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 "Physics of the Earth and of the circumterrestrial medium"
Degree	Master Energy Engineering
Semester	2
Year	*OPT*
Academic year	2021/2022
Credits	6
Modular	No

Total lecturing hours	52
Total lab and exercise hours	8
Attendance	Not mandatory, but strongly recommended
Recommended preliminary knowledge	Basic background of mathematics and physics usually acquired in a 3-year bachelor's degree in engineering or physics. Basic contents of meteorology will be provided in the first part of the course.
Connections with other courses	This course focuses on the atmospheric factors affecting the availability of renewable energy resources, as well as on the methodologies and techniques for their assessment and forecast. To this regard, the topics covered in this course can be useful for other courses dealing with the infrastructures and plants to exploit renewable energy resources and in particular: "Hydropower and Wind Power Systems", "Solarenergiesysteme" and "Environmental Fluid Mechanics/Hydropower Plants". Basic knowledge of the factors affecting meteorological fields can also be useful for courses dealing with energy consumption in buildings for space heating/cooling, such as: "Advanced Applications of Building Physics", "Building HVAC Systems" and "District Heating Systems Design".
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Specific educational objectives	The course offers an overview of the main atmospheric factors affecting the processes controlling the availability and conversion of renewable energy sources. In particular, the course focuses on factors affecting solar radiation (season, weather, cloud cover, atmospheric absorption, orographic effects, urban effects, etc.) and wind (dynamical mechanisms, terrain effects, urban effects, vertical profiles, etc.), as well as on the tools and instruments for assessing and forecasting their availability.

Lecturers	Dr. Lorenzo Giovannini
Scientific sector of the lecturers	FIS/06
Teaching language	English
Office hours	On appointment by email
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	<u>Part I: Introduction to atmospheric processes</u> • Overview of the mean atmospheric properties (chemical composition, thermal structure) • Scales of atmospheric motion • Atmospheric thermodynamics • Hydrostatic balance • Atmospheric stability • Atmospheric dynamics: synoptic-scale motion, geostrophic wind • Mesoscale circulations, coastal breezes, mountain and valley winds <u>Part II: Solar radiation measurement and modelling</u> • Factors determining the solar radiation availability at the Earth's surface • Instruments for solar radiation measurements • Models for the estimate of the solar radiation components under different meteorological conditions, and over horizontal and inclined surfaces • Overview of the databases (solar atlases) presently available for the estimate of the solar resource at a specific site • Overview of the different approaches nowadays used to forecast solar radiation for energy-related applications • Practical exercise on the assessment of the solar resource <u>Wind measurement and modelling</u> • Wind climatology: synoptic-scale winds, mesoscale circulations and local effects • Monin-Obukhov similarity theory and dependence of the vertical wind profile on atmospheric stability • Overview of the wind atlases presently available: strengths and weaknesses • Instruments for wind measurements, correct siting of anemometers and planning of field measurements • Tools and methodologies for wind resource assessment • Analysis of wind data from experimental campaigns: relevant statistics for wind power assessment

	• Introduction to meteorological models and techniques to forecast wind power production • Practical exercise on the assessment of the wind resource
Professional applications of the covered topics	The knowledge acquired through this course can be applied in the planning and management of renewable energy plants, with particular regard to solar and wind energy plants. Therefore, these competences can be exploited in companies operating plants and in societies providing meteorological and climate services for the energy sector.
Teaching format	The course mainly consists of frontal lectures in the classroom. Lectures will be carried out both with blackboard demonstrations and with slides. Part of the course is dedicated to two practical exercises to apply methods and tools for the assessment of the solar and wind energy potential of a site.

Learning outcomes	**Intended Learning Outcomes**: 1. **Knowledge and understanding:** The students will learn the basics of atmospheric processes affecting renewable energy resources availability for their optimal planning and management. 2. **Applying knowledge and understanding:** The students will learn to use meteorological concepts, models and instruments for the assessment of the availability of renewable energy resources (especially solar radiation and wind). 3. **Making judgments:** The students will be able to identify the most appropriate information source, critically assess the quality of datasets and the uncertainty of the results from the application of meteorological data processing and modeling. 4. **Communication skills:** The students will learn the basic technical vocabulary and concepts of the discipline. Through the exercises the students will learn how to write a short technical report. 5. **Ability to learn:** The students will be stimulated to search for proper datasets and other useful information required to assess renewable energy resources. They will learn to critically evaluate and sort sources of data according to their use.
Assessment	Students are asked to prepare two written reports on the practical exercises on the assessment of solar and wind energy resources, that will be sent to the lecturer before the oral exam for evaluation. The reports will be then discussed during the oral exam. The oral exam includes also questions to assess the knowledge and the understanding of the topics of the course.

Formative assessment

Form	Length/duration	ILOs assessment
Anonymous tests on the topics covered	During the course, at the end of each module	1,2,3

Summative assessment

Form	%	ILOs assessment
Oral exam - theory	50%	1,2,3,4
Written reports - practical exercises	50%	4,5

Assessment language	English
Evaluation criteria and criteria for awarding marks	Oral exam at the end of the course, with the aim of evaluating the ability of the student to reproduce the topics of the course with critical reasoning. Moreover, students are required to prepare two written reports on the practical sessions proposed during the course. The reports are discussed during the oral exam. The final grade is the result of the evaluation of both the oral exam (50%) and the written reports (50%).

Required readings	Slides provided to the students and notes taken by the students
Supplementary readings	Wallace J.M., Hobbs P.V., Atmospheric Science, Academic Press, New York, 2006. Stull R., Practical Meteorology: an Algebra-based Survey of Atmospheric Science, University of British Columbia, Vancouver, 2015. Stull R., An Introduction to Boundary Layer Meteorology, Kluwer Academic Publishers, Dordrecht, 1988. Iqbal M., An Introduction to Solar Radiation, Academic Press, Don Mills, 1983. Badescu V., Modeling Solar Radiation at the Earth's Surface: Recent Advances, Springer, Berlin, 2008. Emeis S., Wind Energy Meteorology, Springer, Berlin, 2013. Landsberg L., Meteorology for Wind Energy: An Introduction, Wiley, Chichester, 2015. Brower M., Wind resource assessment: a practical guide to developing a wind project, Wiley, 2012.