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Deliverable Title	***Selection of Pilot Courses and Labs***		
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The MUREE project foresees the development and implementation of a new national undergraduate degree programme in renewable energy (RE) in the Jordanian universities, according with EU practices. The undergraduate degree has been elaborated following the suggestions of the report on the scoping and needs analysis, carried out in the WP1, but also evaluating the internal potential of Jordanian universities in term of state-of-art of courses on renewable energies, laboratories, internal didactic proposals.
On the base of the results of needs analysis, and the discussions during the workshop was held at TUG particularly to update the curricula and study plans and select the pilot courses, a new Study Plan has been elaborated. The attached report entitled: “Selection of Pilot Courses and Labs” has been elaborated which includes information on selected courses (credits, prerequisites, list of contents, text books and notes), the adopted methodology for the elaboration of didactic materials, the list of equipment for the Traditional Laboratory and the Remote Laboratory and a hypothesis of Action plan. The Report includes also the Form “Annex I” for the request of accreditation.
As the main objective of the project is to update, improve and deliver the content of 6 state-of-the art courses and adapt to add value to existing programme at universities in Jordan, the contents of each course are summarized in the description reported below:

• **Energy Conversion**: Energy classification, resources and utilization; Principal fuels for energy conversion; Production of thermal energy; Fossil fuel systems; Environmental impact of power plant operation; Production of electrical energy (by direct energy conversion); Wind energy; Solar energy; geothermal energy; Energy storage and conservation.
• **Solar-Thermal Energy**: This course provides the student with an introduction to state of the art solar thermal technologies, their advantages and shortcomings as well as their implementation fields and potentials. An overview of the individual components, forming the solar thermal systems as well as an explanation of their design and function will be provided. These components include solar collectors, solar storage units, circulation pumps, valves, expansion tanks etc. Students are provided with information on quality criteria and are made familiar with the criteria important for selecting individual components or whole systems.
• **Wind Energy**: Students will be expected to develop the following skills/understanding upon the successful completion of the course:
1. Distinguish and understand the different types of wind turbines and their main components
2. Understand and characterise wind energy resources assessment at different sites
3. Understand and analyse the aerodynamics of wind turbines
4. Understand and estimate the performance of wind energy conversion systems
5. Understand the electrical aspects of wind turbines including control systems
6. Understand and carry out economic aspects of wind energy conversion systems

• **Drives and Machines**: The course introduces students to the fundamentals of electrical drives; it starts with a review of fundamentals regarding the electric machines, Electromagnetic theory and power electronic devices and converters. The construction, operation, circuit models and performance characteristics of AC & DC machines are revisited. As well, the course will include a review for power electronics basic converters, basic theory and device characteristics and capabilities. Basic inverter system, VSI and modulation techniques are clarified. Also, the adjustable speed drives of DC machines are explained with a review of the torque and speed control of DC machines. The scalar control using the constant V/Hz for induction motor drives based on steady-state per-phase equivalent circuit is discussed. These include the slip-compensation, current controlled, open loop and closed loop structures of constant V/Hz scheme. Furthermore, the dynamic modeling of induction machine is introduced. Using the dynamic model, the high-performance induction motor control schemes such as the field-oriented control and the direct torque control. Finally, the synchronous machine control is presented with emphasis on the PM machines.
• **Photovoltaic** (E-Learning format): The course in Photovoltaic Systems will outline the significance of Photovoltaic renewable energy technologies and in particular introduce students to aspects of photovoltaic technology. An important aim of the course is to equip participants with a basic understanding of the physical and operational aspects of Photovoltaic cells. Furthermore, the course will introduce important fundamental topics and concepts in photovoltaic system engineering, design, sizing and component specifications, as well as show how photovoltaic technologies are evolving and are being employed worldwide.
• **Renewable Energy Systems** (E-Learning format): This course is an introductory course to last-year students in field of Mechatronics, Mechanical, Electrical, and industrial Engineering. The main aim of this course is to cover topics in solar thermal, photovoltaic, wind, biomass/fuel, hydropower and geothermal systems. In each topic, main components and theory are explained. Furthermore, design concepts for solar thermal, photovoltaic and

wind systems are discussed. Economics feasibility of these systems and a comparison between them is addressed. Software packages for design and economic feasibility are incorporated in this course.
The content of the 2 traditional labs to be installed at PSUT was also selected in a way to demonstrate, explain and relate the link between the renewable energy and the actual electric power systems and machines. Being able to demonstrate the fundamental characteristics and capabilities of the power electronics devices, allows the student to understand the operation of the converters used to integrate between the renewable energy sources and the power systems, contributing into a better understanding of what so called the 'Smart Grid', as well the use of these converter devices for efficient driving and controlling of the electric motors and generators.
The equipment to be purchased and topics to be covered for the electric machines and power electronics lab space, in order to achieve the desired objectives above:

- Performance Characteristics of Motors
    - Single phase induction motor
    - Three-Phase induction motor
    - Reluctance motor
- Power Electronics Converters
    - DC Choppers.
    - AC inverters.
    - Frequency Converters
    - Servo-Drives

Investigating the characteristics, and operational states of power systems that integrate renewable energy with conventional generation methods and its transmission and distribution as well. Furthermore, determination of the different power systems parameters of transmission lines and substations of the grid associated with the power quality metering standards. The labs will explain and demonstrate some modern energy management systems making use of SCADA systems and smart energy metering devices. Also, it will introduce students to the coordination and communication between the protective equipment installed over the 'Smart Grid', as well as the fundamental characteristics of this protection equipment.
The equipment to be purchased and topics to be covered for the electric machines and power electronics lab space, in order to achieve the desired objectives above:

- Power systems & Protection:
    - Double bus bar systems characteristics.
    - Transmission lines parameters.
    - Smart Grid Software.
    - SCADA.
    - Power Protection Relays (Differential and Overcurrent)

The power systems laboratory will include transmission lines, substations models, we will be able to demonstrate a model of a smart grid, as will with the protection devices of that system.

Attachment

1. Report on "Selection of Pilot Courses and Labs"