MEE510 Sustainable Energy Resources

Course Title	Sustainable Energy Resources				
Course Code	MEE 510				
Course Type	Compulsory				
Level	Masters (2nd Level)				
Year / Semester	1st year / Fall Semester				
Teacher's Name	Dr.-Ing. Paris A. Fokaides, Dr. Nicholas Christofides				
ECTS	10	Lectures / week	3	Laboratories/week	0
Course Purpose	In the history of mankind renewable energies have for a long time been the primary possibility of generating energy. This only changed with industrial revolution when lignite and hard coal became increasingly more important. Later on, also crude oil gained importance. Offering the advantages of easy transportation and processing also as a raw material, crude oil has become one of the prime energy carriers applied today. Moreover, natural gas used for space heating and power provision as well as a transportation fuel has become increasingly important, as it is abundantly available and only requires low investments in terms of energy conversion facilities. Yet, the utilisation of fossil energy carriers involves a series of undesirable side effects which are less and less tolerated by industrialised societies increasingly sensitised to possible environmental and climate effects at the beginning of the 21st century. Against this background, this course aims at presenting the physical and technical principles of the main possibilities of utilising fossil and renewable energies. In this context, firstly the main characteristics of the available energy streams are outlined. Subsequently, the technologies of heat provision from passive and active solar systems, ambient air, shallow geothermal energy as well as energy from biomass, deep geothermal sources are presented. Also the processes of electricity generation from solar radiation (photovoltaic and solar thermal power plant technologies), wind energy, hydropower and geothermal energy are addressed. For the main possibilities of renewable energies utilisation, in addition, parameters and data are provided which allow for an economic and environmental assessment of the discussed options. The assessment thus enables a better judgment of the possibilities and limits of the various options of utilising renewable sources of energy..				
Learning Outcomes	By the end of the course, students must be able to: 1. Analyze methodological approaches with regard to the key figures, which are characteristic for the individual sustainable energy resources application 2. Describe most important technologies for exploiting fossil energy carriers for the provision of heat and electricity 3. Demonstrate the main characteristics of renewable and fossil energy resources 4. Distinguish between passive and active solar thermal systems 5. Assess the utilization of passive solar energy by the use of the building envelope as absorber 6. Design simple solar thermal systems for domestic hot water and space heating with the use of flat plate collectors 7. List the main technologies for power production using concentrated solar panels 8. Analyze the main technical properties of photovoltaic systems and design a small-scale grid connected system 9. Evaluate alternative utilization routes for biomass to biofuel conversion 10. Calculate the wind potential of selected sites and the energy yield based on given wind turbine power curves 11. Describe the operation of a shallow geothermal system and the operation of a ground coupled heat pump				
Prerequisites	Prior taught experience on energy resources issues or instructor's approval			Corequisites	None
Course Content	**1. Introduction** - Energy system - Energy terms				

- Energy consumption
- Applications of renewable energies
- Conventional energy provision systems
- Power generation technologies
- Heat provision technologies

2. Basics of Renewable Energy Supply

- Energy balance of the earth
- Renewable energy sources
- Balance of energy flows
- Solar radiation
- Wind energy
- Run-of-river and reservoir water supply
- Photosynthetically fixed energy
- Geothermal energy.

3 Utilisation of Passive Solar Energy

- Principles
- Technical description.
- Definitions
- System components
- Functional systems

4 Solar Thermal Heat Utilisation

- Principles
- Technical description
- Collectors
- Collector components
- Further system elements
- Heat store
- Energy conversion chain and losses
- System design concepts
- Applications
- Economic and environmental analysis

5 Solar Thermal Power Plants

- Principles
- Solar tower power stations
- Parabolic trough power plants
- Dish/Stirling systems
- Solar updraft tower power plant
- Solar pond power plants

6. Photovoltaic Power Generation

- Principles
- Energy gap
- Conductors, semiconductors and insulators
- Photovoltaic effect
- Technical description
- Photovoltaic cell and module
- Further system components
- Grid-independent systems
- Grid-connected systems
- Economic and environmental analysis

7. Biomass Utilization

- Principles
- Biomass Resources
- Biochemical and thermochemical biomass to biofuels conversion routes
- Mechanical biomass to biofuels conversion routes
- Technical description
- Biomass boilers and combustors
- Further system components
- Space heating systems

	- Industrial heating systems - Biogas power generation systems - Biofuels in the transportation sector - Economic and environmental analysis **8. Wind Power Generation** - Principles - Technical description - Wind turbine design - System elements - Rotor, Gearbox, Generator - Wind direction yaw mechanism - Energy conversion chain, losses and characteristic power curve - Wind parks - Grid-independent applications - Economic and environmental analysis **9 Hydroelectric Power Generation** - Principles - Technical description - Schematic layout - Categorisation and construction types - Low-head plants - System components - Isolated and grid operation - Energy conversion chain, losses, and power curve - Economic and environmental analysis **10. Utilisation of Ambient Air and Shallow Geothermal Energy** - Principles - Heat pump principle - Technical description - Heat source systems for shallow geothermal energy utilisation - Closed systems - Open systems - Heat pump - System configurations - Economic and environmental analysis
Teaching Methodology	The teaching methodology of this course will be based on lecturing, demonstrating and collaborating. - Lecture notes, comprising of the fundamentals of each module of the course will be prepared and presented in class on a weekly basis. The notes will introduce the major concepts and will focus on specific learning outcomes of the course. - Demonstration activities including the solution of worked examples in class on a weekly basis, as well as laboratorial work will also be employed. For each fundamental concept, at least one worked example will be solved during lectures. The laboratory work will cover all major topics of the course, allowing the students to personally relate to the presented knowledge. - Collaborating teaching through classroom discussion and debriefing will also be encouraged during lectures. Besides from the notes taken by students in class, all of the course material will be made available through the class website and also through the eLearning platform. The instructor will also be available to students during office hours or by appointment in order to provide any necessary tutoring.
Bibliography	**Textbook:** Kaltschmitt, M., Streicher, W., & Wiese, A. (Eds.). (2007). Renewable energy: technology, economics and environment. Springer Science & Business Media. **References:** 1. Electric Machinery Fundamentals, 5 edition, Stephen J. Chapman, McGraw Hill, 2011

	2. K. Mertens, Photovoltaics: Fundamentals, Technology and Practice, Wiley-Blackwell, 2014 3. K. Mertens, Photovoltaics: Fundamentals, Technology and Practice, Wiley-Blackwell, 2014 4. Solar Energy International, Photovoltaics: Design and Installation Manual, New Society Publishers, 2004
Assessment	Students will be assessed through: - A midterm test at the 7th week of the course - A personal assignment which will be handed out at the beginning of the semester (week 2) and will be collected by completion of semester (week 12). - A final test at the end of the semester, in which all material will be examined. The weights of the course assessment are as follows: Assignment: 20% Midterm Exams: 20% Final Exams: 60%
Language	English