

## Scattering of Wind Turbines - Radar Wave Propagation Analysis in Wind Farms

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As the wind power industry thrives, more wind turbines are being installed across the country. A large group of wind turbines built next to each other forms a wind farm, which may cause potential EMI (Electromagnetic Interference) to nearby radio devices. Some studies have been performed to investigate this impact on radio applications, mostly on radar, because by far there have been many cases found to have severe impact on radar networks.

Modern wind turbines typically have rotor diameter of 80 m to 100 m, hub height at 100 m and tower base diameter at 4 to 5 m. The extremely large physical dimension of wind turbines will result high backscattered RCS (Radar Cross Section) on the orders of 10,000 m<sup>2</sup>, which may even saturate radar receivers if installed close up. Given the high RCS, wind turbines are generally visible to nearby radar as long as it falls in the LOS. The rotor blades rotate at speed approximately between 15 rpm to 20 rpm. Combined with the blade length, this rotation rate will result extremely high tip speed of more than 100 m/s. The continuous distribution of scatters along the blade results in continuous contamination of Doppler spectrum with possible aliasing effect. Furthermore, this wind turbine clutter effect is non-stationary as the statistics of the return signal varies from scan to scan. Therefore, conventional ground clutter filter has failed to mitigate this recently recognized type of clutter. The isolated clutter effect refers to clutter only detectable within the wind farm area, which has limited effect as long as the locations of the wind farms are known. However, the multi-path scattering mechanism may also result in the multi-path clutter effect, which may extend the clutter contaminated area far beyond the wind farm by creating spurious images of wind turbines. All these effects will be investigated in this study, with actual cases shown. The understanding of the scattering mechanisms of wind turbines may help properly site wind farms and search of effective mitigation solution in general.