Seminar Series

INDUSTRIAL ENGINEERING

Optimal Replacement Policies for Wind Energy Systems

Thursday, June 27th, 2013

11:00 am – 12:00 pm – Imhoff Study Center – Bell 4008

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Motivated by rising energy prices, global climate change, escalating demand for electricity and global energy supply uncertainties, the U.S. government has established an ambitious goal of generating 80% of its electricity supply from clean, renewable sources by 2035. Wind energy is poised to play a prominent role in achieving this goal as it is estimated that 20% of the total domestic electricity supply can be reliably generated by land-based and offshore wind turbines by 2030. However, the cost of producing wind energy remains a significant barrier with operating and maintenance costs contributing as much as 20 to 47.5% of the total cost of energy. Given the urgent need for clean, renewable energy sources, and the widespread appeal of wind energy as a viable alternative, it is imperative to develop effective techniques to reduce the total cost of wind energy in general, and the operating and maintenance costs in particular.

In this talk, I will present a framework within which real-time, condition-based data can be exploited to optimally time the replacement of critical wind turbine components. First, we develop hybrid analytical-statistical tools to estimate the current health of the component and approximate the expected time at which it will fail by observing a surrogate signal of degradation. The signal is assumed to evolve as a switching diffusion process, and its parameters are estimated via a novel Markov chain Monte Carlo procedure. Next, I will address the problem of optimally replacing a critical component that resides in a partially-observable environment. Two models are formulated using a partially-observed Markov decision process (POMDP) framework. The first model ignores the cost of turbine downtime, while the second includes this cost explicitly. For both models, it is shown that a threshold replacement policy is optimal with respect to the cumulative level of component degradation. Moreover, these thresholds depend on the decision maker's assessment of the environmental conditions. Time permitting, I will present a third model that considers cases in which the environment is partially observed and degradation measurements are uncertain. It will be shown that a threshold policy is also optimal for this challenging scenario. Several numerical examples will illustrate the main results and the value of including environmental observations in the wind energy setting.

Jeffrey P. Kharoufeh is an Associate Professor in the Department of Industrial Engineering at the University of Pittsburgh. His methodological area of expertise is applied probability, and his application interests include reliability theory, maintenance optimization and computer and communications systems. His research has been funded by the National Science Foundation, the Air Force Office of Scientific Research, the National Reconnaissance Office, the Department of Veterans Affairs and other federal agencies. Dr. Kharoufeh earned a Ph.D. in Industrial Engineering and Operations Research at the Pennsylvania State University where he was an inaugural Weiss Graduate Fellow. He currently serves as Area Editor of *Operations Research Letters*, Area Editor of Stochastic Models for the *Wiley Encyclopedia of Operations Research and Management Science* and Associate Editor of *Operations Research*. He is a Senior Member of IIE and a professional member of the INFORMS Applied Probability Society.