| *Code* | *Title* |
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| 4.1 | **Renewable energy technologies and decentralization of energy production** |
| *ECTS/Credits* | *Language* |
| Up to 12 ECTS | English |

| *Specific teaching Objectives of the course/Learning outcomes (Dublin Descriptors )* |
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| *a. Knowledge and Understanding* |
| At the end of the course, students should be able to:<br>1. Understand the basics of renewable sources of energy and relevant technologies;<br>2. Understand the role of energy in sustainable development;<br>3. Appreciate the trends of renewable energy in the global and national energy mix, and the environmental impacts;<br>4. Understand the importance and pivotal role of decentralisation of energy systems towards attaining energy security and access to clean energy. |
| *b. Applying knowledge and understanding* |
| At the end of the course, students should be able to:<br>1. Appreciation of the abundance of renewable energy resources and their energy potential;<br>2. Select the best renewable technologies as solution for a specific energy problem;<br>3. Utilise and allocate the renewable energy resources;<br>4. Estimate the practical functionality of electricity decentralisation, challenges and opportunities. |
| *c. Making Judgements* |
| At the end of the course, students should be able to:<br>1. Compare different renewable energy technologies;<br>2. Choose the most appropriate based on local conditions;<br>3. Exam the environmental implications of the different forms of energy;<br>4. Discuss how to utilize local energy resources (renewable and non-renewable) to achieve the Renewable Energy system. |
| *d. Communication skills* |
| At the end of the course, students should be able to:<br>1. Describe the various types of renewable energy;<br>2. Explain the technological basis for harnessing renewable energy sources;<br>3. Make presentations of modelled scenarios in group/project assignments. |
| *e. Learning skills* |
| At the end of the course, students should be able to:<br>1. Enhance learning skills through application of knowledge attained in case studies, projects work assignments. |

| *Main topics* | | | |
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| | **Estimated number of hours** | | |
| | **Lectures** | **Laboratory** | **Tutorial** |
| INTRODUCTION | | | |
| 1. Climate change and global energy dynamics.<br>2. Major energy options.<br>3. Definition of renewable source, renewable and conventional energies.<br>4. Environmental impacts associated with energy.<br>5. National and Global trends in the energy sector. | | | |
| CHAPTER 1 | | | |
| PHOTOVOLTAIC SYSTEM<br>1. Solar radiation, angles, solar diagram and shading.<br>2. The cell, the photoelectric effect. Electrical characteristics, nominal data.<br>3. Photovoltaic cells: first, second and third generation.<br>4. Inverter and electric connections.<br>5. Grid-Connected and Stand-Alone systems.<br>6. Switchboards, fuse string diodes, electric connections.<br>7. National regulations, norms and incentives.<br>8. Design of Photovoltaic plants. Evaluation of the economical sustainability. | | | |
| CHAPTER 2 | | | |
| THERMAL SOLAR COLLECTORS<br>1. Solar radiation, efficiency, main components.<br>2. Small systems, configurations, collectors, heat accumulators, solar circuit and controllers.<br>3. Solar collectors for hot water and heating. Main solutions and configurations for low temperature applications.<br>4. Medium / high enthalpy plants.<br>5. Conditioning: Solar cooling<br>6. Solar Concentrators: parabolic, Fresnel, solar towers, etc<br>7. National regulations, norms and incentives.<br>8. Software for Sizing and productivity calculation. | | | |
| CHAPTER 3 | | | |
| BIOMASS and BIOENERGY<br>1. Definition and characterization of biomass.<br>2. Thermo-chemical and Biochemical conversion processes.<br>3. Thermo-chemical systems<br>4. Biochemical systems and biofuels<br>5. urban waste: energy production and management;<br>6. Drivers of biomass development and application, | | | |

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| challenges and barriers. Trends in biomass energy utilisation;<br>7. Economics of biomass. | | | |
| CHAPTER 4 | | | |
| WIND ENERGY<br>1. Global trends and wind energy potential<br>2. Wind source, site, measurement, onshore and offshore turbines<br>3. Theoretical limit of the efficiency<br>4. Coefficients of performance of a turbine (Cp, Cs, λ)<br>5. Aerodynamic Theory applied to a blade's section<br>6. Components of a wind turbine (blades, hub, shaft, gearbox, electric generator, brakes, yaw<br>7. System, towers, foundations, control system)<br>8. Sizing of a wind turbine: simulation and modeling<br>9. Environmental impacts, market, policies, IEC standard and certification. | | | |
| CHAPTER 5 | | | |
| OTHER RENEWABLE ENERGIES<br>HYDRO<br>1. The hydro resource in the Countries, exploitation, flow and leap assessment<br>2. Specific number of revolutions and classification of turbines: Kaplan, Pelton and Francis<br>3. Classification of Hydro energy plants<br>4. Incentives and regulations.<br><br>GEOTHERMAL<br>1. Steam diagram in the thermodynamic planes<br>2. Exploitation of geothermal energy. Classification of geothermal systems: low, medium and high enthalpy<br>3. High enthalpy geothermal plants: conventional plants and binary plants<br>4. Medium and low enthalpy geothermal systems: direct uses. Heat pumps. Geothermal probes and type of plants.<br><br>OPTIONAL:<br>TIDAL and WAVEs<br>1. Wave Energy Conversion (WEC)<br>2. Tidal streams Energy Conversion (TEC)<br>3. Emerging solution: Ocean Thermal Energy Conversion (OTEC), Salinity Gradient | | | |
| CHAPTER 6 | | | |

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| ELECTRICITY DECENTRALISATION<br>1. Definition of electricity decentralisation<br>2. Factors to consider<br>3. Types of Decentralisation: traditional and renewable electrical transmission and distribution<br>4. Power network stability, management and control<br>5. Integration of renewable energy generation<br>6. Challenges and opportunities associated with integration of renewable energy generation onto the network. | | | | |

| *Course description* |
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| This course will give a strong understanding of the renewable energy and technologies highlighting the working principles of solar PV and thermal, hydro, biomass, wind as well as other renewable energy sources that can be developed in Uganda and Tanzania. Also, appreciation of the local context in relation to the renewable energies, reflecting on the current status and intended future projects will be handled here, giving an understanding of the available resources and energy production phase.<br>It will further focus on power systems, their operation and control and particularly to the integration and distribution of renewable energy grid or stand-alone decentralized systems (mini grids) applications in Tanzania and Uganda. The content will emphasize on technical aspects of traditional and renewable electrical power generation, power transmission and distribution, power network stability, management and control, electricity market operations and smart grid technologies with particular emphasis on the integration of renewable generation onto the network at both transmission and distribution level and the challenges and opportunities associated with that. A solid basis in the understanding of future power networks with distributed generation, storage and smart grid technology will be given. |