed the effects of pulse rise times, amplitudes and duty cycles that did the biggest damage. To assess the mechanical and electrical integrity of the transformers, he created digital simulations and used frequency response analysis, looking for the resonance frequencies that amplified the voltage spikes.

Both approaches revealed the most critically damaging transients had a duty cycle of 50 per cent and pulse rise times of less than 300 nanoseconds. Armed with these insights, engineers can design insulation to withstand high-frequency transients — creating long-lived transformers specifically optimized for wind farms.

***Researchers**: Shesha Jayaram, Mahdi Khanali and Anurag Devadiga*

***Partners**: Natural Sciences and Engineering Research Council of Canada*

Source: Devadiga, A., & Jayaram, S. (2022). Influence of pulse rise time and duty cycle on distribution of transients along the wind turbine step-up transformer windings. *Electric Power Systems Research*, 203, 107646.

Source: Khanali, M. (2017). Effects of Distorted Voltages on the Performance of Renewable Energy Plant Transformers [Doctoral Dissertation, University of Waterloo]. Waterloo's Institutional Repository. https://uwspace.uwaterloo.ca/handle/10012/12368

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