COURSE DESCRIPTION
TECHNIQUE OF ENVIRONMENTAL CONTROL

SSD: FISICA TECNICA AMBIENTALE (ING-IND/11)

DEGREE PROGRAMME: ARCHITETTURA (N14)
ACADEMIC YEAR 2022/2023

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: 07142 - LABORATORIO DI SINTESI FINALE
MODULE: 11096 - TECNICA DEL CONTROLLO AMBIENTALE
CHANNEL: 03 Cognome A - Z
YEAR OF THE DEGREE PROGRAMME: V
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER I
CFU: 6

REQUIRED PRELIMINARY COURSES

Environmental Technical Physics

PREREQUISITES

The student must know and understand the energy relationships and physical laws that describe the heat exchange mechanisms between the confined environment, the envelope, and the outdoor environment, and must be able to evaluate the thermophysical properties of the opaque and transparent building envelope. It must know how to size simple components of the building envelope to contain heat loss and control solar radiation. It must also know how to carry out quantitative assessments relating to the main control parameters of the environments.

LEARNING GOALS

The course Technique of Environmental Control is integrated into the Final Design Studio which deals with a multiplicity of aspects that allows students to develop a proposal for the transformation of the existing by deepening the various levels of complexity of the project in its

entirety.
The course aims at providing advanced theoretical and applicative tools to evaluate and design the building-plant systems and their integration into the urban context.
Students will know the theoretical and applicative tools to evaluate and design buildings and outdoor spaces in view of the essential needs of energy efficiency and environmental comfort, taking into account the EU Directives with reference to the need to reduce climate-change emissions and above all in harmony with objectives 7 (Ensure everyone has access to energy sources, in an economic, reliable, sustainable and modern way) and 11 (Make cities and human settlements inclusive, safe, resilient and sustainable), proposed by the ONU for sustainable development (SDG - Sustainable Development Goals).
The course introduces materials and technologies for thermal and energy-efficient building envelopes, for new buildings, and for the refurbishment of existing ones. In addition, the design criteria for technological systems are introduced, with reference to heating, ventilation, and air conditioning systems (HVAC) and systems from renewable energy sources.
Students will participate in the development of methods aimed at satisfying energy needs, through the management and use of available sources and networks, with particular attention to renewable energy sources.
Students will interact in an interdisciplinary and participatory way in the various stages of drafting project proposals, both with reference to existing buildings and new architectures.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must demonstrate knowledge and understanding of criticalities and thermal and energy interactions relating to the building envelope, technological systems, and renewable energy sources in buildings, taking into account energy optimization and environmental comfort. The student must also identify possible design solutions that guarantee maximum sustainability and integration with the architecture, by interacting actively and consciously with other specialists in the sector.

Applying knowledge and understanding

The student should know how to identify and propose solutions, at different scales, to satisfy the energy needs of the buildings and the quality conditions of the indoor environment, depending on the possible and intended uses. These objectives will be pursued by focusing attention on the rational use of energy, in the design phase of the building-plant system, taking into account the regulations in force, the reduction of environmental impact and climate-change emissions, and the contextual peculiarities relating to locally available resources, preferably renewable.

COURSE CONTENT/SYLLABUS

A. General information on the energy efficiency of the Building-Plants-Renewable Sources System (0.5 ECTS). General overview of the reference context. Current legislation, the building envelope, and its thermophysical properties, systems for microclimatic control, and systems from renewable sources.

B. Thermal comfort and air quality (0.5 ECTS). Definition of the thermal comfort of the occupants. Identification of descriptors and indices of the occupant well-being. Local discomfort factors. Measurement of environmental parameters. Adaptive comfort.

C. Thermophysics of the building envelope and outline of the relevant legislation (0.5 ECTS). The building envelope, both transparent and opaque, and its thermophysical properties. Outline of the relevant legislation (Legislative Decree 192/2005 and 311/2006 and Presidential Decree 59/2009, Law 90/2013, Ministerial Decree 26/06/2015).

D. Components and Technologies for the opaque building envelope (0.5 ECTS). Energy efficiency interventions, feasible for new buildings and/or for existing buildings, aimed at improving the thermal behavior, in winter and/or summer, of the building envelope including: products and systems for thermal insulation, thermal plasters insulators, special blocks (thermoblocks), nanotechnological paints and finishes.

E. Components and Strategies for the transparent building envelope (0.5 ECTS). Traditional technologies for the transparent envelope: windows, frames, bins, solar screens.

F. Opaque and transparent envelope in bioclimatic buildings (0.5 ECTS). Bioclimatic technologies for the opaque envelope (vented facades, ventilated roofs, green roofs, Trombe-Michel walls) and for the transparent envelope (double-skin facades, solar greenhouses, curtain walls, the exploitation of the greenhouse effect).

G. The calculation of Humid Air properties and the Psychrometric Diagram (0.5 ECTS). Definitions of the humid air properties. Thermodynamic properties: dry bulb, wet bulb, adiabatic and dew saturation temperatures. Specific enthalpy. Specific volume. Specific humidity. Relative humidity. Hygrometric degree. Psychrometric chart. The transformations of humid air: simple heating and cooling, cooling with dehumidification, adiabatic mixing, liquid water, and steam humidification.

H. The calculation of the heating and cooling loads of the buildings (0.5 ECTS). Definition and calculation of summer and winter thermal loads. The winter thermal load and the calculation of the thermal power dispersed through the surfaces of the envelope, due to external air infiltrations, through thermal bridges. The summer heat load and the calculation of the incoming thermal power through the surfaces of the building envelope, due to lighting devices and electrical devices, and due to the infiltration of outdoor air and people.

I. Air conditioning systems (0.5 ECTS). Air conditioning systems for civil use. Regulatory references on energy efficiency from European Directives to National ones. The design conditions for the sizing of an air conditioning system. Types of air conditioning systems. Full-air systems. Mixed air to water systems. The water systems. The refrigerant systems.

J. The air handling units (0.5 ECTS). The components of an air handling unit (fans, filter sections, mixing chamber, control dampers, air preheating coil, air cooling and dehumidification coil, humidifiers and droplet separator, post-heating coil). The terminals of the air systems.

K. The generation of energy (0.5 ECTS). Direct energy generators (gas stoves, electric stoves, fireplaces, split-systems) and generators with intermediate fluid (water, air, HFC, refrigerant fluids). The fuel generators, the reversible heat pumps, the thermo-refrigeration unit, the chimneys, and flue pipes. Advantages and disadvantages of power generation systems.

L. Renewable sources in the construction sector (0.5 ECTS). The reference regulatory framework on renewable sources in the construction sector: the legislative overview, obligations, and incentives. Heat Pumps/Chillers and the partial "renewability" of energy. The conversion of thermal and cooling energy from solar sources. The production of domestic hot water from a solar source. Solar heating and solar cooling. The production of electricity from solar sources. The production of electricity from the wind. The production of thermal energy by low enthalpy geothermic. Reversible heat pump and ground coupling: borehole. The sizing of a photovoltaic system and a micro-wind system. The dimensioning of a field of vertical borehole.

READINGS/BIBLIOGRAPHY

The professor will provide students with the necessary teaching material in the form of notes, handouts, tables, and diagrams.
Book for further information on humid air, air and mixed air conditioning systems, and heat exchange through the envelope: L. Bellia, P. Mazzei, F. Minichiello, D. Palma: ARIA UMIDA - Climatizzazione ed involucro edilizio. Liguori Editore.
Further reference texts:
- Gli impianti nell'architettura. Giuliano Dall'Ò, Edizioni UTET, Collana Architettura, 2000.
- Fabrizio Ascione, Energy conservation and renewable technologies for buildings to face the impact of the climate change and minimize the use of cooling, Solar Energy, Volume 154, 2017, pp. 34-100.

TEACHING METHODS OF THE COURSE (OR MODULE)

The professor will carry out:
- frontal lessons for about 75% of the course, including numerical exercises.
- laboratory activities for about 25% of the course.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- [ ] Written
- [x] Oral
- [x] Project discussion
- [ ] Other

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [ ] Open answers
- [ ] Numerical exercises

b) Evaluation pattern

The final grade will be weighted on the credits (ECTS) of each course and module: Architectural and Urban Design (8 ECTS), Executive Architectural Design (4 ECTS), Urban Planning (4 ECTS), Economics and Environmental Assessment (4 ECTS), Environmental Control (6 ECTS),

Construction Technique (2 ECTS).