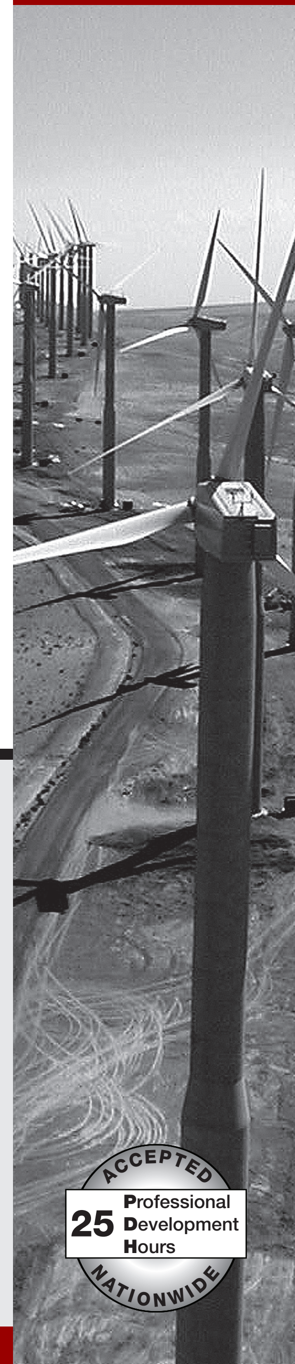
THE UNIVERSITY of WISCONSIN MADISON

College of Engineering ■ Department of Engineering Professional Development



Tour a newly commissioned wind farm.

Fundamentals of Wind Power Plant Design

- Intensive, practical course
- Wind energy and power generation basics
- Wind turbine components and standards
- Machinery review and comparisons
- Collector system and SCADA
- Reactive compensation
- Interconnection with the grid

ACCEPTED 25 Professional Development Hours NATIONWIDE

March 10–13, 2009
Madison, Wisconsin

For persons working in the development, planning, design, construction or maintenance of wind energy...

Fundamentals of Wind Power Plant Design

March 10–13, 2009
Madison, Wisconsin

Comprehensive information on

- ☑ *Wind energy principles and power engineering basics*
- ☑ *Wind generation machinery and control*
- ☑ *Balance of plant*

Tour a newly commissioned wind farm.

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THE UNIVERSITY of WISCONSIN MADISON
Department of Engineering Professional Development
432 North Lake Street Madison, Wisconsin 53706

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Fundamentals of Wind Power Plant Design

March 10–13, 2009 in Madison, Wisconsin

Results-oriented Instruction

This introductory course in design fundamentals provides you an excellent opportunity to learn about wind power plant design from engineers and educators who have real-life experience in the wind energy and electrical delivery fields. During four days of comprehensive coursework, you will learn about:

- Where wind energy comes from and how a site is assessed for potential
- Basics of electric power generation and control
- How wind turbines work, what their components are, and what standards apply
- How the wind energy conversion machines work
- Advantages/drawbacks of the various machine topologies
- How wind turbine control systems work
- What the collector system is comprised of and how the wind farm is monitored and controlled
- What is significant about reactive compensation and interconnection

Why You Should Attend

There have been, and continue to be, advances in wind turbine technology and wind power plant capabilities. Sites that may have, only 10 years ago, been overlooked for energy capture are now being developed. Meanwhile, the standards that wind power plants must meet in order to connect to the electric utility grid are evolving. Additionally, the turbine topologies that are being fielded are multiplying in terms of mechanical energy conversion and electrical interface. Attend this course to grasp the fundamentals of wind power and gain insights into considerations pertinent to wind power plant design.

Who Should Attend

- Wind farm developers
- Electric utility design engineers
- Electric utility planning engineers
- Power system dispatchers
- Consulting engineers
- Project managers
- Managers of design departments
- Engineering technicians

Wind Farm Tour!

To enhance your learning there will be a tour of a recently commissioned wind farm in the Fond du Lac, WI area. This tour is included as a part of the course and will include dinner following the site visit. This will be an excellent opportunity to see equipment in operation.

Your Faculty

Larry Jacobs is a technical marketing specialist with NRG Systems of Hinesburg, Vermont, a global manufacturer of wind measurement systems. He is responsible for sales and technical support of turbine control sensors. He is a member of the American and Canadian Wind Energy Associations. Larry holds a BSEE from the University of Vermont and a BA from St. Michael's College.

Ian Hiskens PhD is a professor of electrical engineering at the University of Michigan–Ann Arbor. Prior to academia, he was an EMS security applications engineer and transmission system planning engineer with Queensland Electricity Supply in Australia. Ian received the PhD degree from the University of Newcastle, Australia. He is a Fellow of the IEEE, a Fellow of Engineers Australia, and a Chartered Professional Engineer in Australia

Steven Saylors PE is the chief electrical engineer at Vestas Americas located in Portland, Oregon, a division of Vestas Wind Systems. Steve's career has included design, construction and operation of wind farms, nuclear and coal-fired power plants, and T&D projects. Steve received his BSEE from California State University–Sacramento.

Mitch Bradt PE is an electrical engineer at The University of Wisconsin–Madison responsible for development and instruction of courses in the topics of wind power, electrical distribution, and rotating machinery. He has worked for a manufacturer of utility reactive compensation systems and has designed substations as a consulting engineer.

Theodore Nicolai is a project manager with the Power Systems Services Division of S&C Electric in Chicago, Illinois. His work includes turnkey installations of wind farm collector systems, electrical substations, and power quality products. Ted is a member of the IEEE Power Engineering Society and holds a BSEE from the University of Illinois–Chicago.

Jim Niemira PE is a senior engineer and project manager with the Power Systems Services Division of S&C Electric. He is extensively involved in automation, control, substation design, and protection design and project management. Jim is an active senior member in the IEEE Power System Relay Committee and the Power Engineering Society. He holds a BSEE from the University of Missouri–Rolla and an MS Engineering in Electric Power from Rensselaer Polytechnic Institute.

Ernst Camm is a principal engineer at S&C Electric. His current responsibilities include load flow and voltage stability analysis, wind plant modeling and interconnect studies, transient and power quality analyses, and application of large-scale power quality equipment solutions. He is the current secretary of the IEEE-PES Task Force on Dynamic Performance of Wind Power Generation. Ernst holds a BSEE from the University of Cape Town, South Africa and an MSEE from The Ohio State University.

Continuing Education Credit

This course provides 2.5 Continuing Education Units (CEU) and 25 Professional Development Hours (PDH).

Fundamentals of Wind Power Plant Design

March 10–13, 2009 in Madison, Wisconsin

Course Topics

Energy in the Wind

- Wind flow and the boundary layer
- Development of power equation ($P_{wind} = \rho \bullet A \bullet V^3$)
- Wind power classes
- Wind resource mapping
- Effect of terrain and vegetation on effective wind
- Wind shadowing
- Wind resource versus altitude
- Diurnal/seasonal pattern of wind

Wind Site Assessment

- Site issues
- Standards
- Uncertainty
- Site specific wind assessment
- Parameters
- Data collection and formats
- Analysis
- Reports and graphs, including the wind rose

Electric Power Generation and Control Fundamentals

- Power system fundamentals
- Power flow analysis example
- Real and reactive power
- Power system operation and control
- Power system protection

Wind Turbine Basics

- Lift and drag: Aerodynamic forces
- Rotational motion and linear wind—The effective wind vector
- Angle of attack α and blade pitch β
- Betz's Theory
- The power coefficient—Cp
- Effects of wake rotation and drag
- Wind speed versus blade speed—tip speed ratio λ
- Torque production
- Fixed speed or variable speed concept
- Power control: Stall regulated or pitch control
- Power regulation Cp = f(λ, β)

Wind Turbine Components

- Blades
- Hub and blade pitch mechanics
- Turbine shaft and gearbox
- Generator configurations
- Tower and foundation
- Auxiliaries

Wind Turbine Standards and Certification

- Wind classifications
- IEC 61400 and IEEE
- Design standards—Germanischer Lloyd
- Lightning standards
- Standards for safety UL/CSA

Synchronous Generators—A Review

- Construction of a synchronous machine: Rotor and stator
- Generation of the electromotive force
- Power output: The power angle δ
- Reactive power control: Excitation of rotor field
- The P-Q capability curve

Induction Generators

- Construction of an induction machine: Rotor and stator
- Steady-state equivalent circuit
- Generation of real power—Concept of slip
- Reactive power consumed
- Introducing limited speed control with variable rotor resistance

Doubly-Fed Induction Generator

- Inverter construction and topology
- Connection of inverters to stator and rotor circuits
- Power control schemes of each inverter
- Real and reactive power control on machine
- Variable speed

Wind Turbine Control Systems

- Control objectives
- Control strategies
- Rotor speed control
- Optimizing tip speed ratio λ for energy capture
- Control of magnetizing current in generator with power electronics
- Turbine SCADA and power plant controllers

The Collector System

- Collector system overview
- Collector system grounding
- Collector system layout
- Underground feeder circuits
- Impact of thermal resistivity (Rho) on circuit configuration
- Cable installation
- Overhead feeder circuits
- Collector system substation—Main components
- Commissioning the collector system

Monitoring, Control, and Automation Solutions

- Wind farm SCADA components and functions
- Interfacing wind power plant and substation SCADA
- Effective data acquisition and management

Reactive Compensation

- Wound rotor synchronous machines (D-Curve)
- Capacitor banks—Centralized or distributed
- Inverters in turbines
- Flexible AC Transmission Systems (FACTS) device

Interconnection of Wind Power Plants with Electric Grid

- Grid codes
- Interconnection agreements and studies
- Voltage regulation—Reactive power control
- Low-voltage ride through
- Flicker/power quality
- Harmonics-IEEE 519
- Post-fault recovery—Transient stability of grid
- Turbine modeling

Daily Schedule

Registration will be at 8:00 a.m. on the first day of the course at The Pyle Center, 702 Langdon Street on the University of Wisconsin–Madison campus. Class will begin at 8:30 a.m. on all four days of the course and continue until 5:00 p.m. on the first three days of the course, with final adjournment at 3:30 p.m. on the fourth day of the course. The daily schedule will include refreshments prior to the start of the course, morning and afternoon refreshment breaks, and lunch served at noon.

Note for Wind Farm Tour: We will ride a bus from Madison to the Fond du Lac, Wisconsin area during the afternoon of March 11 or 12 (TBD). The tour will occur in the late afternoon, so dinner that evening will be held near the wind farm site. We expect to arrive back in Madison around 9:00 p.m.

Past Participants Say...

"Great course. I would recommend this course to anyone interested in learning more about wind farms."
Bruce Cram, Project Manager, Hooper Corporation, Madison, WI

"Simply excellent. Packed with a wealth of information that is very applicable. Exceedingly helpful and practical."
Richard Marsan, Director-Environmental Project Development, Duke Energy, Cincinnati, OH

"With hardly any time in the wind industry I have learned a ton! Great information and pretty well organized. I am looking forward to getting back to the office and applying this new information!"
Amanda Wrangler, Electrical Engineer, Basin Electric Power Cooperative, Bismarck, ND

Enroll online today! http://epd.engr.wisc.edu/webK494

Related Courses

Underground Electrical Distribution Systems
February 24–26, 2009, Austin, TX
Course #K284

Principles of Substation Design and Construction
April 1–3, 2009, Las Vegas, NV
Course #K627

Fundamentals of Substation Equipment and Control Systems
April 6–8, 2009, Las Vegas, NV
Course #K626

National Electrical Code
April 14–16, 2009, Madison, WI
Course #K167

Electrical Systems Design for the Non-Electrical Engineer
April 27–May 1, 2009, Madison, WI
Course #K510

Permanent Magnet Machines and Drives: Principles, Design and Applications
June 2–4, 2009, Madison, WI
Course #K628

National Electrical Safety Code IEEE C2-2007
September 15–17, 2009, Madison, WI
Course #K336

Understanding Power Cable Characteristics and Applications
October 19–22, 2009, Madison, WI
Course #K469

For details, check our Web site at http://epd.engr.wisc.edu/catalogs/electrical.lasso

Four Easy Ways to Enroll

Need to know more?

Call toll free **800-462-0876** and ask for

Program Director:
Mitch Bradt, P.E.
bradt@wisc.edu
(608) 263-1085

Program Associate:
Diane Lange
lange@epd.engr.wisc.edu
(608) 263-3370

Or e-mail **custserv@epd.engr.wisc.edu**

General Information

Fee Covers Notebook, wind farm tour and dinner that evening, break refreshments, lunches, certificate, continuing education credits (CEU/PDH), and rosters.

Cancellation If you cannot attend, please notify us by March 3, and we will refund your fee. Cancellations received after this date and no-shows are subject to the full course fee. You may enroll a substitute at any time before the course starts.

Location The Pyle Center, 702 Langdon Street, Madison, Wisconsin. If you must be contacted during the course, phone messages may be left for you at the Pyle Center's front desk 608-262-1122.

Accommodations We have reserved a block of sleeping rooms (amenities include parking and Madison Taxi's silver cab from the airport) for course participants at the Campus Inn, 601 Langdon Street, Madison, WI. To reserve a room, call 800-589-6285 or 608-257-4391 and indicate that you will be attending this course under group code 77254. Room requests made later than February 16 will be subject to availability.

Phone:
800-462-0876 or
608-262-1299 (TDD 265-2370)

Mail to:
Engineering Registration, The Pyle Center
702 Langdon Street, Dept. 108
Madison, Wisconsin 53706

Internet:
http://epd.engr.wisc.edu/webK494

Fax:
800-442-4214 or 608-265-3448

Course Information

Limited Enrollment

❑ Please enroll me in **Fundamentals of Wind Power Plant Design**
Course #K494 March 10–13, 2009 in Madison, WI **Fee: $1895**
Team Discount: $1695 each when three or more enroll from the same organization.

❑ I cannot attend at this time. Please send me brochures on future courses.

Personal Information (Please print clearly.)

Name ____________________

Title ____________________

Company ____________________

Address ____________________

City/State/Zip ____________________

Phone (______) ____________________ Fax (______) ____________________

E-mail ____________________

Additional Enrollees

Name ____________________

Title ____________________

E-mail ____________________

Name ____________________

Title ____________________

E-mail ____________________

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