INDBIOT-E05 **ENERGY EFFICIENCY IN BIOTECHNOLOGICAL PROCESSING FACILITIES**	
GENERAL INFORMATION	
Course Coordinator(s)	Darko Velić, PhD, full prof. Sandra Budžaki, PhD, assoc. prof.
Associate(s)	Marta Ostojčić, MSc
Study Programme	Interdisciplinary Graduate Study Programme in English: Biotechnology
Course Status	Elective
Year of Study, Semester	2nd Year / 4th Semester
Credits (ECTS)	**4**
Teaching Method (number of classes)	Lectures 20; Seminars 10; Exercises 15
Expected Number of Students in the Course	25-30
COURSE DESCRIPTION	
Course Aims	
The objective of this course is to upgrade the existing and acquire new knowledge in the field of heat management in biotechnological facilities with the aim of better energy management and to estimate the consumption of the existing process as well as to recommend energy efficiency measures.	
Prerequisites for Enrolment and the Entry Competencies Required for the Course	
-	
Learning Outcomes at the Programme Level Contributed by the Course	
BIOTECH-7; INDBIOT-4	
After successful completion of this course students are expected to be able to: 1. Interpret the requirements of the European Energy Efficiency Directives. 2. Critically evaluate the concept of energy management and its environmental impact. 3. Determine the relationship between energy consumption and production. 4. Identify sources of waste heat and possibilities of their utilization. 5. Analyse industrial energy systems: steam systems, compressed air systems, refrigeration systems. 6. Analyse and valorise cogeneration systems.	
Course Content	
Lectures. Introduction. Legal framework for energy management. European Energy Efficiency Directives. System and concept of energy and environmental management. Relationship between energy consumption and production. Technical aspects of industrial energy management - Industrial energy systems. Sources of waste heat and its potential applications. Process integration - a heuristic approach. Energy integration. Analysis of industrial energy systems: steam systems, compressed air systems, refrigeration systems. Industrial cogeneration. Thermoeconomic analysis and exergoeconomic cost theory. **Seminars.** Engineering calculations of the energy efficiency of equipment, processes and plants that form a single whole with lectures: The pinch technology and optimization of the heat exchanger network in the bioprocessing industry. **Exercises.** Numerical examples (accompanying the course material).	
Teaching Methods	
Lectures; seminars; exercises	
Students' Obligations	
Attendance at all forms of classes is mandatory and the students are obligated to attend all knowledge tests. The students may be absent from 30% (full-time students) and 50% (part-time	

students) of each of the forms of classes, provided that the absence is justified. An exercise or a seminar which has not been completed must be made up through a midterm exam.

Monitoring the Activity of the Students *(Connecting Learning Outcomes, Teaching Methods, and Grading)*

Class-related activity	ECTS	Learning outcome	Student activity	Evaluation method	Grade points	
					Min.	Max.
Attending classes	0.2	1-6	Attendance at classes	Keeping records	5	10
Seminars	1	3-6	Seminar paper	Oral presentation	10	25
Exercises	0.8	4-6	Attendance at exercises	Report	5	15
Final exam	2	1-6	Studying for the final exam	Written exam	30	50
Total	**4**				**50**	**100**

Evaluation of the written part of the final exam

Percentage of correct answers (%)	Grade
>95.00	50
90.00-94.99	47
85.00-89.99	45
80.00-84.99	40
75.00-79.99	38
70.00-74.99	35
65.00-69.99	33
60.00-64.99	30

Forming the final grade:
The points granted for the final exam are added to the grade points awarded during class attendance. The grading process is conducted by absolute distribution, i.e. based on total achievements, and compared to the numerical system in the following manner:
A – Excellent (5): 90-100 grade points; B – Very Good (4): 80-89.99 grade points; C – Good (3): 65-79.99 grade points; D – sufficient (2): 50-64.99 grade points

Mandatory Literature (available in the library and via other media)

Title	Number of copies in the library	Availability via other media
Capehart BL, Turner CW, Kennedy WJ. Guide to Energy Management, The Fairmont Press, Inc., 2016.	-	-
Kreith K, Goswami DY. Energy Management and Conversation Handbook. Taylor & Francis Group, LLC, CRP Press, 2017.	-	-

Additional Literature

1. Rossiter AP, Jones BP. Energy Management and Efficiency for the Process Industries. John Wiley & Sons, Inc., Hoboken, New Jersey, 2015.
2. LaGrega MD, Buckingham PL, Evans JC, Hazardous Waste Management, 2nd Ed., Waveland Press, Inc., 2010.

3. Çangel YA, Boles MA. Thermodynamics – an engineering approach. McGraw-Hill Publishing Co. Ltd., 2002.
4. Smith R. Chemical Process Design. McGraw Hill, 1995.
5. Seider WD, Seader JD, Lewin DR. Proces Design Principles Synthesis, Analysis and Evaluation of Process Flowsheets. J. Wiley & Sons, 2000.
6. Scientific and professional papers presenting an analysis of energy management and efficiency of biotechnological processes (available online)

Quality Assurance Procedures Designed to Ensure the Acquisition of Outcomes and Competencies

Anonymous, quantitative, standardised student survey on the course and the teacher's work implemented by the Quality improvement office of the Faculty of Food Technology Osijek and/or the Faculty of Medicine Osijek.

Note

E-learning is not included in the class quota, but it is used in teaching and it contains links to various sites and video and audio materials available on websites.