IPRO 344 Technical & Market Integration of Wind Energy

ILLINOIS INSTITUTE OF TECHNOLOGY

Transforming Lives. Inventing the Future.

Problems

- Conventional electricity generation causes air emissions.
- Fossil fuel-fired power plants are responsible for 67 % of the nation's sulfur dioxide emissions, 23 % of nitrogen oxide emissions, and 40 % of man-made carbon dioxide emissions.
- Electricity generation using wind energy offers an alternative with zero emissions.

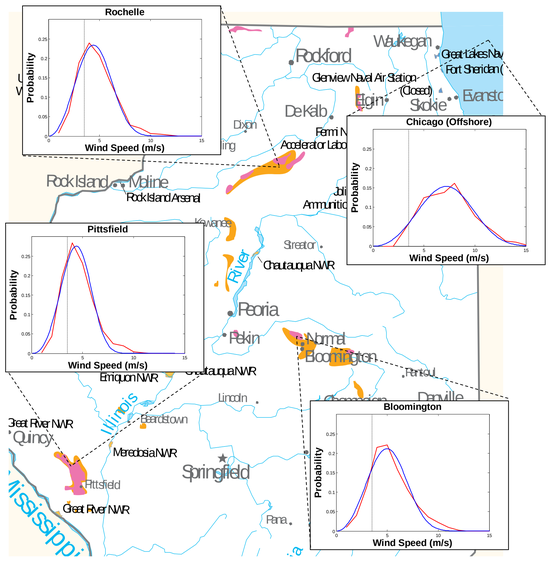
Objectives

- Develop the mechanical and electrical design of a wind turbine to be installed in Illinois
- Evaluate impacts in the environment and in the ComEd power system
- Assess the profitability of the wind plants at each location

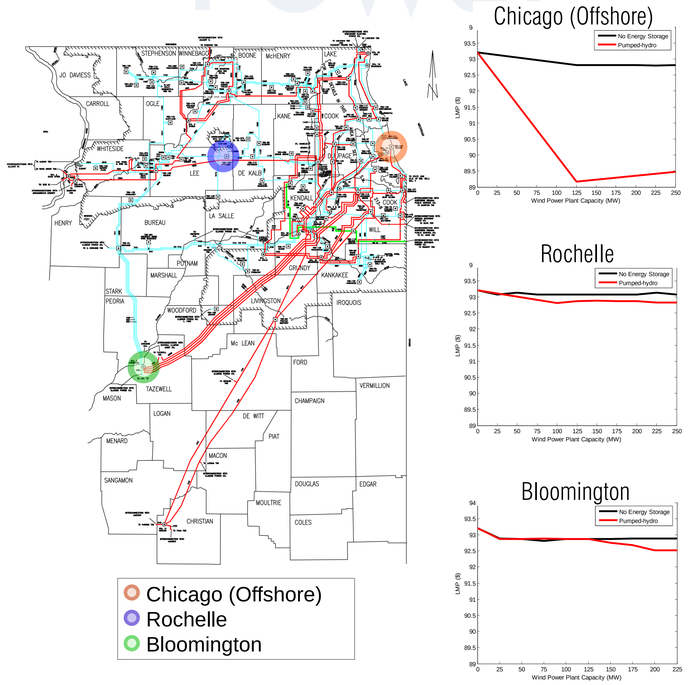
Methodology

- Design Team: Responsible for coming up with the most cost-effective design
- Environmental Team: Explore the effects of wind turbine in the Illinois environment.
- Market Team: Analyze the project feasibility and other market integration issues.

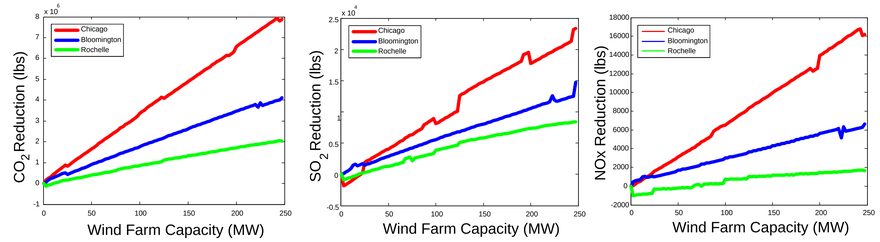
Wind Speeds



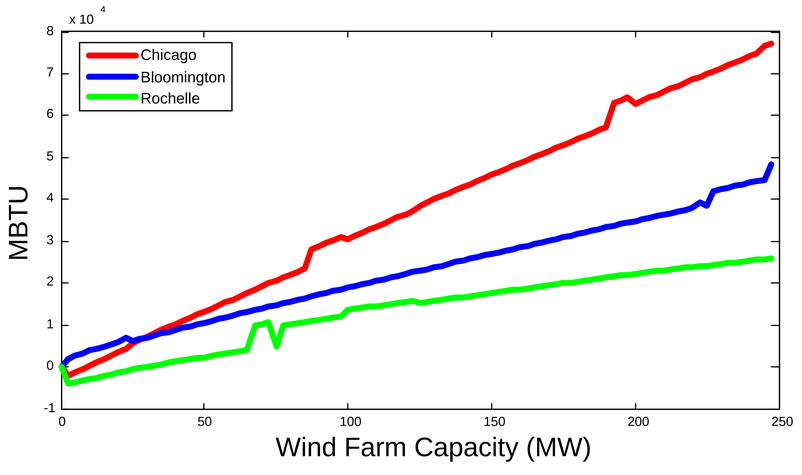
Power System



Emissions Reduction

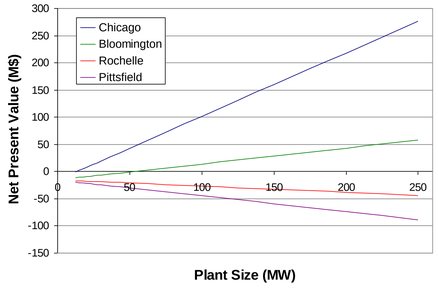


Fuel Reduction

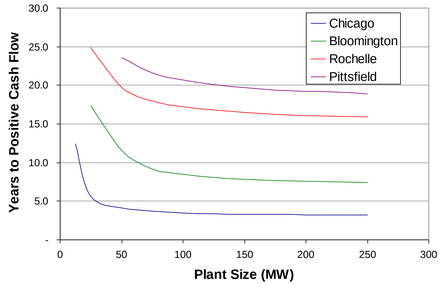


Profitability

Net Present Value



Year-to-Positive Cash Flow



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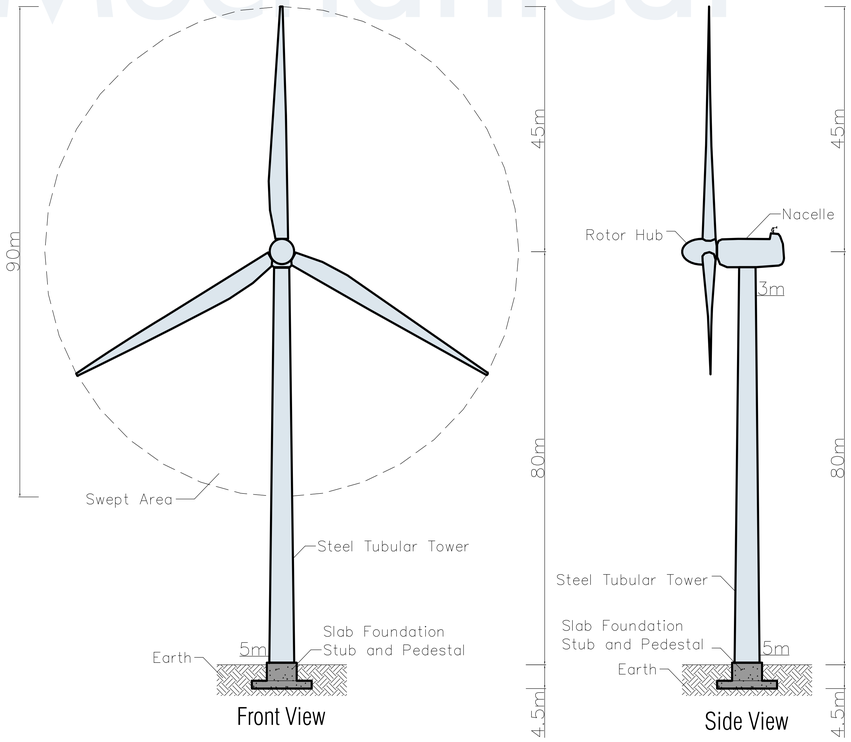
Mechanical Design



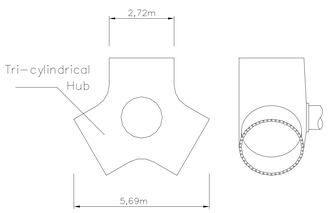
Operating Data:

- Capacity: 2.5 MW
- Cut-in speed: 3.5 m/s
- Rated speed: 12 m/s

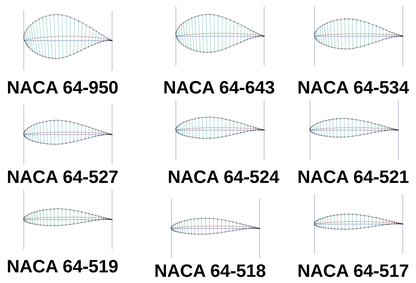
Mechanical Data:

- Cut-out speed: 25 m/s
- Number of blades: 3
- Rotor diameter: 90 m
- Swept area: 6,082 m2
- Hub height: 80m
- Tower: Tubular steel

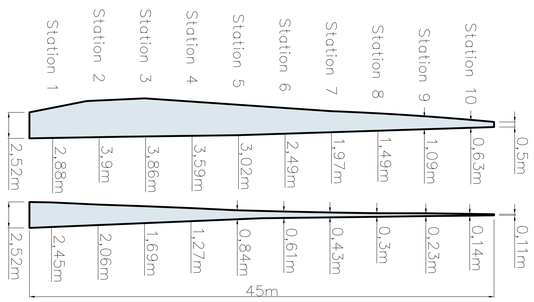
Hub



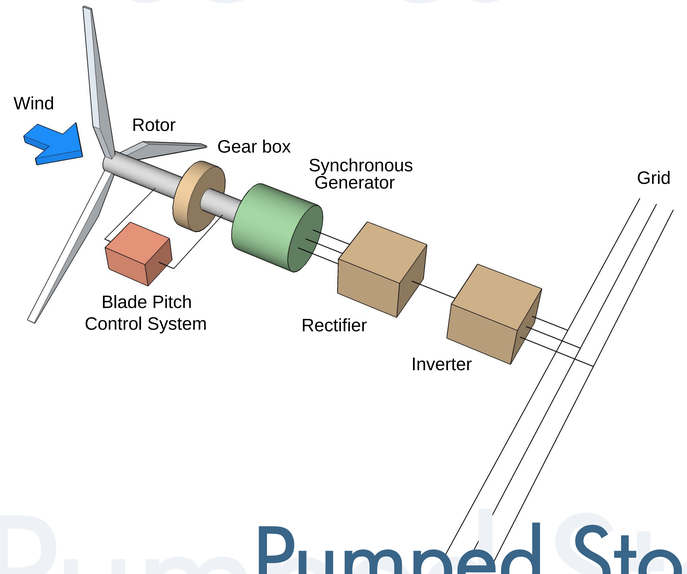
Blade Cross Sections



Blade Dimensions



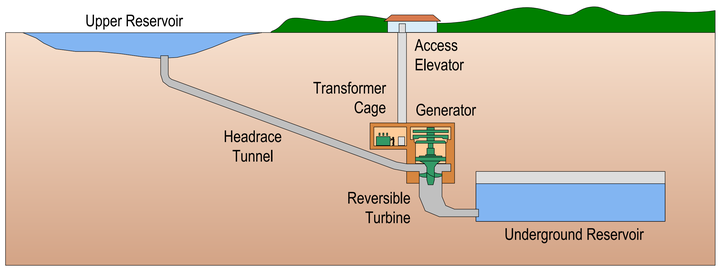
Electrical Design



Electrical Data:

- Active blade pitch control
- Variable speed synchronous generator
- Rated power: 2.5 MW
- Interconnection type: Rectifier/Inverter

Pumped Storage Design



- Wind energy can be stored with pumped storage and used at peaking hours
- Underground storage applies at Illinois.

Conclusions

- Each blade has an independent pitch control to maximize efficiency or maintain rotational speed
- Rotor is driven by wind direction sensor (yaw system) located at the top rear of the nacelle
- The rotor blades, nacelle and gearbox are designed to reduce noise
- Chicago location showed the best results. Although, wind turbines placed offshore have a very high O&M cost.
- Wind Energy can directly displace emissions in Illinois, and therefore solve the problem of air polution.