BUILDINGS ENERGY PERFORMANCE SIMULATION

COURSE OUTLINE

Responsible: Georgios Stavrakakis

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	8000.1.211.0	**SEMESTER**	1st
COURSE TITLE	BUILDINGS ENERGY PERFORMANCE SIMULATION		

INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	**WEEKLY TEACHING HOURS**	**CREDITS**
Total		

COURSE TYPE general background, special background, specialised general knowledge, skills development	
PREREQUISITE COURSES	Heat and mass transfer, Fluid mechanics, Mechanical design, Numerical methods.
LANGUAGE OF INSTRUCTION and EXAMINATIONS	
OFFERED TO ERASMUS STUDENTS	Yes (in English) — Winter Semester
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES

Learning outcomes

The aim of the course is for students to acquire comprehensive knowledge on buildings' energy performance simulation, specifically regarding established methods for dynamic and simple energy analysis, special focus on the zonal modelling method including building discretization into thermal zones, interpretation of energy-audits data to model input conditions, understanding of building-shell thermophysical and optical properties, calculation of heating and cooling systems efficiency ratio, simulation set-up, modelling procedure and assessment of results referring to state and impact Key Performance Indicators (KPIs). The course includes an energy analysis project concerning the parametric analysis of building-energy upgrading and techno-economic impact assessment.

General Competences

Upon successful completion of the course, students will be able to:

- Understand the steps of a building energy audit
- Discretize buildings into thermal zones
- Compile energy-audit information to suitable modelling input conditions
- Compute thermophysical and optical properties of building envelope
- Calculate building heating and cooling systems efficiency ratios/performance coefficient
- Familiarized with energy simulation through setting-up a case study using building energy simulation

software

- Analyse simulation results towards state and impact KPIs in the framework of techno-economic studies using building energy simulation techniques

3. SYLLABUS

Energy balance in buildings: Building-physics principles, heat transfer in buildings, energy breakdown in energy consumption per end-use and per energy vector, compilation of primary energy consumption, energy-induced emissions, buildings' energy-saving potential.

Energy audits: Energy-related data collection, recording of building use, systems and operation schedules, interpretation of architectural design, recording of structural elements, extraction of properties used as input conditions in energy modelling, Building energy benchmarking/rating.

Building thermal zones: Discretization into thermal zones, calculation of air infiltration, ventilation specifications, impact of shading in energy performance.

Building envelope thermophysical and optical properties: Calculation of thermal transmittance and the impact on energy performance, building thermal-insulation adequacy assessment, structural elements reflectivity and emissivity.

Building-systems' properties calculation: Estimation of heater-boiler efficiency, calculation of COP/EER of air-conditioning systems, efficiency of solar collector for hot water production purposes, lighting adequacy, etc.

Energy-performance simulation: Exhibition of building energy modelling set-up, thermal zoning, imposing suitable input conditions (based on previous knowledge on building envelope systems' properties affecting the energy balance), execute simulations, simulation data processing towards state and impact KPIs for various energy-upgrading scenarios.

Assessment of energy investments in buildings: Prediction of Net Present Value, Internal Rate of Return and other special indicators for assessing the viability of retrofit scenarios for various building uses.

Assignment: Techno-economic study for energy-upgrading of a building case study.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY Face-to-face, Distance learning, etc.	Face to face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students	Presentation of electronic slides
TEACHING METHODS The manner and methods of teaching are described in detail.	**Activity** | **Semester workload** **Course total** |
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure	Students will conduct an assignment / case study involving building energy analysis. There will be a final exam. Student final grade will be the average of the grade of final exam and of the assignment.

5. ATTACHED BIBLIOGRAPHY

Hensen, J., & Lamberts, R. (Eds.) (2019). Building performance simulation for design and operation. (2nd expanded ed.) Routledge Taylor & Francis Group.

Fundamentals of Building Performance Modeling Handbook, IESVE 2025.

Brackney, L., Parker, A., Macumber, D., & Benne, K. (2018). Building energy modeling with OpenStudio: A practical guide for students and professionals. Springer International Publishing.