Module Handbook 2nd Semester Specialisation Wind Energy at NTUA, Athens

Module name:	**Wind potential, Aerodynamics & Loading of Wind Turbines**		
Section			
Classes	▪ Status of Wind Energy ▪ Status of European Wind Energy and R&D ▪ Advanced Wind Structure and Statistics ▪ Evaluation of Wind Energy Potential ▪ Wind turbine Aerodynamics ▪ Static and dynamic Loading of Wind turbines / Aeroelasticity		
Semester	Summer Semester		
Module Coodinator	George Caralis		
Lecturers	A.Zervos, P.Chaviaropoulos, S.Voutsinas, V.Riziotis, G. Sieros, D.Manolas, G.Caralis		
Language	English		
Classification within the curriculum			
Teaching format / class hours during the semester	3h 20h 25h 4h 9h 5h 9h 9 5h 3h	Lecture Lecture Lecture Lecture Lecture Lecture Tutorials Workshop Laboratory Exam	▪ Market Development ▪ Aerodynamics ▪ Static & Dynamic Loading ▪ Technology overview ▪ Advanced Wind Structure and Statistics ▪ Dynamic model of full Wind turbine ▪ Tutorials ▪ Workshop ▪ Laboratory ▪ Exam
Contact Hours/ Workload	Contact Hours: 92 Workload: 95.5		
Credit points	7.5 CP		
Requirements under the examination regulations			
Recommended prerequisites (prior knowledge	Basic Understanding in • Mathematics and Algebra • Aerodynamics • Fluid Mechanics • Computational fluid dynamics		
Target learning outcomes	The objectives of this module are: ▪ Introduction to the current Market development and Technology overview ▪ Advanced issues on wind structure and statistics, on the evaluation of wind energy potential, ▪ Advanced issues on wind turbine aerodynamics ▪ Advanced issues on static and dynamic loading of wind turbines		

Content	**Teaching** 1. Introduction ▪ Status of Wind Energy ▪ Status of European Wind Energy and R&D 2. Advanced Wind Structure and Statistics ▪ Gusts and gust probability distributions ▪ Effects of topography 3. Evaluation of Wind Energy Potential ▪ Wind modelling in flat and complex terrain ▪ Wind energy siting approaches 4. Wind turbine Aerodynamics ▪ Advanced methods ▪ Aerodynamic stall ▪ Unsteady aerodynamics ▪ Vortex wake structure ▪ Advanced wake models ▪ Optimum design of wind turbine blades 5. Static and dynamic Loading of Wind turbines ▪ Aerodynamic and gravity loading ▪ Inertial and structural loads ▪ Aeroelastic modelling ▪ Fatigue of wind turbine blades
Study/ exam achivements	Written exam
Forms of media	Black board, overhead projection, beamer presentation, software demonstration, tutorials
Literature	Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, 2011: Wind Energy Handbook 2nd Edition, Tony Barton. David Sharfpe, Nick Jenkins, Evrim Bossanyi 2001: Wind Energy Handbook 'Wind Energy - The Facts', European Wind Energy Association, 2004. 'Wind Energy Explained – Theory, Design and Application' J.F. Manwell, J.G.McGowan, A.L.Rogers, J.Willey and Sons, 2002. 'Wind Power Plants - Fundamentals, Design, Construction and Operation', R. Gasch, J. Twele, James and James, 2002. 'Wind Power in View', edited by M. J. Pasqualetti, P. Gipe, R.W. Righter, Academic Press, 2002. 'Wind Energy in the 21st Century', R.Y. Redlingen, P.D. Andersen, P.E. Morthorst, UNEP, 2002. 'Wind Energy Handbook', T. Burton, D. Sharpe, N. Jenkins, E. Bossanyi, John Wiley and Sons, 2001. 'Wind Energy Comes of Age', P. Gipe, John Wiley and Sons, 1995.

Module name:	**Wind Turbine Design, electrical & Control Issues, Certification**		
Section			
Classes	▪ Electrical Conversion Systems ▪ Wind turbines control ▪ Design of wind turbines ▪ Performance Testing and Modelling ▪ Measurements - anemometers - calibration ▪ Electrical Integration ▪ Standards and Certification ▪ Large scale integration		
Semester	Summer Semester		
Module Coodinator	George Caralis		
Lecturers	Riziotis Vasilis, Aris Chatzopoulos (Garrad Hassan), Caralis George, Tenzerakis Sokratis, Papathanasiou Stavros, Papakonstantinou Apostolis, Ladakakos Panagiotis (ENTEKA), Stefanos Delikaraoglou.		
Language	English		
Classification within the curriculum			
Teaching format / class hours during the semester	10h 26h 14h 14h 8h 4h 13h 3h	Workshop Lecture & Laboratory Lecture Lecture Lecture Lecture Tutorial Exam	▪ Bladed GH ▪ Performance-Testing & Modelling ▪ Electrical conversion Systems ▪ Electrical inegration ▪ Large scale integration ▪ Certification ▪ Tutorials ▪ Exam
Contact Hours/ Workload	Contact Hours: 92h Workload: 95.5h		
Credit points	7.5 CP		
Requirements under the examination regulations			
Recommended prerequisites (prior knowledge	Basic Understanding in ▪ Electric Circuits and Systems ▪ Electromechanical Power Conversion Systems ▪ Aerodynamics ▪ Physics		
Target learning outcomes	The objectives of this module are: ▪ Understanding of different generators options and their effect on the power system ▪ Understanding of the various control strategies of the wind turbine ▪ Introduction to the design issues of the wind turbines ▪ Introduction of the students on the procedure of performance testing and modelling of wind turbines prototypes ▪ Discussion on electrical integration issues ▪ Discussion on standards and certifications ▪ Measurements analysis ▪ Energy calculations		
Content	1. Electrical Conversion Systems ▪ Synchronous and induction generators		

	▪ Direct drive generators ▪ Constant and variable speed systems 2. Wind turbines control ▪ Aerodynamic power control (stall, pitch, yaw) ▪ Electromagnetic torque control ▪ Control – dynamic analysis and stability ▪ Control strategies 3. Design of wind turbines ▪ Important factors ▪ Design options ▪ Design parameters ▪ Design of components ▪ System design ▪ Megawatt scale design ▪ Offshore design 4. Performance Testing and Modelling ▪ Measurements under controlled conditions ▪ Field testing instrumentation 5. Measurements - anemometers - calibration 6. Electrical Integration ▪ Weak grids ▪ Power quality ▪ Network costs and benefits 7. Large scale integration ▪ Technical, economical and policy issues ▪ Grid connection requirements, infrastructure ▪ Economic aspects 8. Standards and Certification ▪ WT certification ▪ International standards
Study/ exam achivements	Written exam
Forms of media	Black board, overhead projection, beamer presentation, software demonstration, tutorials
Literature	Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, 2011: Wind Energy Handbook 2nd Edition, Tony Barton. David Sharfpe, Nick Jenkins, Evrim Bossanyi 2001: Wind Energy Handbook 'Wind Power in Power Systems', Ackermann T., Wiley, 2005. 'Wind Energy - The Facts', European Wind Energy Association, 2004. 'Wind Energy Explained – Theory, Design and Application' J.F. Manwell, J.G.McGowan, A.L.Rogers, J.Willey and Sons, 2002. 'Wind Power Plants - Fundamentals, Design, Construction and Operation', R. Gasch, J. Twele, James and James, 2002. 'Wind Power in View', edited by M. J. Pasqualetti, P. Gipe, R.W. Righter, Academic Press, 2002. 'Wind Energy in the 21st Century', R.Y. Redlingen, P.D. Andersen, P.E. Morthorst, UNEP, 2002.

	'Wind Energy Handbook', T. Burton, D. Sharpe, N. Jenkins, E. Bossanyi, John Wiley and Sons, 2001. 'Grid Integration of Wind Energy Conversion Systems' S. Heier, John Wiley and Sons, 1998. 'Wind Energy Comes of Age', P. Gipe, John Wiley and Sons, 1995. 'Wind Energy Conversion Systems', edited by L.L. Freris, Prentice Hall, 1990.

Module name:	**Wind Farm Technology, Economics & Environmental Issues**		
Section			
Classes	• Wind Farm Technology Issues • Wind Farm design, wake effect • Economics of WT • Externalities • Environmental Issues • Market development and status of industry • Offshore • Wind forecast		
Semester	Summer Semester		
Module Coodinator	George Caralis		
Lecturers	Caralis George, Bernard Budler, Papalexandrou Marios, Tom Levick (DNV-GL), Papastamatiou Panagiotis (ENTEKA), Cristobal Gallego, Prospathopoulos John, Manolas Dimitris		
Language	English		
Classification within the curriculum			
Teaching format / class hours during the semester	10h 15h 9h 10h 14h 5h 4h 19h 3h 3h	Lecture Lecture Lecture Workshop Lecture Lecture Tutorial Lecture Visit Exam	▪ Economics & Externalities ▪ Offshore ▪ Wind farms ▪ Wind Farmer GH ▪ Environmental issues ▪ Forecast ▪ Wind energy in urban areas ▪ Tutorials ▪ Visit to a wind farm ▪ Exam
Contact Hours/ Workload	Contact Hours: 92h Workload: 95.5h		
Credit points	7.5 CP		
Requirements under the examination regulations			
Recommended prerequisites (prior knowledge	Basic Understanding in • Mathematics and Algebra • Aerodynamics • Fluid Mechanics		
Target learning outcomes			
Content	9. Wind Farm Technology Issues ▪ Wind eploitation in wind farms ▪ Energy predictions and optimization ▪ Balance of plant ▪ Wind farms electrical design ▪ Wind Farm design, wake effect (simple and advanced wake models, numerical methods - CFD approach) 10. Economics of WT and Externalities ▪ Calculation methods ▪ Current plant costs ▪ Wind energy prices ▪ The value of wind energy		

	▪ External costs ▪ Future price trends 11. Environmental Issues ▪ Environmental benefits ▪ Environmental effects ▪ Amenity (land use, visual impact) ▪ Technical analysis of noise and electromagnetic interference ▪ Ecology (birds) ▪ Consumption of energy and materials 12. Market development and status of industry ▪ Characteristics of the EU industry ▪ Present status of wind power ▪ Market description ▪ Market predictions ▪ Wind energy targets ▪ Wind energy market incentives in Europe 13. Offshore ▪ Turbine modelling ▪ Support structures – foundation ▪ Wind farms aspects ▪ Grid connections 14. Wind energy in urban areas 15. Wind forecast ▪ Introduction to Coupled Ocean / Atmosphere Mesoscale Prediction System (COAMPS)
Study/ exam achivements	Written exam
Forms of media	Black board, overhead projection, beamer presentation, software demonstration, tutorials
Literature	Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, 2011: Wind Energy Handbook 2nd Edition, Tony Barton. David Sharfpe, Nick Jenkins, Evrim Bossanyi 2001: Wind Energy Handbook 'Wind Power in Power Systems', Ackermann T., Wiley, 2005. 'Wind Energy - The Facts', European Wind Energy Association, 2004. 'Wind Energy Explained – Theory, Design and Application' J.F. Manwell, J.G.McGowan, A.L.Rogers, J.Willey and Sons, 2002. 'Wind Power Plants - Fundamentals, Design, Construction and Operation', R. Gasch, J. Twele, James and James, 2002. 'Wind Power in View', edited by M. J. Pasqualetti, P. Gipe, R.W. Righter, Academic Press, 2002. 'Wind Energy in the 21st Century', R.Y. Redlingen, P.D. Andersen, P.E. Morthorst, UNEP, 2002. 'Wind Energy Handbook', T. Burton, D. Sharpe, N. Jenkins, E. Bossanyi, John Wiley and Sons, 2001. 'Grid Integration of Wind Energy Conversion Systems' S. Heier, John Wiley and Sons, 1998. 'Wind Energy Comes of Age', P. Gipe, John Wiley and Sons, 1995.

	'Wind Energy Conversion Systems', edited by L.L. Freris, Prentice Hall, 1990. 'Large scale integration of wind energy in the European power supply: Analysis, issues and recommendations', EWEA, December 2005.

Module name:	**Module 4: Mini Project & Wind Farm study**		
Section			
Classes	-		
Semester	Summer Semester		
Module Coodinator	George Caralis		
Lecturers	V.Riziotis, G.Caralis		
Language	English		
Classification within the curriculum			
Teaching format / class hours during the semester	-	Worskshops (for the wind farm study - included in the other modules)	-
Contact Hours/ Workload	Contact Hours: - Workload: 187.5h		
Credit points	7.5 CP		
Requirements under the examination regulations			
Recommended prerequisites (prior knowledge	-		
Target learning outcomes	Module 4 is consisted of the mini project and wind farm study. Module 4 is equivalent to each one of the above presented modules. There is no exam. Students have to deliver technical reports and make a presentation. The target of the mini-project is to give the opportunity to the students to focus on a topic that is really interesting and useful for them. It could be connected or could be preparatory for their last semester's internship. The target of wind farm study is each one of the student using individual data to perform a very detailed and analytical study on wind energy. Tools and softwares are provided by NTUA to be applied by the students in the framework of this study. Dedicated workshops are organized during the lectures of modules 1,2 and 3 to support the completion of this study.		
Content	The typical form of the mini-project's report submitted is: ▪ Abstract – key words ▪ Introduction / scope /objectives ▪ Bibliographic research ▪ Methodology ▪ Computational part ▪ Results ▪ Discussion / conclusions The report's structure of wind farm study is analytically described in the detailed description oft he project.		
Study/ exam achivements	For mini project: Report submission (up to 3500words) and 15-20 minutes presentation plus Questions & Answers For wind farm study: Report submission		
Forms of media	-		

	Tony Barton. David Sharfpe, Nick Jenkins, Evrim Bossanyi 2001: Wind Energy Handbook 'Wind Energy - The Facts', European Wind Energy Association, 2004. 'Wind Energy Explained – Theory, Design and Application' J.F. Manwell, J.G.McGowan, A.L.Rogers, J.Willey and Sons, 2002. 'Wind Power Plants - Fundamentals, Design, Construction and Operation', R. Gasch, J. Twele, James and James, 2002. 'Wind Power in View', edited by M. J. Pasqualetti, P. Gipe, R.W. Righter, Academic Press, 2002. 'Wind Energy in the 21st Century', R.Y. Redlingen, P.D. Andersen, P.E. Morthorst, UNEP, 2002. 'Wind Energy Handbook', T. Burton, D. Sharpe, N. Jenkins, E. Bossanyi, John Wiley and Sons, 2001. 'Grid Integration of Wind Energy Conversion Systems' S. Heier, John Wiley and Sons, 1998. 'Wind Energy Comes of Age', P. Gipe, John Wiley and Sons, 1995. 'Wind Energy Conversion Systems', edited by L.L. Freris, Prentice Hall, 1990. 'Wind Power in Power Systems', Ackermann T., Wiley, 2005.