Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

# Syllabus

## *Course Description*

| | |
|---|---|
| **Course Title** | Power Production, CHP and District Heating Systems |
| **Course Code** | 45510 |
| **Course Title Additional** | |
| **Scientific-Disciplinary Sector** | NN |
| **Language** | English |
| **Degree Course** | Master in Energy Engineering |
| **Other Degree Courses (Loaned)** | |
| **Lecturers** | Prof. Francesco Patuzzi, Francesco.Patuzzi@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/30127 Prof. Massimiliano Renzi, Massimiliano.Renzi@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/32541 Prof. Marco Baratieri, Marco.Baratieri@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/27442 |
| **Teaching Assistant** | |
| **Semester** | First semester |
| **Course Year/s** | 2 |
| **CP** | 12 |
| **Teaching Hours** | 72 |
| **Lab Hours** | 48 |
| **Individual Study Hours** | 214 |
| **Planned Office Hours** | 36 |
| **Contents Summary** | The courses “Engineering Thermodynamics, Heat and Mass Transfer” and “Fluid Machines Engineering”, offered in the first semester, supply the main concepts of Engineering |

| | |
|---|---|
| | Thermodynamics and Fluid Machines. These topics are deepened in the Power Production, CHP and District Heating Systems course and specific and practical applications of power conversion systems are presented.<br>The know-how acquired in the present course will be useful to follow the curricular courses "District Heating System Design" and "Bioenergy" and the elective course "Electric and hybrid mobility". |
| Course Topics | The Power Production, CHP and District Heating Systems course is a core teaching in the context of the Master in Energy Engineering and, specifically, it deals with the industrial plants used for electric and thermal power production both for small scale and community scale appliances. The course consists of two modules.<br><br>The first module (A) introduces the fundamental concepts of cogeneration and presents the most used cogeneration solutions for civil and industrial applications based on thermal engines. The working principles of the core devices of power production plants are presented. The main<br>mechanical, fluid-dynamic and energy ceonversion principles and equations will be described and applied to the presented components of the power production plant. In particular, the following educational objectives will be addressed: constructive aspects of machines for energy conversion, behavior of the fluid machines employed in power production plants, components, thermo-fluid-dynamic laws, evaluation of the plant performance in design and off-design<br>operating conditions.<br><br>The second module (B) starts with the description of the main energy resources with a particular focus on renewable sources. Then, fundamentals of energy conversion are presented, along with the working principles and the main operational aspects of the most<br>used cogeneration plants both for large scale and for small scale distributed generation. Thermochemical processes are analyzed by means of thermodynamic and kinetic approaches, as well as direct conversion technologies. Technical aspects of power generation systems and solutions to improve their energy and environmental performance are presented, dealing also with constructive aspects, plant operation and management issues and heat distribution |

| | |
|---|---|
| | networks. |
| **Keywords** | Power Production; Cogeneration; Fluid Machines; Thermochemical processes; Energy conversion; Heat distribution networks |
| **Recommended Prerequisites** | Engineering Thermodynamics, Heat and Mass Transfer, Fluid Machine Engineering |
| **Propaedeutic Courses** | |
| **Teaching Format** | Module A - "Thermal Engines"<br>This is a lecture course in which topics are presented by the Professor using power point presentations and the virtual witheboard. Practical parts consisting in numerical exercises are explained by the Professor using the virtual witheboard, spreadsheets and additional materials.<br>Power Point presentations will be given to the students in pdf format before each single lecture. Additional material will be provided by the Professor.<br><br>Module B - "Thermal Power Production and Distribution"<br>The course consists of lectures in which the topics are presented by the professor. There are also classes (exercises) that will give practical examples of the application of theoretical topics. Course topics will be presented on the blackboard and using electronic slides. Teaching material and additional materials will be provided by the Professor during the semester. |
| **Mandatory Attendance** | Attendance not mandatory |
| **Specific Educational Objectives and Learning Outcomes** | Intended Learning Outcomes (ILO)<br><br>Knowledge and understanding<br>Students should acquire the knowledge and the understanding of:<br>1. the most important separate-generation and co-generation plant configurations for centralized or small and community scale power production, considering their energy and environmental performance<br>2. the fundamental plant components used in power production plants and their operative function<br>3. the fundamental design principles of the core components, their integration in a complex plant and the use of power plants in industrial and civil applications |

| | |
|---|---|
| | Applying knowledge and understanding<br>4. the ability to apply basic thermodynamic, kinetic and fluid-dynamic laws to the design of the components of power production plants<br>5. the ability to apply the studied power production plants to industrial and civil users<br><br>Making judgements<br>6. to be able to make autonomous judgements in the choice of the design solutions, of the suitable machines and of the plant solutions in relation to their applications<br><br>Communication skills<br>7. the ability to correctly and properly present the concepts acquired in the course both in written and oral form<br>8. the ability to use the proper technical terms to describe the design solutions of the power production plants.<br><br>Ability to learn<br>9. the ability to acquire lifelong learning skills in the field of power production plants and cogeneration by applying the methods and the concepts acquired in the course |
| **Specific Educational Objectives and Learning Outcomes (additional info.)** | |
| **Assessment** | The student is asked to produce a project work on the design of an energy system (integrating the topics of the both modules of the course); this part of the assessment evaluates the ability of the student to apply the topics of the course in practical applications, the comprehension of the theoretical concepts and the ability to make judgments.<br>The student is also asked to carry out an oral exam for each module of the course. The oral examination includes questions to assess the knowledge and understanding of the course topics and questions designed to assess the ability to transfer these skills to case studies of energy plants and thermal and electric energy production devices.<br><br>Summative assessment |

| | |
|---|---|
| | Form, Length and duration, ILOs assessed<br>Oral exam – theory 70% 2 or 3 open-end questions per each module (1 hour), ILO assessed 1,2,3,4,5,7,8<br>Project work presentation<br>30% Preparation, presentation and discussion of the design of a power plant integrating the topics of the two modules (20 minutes), ILO assessed 4,5,6,7,8,9<br>It will not be possible to pass the exam if the oral exam of both the modules and the project work have not been positively evaluated. |
| **Evaluation Criteria** | Assessment language: English<br><br>Students regularly enrolled in the 2nd year of the Master in Energy Engineering are eligible for the attendance of the exam. Other exceptional cases have to be discussed with the Professors.<br><br>Oral exam – theory (open-end questions):<br>The oral exam on the theory assesses the knowledge and understanding of the course topics, namely the fundamentals of conversion technologies and of the operating principles of the presented technologies; the design choices of energy production plants for community scale and small-scale cogeneration are also assessed, as well as the ability to transfer these skills to case studies and to make judgment.<br>The following criteria will be considered:<br>Theoretical knowledge (75% of the mark)<br>Ability to provide examples/applications of the theoretical concepts (25 % of the final mark)<br><br>Project work presentation<br>The following criteria will be taken into account:<br>Correctness of the design choices (25% of the final mark)<br>Correctness of the dimensioning procedure (25% of the final mark)<br>Correctness of the numerical solution (20% of the final mark)<br>Communication skills and master of the technical language (30% of the final mark) |
| **Required Readings** | Slides and material provided by the professors on the Teams channel. |

| | |
|---|---|
| Supplementary Readings | • G. Rogers, Y. Mayhew. Engineering Thermodynamics: Work and Heat Transfer. LongmaN Scientific.<br>• F. P. Incropera, D.P. DeWitt, T. L. Bergman, A. S. Lavine. Fundamentals of Heat and Mass Transfer. John Wiley & Sons.<br>• J.M. Smith, H. C. Van Ness, M. Abbott. Introduction to Chemical Engineering Thermodynamics. McGraw-Hill Series in Civil and Environmental Engineering.<br>• J. Warnatz, U. Maas, R. W. Dibble. Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation. Springer.<br>• H. Spliethoff, Power generation from solid fuels. Springer.<br>• R. Kehlhofer, F. Hannemann, F. Stirnimann, B. Rukes, Combined cycle Gas and Steam Turbine Power Plants, PennWell, 2009.<br>• J. Heywood, Internal Combustion Engine Fundamentals, Mcgraw Hill, 1988.<br>• G. Negri di Montenegro, M. Bianchi, A. Peretto, Sistemi energetici e loro componenti. Considerazioni teoriche e valutazioni numeriche, Pitagora Editrice, Bologna, 2003.<br>• S. Sandrolini, G. Naldi, Macchine. Vol. 3: Gli impianti motori termici e i loro componenti, Pitagora Editrice, Bologna, 2003. |
| Further Information | Connections with other courses:<br>The courses "Applied Energetics" and "Fluid Machines Engineering", offered in the first semester, supply the main concepts of Engineering Thermodynamics and Fluid Machines. These topics are deepened in the Power Production, CHP and District Heating Systems course and specific and practical applications of power conversion systems are presented. The know-how acquired in the present course will be useful to follow the curricular courses "District Heating System Design" and "Bioenergy" and the elective course "Electric and hybrid mobility".<br><br>Professional applications of the covered topics:<br>The knowledge acquired through the module Thermal Power Production and Distribution can be applied in the design and management of thermal plants and industrial energy systems. The related professional tasks are relevant to traditional and innovative technologies for thermal power generation, e.g. combustion, gasification and pyrolysis. The competences can be deployed in private engineering companies, in public agencies, in utilities companies, as well as in the industry. |

| | |
|---|---|
| | The contents of the module Thermal engines will be useful for all the professional tasks, in the industry or in the public sector, related to the use of power plants and fluid machines in the energy conversion process. Typical jobs can be related to the design of cogeneration systems, boilers, fluid machines for power conversion (steam and gas turbines, combustion engines), management and control of power plants. These competences are necessary in the companies designing, managing and maintaining power plants, in utilities' companies and in the industries designing components and solutions for the power conversion. |
| **Sustainable Development Goals (SDGs)** | Affordable and clean energy, Industry, innovation and infrastructure, Climate action, Responsible consumption and production, Sustainable cities and communities |

# *Course Module*

| | |
|---|---|
| **Course Constituent Title** | Thermal Engines |
| **Course Code** | 45510A |
| **Scientific-Disciplinary Sector** | IIND-06/A |
| **Language** | English |
| **Lecturers** | Prof. Massimiliano Renzi, Massimiliano.Renzi@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/32541 |
| **Teaching Assistant** | |
| **Semester** | First semester |
| **CP** | 6 |
| **Responsible Lecturer** | |
| **Teaching Hours** | 36 |
| **Lab Hours** | 24 |
| **Individual Study Hours** | 90 |
| **Planned Office Hours** | 18 |
| **Contents Summary** | The Thermal Engine module is intended to give the students the design solutions for both large scale plants and small micro-cogeneration units for the local and distributed generation. The traditional fossil fuel feeding and the alternative or renewable energy feeding of the generation devices will be presented. |

| | |
|---|---|
| **Course Topics** | The course will cover the following topics:<br><br>• Energy auditing and cogeneration indexes<br>• Gas turbine plants design and microturbines<br>• Internal combustion engine co-generators<br>• Traditional and low temperature steam cycles<br>• Combined cycles<br>• External combustion thermal engine co-generators<br><br>The contents of this module will be useful for all the professional tasks, in the industry or in the public sector, related to the use of power plants and fluid machines in the energy conversion process. Typical jobs can be related to the design of cogeneration systems, boilers, fluid machines for power conversion (steam and gas turbines, combustion engines), management and control of power plants. These competences are necessary in the companies designing, managing and maintaining power plants, in utilities' companies and in the industries designing components and solutions for the power conversion. |
| **Teaching Format** | This is a lecture course in which topics are presented by the Professor. Practical parts are explained by the Professor.<br>Power Point presentations will be given to the students in pdf format before each single lecture. Additional material will be provided by the Professor. |
| **Required Readings** | Slides of the course and additional material provided by the lecturer. |
| **Supplementary Readings** | |

# *Course Module*

| | |
|---|---|
| **Course Constituent Title** | Thermal Power Production and Distribution |
| **Course Code** | 45510B |
| **Scientific-Disciplinary Sector** | IIND-07/A |
| **Language** | English |
| **Lecturers** | Prof. Marco Baratieri,<br>Marco.Baratieri@unibz.it<br>https://www.unibz.it/en/faculties/engineering/academic-staff/person/27442 |

| | |
|---|---|
| | Prof. Francesco Patuzzi,<br>Francesco.Patuzzi@unibz.it<br>https://www.unibz.it/en/faculties/engineering/academic-staff/person/30127 |
| **Teaching Assistant** | |
| **Semester** | First semester |
| **CP** | 6 |
| **Responsible Lecturer** | |
| **Teaching Hours** | 36 |
| **Lab Hours** | 24 |
| **Individual Study Hours** | 90 |
| **Planned Office Hours** | 18 |
| **Contents Summary** | The Thermal Power Production and Distribution module is intended to give the students the fundamentals of energy conversion processes from fossil or renewable sources to thermal power in centralized and distributed generation systems. |
| **Course Topics** | The course will cover the following topics:<br><br>• Fuels and energy vectors<br>• Fundamentals of thermochemical conversion<br>• Fundamentals of direct conversion<br>• Cogeneration and polygeneration systems<br>• Thermal energy distribution<br><br>The knowledge acquired through this module can be applied in the<br><br>design and management of thermal plants and industrial energy systems. The related professional tasks are relevant to traditional and innovative technologies for thermal power generation, e.g. combustion, gasification and pyrolysis. The competences can be deployed in private engineering companies, in public agencies, in utilities companies, as well as in the industry. |
| **Teaching Format** | The course consists of lectures in which the topics are presented by the professor. There are also classes (exercises) that will give practical examples of the application of theoretical topics. Course topics will be presented on the blackboard and using electronic slides. Teaching material and additional materials will be provided |

| | |
|---|---|
| | by the Professor during the semester. |
| **Required Readings** | Slides of the courses |
| **Supplementary Readings** | |