Energy in Buildings

Academic Year: (2023 / 2024) **Review date: 07-06-2023**

Department assigned to the subject: Electrical Engineering Department, Thermal and Fluids Engineering Department

Coordinating teacher: SANCHEZ GONZALEZ, ALBERTO

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Thermal Engineering
Fluid Transport and Hydraulic Machinery
Solar Energy

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG4. Being able to do design, analysis, calculation, manufacture, test, verification, diagnosis and maintenance of energetic systems and devices.
CG7. Assess, control, and reduce the social and environmental impact of projects and facilities within the field of energy engineering.
CG8. Know and deal with current legislation in addition to mandatory specifications, regulations and norms within the energy engineering field.
CG10. Being able to work in a multi-lingual and multidisciplinary environment
CE20 Módulo CRI. Basic knowledge on environmental and sustainability technologies and their application.
CE1 Módulo TE. Applied knowledge on thermal engineering.
CE8 Módulo TE. Applied knowledge on renewable energies.
CT1. Ability to communicate knowledge orally as well as in writing to a specialized and non-specialized public.
CT2. Ability to establish good interpersonal communication and to work in multidisciplinary and international teams.
CT3. Ability to organize and plan work, making appropriate decisions based on available information, gathering and interpreting relevant data to make sound judgement within the study area.
CT4. Motivation and ability to commit to lifelong autonomous learning to enable graduates to adapt to any new situation.

By the end of this content area, students will be able to have:
RA1.1 knowledge and understanding of the scientific principles underlying the branch of energy engineering;
RA1.2 a systematic understanding of the key aspects and concepts of the branch of energy engineering.
RA1.4 awareness of the wider multidisciplinary context of engineering.
RA2.1 the ability to apply their knowledge and understanding to identify, formulate and solve energy engineering problems using established methods;
RA2.3 the ability to select and apply relevant analytic and modelling methods.
RA3.1 the ability to apply their knowledge and understanding to develop and realise designs to meet defined and specified requirements

RA4.1 the ability to conduct searches of literature, and to use data bases and other sources of information;
RA5.1 the ability to select and use appropriate equipment, tools and methods;
RA5.3 an understanding of applicable techniques and methods, and of their limitations;
RA6.1 function effectively as an individual and as a member of a team;
RA6.2 use diverse methods to communicate effectively with the engineering community and with society at large;
RA6.3 demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice.

OBJECTIVES

At the end of the course the students will be able to:
1. Know and understand the technological principles of HVAC, lighting and renewable energy systems in buildings.
2. Be aware of the wider multidisciplinary context of energy engineering and buildings.
3. Apply their knowledge to the sizing of thermal and electrical systems in buildings.
4. Use computer software for building energy simulation.
5. Design buildings and systems to minimize the consumption of energy.
6. Search and apply valid codes and standards for energy in buildings.
7. Size and select thermal and electrical equipment for buidings.
8. Develop and show an energy project applied to buildings.
9. Undestand the relationship between buildings, energy consumption and environmental impact.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Energy Consumption in Buildings

Building energy use, environmental impact and sustainability. Energy sources, primary/final energy, CO2 emissions. European energy performance of buildings directive (EPBD), certification of new and existing buildings, energy rating/labeling, nearly zero energy buildings (nZEB), energy audit. Energy codes for buildings, Código técnico de la edificación - Ahorro de energía (CTE-HE), ASHRAE standard 90.1.

2. Heating and Cooling Loads

Outdoor design conditions, climatic zones, typical meteorological year (TMY). Indoor comfort conditions, air quality, ventilation (CTE-HS3). Heat transfer through building envelope, insulating materials, U-value. Glazings, shadings, solar heat gains (SHGC). Passive heating and cooling, bioclimatic design. Internal loads, latent heat, psychrometric chart. Building energy simulation tools.

3. Refrigeration and Heat Generation

Vapor compression cycle, refrigerant charts, coefficient of performance (COP). Compressor, condenser, evaporator. Electric heat pumps. Electric heaters. Natural gas and fuel-oil boilers. Service water heating (SWH).

Renewable energy systems: low-temperature geothermal energy, solar thermal (CTE-HE4), solar cooling, biomass. Thermal energy storage (TES), district heating and cooling (DHC), combined heat and power (CHP). Integration in buildings.

4. HVAC Systems

Heating, ventilating, and air conditioning (HVAC), decentralized vs. centralized systems, zoning. Direct expansion systems. Air-and-water systems, fan-coils. All-water systems: pumps, pipes, radiators, radiant panels. All-air systems: air handling unit (AHU), fans, ducts, diffusors.

5. Lighting systems.

Main types of lamps. Parameters of visual comfort. Luminaries and lighting systems. Regulation of lighting (regulation 0-10 V, DSI regulation, regulation DALI).

6. Photovoltaic Systems

Types of photovoltaic cells. Installation configuration (panels, wiring, protections and investor). Resource assessment, integration into the building.

7. Power factor compensation.

Concept of power factor compensation. Estimation of consumption of reactive power. Capacitor banks and its regulation.

LEARNING ACTIVITIES AND METHODOLOGY

The learning methodology includes:
1. Lectures in which the course contents are presented.
2. Workshops, usually held in a computer room, where each student works on their projects.

ASSESSMENT SYSTEM

Continuous assessment (70%) based on the development of a project.Each student will be assigned a building case study, in which the student will apply the knowledge gained during the course.

To check the progress, there will be four mid-term assignments:

1. Building model and annual energy demand (compliance with building codes).
2. Heating and cooling loads.
3. Lighting system design.
4. Photovoltaic system.

% end-of-term-examination:	30
% of continuous assessment (assigments, laboratory, practicals…):	70

BASIC BIBLIOGRAPHY

- ASHRAE. ASHRAE Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings, ASHRAE, 2016
- Anna Yudina. Lumitecture: Illuminating Interiors for Designers and Architects , Thames & Hudson, 2016
- Harry Box. Set Lighting Technician's Handbook: Film Lighting Equipment, Practice, and Electrical Distribution , Elsevier Inc., 2010
- Michael Boxwell. Solar Electricity Handbook: A Simple Practical Guide to Solar Energy - Designing and Installing Photovoltaic Solar Electric Systems, Greenstream Publishing , 2014
- Paul Tymkow. Building Services Design for Energy Efficient Buildings, Routledge, 2020
- T.A. Reddy, J.F. Kreider, P.S. Curtiss, A. Rabl. Heating and Cooling of Buildings: Design for Efficiency, Taylor & Francis, 2010

ADDITIONAL BIBLIOGRAPHY

- ASHRAE Fundamentals (SI Edition), ASHRAE.
- F.C. McQuiston, J.D. Parker, J.D. Spitler Heating, Ventilating, and Air Conditioning: Analysis and Design, John Wiley & Sons, 2005
- G.F. Hundy, A.R. Trott, T.C. Welch Refrigeration and Air-Conditioning, Elsevier, 2008
- Robert McDowall Fundamentals of HVAC Systems, Elsevier, 2007
- W.P. Jones Air Conditioning Engineering, Elsevier, 2001
- W.T. Grondzik Air-conditioning System Design Manual, ASHRAE, 2007

BASIC ELECTRONIC RESOURCES

- European Union . Directive on the Energy Performance of Buildings EPBD 2010: http://eur-lex.europa.eu/legal-content/FR/TXT/PDF/?uri=CELEX:32010L0031&from=EN