Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Renewable Energy and Meteorology
Course code	45524
Scientific sector	FIS/06
Degree	Master Energy Engineering
Semester	2
Year	2
Academic year	2017/2018
Credits	6
Modular	Yes

Total lecturing hours	60
Total lab hours	
Total exercise hours	
Attendance	
Prerequisites	The basic background of mathematics and physics usually learned to achieve a 3-year bachelor degree in engineering of physics is enough. Contents of meteorology will be provided in Part I of the course.
Course page	

Specific educational objectives	The course offers an overview of the main atmospheric factors affecting the processes controlling the conversion of renewable energy sources and the efficient use of energy. In particular the course will focus on factors affecting solar radiation (season, weather, cloud cover, atmospheric absorption, orographic effects, urban effects, etc.), wind (dynamical mechanisms, terrain effects, urban effects, vertical profiles, etc.), temperature (vertical profiles, terrain and urban effects, etc.), condensation processes (clouds, precipitation, freezing, frost, etc.) and pollutant dispersion (turbulent mixing, atmospheric stability, etc.).

Module 1	Introduction to atmospheric processes
Lecturer	Dino Zardi
Scientific sector of the lecturer	FIS/06
Teaching language	English
Office hours	
Teaching assistant ***(if any)***	
Office hours	
List of topics covered	• Overview of the mean atmospheric properties (chemical composition, thermal structure). • Scales of atmospheric motions.

	• Climatological effects. • Atmospheric thermodynamics • Properties of dry air. Dry unsaturated adiabatic processes. Potential temperature. Hydrostatic balance. • Moist unsaturated processes. Virtual temperature. • Saturated processes. Dew/frost point. Wet bulb temperature. Lifting condensation level. Thermodynamic diagrams. Clouds and precipitations • Atmospheric dynamics • Synoptic-scale motions. Geostrophic wind. Fronts. • Mesoscale circulations. Coastal breezes. Mountain and valley winds. • Atmospheric boundary layers and turbulence. • Environmental impacts of energy production and use: concepts and models in support of atmospheric pollutant dispersion assessment. • Fundamentals of diffusion processes. • Atmospheric turbulence and diffusion. • Models of pollutant dispersion in the atmosphere
Teaching format	Lectures

Module 2	Solar resource assessment
Lecturer	To be appointed
Scientific sector of the lecturer	FIS/06
Teaching language	English
Office hours	
Teaching assistant ***(if any)***	
Office hours	
List of topics covered	• Introduction to the factors determining the solar radiation availability at the Earth's surface. • Instruments and types of radiation measurements. • Empirical methods for the estimate of the solar resource from other meteorological quantities. • Models for the estimate of the solar radiation components under clear or cloudy skies, and over horizontal and inclined surfaces. • Overview of the databases (solar atlases) presently available for the estimate of solar resource at a specific site. Trentino region will be adopted as case study, providing the necessary tools for the assessment of the solar potential and of the optimal inclination of photovoltaic modules for complex terrain areas. • Overview of the different approaches nowadays used for the forecasting of solar radiation for energy-related applications.
Teaching format	Lectures. Exercises in the lecture room on practical examples of analysis of meteorological data for the assessment of solar resources.

Module 3	Wind resource assessment
Lecturer	To be appointed
Scientific sector of the lecturer	FIS/06
Teaching language	English
Office hours	
Teaching assistant *(if any)*	
Office hours	
List of topics covered	• Wind climatology of a region: effects of synoptic-scale events and terrain-induced winds. • Monin-Obukhov similarity theory and dependence of vertical wind profiles on atmospheric stability. • Experimental techniques for measuring wind speed, including planning field measurements and correct siting of anemometers. • Analysis of wind data from experimental campaigns: relevant statistics for wind power assessment (e.g. Weibull distribution). • General overview about prognostic and diagnostic meteorological models, and related tools for wind resource assessments. • Wind atlases: how to use them, how to deal with uncertainty, especially in regions with complex terrain, where the wind field is characterized by high spatial variability.
Teaching format	Lectures. Exercises in the lecture room on practical examples of analysis of meteorological data for the assessment of wind resources.

Learning outcomes	**Knowledge and understanding:** The students will learn the basics of the atmospheric variables affecting the energy conversion processes in view of their optimal planning and management. **Applying Knowledge and understanding:** The students will become confident in the use of meteorological concepts, models and instruments for the assessment of renewable energy resource availability. **Making judgments:** The students will be enabled to identify the most appropriate sources of information, critically asses the quality of datasets and the range of reliability of the results of data processing procedures. **Communication skills:** The students will learn how to discuss a topic in a given time. Through the exercises the students will learn how to write a short technical report. **Learning skills:** The students will be stimulated to find out datasets and other useful information required to accomplish the assessment of renewable energy resources.
Assessment	In the final exam (oral only) the candidate is expected to show he/she has learned and understood the basic

	concepts explained in Module I, and will discuss some exercises proposed during the subsequent Modules II and III.
Assessment language	English
Evaluation criteria and criteria for awarding marks	Final grade will be determined from an overall assessment of the oral exam and of the exercises.

Required readings	
Supplementary readings	Wallace J.M. & Hobbs P.V., Atmospheric Science, Academic Press, New York, 2nd edition, 2006. Stull R. B., An Introduction to Boundary Layer Meteorology, Kluwer Academic Publishers, 1988. Panofsky, H. A. & Dutton J. A., Atmospheric Turbulence: Models and Methods for Engineering applications, John Wiley & Sons, New York, 1984. Iqbal, M., 1984: An introduction to solar radiation, Academic Press. Badescu, V., 2008, Modeling Solar Radiation at the Earth's Surface: Recent Advances, Springer, 518pp. Oke, T. R., 1987, Boundary layer climates (Second edition), Routledge, 435pp. Troen, I. e Lundtang Petersen, E., 1990, European Wind Atlas http://www.wasp.dk/News/2015/08/European-Wind-Atlas-now-available-for-download?id=f999e21a-4243-428c-a878-f2268113221c Stull, R.B., 2015: Practical Meteorology: An Algebra-based Survey of Atmospheric Science. 938 pp. https://www.eoas.ubc.ca/books/Practical_Meteorology/prmet/PracticalMet_WholeBook-v1_00b.pdf