COURSE OUTLINE

SMART ENERGY GRIDS & DISTRIBUTED GENERATION

1. GENERAL

SCHOOL	**ENGINEERING SCHOOL**		
DEPARTMENT	**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**EEE.9-1.9**	**SEMESTER**	**9th**
COURSE TITLE	**SMART ENERGY GRIDS & DISTRIBUTED GENERATION**		

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/EEE321/

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 aim of the course is to introduce the students to the field of Smart/Intelligent Energy Grids (SEG) integrating Distributed Generation Units (DGs), transmit the various techniques of design, calculation and application study of DG Units in SEG mainly at the level of Distribution Power Network (Medium Voltage-MV and Low Voltage-LV), as well as contribute to the understanding of the advantages of using the DG Units (their coordinated control) in Smart Grids (SG) with emphasis on Microgrids (MGs) which are its main part. In addition, the analysis of individual key issues of SEGs related to smart meters, the

telecommunications infrastructure required for its implementation as well as the processing of information data are also included in the above objectives.

Students who have successfully completed the course are expected to:

1. Know, name, describe and classify the modern and innovative application fields of Distributed Generation (DG) Units (e.g., RES, Fuel Cells, Microturbines, Cogeneration Systems - CHP, Electric Cars-EVs etc.).
2. Know all the basic calculations to present a complete application study of any Distributed Generation Unit.
3. Use tools for calculating the expected power output of DGs Units and know optimization methodologies and techniques of DGs.
4. Understand and explain the basic terms and importance of a Power System Grid integrating various DG Units.
5. Demonstrate technical skills, adopt innovative solutions, and develop new knowledge in Intelligent DG incorporating knowledge from the various fields of RES, mCHPs, Electronic Powers, Energy Storage Devices, etc.
6. Know, describe by drawing a block diagram and explain the operation of the basic part of a Smart Grid (SG) and a Microgrid (MG); quantify its technical, operational, economic, and environmental advantages.
7. Know, understand, and explain the concept of a smart grid; identify the telecommunication infrastructure needed for its operation; identify and classify smart metering devices of various DGs technologies and discuss their relative merits.
8. Have the ability of SG modeling and know the various software for this purpose.
9. Understand the necessity of Digitization in the modern energy era.

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 developing the following capabilities:

1. Search, analysis and synthesis of data and information
2. Independent work
3. Teamwork
4. Promoting creative and inductive thinking
5. Respect of natural environment and understanding of the various environmental constraints associated with the penetration of DG Units under Smart Grid frame.

3. COURSE CONTENT

The subjects covered in the course are:

1. Distributed Generation Units (DGs)

2. Operation and Calculations Study in Various Energy Systems
   - Photovoltaics,
   - Wind,
   - Microturbines,
   - Hydrogen Fuel Cells,
   - Small Hydroelectric Power Plants,
   - High Efficiency Combined Heat and Power Units,
   - Geothermal Energy Systems,
   - Biomass, Solar Thermal Systems,
   - Electric Vehicles,
   - Hybrid and Storage Units (e.g. Pumped Storage).
3. Study for the combined use of DGs Units in a Smart Energy Grid.
4. Analysis of basic structures and presentation of basic tools of a Smart Grid.
5. Technical, Operational, Economic and Environmental characteristics of a Microgrid as a basic structure of a SEG.

More specifically, the modules of the course are:

1 INTRODUCTION TO ELECTRICAL POWER SYSTEMS

- Introduction: Basic Principles
- Electric Industry Structure
- Modern Power System: Generation-Transmission-Distribution-Loads
- Reliability, Protection and Control of Power Systems
- Stability and Power Load Flow Analysis
- The system of SCADA: Supervisory Control and Data Acquisition
- Power System and Liberalization Market
- Environmental Policies in Power System

2 DISTRIBUTED ENERGY RESOURCES (DER TECHNOLOGIES)

- Modern Power Systems and Technologies of Distributed Generation
- Renewable Energy Sources (RES)
  - Small scale hydro generation and Hybrid Pumped Storage Units
  - Wind Power Plants
  - Offshore Wind Energy
  - Solar Photovoltaic Generation and Thermal Power Plant (CSP)
  - Biomass Power Plants
  - Geothermal Power Plants
  - Examples of integrating RES applications in the grid through power electronics
- Microturbines
- High Efficiency Micro Combined Heat and Power Plant (mCHP)
- Hydrogen Fuel Cell
- Electric Vehicles
- Storage Systems

3 PENETRATION OF DGs UNITS IN POWER SYSTEMS

- Integration of DGs Units in Distribution Network – Penetration Limits
- Modern Power Electronics for DGs Applications – Examples
- Technical restrictions and prerequisites. Existing analysis methodologies
- Protection of DGs

- Economics of DGs – Legal, Pricing and Financing framework for DG units
- Active Power Network - Microgrids

4 MICROGRIDS AS A BASIC PART OF SMART ENERGY GRIDS

- Introduction to Microgrids – Coordinated Control of DGs
- Operational Framework of Microgrids
    - Distribution Management System (DMS)
    - Microgrid System Central Controller (MGCC)
    - Local Controllers (LC)
- Technical, Economic, Environmental, and Operational benefits of Microgrids due to High Penetration of DGs Units in a Distribution Power Network
- Demand Response Management in Microgrids
- Business Models and Pricing Mechanisms/Policies in Microgrids – Participation in Energy Market
- Microgrids and Smart Grids

5 SMART GRIDS

- Introduction to Smart Grids (SG)
- Factors affecting the Growth of SG
- The global reality in the field of SGs and Transition into Future Grids
- Smart Agents
- Electronics and Communications Infrastructure in SG
- ICT Technologies
- The need of using Smart Meters
    - Description and Definition of Metering Infrastructures
    - Metering Equipment
    - Communication of Metering Equipment - Protocols
    - Metering Data Management Systems (MDMS)
- Interconnections Issues between SGs
- Active Consumers (Prosumers) in SGs
- Application of SGs in Europe and Digitalization in Modern Energy Era

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.*	The teaching is organized in lectures, exercises / works, and study:

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*	<table><tr><th>*Activity*</th><th>*Semester Course Load*</th></tr><tr><td>Lectures</td><td>45</td></tr><tr><td>Study of the material of the lectures - solution of exercises</td><td>45</td></tr><tr><td>Study and preparation for the exams</td><td>30</td></tr><tr><td>**Total Course Load**</td><td>**120**</td></tr></table>
STUDENT PERFORMANCE EVALUATION *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.*	Written final examination on the theoretical part of the course that includes solving exercises and problems of graded difficulty. Each query lists the units being evaluated. The syllabus of the course is announced at the beginning of the semester on the course's website and students can have any relevant book during the examination. Optionally and in cooperation with the teacher of the course, work with a weight of 20% can be performed. ***Theory*** The grade of the mixed course is obtained: 80% x Degree of theory + 20% x Grade of Semi-monthly work (optional)

5. ATTACHED BIBLIOGRAPHY

1. **Anastasiadis Anestis – Vokas Georgios**., «*Lectures Notes*», 2020.
2. **N. Hatziargyriou**, "*Microgrids: Architectures and Control*", Wiley-IEEE Press, 1st Edition, 2014.
3. **Bernd M. Buchholz, Zbigniew Styczynski**, "*Smart Grids – Fundamentals and Technologies in Electricity Networks*", Springer Heidelberg New York Dordrecht London, 2014.
4. **N. Jenkins, R. Allan, P. Crossley, D. Kirschen and G. Strbac**, "*Embedded Generation*," London: The Institution of Electrical Engineers (IEE), 2000.
5. **H. A. Gil and G. Joos**, "*Models for Quantifying the Economic Benefits of Distributed Generation*," IEEE Transactions on Power Systems, vol. 23, no. 2, May 2008.
6. **R. Lasseter, A. Akhil, C. Marnay, J. Stephens, J. Dagle, R. Guttromson, A. Meliopoulos, R. Yinger and J. Eto**, "*White Paper on Integration of Distributed Energy Resources. The CERTS MicroGrid Concept*", Consortium for Electric Reliability Technology Solutions (CERTS), CA, Tech. Rep. LBNL-50829, Apr. 2002.
7. **"MORE MICROGRIDS** – *Advanced Architectures and Control Concepts for More Microgrids*", EU Contract No: SES6 -019864, Technical Annex, January 2006.
8. **Polyzakis Apostolos** "*Energy, Environment and Sustainable Growth*", 1st Edition, Power Heat Cool, 2019 (www.powerheatcool.gr).
9. **Flávia de Andrade, Miguel Castilla, Benedito Donizeti Bonatto**, "*Basic Tutorial on Simulation of Microgrids Control Using MATLAB® & Simulink® Software*", Springer SpringerBriefs in Energy, ISBN 978-3-030-43013-9 (eBook), 2020 / https://doi.org/10.1007/978-3-030-43013-9