EEE.7-1.7 ENERGY STORAGE

COURSE OUTLINE

ENERGY STORAGE

1. GENERAL

SCHOOL	**ENGINEERING SCHOOL**		
DEPARTMENT	**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**EEE.7-1.7**	**SEMESTER**	**7th**
COURSE TITLE	**ENERGY STORAGE**		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS (ECTS)**
Lectures		3	**4**
Laboratory exercises			
Total		**3**	
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Special Background Course		
PREREQUISITE COURSES:	NO		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (official)		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	NO		
COURSE WEBSITE (URL)	www.eee.uniwa.gr https://eclass.uniwa.gr/courses/EEE271/		

2. LEARNING OUTCOMES

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
The optimal use and management of energy reserves worldwide has led to the discovery of new, feasible and technologically acceptable solutions. Apart from these issues, an important factor accelerating such solutions is the improvement of the stability of the electrical grids, mainly in areas where Renewable Energy Sources (RES) systems are installed and especially

when they are located in the unconnected electricity grid. Energy Saving is now an important area in which the research community is showing increasing interest.
The aim of the course is for the students to acquire knowledge on energy storage technologies, the evaluation of different storage methods and the calculation of basic storage systems connected to RES, so that they perform according to the provisions.

Upon successful completion of the course students are expected to be able to:

1. know the modern energy storage technologies.
2. Understand the operation and basic technical characteristics of the various energy storage systems.
3. understand the function and the typical sizes of electricity accumulators and fuel cells.
4. study methods of energy storage and efficiency in installations that require continuous power supply.
5. study methods of energy storage and efficiency in energy systems with RES, interconnected and non-interconnected.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking

The course aims at fostering the following capabilities:

1. Search, analysis and synthesis of data and information
2. Independent work
3. Teamwork
4. Promoting free, creative and inductive thinking

3. COURSE CONTENT

The content of the course consists of the following modules:

1. Need to store energy.
2. Main categories of energy storage methods.
3. Dynamic and kinetic energy storage: Pump storage systems, compressed air, rotating mass-flywheel.
4. Storage of electricity by means of electrochemical methods: Batteries - Accumulators, Fuel cells. Basic elements of Electrochemistry. Galvanic components - Batteries - Accumulators. Types of batteries. Battery construction and operating components.

Factors that affect their function. Charging - discharging curves. Storage capacity. Types of fuel cells. Hydrogen production and storage.

5. Storage of electricity with supercapacitors and superconducting coils.
6. Storage of thermal energy. Phase change materials.
7. Storage of chemical energy: Fuels (solids, liquids and gases).
8. Storage of short, medium and long duration. Seasonal storage.
9. Design of an autonomous Photovoltaic system with batteries. Calculation of batteries and basic system components.
10. Calculation and selection of continuous power supply systems for industrial applications.
11. Use of accumulation technologies to improve the stability of RES systems and the electricity grid in general.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	*Face-to-face* lectures and presentations.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• Teaching using ICT, • Learning process support through the course website (study aids - notes, exercises, solved exam topics), • Demonstration of computer simulations using computer tools (HOMER, etc), • Communication with students through email and the course website
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Teaching is organized in lectures, exercises / work and study:

Δραστηριότητα	***Φόρτος Εργασίας Εξαμήνου***
Lectures	60
Study of the material of the lectures - solution of exercises	45
Project preparation and presentation	45
Study and preparation for the exams	30
Total Course	**120**

STUDENT PERFORMANCE EVALUATION	Evaluation Language : Greek

Description of the evaluation procedure *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Assessment is made through optional assignments assigned to students during the semester with 30% of the total grade and with a written final exam in Greek that includes comprehension or development questions and solving exercises with 70% of the total grade.

5. ATTACHED BIBLIOGRAPHY

1. N. Kouloumpi, "Electrochemistry", SYMEON publications, Athens, 2005.
2. N. Markopoulou, "Introduction to Electrochemistry", University Studio Press, Thessaloniki, 2002.
3. N. Kyratzi, "Introduction to Electrochemistry", Ziti publications, 2005.
4. N. Andritsos, "Energy and Environment", Teaching Notes, University of Thessaly, Department of Mechanical Engineering, 2008.
5. R. Baxter “Energy storage”, Ed. Pennwell books, 2006.
6. G. Vokas, "ENERGY STORAGE AND SAVING - ACCUMULATORS", Funds for Storage and Production of Energy from RES text of the Postgraduate Program TEI Piraeus- OREN Univ., Jun 2002.
7. G. Vokas, "STORAGE AND SAVING OF ENERGY - AUTONOMOUS PV SYSTEMS AND ACCUMULATION", Funds for Storage and Production of Energy from RES textbook of the Postgraduate Studies Program TEI of Piraeus - OREN Univ., June 2002.D. Linden, Th. Reddy Th., “Handbook of batteries”, 3rd ed., McGraw-Hill, 2002.
8. V.S. Bagotsky, A.M. Skundin, Y.M. Volfkovich, “Electrochemical Power Sources. Fuel Cells and Supercapacitors”, John Wiley & Sons Inc, The Electrochemical Society Series ECS, 2015.
9. J. Larminie, A. Dicks, “Fuel cell systems explained”, 2nd ed., John Wiley & Sons Ltd, 2003.
10. C. Spiegel, “Designing and Building Fuel Cells”, Mc Graw Hill, 2007.
11. Bei Gou, Woon Ki Na, Bill Diong, “Fuel Cells. Modeling, Control and Applications”, CRC Press, 2010.
12. V.S. Bagotsky, “Fuel Cells. Problems and Solutions”, 2nd ed., John Wiley & Sons Inc, The Electrochemical Society Series ECS, 2012.
13. C. Vincent, B. Scrosati, “Modern batteries: An introduction to electrochemical power sources”, Edward Arnold Publishers, 1997.