PHYSICAL MATHEMATICS SEMINAR

The Spectrum of Wind Power Fluctuations

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ABSTRACT:

Conventional energy sources such as nuclear or coal generate energy at a constant rate. Renewables on the other hand fluctuate with the variability in the natural sources from which they derive energy. Such fluctuations are particularly acute for wind and solar photovoltaics. On one hand, such fluctuations threaten the stability of the grid, whereas on the other, matching the fluctuating power production with a variable consumer demand presents scheduling difficulties for grid operators. Understanding fluctuations in renewables is also important for the design of robust smart grid technologies for the future.

In this talk, I will chart out the non-equilibrium character of wind power fluctuations which depend upon the turbulent wind blowing past the wind turbines. Indeed, the spectrum of wind power fluctuations is widely known to reflect the Kolmogorov spectrum of turbulence; both vary with frequency f as $f^{-5/3}$. Yet it has not been possible to derive this spectrum from the turbine power equation which relates the generated power P to the wind speed v. I will explain the wind power fluctuation spectrum and show it arises from the violation of an underlying assumption in Kolmgorov theory of 1941 with crucial implications for wind power. In particular, every individual turbine feels the influence of the largest length scales of atmospheric turbulence. As a result, turbines within and between wind farms become coupled with each other at low turbulent frequencies over large distances. Consequently, when geographically distributed wind farms feed their power to the electrical grid, the fluctuations remain correlated and smooth out until they reach a theoretical bound that can be deduced from Kolmogorov theory. I will close my talk with a summary of engineering and policy implications of these results.

TUESDAY, DECEMBER 8, 2015
2:30 PM
Building E18, Room 466A

Reception following in Building E17, Room 401A
(Math Dept. Common Room)

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