A Close Look into Wind Turbines
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Introduction
Key Question: To what extent is wind technology a viable power source based on its affordability, reliability, and compatibility with our current power grid?

A Look Inside
Faraday’s Law: $\varepsilon = \frac{d\Phi}{dt}$

- Wind turbines act as generators that take advantage of Faraday’s Law
- The wind causes the turbine blades to rotate, which in turn causes the crank to turn

Cost
Levelized Cost of Energy (LCOE): Total cost to generate 1 MWh of energy ($)  

Capacity
Capacity Value: how much power a given technology generates (MW)

Part I: Analyzing Global Trends
- ~500% increase in wind power global capacity between 2007 and 2017
- Peak in annual new increase in 2015
- Wind energy has been shown to generate between 12 and 14% of all US electricity (EIA 2019)

Part II: The Fluid-Mechanical Wind Power Equation
$P_{out} = \frac{1}{2} \rho A v^3 C_P$

- Large variability in wind speed
- Since $P \sim v^3$, there is large variability in power output
- $C_{P, max} = 0.59, C_{P, avg} = 0.15$

Part III: Experimental Test of Turbine with Test Load

Load lift at constant velocity
$P = \frac{d}{dt}(mg h + \frac{1}{2} mv^2)$

Eventually
$P = mg \frac{\Delta h}{\Delta t}$

$\Delta t = \frac{g \Delta h}{P - m}$

Connection
Loss of Load Expectation (LOLE): measurement of predicted power loss (h/4392 h)
Capacity Factor (CF): measurement of the amount of power sent from one site to another as a fraction of the total possible power distribution (%)

Key Insight: By isolating power outages and congestion areas, grid reliability can be improved

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Wind technology is projected to remain market-competitive (Hazard 2018)

Agarwal and Crossley 2019.