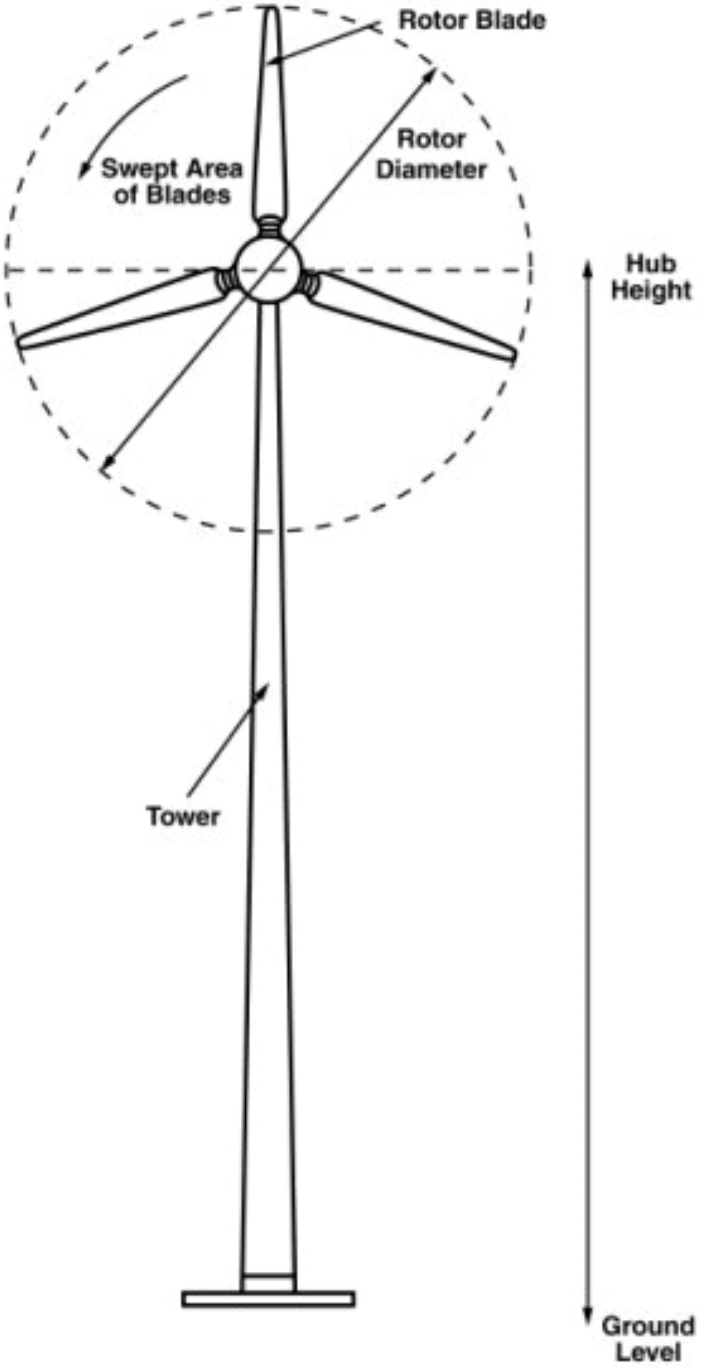
Spring – 2009
58:195 – Contemporary Topics: Fundamentals of Wind Turbines



Spring – 2009
58:195 – Contemporary Topics: Fundamentals of Wind Turbines

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Time: 4:30 – 5:45 pm, Monday and Wednesday

Place: TBD

Text: Wind Energy Handbook (John Wiley and Sons)
Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi

Course Description:

The goal of this course is to learn how to apply fundamental principles of thermodynamics, fluid mechanics and mechanical systems to wind turbine engineering. Fundamentals of horizontal-axis wind turbines will be emphasized: wind energy conversion to useful work; wind turbine aerodynamics; performance; design of wind turbine components. An overview of wind resource and historical development of wind turbines, and introduction of wind turbine installation and wind farm operation will also be covered. Term project is an integral part of this course: students will form 3-member teams and conduct a term project that applies fundamental principles to wind turbines. The term project could be a computational or design/demonstration project of nature, and of the team's choice.

Pre-requisite: 57:020, 58:040, 58:052; or consent of instructor

Course Outline

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1 - Introduction
- 1.1 Historical Development
- 1.2 Modern Wind Turbines

2 - The Wind Resource
- 2.1 The Nature of the Wind
- 2.2 Geographical Variation in the Wind Resource
- 2.3 Long-term Wind-speed Variations
- 2.4 Annual and Seasonal Variations
- 2.5 Synoptic and Diurnal Variations
- 2.6 Turbulence
- 2.7 Gust Wind Speeds
- 2.8 Extreme Wind Speeds
- 2.9 Wind-speed Predictions and Forecasting
- 2.10 Turbulence in Wakes and Wind Farms
- 2.11 Turbulence in Complex Terrain

3 - Aerodynamics of Horizontal-axis Wind Turbines

3.1 Introduction
3.2 The Actuator Disc Concept
3.3 Rotor Disc Theory
3.4 Vortex Cylinder Model of the Actuator Disc
3.5 Rotor Blade Theory
3.6 Breakdown of the Momentum Theory
3.7 Blade Geometry
3.8 The Effects of a Discrete Number of Blades
3.9 Calculated Results for an Actual Turbine

4 - Wind-turbine Performance

4.1 The Performance Curves
4.2 Constant Rotational Speed Operation
4.3 Comparison of Measured with Theoretical Performance
4.4 Variable-speed Operation
4.5 Estimation of Energy Capture
4.6 Wind-turbine Field Testing
4.7 Wind-turbine Performance Measurement
4.8 Analysis of Test Data
4.9 Turbulence Effects
4.10 Aerodynamic Performance Assessment

6 - Conceptual Design of Horizontal Axis Wind Turbines

6.1 Introduction
6.2 Rotor Diameter
6.3 Machine Rating
6.4 Rotational Speed
6.5 Number of Blades
6.6 Teetering
6.7 Power Control
6.8 Braking Systems
6.9 Fixed-space, Two-speed or Variable-speed Operation
6.10 Type of Generator
6.11 Drive-train Mounting Arrangement Options
6.12 Drive-train Compliance
6.13 Rotor Position with Respect to Tower
6.14 Tower Stiffness

7 - Component Design

7.1 Blades
7.2 Pitch Bearings
7.3 Rotor Hub
7.4 Gearbox
7.5 Generator
7.6 Mechanical Brake
7.7 Nacelle Bedplate
7.8 Yaw Drive
7.9 Tower
7.10 Foundations

9 - Wind-turbine Installations and Wind Farms

- 9.1 Project Development
- 9.2 Visual and Landscape Assessment
- 9.3 Noise
- 9.4 Electromagnetic Interference
- 9.5 Ecological Assessment
- 9.6 Finance