SYLLABUS

WIND POWER ENGINEERING

Course Description:

The course is worth 4 ECTS (144 hours), and is intended for the students majoring in wind power engineering. It will introduce them to the theory and practice of wind power generation and storage. Students will get acquainted with all the known types and classes of wind turbines, with operation principles of wind farms. They will learn basic mathematical and physical concepts of wind power, methodologies of wind turbine design, ways to optimize wind turbine parameters, site assessment techniques and methodologies of assessing cost-effectiveness of a wind-turbine project.

Learning Objectives:

Upon completion of this course, students will be able to:

- Design energy supply systems based on wind power;
- Design, operate and maintain wind turbines under certain meteorological, technical or budget restrictions;
- Make calculations for optimization of reliability or performance of wind power turbines;
- Make feasibility analysis for a wind power station;
- Offer solutions for optimization of decentralized energy supply systems with distributed generation;
- Identify the best location for a wind turbine installation; make site assessment.

Contents of the modules

#	Name of the Module
1	Introduction
2	Wind farm
3	Wind power standards
4	Wind turbine technologies
5	Methodologies of wind turbines components development
6	Wind turbine cost-efficiency
7	Safety in wind power

Contents of lectures

#	Titles of the Modules	Contents of the modules

1	Introduction	Environmental engineering, global warming and fossil fuel depletion. History and statistics of wind power. Capacity of wind power in the world (annual, cumulative, world production). Experience in wind energy development (Europe, China, USA, Russia - offshore, onshore wind farms).
2	Wind farm sites	Global energy conversion. The evaluation of sites for wind power plants on land and at sea.
3	Wind power standards	Basic terminology. IEC international standards. National and local standards (options).
4	Wind turbine technology	The main applications for the wind energy, the main parameters. Classification of wind power plants (wind turbines). Centralized and decentralized (autonomous) wind power. Advantages and disadvantages of large and small wind turbines, grid-connected and autonomous wind turbines. Power factor and speed.
5	Methodologies of development of wind turbine components	Calculations and development of the blade profile, testing and optimization Development of wind turbine rotor, strength calculations and optimization. Home-made wind turbines. Development of the transmission, Lighting system based on hybrids, including solar module and vertical-axis wind turbine. Electrical connections and circuits (for large and small wind turbines). Basic concepts of design of electrical circuits of wind power plants. Development of tower / mast and foundation; calculation, optimization. Offshore wind turbine foundations. Installation of large and small wind power plants. Development of perspective multi-tiered small vertical axial wind power plants (option). Hybrid power complexes and systems (option).
6	Wind turbine feasibility	Energy-efficiency and cost-efficiency. Wind farm. Wind farm planning. Wind energy budgeting -net present value (NPV) (options), aligned energy cost (LCoE) (options).
7	Safety in wind power	Wind farms Weaknesses of the wind industry. Common and individual equipment for installation; maintenance, repair. Rescue and evacuation.

Contents of the workshops

#	Titles of the modules	Contents of the modules
1	Introduction	Problem solving: Calculate when we have run out of fossil fuels (oil, natural gas, coal, uranium) - To, Tg, Tc, Tu. Problem solving: Calculate when the greenhouse effect causes global problems, given the mass of CO2 in atmosphere, its natural annual absorption and anthropogenic contribution. Calculate what the volcanoes contribution to the greenhouse effect is, if compared with anthropogenic emissions.

		Problem solving: Calculate the global anthropogenic power contribution Pa into the Global Energy Balance and its share Pa%. Problem solving: Calculate if the wind Industry is likely to meet the electricity needs of the mankind; do we have enough space; is wind energy cost and time effective way of energy generation
2	Wind farm site selection	Problem solving: Determine air density ρ at the Reference Temperature and Pressure (RTP). Problem solving: Calculate the air density ρ at different levels of height H. Problem solving: Calculate the daily, monthly and annual wind speed. Problem solving: Calculation of the wind rose using recurrent periods of still and wind weather; and tendencies in the directions of wind. Problem solving: Calculate the wind speed uH measured at the level of H height on the basis of wind speed uh measured at the level of h height. Problem solving: Wind speed probability; integral and differential repeatability. Problem solving: Given the measurement data, determine mean wind speed um, the most probable wind speed up, and compare them. Problem solving: Build the Rayleigh Distribution using known annual mean wind speed um. How many hours per year T the wind speed (probably) exceeds 1.5·um? Problem solving: How many hours per year T does the wind speed exceed u-given? Find time Ts of useful output production. Probability of wind umin < P < umax . Problem solving: Calculate wind speeds ui for Wind Classes. Wind Farm to be built on plateau at 692 m above sea level. Estimate WPDR (Rayleigh distribution, K=1.91) using (3). What wind class does this represent? Make feasibility analysis for the calculated wind class.
3	Wind power standards	Discussion: Wind Power Standards (IEC, ISO, AS, ANSI, BS, GOST)
4	Wind turbine technology	Problem solving: Determine specific power of Wind Turbine Pw as compared with specific power of air wind flow Pa and calculate the maximum efficiency. Problem solving: Determine specific Power density Pd for nominal wind speed u-N and cut off wind speed u-cutoff. Problem solving: Since the linear velocity of blades tips may exceed the wind speed (up to 9 times), it may exceed sonic speed as well. What is the wind speed if the speed of Wind Turbine blade tip uB exceeds sonic speed uS? What effect may occur when uB > uS? Problem solving: Given NACA/CAHI, draw the airfoil profile. Problem solving: Determine Reynolds number R for the given chord b moving at v. Problem solving: Determine length L and airfoil of bladesB for the given requirements and conditions. Determine rotor power loading PL. Problem solving: Calculate alternator parameters. Build the diagrams of electric losses, output voltage, output power, and energy-efficiency.
5	Wind turbine feasibility	Problem solving: Calculate the power of the wind farm P equivalent to the cost C of air electric line construction

Contents of the lab classes

#	Title of the Module	Contents of the Modules
1	Introduction	Movie: 01-01 Global Warming Movie: 01-02 Fossil Fuels Movie: 01-03 How Earth Would Look If All The Ice Melted
2	Wind farm	Movie: 02-01 Wind Power History Movie: 02-02 Wind Power in China Movie: 02-03 Gold Wind China's leader Movie: 02-04 China Road Map 2050
3	Wind power standards	Movie: 03-01 Siemens Wind Turbine Park Movie: 03-02 Inside Wind Turbine 1 Movie: 03-02 Inside Wind Turbine 2 (test) Extras PDF: 03-03 Wind Turbine SWT-3.6-120 Technical Specifications Extras: 03-04 Wind Turbine SWT-3.6-120 Planning and Testing Extras: 03-05 Overview of Wind Power in China: Status and Future Test: Classification of Wind Turbines
4	Wind turbine technology	Movie: 04-i Montage VAWT; 05-i Montage HAWT
5	Development methodologies of wind turbines components	Movie: 05-01 Wind Turbine Operation Drawing: 05-01 Airfoil Drawing from Database Movie: 05-02 Blade Strength Test Movie: 05-03 Synchronous and Asynchronous Generators (Difference) Test: 05-10 Wind turbine performance and efficiency test (in writing)
6	Safety in wind power	Movie: 7-01 Failure Cases … 7-07 Failure Cases Movie: 7-08 Injuries; 7-12 Injuries Movie: 7-13 Air traffic protection