## AEEE457 - Renewable Energy Sources

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| Course Title | Renewable Energy Sources | | | | |
| Course Code | AEEE457 | | | | |
| Course Type | Technical Elective | | | | |
| Level | BSc (Level 4) | | | | |
| Year / Semester | 4th (Spring) | | | | |
| Teacher's Name | Assoc. Prof. Antonis Papadakis | | | | |
| ECTS | 6 | Lectures / week | 3 | Laboratories/week | 0 |
| Course Purpose | The aim of the course is to familiarize the students with the concepts and the principles of renewable energy sources. Specifically, we discuss the most popular and widely used renewable technologies in Cyprus that of solar cells and wind turbines. Additionally, we introduce briefly the fusion reaction process which is expected to be a game changing renewable energy technology of the future. | | | | |
| Learning Outcomes | By the end of the course, students must be able to:<br>1. Explain the basic concepts behind available renewable energy sources, and their impact on the environment and economy markets.<br>2. Describe the different existing silicon and non-silicon based photovoltaic technologies and identify future disruptive technologies.<br>3. Describe the advantages and disadvantages of solar photovoltaics<br>4. Summarize the solar cell timeline development<br>5. Compare crystallinity and efficiency in solar cells (monocrystalline, polycrystalline and amorphous)<br>6. Describe thin film solar cell operation<br>7. Describe the structure of a PV cell and a PV module<br>8. Calculate the cost and payback time in Cyprus and abroad<br>9. Electromagnetic spectrum, frequency, energy and luminosity<br>10. Comprehend the photovoltaic generation phenomenon<br>11. Understand concepts of Fermi level, conduction band, valence band, the doping process. | | | | |

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| | 12. Draw the current-voltage characteristics, maximum power point tracking and variable resistance<br>13. Arrays, panels, difference between off-grid and on-grid photovoltaics<br>14. Describe certifications of solar panel modules and typical specifications<br>15. Explain the wind resource<br>16. Calculate the power and energy in the wind<br>17. Draw the Weibull distribution and explain its use<br>18. Discuss typical values of the power wind turbine coefficient<br>19. Compare pitch and stall-controlled wind turbines<br>20. Design wind parks and turbine placement<br>21. Proof Linear Momentum Theory including interference factor and tip speed ratio<br>22. Describe the advantages and disadvantages between small and large wind turbines<br>23. Comprehend Reynolds number and laminar and turbulent flows<br>24. Describe the different parts of a horizontal wind turbine<br>25. Explain the Bentz limit and typical efficiencies of wind turbines<br>26. Explain wind turbine operational principles and the various existing technologies.<br>27. Examine fusion principles and fundamentals, as well as current and future fusion experiments worldwide.<br>28. Distinguish differences between cold and hot fusion<br>29. Design a Tokamak reactor (toroidal and poloidal fields) and explain the plasma gas heating<br>30. Describe the strong and electrostatic force effect in fusion reactions<br>31. Describe the Lawson criterion<br>32. Comprehend the advantages and disadvantages of fusion reaction | | |
| Prerequisites | None | Corequisites | None |
| Course Content | **Introduction to Renewable Energy Sources:** Renewable Energy Sources, impact on the environment and the economy markets.<br>**Solar Energy:** Various Photovoltaic technologies, such as silicon or non-silicon based, the existing generations of PV, as well as the emerging | | |

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| | technologies of thin film and concentrate Various Photovoltaic technologies, such as silicon or non-silicon based. Three existing generations of PV, various categories of silicon-based PVs, which are monocrystalline, polycrystalline, ribbon and sheet, and amorphous silicon, as well as the emerging technology of thin film and concentrated PVs, market analysis of the aforesaid past and present technologies, including price evolution, factory capacity evolution at different countries, installation facilities, and external factors affecting the PV industry, such as the silicon crisis, oil prices, and exchange rates, comparison between current and future technologies, future prospects of going beyond silicon, using non-silicon thin film solar cells of type CIGS.<br>**Wind Energy:** Basic systems of wind turbines such as mechanical and aerodynamics systems, connection possibilities of Grid Connected Wind Farms to High Voltage, Medium Voltage and Low Voltage networks, aerodynamic control (Stall) and step control (pitch), constant and variable speed operation, inverters, existing wind turbine technologies investigated in terms of cost, reliability and practicality.<br>**Fusion Energy**: General principles of fusion reaction, Electromagnetic and Inertia Confinement, Tokamaks (ITER, JET, JT-60, EAST, MAST, ALCATOR C-Mod), Lawson criterion, Incentives for Developing Fusion, Advantages and Disadvantages of Fusion Energy. |
| Teaching Methodology | Students are taught the course through lectures (3 hours per week) in classrooms or lectures theatres, by means of traditional tools or using computer demonstration.<br>Auditory exercises, where examples regarding matter represented at the lectures, are solved and further, questions related to particular open-ended topic issues are compiled by the students and answered, during the lecture or assigned as homework.<br>Topic notes are compiled by students, during the lecture which serve to cover the main issues under consideration and can also be downloaded from the e-learning platform or the lecturer's webpage. Students are also advised to use the subject's textbook or reference books for further reading and practice in solving related exercises. Tutorial problems are also submitted as homework and these are solved during lectures or privately during lecturer's office hours.<br>Teaching is based on lectures.<br>The course delivery will be based on theoretical lecturing, assignments and exercises solved in class. Exercises will be handed to students and their solutions shall be analysed at lecture periods. Additional tutorial time at the end of each lecture will be provided to students. Students are expected to demonstrate the necessary effort to become confident with the different concepts and topics of the course. |
| Bibliography | **(a)<u>Textbooks:</u>**<br>• John Twidell, and Tony Weir, ***Renewable Energy Resources***, Taylor & Francis, 3rd Edition, 2015.<br>**(b)<u>References:</u>** |

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| | • B. Sharpe, ***Wind Energy Handbook***, 2nd Edition, John Wiley & Sons, 2011.<br>• M. Rogers, ***Wind Energy Explained***, 2nd Edition, John Wiley & Sons, 2010.<br>• T. Ackermann, ***Wind Power in Power Systems***, 2nd Edition, John Wiley & Sons, 2012.<br>• J. P. Freidberg, ***Plasma Physics and Fusion Energy***, Cambridge University Press, 2007.<br>• A.A.Harms, ***Principles of Fusion Energy: An Introduction to Fusion Energy for Students of Science and Engineering***, World Scientific Publishing, 2005.<br>• M.A. Green, ***Third Generation Photovoltaics: Advanced Solar Energy Conversion***, Springer Verlag, 2013.<br>• V.P. Koch, R. Hezel, and A. Goetzberger, ***High-Efficient Low-Cost Photovoltaics: Recent Developments***, Springer Verlag, 2008. |
| Assessment | The students are assessed via continuous assessment throughout the duration of the Semester, which forms the Coursework grade and the final written exam. The coursework and the final exam grades are weighted 40% and 60%, respectively, and compose the final grade of the course.<br>Various approaches are used for the continuous assessment of the students, such as mid-term written exam and assignments. The assessment weight, date and time of each type of continuous assessment is being set at the beginning of the semester via the course outline. An indicative weighted continuous assessment of the course is shown below:<br>• Assignments 30%<br>• Mid-Term written exams 70%<br>Students are prepared for final exam, by revision on the matter taught, problem solving and concept testing and are also trained to be able to deal with time constrains and revision timetable.<br>The criteria considered for the assessment of each type of the continuous assessment and the final exam of the course are: (i) the comprehension of the fundamental concepts and theory of each topic, (ii) the application of the theory in solving related problems and (iii) the ability to apply the above knowledge in more complex design problems. The final assessment of the students is formative and summative and is assured to comply with the subject's expected learning outcomes and the quality of the course. |
| Language | **English** |