Engineering Wind Parks

Andrew Kusiak
Intelligent Systems Laboratory
2139 Seamans Center
The University of Iowa
Iowa City, Iowa 52242 - 1527
andrew-kusiak@uiowa.edu
Tel: 319-335-5934 Fax: 319-335-5669
http://www.icaen.uiowa.edu/~ankusiak

Outline

• Introduction and definitions
• Taxonomy of engineering problems
• Wind farm design
• Wind farm operations
• Role of data
• Emerging tools

Why Optimize Performance?

1% (4MW) power loss at a 400 MW wind park translates into $1M revenue loss
Gerrad Hassan Corporation 2007

Note
1MW of energy powers 225-300 households

Definition

Capacity factor

Capacity factor = Ratio of the actual amount (MW) of power produced over a year the power that would have been produced if turbine operated at maximum output 100% during the same time

Conventional power plant: 40% to 80% capacity factor
Wind turbine: 25% to 42%, though turbines typically operate 65% to 98% of the time

Note
✓ A 60-80% capacity factor possible with a large rotor and a small generator
✓ Turbine are designed to maximize return on investments from electricity production
Availability Factor

Availability factor (availability): The percentage of time that a turbine (park) is ready to generate energy (i.e., not out of service for maintenance or repairs)

✓ Availability reflects the reliability of a wind turbine (or a wind park)
✓ Modern wind turbines have an availability of more than 98% - better than most of classical power plants

Park Design and Operations

From Wind Farm Design to Wind Farm Operation

Engineering Research and Practice Problems

✓ Design
  • Wind farm site selection
  • Turbine selection
  • Wind farm layout optimization

✓ Operations
  • Power output management
  • Power output prediction
  • Condition monitoring and maintenance
  • Fault detection and avoidance
  • Performance optimization

We Want to Be Here

Living Industrial Laboratory

Data

Virtual Laboratory
What is Common?

Industrial Plant

Wind Farm

Process A

Automation

Process B

Technical Challenge (1)

Input

- Wind parameters (internal, external)
- Air parameters
- ...

Model

- Turbine
- Farm

Output

- Power at different time scales (Accurate prediction)

Given: Turbine parameters

Technical Challenge (2)

Input

- Wind parameters
- Weather parameters
- SCADA parameters

Model

Objective: • Max power

Output

- Biases of turbine control parameters

Technical Challenge (3)

Input

- SCADA data
- Wind data
- Weather data

Model

Output

- Maintenance schedule
- Minimum maintenance cost
- Max availability
- Failure prevention
Technical Challenge (4)

**Input**
- Wind data
- Weather data
- Oil temperature
- Vibration
- Blade behavior

**Model**
- Turbine parameters

**Output**
- Detection of emerging faults (e.g., gearbox)
- Prevention of faults