Syllabus

Course Description

Course Title	Solar Energy and Smart Water Systems
Course Code	45548
Course Title Additional	
Scientific-Disciplinary Sector	IIND-07/B
Language	English
Degree Course	Master in Energy Engineering
Other Degree Courses (Loaned)	
Lecturers	Prof. Maurizio Righetti, Maurizio.Righetti@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/33740 dr. Giuseppe Roberto Pisaturo, GiuseppeRoberto.Pisaturo@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38803 dr. Federica Morandi, Federica.Morandi@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/41968
Teaching Assistant	
Semester	First semester
Course Year/s	2
CP	12
Teaching Hours	76
Lab Hours	44
Individual Study Hours	180
Planned Office Hours	
Contents Summary	Module 1: Solar Energy Systems The course aims to introduce students to different aspects of solar

	energy. The course starts with an introduction to the properties of solar radiation. Fundamental properties such as energy content and spectral distribution and air mass will be defined. From there, the course explores the different strategies to harvest this vastly abundant source of energy in different sectors (residential and commercial, as well as industrial applications). The topics covered range from the fundamentals and latest advances in photovoltaics to the thermal uses of solar energy such as solar heating and cooling as well as concentrated solar thermal power plants. The students will learn the fundamental principles and the system design indications of each of the covered technologies. As regards the integration of solar energy into different energy systems, the study of the state-of-the-art solutions of solar harvesting will be tackled at both single building and at multiple buildings scale, encompassing also the role of solar energy in the design of renewable energy communities. Module 2: Energy Efficiency of Smart Water Systems The course aims at providing students with innovative tools for the design, management and optimization of smart water systems with a focus on sustainability and efficiency of the water-energy nexus. Students will have the opportunity to take advantage of the specific knowledge acquired within the course, e.g., fundamentals on data analysis and on Artificial Intelligence, also in educational and professional contexts, with potential extensions also to other technical fields.
Course Topics	Module 1: Solar Energy Systems 1. Fundamentals of solar radiation 2. Photovoltaic power generation 3. Solar water heating and storages 4. Passive and active solar heating and example of applications in different sectors 5. Solar thermal power plants 6. Integration of solar energy into existing energy systems: buildings and renewable energy communities Module 2:

	Energy Efficiency of Smart Water Systems 1. General overview on water grids 2. Energy and natural resources audit methodologies in fluid systems (analysis of the water-energy nexus) 3. Systems hydraulic modelling 4. Smart grids and devices for measurement/control 5. Data analysis: data management, demand characterization and prediction 6. Optimization of the water smart systems network also considering energy efficiency of machines, sustainability of resources, and electricity prices.
Keywords	solar energy; PV systems; solar thermal systems; smart water networks; water grids; water-energy nexus
Recommended Prerequisites	Basic knowledge of building physics, building energy balance, and hydraulic
Propaedeutic Courses	
Teaching Format	Class lectures (blackboard and slides) and design exercises using spreadsheets and energy simulation software. Lecture material (slides) will be available for download by the students.
Mandatory Attendance	Not mandatory but recommended, especially as far as the exercises are concerned
Specific Educational Objectives and Learning Outcomes	Intended Learning Outcomes (ILO) 1) Knowledge and understanding As regards Module 1, students will learn: • the fundamentals of solar radiation and the measuring techniques used to monitor these. • The basic working principles of a photovoltaic (PV) cell, its limitations and concepts on how to possibly overcome these problems. • System design principles for a PV plant, including shading considerations as well as tracking systems. • Special aspects of building and product integrated PV (BIPV and PIPV). • The basic working principles of solar thermal collection and its different applications such as solar heating (passive vs. active), solar heat for industrial processes as well as solar cooling applications.

	• The working principles of concentrating solar thermal power plants. • How to estimate the efficiency for each of the covered systems, as well as to be introduced to different ways to simulate the respective systems. • Integration of solar energy into existing energy systems, ranging from single buildings to renewable energy communities. As regards Module 2, students will learn: • About different types of water distribution networks (water supply systems, agricultural aqueducts, raw water conduits). • On hydraulic modelling for the characterization of water systems. • About smart distribution systems and control. • How to optimize prosumer systems considering the energy efficiency. • Data analysis and AI for systems characterization and demand forecasting. 2) Applying knowledge and understanding Capability to implement the procedures and calculation methods presented in the course and to develop design and diagnostic skills. 3) Making judgements Acquisition of critical assessment tools and critical evaluation of product specifications, in order to allow the design of both solar energy systems and advanced smart water networks. Moreover, students will be able to analyse and evaluate the potential performance, the efficiency and how to optimize a water network and system. 4) Communication skills The student will be able to discuss the learned knowledge with vocabulary and technical terms of the discipline thanks the project report. 5) Ability to learn Student will learn to develop in detail the optimization of solar systems and water networks, including integration in current energy systems, demand forecasting, choice of smart sensors,

	network modelling, energy market, data analysis.
Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	Each module will include an oral examination with questions aimed at verifying the knowledge and the capability to understand the topics of the course and the mastery of the technical language. The ability to transfer these competences to applicative cases and the developed autonomy of judgment will be evaluated through the discussion of the design work assigned during the course and the report writing. Formative assessment: Form: Report/project Length /duration: During the course ILOs assessed: (2), (3), (5) Summative assessment: Form: Oral examination, including presentation and discussion of a project report Length /duration: About 1 hour per each module ILOs assessed: all except (5). 100% Assessment language: English
Evaluation Criteria	The same exam consists into two assessments (one per module). The adopted structure is the same for both modules: - oral presentation and discussion of the projects and deliverables of the individual working groups, with the identification and evaluation of the contributions of individual participants (40 %); - oral exam about the course topics (60 %). Possible / typical projects topics are: For Module 1: - Design of solar PV plant, - Design solar thermal plant, - Integration of solar energy systems into a renewable. energy

	community For Module 2: - Energy recovery from water supply systems, - Management of snowmaking plant, - Agricultural water supply system management.
Required Readings	PowerPoint presentations will be available in the course reserve collection database.
Supplementary Readings	- Renewable Energy Resources (John Twidell & Tony Weir) - Solar Engineering of Thermal Processes (J.A. Duffie & W.A. Beckman) - Water distribution systems handbook (Mays) Additional material will be provided by the Professors
Further Information	Connection with other courses: Module 1 - Solar Energy Systems: - Advanced Applications of Building Physics - Building HVAC Systems - Special Issues of Building Physics - Applied Energetics Module 2 - Energy Efficiency of Smart Water Systems: - Environmental Fluid Mechanics / Hydropower Plants - Hydropower and wind power Systems - Fluid Machines Engineering - District heating systems design - Electrical System Engineering Professional applications of the covered topics: Module 1 - Solar Energy Systems The module "Solar Energy Systems" will provide a state-of-the-art overview of the current technologies available on the market to harvest solar energy, for both thermal applications and photovoltaics. Students will also learn how to design such systems and integrate them into existing energy systems (e.g., single

	building systems and renewable energy communities), fostering the achievement of decarbonization goals. Professional applications can be found in companies designing, manufacturing and selling PV/T systems, in companies providing energy consultancy on solar energy systems, as well as in public energy authorities and Energy Saving Companies. Module 2 - Energy Efficiency of Smart Water Systems The topics studied will allow the student to find employment in companies, public and private bodies and professional firms for the design, planning, construction, and management of works and plants for water displacement and, in general, where the transport of fluids is important. The knowledge from this course will permit to the student to focus his experience on the efficiency, sustainability and smart management of water and energy distribution systems and to apply the acquired competences also in different fields (e.g. Efficiency of industrial systems, energy management of hydropower plants, sustainable use of water resources, prediction of extreme events, …)
Sustainable Development Goals (SDGs)	Clean water and sanitation, Affordable and clean energy, Climate action, Sustainable cities and communities, Responsible consumption and production, Industry, innovation and infrastructure

Course Module

Course Constituent Title	Solar Energy Systems
Course Code	45548A
Scientific-Disciplinary Sector	IIND-07/B
Language	English
Lecturers	dr. Federica Morandi, Federica.Morandi@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/41968
Teaching Assistant	
Semester	First semester
CP	6
Responsible Lecturer	

Teaching Hours	40
Lab Hours	20
Individual Study Hours	90
Planned Office Hours	
Contents Summary	The course aims to introduce students to different aspects of solar energy. The course starts with an introduction to the properties of solar radiation. Fundamental properties such as energy content and spectral distribution and air mass will be defined. From there, the course explores the different strategies to harvest this vastly abundant source of energy in different sectors (residential and commercial, as well as industrial applications). The topics covered range from the fundamentals and latest advances in photovoltaics to the thermal uses of solar energy such as solar heating and cooling as well as concentrated solar thermal power plants. The students will learn the fundamental principles and the system design indications of each of the covered technologies. As regards the integration of solar energy into different energy systems, the study of the state-of-the-art solutions of solar harvesting will be tackled at both single building and at multiple buildings scale, encompassing also the role of solar energy in the design of renewable energy communities.
Course Topics	1. Fundamentals of solar radiation 2. Photovoltaic power generation 3. Solar water heating and storages 4. Passive and active solar heating and example of applications in different sectors 5. Solar thermal power plants 6. Integration of solar energy into existing energy systems: buildings and renewable energy communities
Teaching Format	Class lectures (blackboard and slides) and design exercises using spreadsheets and energy simulation software. Lecture material (slides) will be available for download by the students.
Required Readings	PowerPoint presentations will be available in the course reserve collection database.
Supplementary Readings	- Renewable Energy Resources (John Twidell & Tony Weir)

	- Solar Engineering of Thermal Processes (J.A. Duffie & W.A. Beckman) Additional material will be provided by the Professors

Course Module

Course Constituent Title	Energy efficiency of smart water systems
Course Code	45548B
Scientific-Disciplinary Sector	CEAR-01/B
Language	English
Lecturers	Prof. Maurizio Righetti, Maurizio.Righetti@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/33740 dr. Giuseppe Roberto Pisaturo, GiuseppeRoberto.Pisaturo@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/38803
Teaching Assistant	
Semester	First semester
CP	6
Responsible Lecturer	
Teaching Hours	20
Lab Hours	24
Individual Study Hours	90
Planned Office Hours	
Contents Summary	The course aims at providing students with innovative tools for the design, management and optimization of smart water systems with a focus on sustainability and efficiency of the water-energy nexus. Students will have the opportunity to take advantage of the specific knowledge acquired within the course, e.g., fundamentals on data analysis and on Artificial Intelligence, also in educational and professional contexts, with potential extensions also to other technical fields.

Course Topics	1. General overview on water grids 2. Energy and natural resources audit methodologies in fluid systems (analysis of the water-energy nexus) 3. Systems hydraulic modelling 4. Smart grids and devices for measurement/control 5. Data analysis: data management, demand characterization and prediction 6. Optimization of the water smart systems network also considering energy efficiency of machines, sustainability of resources, and electricity prices.
Teaching Format	Frontal lessons, laboratory and exercises
Required Readings	PowerPoint presentations will be available in the course reserve collection database.
Supplementary Readings	Water distribution systems handbook (Mays) Additional material will be provided by the Professors