Course Title	*Thermotechnical systems in the building industry*
Level and Study Program	*Bachelor's Degree in Civil Engineering (L-7) - Environment and Sustainability Curriculum*
Scientific-Disciplinary Sector (SSD)	*IIND-07/B (ex ING-IND/11)*
Year of Study	*3*
Academic Year	*2025-26*
Total Credits	*9*
Prerequisites	*The "Technical Physics" exam is a prerequisite within the Bachelor's Degree in Civil Engineering*
Instructor	***Pietro Tasselli*** *https://ricerca.unicusano.it/author/pietro-tasselli/* *E-mail: pietro.tasselli@unicusano.it* ***Office Hours:*** *please consult the schedule on our engineering area calendar for videoconference hours.* *http://www.unicusano.it/calendario-lezioni-in-presenza/calendario-area-ingegneristica*
Course Presentation	*The " Thermotechnical systems in the building industry " course is one of the core courses for the third year of the bachelor's degree in civil engineering, with an emphasis on the environment and sustainability. This course, with a particular focus on sustainable development, aims to provide students with technical skills for designing and managing thermal and air-conditioning systems in civil buildings. The primary goal is to integrate solutions that improve the energy efficiency of buildings, reducing consumption and environmental impact, in compliance with Italian and European regulations.* *The syllabus includes an introduction to thermodynamics and heat transfer fundamentals, covering thermal cycles (such as Rankine and Carnot), essential for understanding system operations. It progresses to the design of heating, ventilation, and air-conditioning (HVAC) systems, covering radiator heating technologies, radiant panels, heat pumps, and heat recovery in buildings. A central theme is the integration of renewable energy sources, such as solar thermal and photovoltaic systems, necessary for nearly zero-energy buildings (nZEB), with a focus on sustainable design.* *In addition to theoretical aspects, the course includes practical exercises using professional software such as Termus for heating system design, Blumatica Energy for energy certification, and EnergyPlus for dynamic building simulation. These tools will enable students to develop practical skills for simulating and optimizing systems in different climate contexts, evaluating design solutions, and meeting regulatory requirements.* *Finally, the course provides an in-depth overview of regulations governing building energy efficiency, with reference to the EPBD Directive and Legislative Decree 192/2005. Students will acquire the knowledge needed to ensure that designed systems comply with current regulations and are optimized to reduce CO_2 emissions.* *The evaluation consists of written theoretical and practical exams, with exercises that require the use of software to design systems and improve building energy performance. The final assignments, completed individually, allow students to demonstrate the skills they have acquired.* *Therefore, the course adopts a practical approach, aiming to train professionals capable of designing thermal systems that address contemporary environmental and energy challenges, using the most advanced technologies available in the field.*
Educational Objectives	*The " Thermotechnical systems in the building industry " course has the following educational objectives:* *1. To acquire technical skills for designing and managing thermal and air-conditioning (HVAC) systems in civil buildings, with a focus on energy efficiency.* *2. To understand thermodynamics principles applied to thermal systems, including thermal cycles such as Rankine and Carnot.* *3. To be able to size and optimize heating, ventilation, and air-conditioning systems, considering buildings' energy requirements.* *4. To integrate renewable energy sources (such as solar thermal, photovoltaic, and heat pumps) into*

	the design of sustainable building systems. 5. *To use professional software (Termus, Blumatica Energy, EnergyPlus) for energy simulation and optimization of systems.* 6. *To know and apply Italian and European regulations on building energy efficiency and ensure design compliance.*
Prerequisites	*Students are expected to have a strong foundation in topics typically covered in a "Technical Physics" course, such as:* • *knowledge of fundamental thermodynamics principles, including the concepts of energy, work, heat, and the main thermal cycles;* • *ability to apply heat transfer equations (conduction, convection, radiation) for thermal system analysis;* • *understanding of energy balances and conservation in closed and open systems;* • *familiarity with the concepts of heat exchange between fluids and surfaces and the use of thermodynamic tables for fluid characterization.*
Expected Learning Outcomes	***Knowledge and Understanding*** *Upon passing the course, students will have gained a solid understanding of the principles of thermal systems, with particular reference to energy efficiency and the use of renewable energies. They will be able to design and size heating, ventilation, and air-conditioning (HVAC) systems using advanced simulation software. Additionally, they will have developed the ability to assess and improve the energy performance of buildings, applying the relevant environmental sustainability regulations.*
	Applying Knowledge and Understanding *Upon passing the course, students will be able to transfer theoretical knowledge into practice, addressing real-world problems related to the design and management of thermal systems. They will be capable of critically analyzing the energy needs of complex buildings and proposing optimal solutions for efficient resource use. Students will demonstrate competence in selecting the most suitable technologies for each project, considering environmental, economic, and regulatory factors. They will also have developed the ability to collaborate in multidisciplinary teams to implement integrated and sustainable energy strategies* ***Autonomy of Judgment*** *Students will be able to develop autonomous judgment in evaluating system solutions, identifying the most suitable technologies based on energy efficiency, costs, and regulations. They will be able to make informed and sustainable decisions.* ***Communication Skills*** *At the end of the course, students will acquire strong communication skills, essential for clearly and effectively presenting complex design solutions to various stakeholders, both technical and non-technical. They will be able to explain the principles behind their design choices and collaborate with professionals from other sectors, actively contributing to multidisciplinary projects related to energy efficie* ***Learning Skills*** *Upon passing the course, students will have developed strong independent and continuous learning skills, essential for staying up to date with new technologies and regulations in thermal systems and energy efficiency. They will be able to consult and comprehend complex technical documentation, scientific articles, and continuously evolving regulations. Additionally, they will have acquired mastery of formal and rigorous language, essential for communicating precisely in technical-professional settings, effectively interfacing with industry experts, and ensuring correct interpretation of technical and regulatory information.*

Course Organization

The course is delivered through pre-recorded audio-video lectures, complemented by slides and study materials available on the platform, divided into 6 modules by thematic areas:

- ***Module 1: Fundamentals of Thermodynamics and Heat Transfer*** *- introduction to the principles of thermodynamics applied to thermal systems and heat transfer mechanisms, essential for thermal engineering design.*
- ***Module 2: Heating Systems Design*** *- an in-depth look at types of heating systems (radiators, radiant panels, heat pumps), thermal load calculation, and techniques to improve energy efficiency.*
- ***Module 3: Ventilation and Air Conditioning Systems (HVAC)*** *- focus on HVAC system design and optimization, including heat recovery, controlled mechanical ventilation, and energy efficiency strategies.*
- ***Module 4: Energy Efficiency and Sustainability*** *- study of technical solutions and materials to increase building energy efficiency, including renewable energy integration and an introduction to nearly zero-energy buildings (nZEB).*
- ***Module 5: Legislation and Incentives for Energy Efficiency*** *- in-depth analysis of national and European regulations (EPBD Directive, Legislative Decree 192/2005) and incentives for energy efficiency. Topics include minimum energy performance requirements, procedures for energy certification (APE), and incentives for energy retrofits.*
- ***Module 6: Design and Energy Simulation Software*** *- practical exercises on professional software (Termus, Blumatica Energy, EnergyPlus) for the design, simulation, and energy optimization of thermal systems.*

Additionally, self-assessment tests (both intermediate and end-of-module) accompany the pre-recorded lectures, allowing each student to evaluate their comprehension and knowledge of various topics, identifying any weaknesses and gaps in the curriculum.

Interactive teaching takes place in the "virtual classroom" forums (Collaborative Area of the platform) and includes 6 E-tivities where students apply theoretical knowledge to solve problems and exercises related to the six program modules. When students feel prepared and have acquired the expected knowledge and skills for that module, they can access the graded test (E-tivity) for that module, available on the platform. Past exam topics and solutions are also available among the platform's resources.

Specifically, the Building Thermal Systems course grants 9 CFU (University Educational Credits). The total study workload for this course amounts to approximately 220-230 hours, distributed as follows:

- *approximately 180 hours for watching and studying the recorded material;*
- *about 30 hours of Interactive Teaching for E-tivities;*
- *around 20 hours for exercises on past exam topics uploaded to the platform.*

It is recommended to evenly distribute the course study over approximately 11 weeks, dedicating around 20-25 hours per week to study.

Course Content

Module 1 – Fundamentals of Thermodynamics and Heat Transfer

Fundamental concepts of thermodynamics. Thermodynamic cycles: Carnot, Rankine, refrigeration. Thermodynamic processes: isothermal, isobaric, adiabatic. First and second laws of thermodynamics. Internal energy, enthalpy, entropy. Heat transfer: conduction, convection, radiation. Energy balance in closed and open systems. Heat exchangers

E-tivity 1 – Analysis and Application of Thermodynamic Principles in Real Scenarios

Analyze a practical case of a thermal system and describe how the first and second laws of thermodynamics are applied. Identify the present modes of heat transfer. Share reflections with the instructor by submitting a report in PDF format

Module 2 – Heating Systems Design

Types of heating systems. Radiator systems. Radiant panel systems. Heat pumps. Calculation of the building's thermal load. Energy balance for heating. Optimization of energy efficiency. Integration of renewable energy sources. Reference regulations for heating systems. Strategies for reducing energy consumption

E-tivity 2 – Designing a Heating System for Sustainable Buildings

Design a heating system for a residential building, choosing one of the technologies discussed (radiators, radiant panels, heat pumps). Calculate the thermal load and integrate solutions for energy efficiency. Submit the report in PDF format to the instructor.

Module 3 – Ventilation and Air Conditioning Systems (HVAC)

HVAC system design. Natural and mechanical ventilation. Heat recovery. Controlled mechanical ventilation (CMV). Air conditioning. Dehumidification systems. Energy balance in HVAC systems. Energy efficiency of air conditioning systems. Air filters. HVAC control and automation systems. Reference regulations for HVAC systems. Reduction of energy consumption in HVAC systems.

E-tivity 3 – Designing a High-Efficiency HVAC System for Residential Buildings

Design an HVAC system for a residential building, optimizing ventilation and heat recovery. Choose between natural ventilation or controlled mechanical ventilation (CMV) and calculate the energy balance. Share the design and reflections by submitting a PDF report to the instructor.

Module 4 – Energy Efficiency and Sustainability

Energy efficiency strategies. Renewable energy in buildings. Solar thermal energy. Photovoltaics. Geothermal heat pumps. Nearly zero-energy buildings (nZEB). Reduction of CO_2 emissions. High efficiency insulating materials. Passive systems for energy savings. Life cycle analysis (LCA). Energy certifications. National and European energy efficiency regulations

E-tivity 4 – Designing Sustainable Solutions for Nearly Zero-Energy Buildings (nZEB)

Design sustainable solutions for a nearly zero-energy building (nZEB), integrating renewable energy sources such as solar thermal or photovoltaics. Consider the use of high efficiency insulating materials and passive strategies. Share the proposed solutions by submitting a PDF report to the instructor.

Module 5 – Regulations and Incentives for Energy Efficiency

EPBD Directive. Legislative Decree 192/2005. Minimum energy performance requirements. Energy Performance Certificate (EPC). Regional and local regulations on energy efficiency. Building energy certifications. State incentives for energy retrofitting. Thermal Account. Ecobonus. Tax incentives for sustainable buildings. European renewable energy regulations. Regulatory compliance for nearly zero-energy buildings (nZEB).

E-tivity 5 – Regulatory Analysis and Incentives for the Energy Retrofit of Existing Buildings

Analyze current regulations related to energy efficiency and identify available incentives for the energy retrofit of an existing building. Consider tools such as the Ecobonus and the Thermal Account. Prepare a PDF report describing applicable incentives and submit it to the instructor for evaluation.

Module 6 – Design and Energy Simulation Software

Termus for thermal system design. Blumatica Energy for energy certification. EnergyPlus for dynamic building simulation. DesignBuilder as a graphical interface for EnergyPlus. Edilclima EC700 for calculating energy requirements. Modeling of thermal systems. Simulation of energy performance. Optimization of energy consumption. Regulatory compliance through software. Analysis of alternative energy scenarios.

E-tivity 6 – Thermal and Energy Simulation and Design of a Building Using Professional Software

Use at least two software tools (e.g., Termus for thermal design and Blumatica Energy or EnergyPlus for energy efficiency simulation) to design and optimize a system in a residential building. Prepare a PDF report with the results and submit it to the instructor for evaluation.

Study Materials	*The teaching materials are prepared by the instructor. All study materials on the platform are divided into 6 modules covering the entire syllabus, each containing handouts, slides, and recorded lectures with instructor commentary. This material provides all necessary elements to tackle the subject.* ***Recommended Additional Texts:*** • *A. Motta, Impianti termotecnici, Hoepli Editore.* • *E. Fornasini, Manuale di progettazione degli impianti di riscaldamento, EPC Editore.* • *M. Ceraolo, Impianti HVAC. Progettazione ed efficienza energetica, Maggioli Editore.* • *V. Corrado, A. Capozzoli, Simulazione energetica degli edifici con EnergyPlus, Dario Flaccovio Editore.* • *Blumatica Software Team, Blumatica Energy: Guida alla Certificazione Energetica degli Edifici, Blumatica.* • *S. Corgnati, M. Filippi, Termotecnica: Conoscenze e strumenti per l'efficienza energetica negli impianti, Maggioli Editore.*
Evaluation Methods	*The exam, whether held in Rome or remotely, consists of a 90-minute written test designed to assess the student's acquired knowledge and ability to apply it in solving problems and exercises. The written test includes 5 open-ended exercises and is graded out of a maximum of 28 points.* *During the written exam, students may not use handouts, notes, texts, or paper or digital formulas. Calculators are allowed only if they are non-scientific and non-programmable.* *According to the program's teaching model, the final course grade (expressed in thirtieths) also considers the student's in-progress activity, evaluated through scores assigned to the six E-tivities. Specifically, up to 3 additional points are awarded based on passing the E-tivity tests (1 point for 2 or 3 E-tivities passed; 2 points for 4 or 5 passed; 3 points for 6 E-tivities passed), with the remaining 28 points awarded based on the final written exam. A total score of 31 points corresponds to a final grade of 30/30 with distinction.* *<u>NOTE ON E-TIVITY SCORES</u>* *Five days before the final exam, the instructor will verify the completion of E-tivities on the platform. If a student completes an E-tivity in the five days preceding the final exam, its outcome will NOT be considered by the instructor. The maximum score that can be achieved, as stated above, is 31 points (30 with distinction), with 28 points from the 5 open-ended exercises and 3 from the E-tivities completed on the platform.* ***IMPORTANT:*** *The student taking the exam on the full 9 CFU syllabus may choose, at the time of the exam, to complete it through* ***TWO PARTIAL TESTS****.*
Criteria for the Final Assignment	*The final assignment will be assigned based on a discussion with the instructor, where the student will express specific interests in an area they wish to explore further; there are no restrictions on thesis assignment requests, and no specific grade average is required to request it.* .