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Deliverable Title	***Detailed Design of Pilot Courses***		
Author(s)	***All Consortium Members***		
Organisation Name(s)	***All Consortium Members***		
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The Detailed Design of Pilot Courses was discussed in a number of occasions including the Progress Meeting held at PSUT in the period 4-5 November 2013, in which the matter of developing the curriculum of the traditional courses and training for academic visits to Europe was discussed thoroughly. It was decided that Jordanian partners will provide EU partners with the initial study plan and content of the six selected courses as agreed upon in DEV2.2. Then the European partners will review the content, comment and make suggestions to improve and develop the content in final form. They will also have to add their contribution to the content so as to begin teaching the courses at Jordanian universities by the beginning of the academic year of 2014/2015. A list of the Jordanian staff who will be teaching the proposed courses and making the academic visits to EU partners has also been approved in final form during this progress meeting.
The main goal of the EU visits is to discuss the content of the courses with the EU partners in order to learn from their experience in designing and teaching such courses. What MUREE partners need from their EU partners is how to cooperate in “modernizing and updating” the curricula so that best practices in Europe can be transferred to Jordan in this vital field of Renewable Energy. It was also agreed that for each visit, there should be at least one student participant who should be selected according to a pre-defined criteria. The partners discussed

the criteria of choosing these students, including academic performance, command of English, and interest in the field and gender balance.

A special meeting was then held at Princess Sumaya University for Technology on 6 January 2014 to discuss again DEV2.3: *Detailed Design of Pilot Courses*, and curriculum updating the following courses according to DEV2.2: Selection of Pilot Courses and Labs:

1. Electric Machines and Drives
2. Energy Conversion
3. Renewable Energy Systems
4. Wind Energy
5. Photovoltaic (eLearning format)
6. Solar Thermal (eLearning format)

The following partners attended the meeting:

1. Abdallah Al-Zoubi, Issa Batarseh,Wejdan Abu-El-Haija, Ayman Faza, Majd Batarseh, Yazan Abu Yaghi, Ayman Qamoh, Mohammad Ashi, Mahmoud Suliman, Mohammad Salameh, Zain Dmour, Mahmoud Hassan, Rami Eleiwa, andAyesh Al-Omari, Princess Sumaya University for Technology (PSUT)
2. Ali Badian, Ahmad Sakhrieh, Osama Ayadi, Ahmad Salaymeh, University of Jordan (UoJ)
3. Qais Khasawaneh, Jordan University of Science and Technology (JUST)
4. Ayman Al-Maaitah, Mutah University (MU)
5. Mohammad Al-Abed, Bilal Atieh, Mohammad Saleh, Majdi Al-Omari, Awnai Tradat and Bashar Hammad, Hashemite University (HU)

The partners discussed again the issue of the design and content of the six proposed courses. The discussion commenced with a brief by Dr. Wejdan Abu El-Haija on the methodology she followed in the design of the Machines and Drives course. A thorough discussion was then followed including the definition of the concept of "Course Content and Material", and a template for course design was adopted. In addition, the partners discussed the need to distribute the course outlines amongst all partners that should include course title, description, prerequisites, objectives and learning outcomes, list of topics, text books, schedule, and grading system.

An action plan for each course was then discussed in order to speed up the process of the course development and design as shown in the table below.

Courses	Leader	Universities	Host and Date	Visiting Team
Energy Convention	UoJ, Sapienza	MUTAH, PSUT	Sapienza 2-8 February 2014	Ali Badran Ayman Qamoh
RE System	HU, Sapienza	PSUT, UoJ, MUTAH	Sapienza 2-8 February 2014	Bashar Hammad Osama Ayyadi Handri Ammary Mohammad Salameh
PV	HU, PSUT, UCY	UoJ, MUTAH, JUST	UCY 12-18 January 2014	Ayman Al-Maaitah Ahmed Al-Salaymeh Ayman Faza Mahmoud Hammad Qais Khasawneh Mohammad Al-Abed Mahmoud Hasan

Solar Thermal	MUTAH, TUB	UJ, JUST	TUB 15-21 June 2014	Ayman Maayita, Ahmad Sakhrieh Muntaser Hader
Wind Energy	JUST, TUB	HU	TUB 15-21 June 2014	Kiwan, Omari, Mohammad Hamdan Suhil Kiwan Majd Batarseh Ayman Al-Maaitah Majd Omari
Drive and Machines	PSUT, GUT	HU, JUST	GUT 2-8 February 2014	Wejdan Abu El-Haija Issa Batarseh Hussein Majali Mohammad Saadeh

The final form of course outline have consequently been prepared, approved and adopted for accreditation by partner universities as shown in Appendix 1.
The partners also discussed the need to invite the Higher Education Accreditation Commission to join the consortium and agreed that this would not necessary.

Appendix 1: Course Outlines

Course Title	***Electric Machines Drives***
Course Coordinator	***Professor Wejdan Abu-Elhaija***

I. Course Description

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 modelling 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.

II. Required Background or Experience

Prerequisites by Course:
1.Electric machines.
2.Power Electronics
3.Control Systems.
Prerequisites by Topic:
1.Electric Machines Fundamentals and Electromagnetic Field Theory.
2.Power Electronics, Device characteristics and capabilities, Inverter basics, Speed Drives Basics.
3.Machines control methods theory, Laplace Transform

III. Expected Outcomes

Students will be expected to develop the following skills/understanding upon the successful completion of the course. They will be able to:

1.Understand how three-phase voltages of variable frequency and magnitude can be generated using power electronic circuitry.

2.Understand and analyze the dynamic behavior of AC machines, including synchronous reluctance machines, permanent magnet machines, and induction machines.

3.Understand the different control algorithms used to regulate torque, speed, and/or position in variable speed drives.

4.Compare and contrast the performance of different AC machines in various variable-speed drive applications.

IV. Textbook(s) and Readings

1. Electric Drives: An integrative approach, Ned Mohan
2. Electric Motor Drives, R. Krishnan
3. Introduction to electric machines and drives, T.M. Jahns, T.A. Lipo and D.W. Novotny.

VII. Course Outline

The following topics will be covered in this course:

	Topics	**Number of Hours**
1	Introduction to Electric Drives; Motivation	3
2	DC Machines: Operation, Modelling and Speed Control	3
3	Review : AC Systems and Three-Phase Circuits	1
4	Induction Motor Review	1
5	Power Electronics : Basic Theory, Devices , AC Inverter Basics : VSI, PWM	7
6	Induction Motor Scalar Control Methods	5
7	Dynamic Model of Induction Machines	5
8	Field oriented control: Induction Motor	4
9	Induction Motor Direct Torque and Flux Control	4
10	Synchronous Machines: Steady state	6
14	Application-Specific Selection of Machine and Drive Systems	1

Course Title	***Energy Conversion***
Course Coordinator	***Ahmed Al-Salaymeh***

I. Course Description

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.

II. Required Background or Experience

Prerequisites by Course:

Thermodynamics-2

Prerequisites by Topic:
4.Basic thermodynamic concepts such as systems and properties; energy, work and heat.
5.Thermal power cycles.
6.Vapour and gas mixtures.
7.Chemical reactions of combustion.
8.Basics of fluid mechanics and heat transfer.
Postrequisites: None

III. Expected Outcomes

Students will be expected to develop the following skills/understanding upon the successful completion of the course. They will be able to:
1. Identify energy consumption and utilization features on the global, regional and local levels.
2. Predict energy consumption in a certain country given the growth rate is known.
3. Analyse and calculate energy costs for a certain power plant and find the breakeven point for that plant.
4. Figure out various properties, including the heating values for a mixture of gaseous, liquid and solid fuels.
5.Calculate theoretical and actual air/fuel ratios for the combustion of various kinds of fuels, especially coals, given their analysis are known.
6.Select basic draft systems for a power plant.
7.Estimate boiler efficiency.
8.Assess environmental impact of power plant operation.
9.Size a photovoltaic panel.
10. Select a solar collector.
11. Select a windmill.
12. Size an energy storage system.

IV. Textbook(s) and Readings

4.Principles of Energy Conversion, 2nd. Edition (1991), by Archi W. Culp, Jr., McGraw-Hill.
5.Solar Engineering of Thermal Processes, 2nd. Edition (1991), by John A. Duffie and William A. Beckman, Wiley Interscience.

VII. Course Outline

The following topics will be covered in this course:

	Topics	**Number of Hours**
1	Energy classification, resources and utilization	6
2	Principal fuels for energy conversion	6
3	Production of thermal energy	6
4	Fossil fuel systems	6
5	Environmental impact of power plant operation	6
6	Production of electrical energy (by direct energy conversion)	6
7	Wind energy	2
8	Solar energy	2
9	Geothermal energy	2
10	Energy storage and conservation	6

Course Title	***Renewable Energy systems***
Course Coordinator	***Bashar Hammad, Hashemite University***

I. Course Description

This course is an introductory course to last-year students in field of Mechanical, Electrical, Mechatronics and industrial Engineering. The main aim of this course is to cover topics in solar thermal, photovoltaic, wind, biomass/biofuel, 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.

II. Required Background or Experience

Prerequisites by Course:

1. Electronics I
2. Electric Machines
3. Thermo-fluids
4. Heat transfer
5. Chemistry

Prerequisites by Topic:

1. Semiconductor materials, Diodes
2. Electric generators and machines
3. Organic Chemistry
4. First law of thermodynamics
5. Conventional Power cycles

Postrequisites:

1.Advanced Renewable Energy

III. Expected Outcomes

Students will be expected to develop the following skills/understanding upon the successful completion of the course. They will be able to:

1. Appreciate the influence of renewable energy in modern societies
2. Describe components of a renewable energy system.
3. Design solar thermal systems.
4. Design photovoltaic systems (grid-connected and stand-alone).
5. Design wind systems.
6. Apply the fundamentals of renewable energy and applications.
7. Estimate the feasibility of a employing a renewable energy system.
8. Utilize state-of-the-art computer software, to design renewable systems and gain practical experience.

IV. Textbook(s) and Readings

1. Renewable Energy: Power for a Sustainable Future, Oxford University Press, by Godfrey Boyle.
2. Renewable Energy: A First Course, by Robert Ehrlich.

3. Renewable Energy: Physics, Engineering, Environmental Impacts, Economics & Planning, Academic Press, by Bent Sorensen.
4. Renewable and Efficient Electric Power Systems, by Gilbert M. Masters.

6.Electricity from Sunlight: An Introduction to Photovoltaics, by Paul A. Lynn.
7.Solar Engineering of Thermal Processes, John Wiley and Sons, by John A. Duffie and William A. Beckman.
8.Wind Energy Explained: Theory, Design and Application, by James F. Manwell, Jon G. McGowan and Anthony L. Rogers.
9.Biofuels, Solar and Wind as Renewable Energy Systems, Springer, by David Pimentel.

VII. Course Outline

The following topics will be covered in this course:

	Topics	***Number of Hours***
1	Introduction, Overview and Potential of Renewable Energy	2-3
2	Solar Thermal Energy	11-13
3	Photovoltaics	9-11
4	Wind Energy	8-10
5	Biomass/Biofuel	6-8
6	Hydropower	3-4
7	Geothermal Energy	3-4
8	Hybrid Systems and Economics	1-2

Course Title	***Wind Energy Technology***
Course Coordinator	***Suhil Kiwan***

I. Course Description

This course covers an introduction to modern wind energy convertors, wind characteristics and resources, wind data analysis and resource estimation, wind measurements and instrumentation, aerodynamics of wind turbines, wind energy conversion systems and components, performance of wind energy conversion systems, electrical aspects of wind turbines, wind turbine control, and economics of wind energy. Software packages for design, analysis, and economic feasibility are incorporated in this course.

II. Required Background or Experience

Prerequisites by Course:

1. Fluid Mechanics
2. Thermodynamics
3. Electric Machines

Prerequisites by Topic:

1. Fundamentals of fluid mechanics including conservation equations (mass and momentum).
2. Basic laws of thermodynamics including energy equations.
3. Electric machines fundamentals: AC and DC machines.

III. Expected Outcomes

Students will be expected to develop the following skills/understanding upon the successful completion of the course. They will be able to:

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

IV. Textbook(s) and Readings

1.J.F. Manwell, J.G. McGowan and A.L. Rogers, *Wind Energy Explained: theory, design and applications*, John Wiley & Sons Ltd, 2002
2.Gary L. Johnson, WIND ENERGY SYSTEMS, Manhattan, KS, 2006
3.Nelson, Vaughn, WIND ENERGY Renewable Energy and the Environment, CRC Press, Taylor & Francis Group, 2009.

VII. Course Outline

The following topics will be covered in this course:

	Topics	Number of Hours
1	INTRODUCTION: MODERN WIND ENERGY CONVERTORS	2-3
2	WIND CHARACTERISTICS AND RESOURCES	11-13
3	AERODYNAMICS OF WIND TURBINES	9-11
4	PERFORMANCE OF WIND ENERGY CONVERSION SYSTEMS	8-10
5	ELECTRICAL ASPECTS OF WIND TURBINES	6-8
6	WIND TURBINE CONTROL	3-4
7	ECONOMICS OF WIND ENERGY	3-4

Course Title	***Photovoltaic Systems***
Course Coordinator	***Mohammad Al-Abed, Hashemite University***

I. Course Description

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.

II. Required Background or Experience

Prerequisites by Course

- Electronics I

Prerequisites by Topic:

1. Semiconductor materials
2. Diodes

3. Transistors
4. Feedback circuits

Postrequisites:

- Advanced Photovoltaic

III. Expected Outcomes

Students will be expected to develop the following skills/understanding upon the successful completion of the course. They will be able to:

1. familiarization on aspects of solar energy and its utilization as a renewable source of energy
2. Extend their knowledge on a range of principles and techniques for the analysis and description of the physical and operational aspects of solar cells.
3. Be introduced to photovoltaic systems (grid connected and standalone) analysis.
4. To have hands on experience on PV system design.
5. Gain awareness on PV as a potential alternative source of energy
6. To have exposure to different PV technologies
7. Gain familiarization with experimental setups involving PV systems
8. To utilize state-of-the-art computer software, to design photovoltaic systems and gain practical experience.
9. Understand solar cell theory and techniques that are available for analyzing their operational performance of PV systems.
10. Understand the design and operation of photovoltaic systems (stand alone and grid connected).

IV. Textbook(s) and Readings

[1] M. Green, "Solar Cells, Operating Principles, Technology and System Applications", NSW, December 1998.
[2] C. Honsberg, S. Bowden, "Photovoltaic Devices", Part 1, UNSW, 1998.
[3] J. Singh, "Semiconductor Devices, Basic principles", John Willey & Sons, Inc., 2001.
[4] M.S. Tyagi, "Introduction to semiconductor materials and devices", John Willey & Sons, Inc., 1991.
[5] E. Lorenzo, "Solar Electricity, Engineering of Photovoltaic Systems", Institute of Solar Energy, Polytechic Univesity of Madrid, April 1994.
[6] Applied Photovoltaics by Stuart R Wenham, Martin A Green, Muriel E Watt and Richard Corkish.
[7] Electricity from Sunlight: An Introduction to Photovoltaics by Paul A. Lynn.

VII. Course Outline

The following topics will be covered in this course:

	Topics	**Number of Hours**
1	Introduction overview	3
2	The solar resource	6
3	Semiconductor physics	6
4	Solar cells	8
5	PV modules and array	5

6	PV systems	10
7	Distributed solar PV generation	6
8	Recent advances and challenges in PV systems	4
9	*Practical challenges that need to be addressed ... PV installations*	*3*
10	Building Integrated PV (BIPV) applications	2

Course Title	***Solar Thermal***
Course Coordinator	***Ayman Maaitah, Mutah University***

I. Course Description

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.

II. Required Background or Experience

Prerequisites by Course:

- Thermodynamics

III. Expected Outcomes

Students will be expected to develop the following skills/understanding upon the successful completion of the course. They will be able to:

1. Identify diverse solar thermal technologies, their physical functionality, applications and main components,
2. Understand the physical mechanisms involved in the solar thermal generation of heating, cooling and power,
3. Correctly asses their implementation potentials in diverse fields of application according to requirements as well as physical and economic constraints,
4. Understand requirements and parameters to take into account while designing a solar thermal system.

IV. Textbook(s) and Readings

Passive Cooling of Buildings (Best (Buildings Energy and Solar Technology)	Routledge	M. Santamouris
Heating and Cooling of Buildings: Design for Efficiency (McGraw-Hill Series in Mechanical Engineering)	MC Graw Hill	Jan F. Kreider
Energy Performance of Residential Buildings: A Practical Guide for Energy Rating and Efficiency	Earthscan	M Santamouris
Solar Cooling Handbook: A Guide to Solar Assisted Cooling and Dehumidification Processes: A Guide to Solar Assisted Cooling and Dehumification Processes	Springer	Hans Martin Hennings

Solar Cell Technology and Applications	CRC Press	A.R. Jha
Solar Installations: Practical Applications for the Built Environment	James & James	Lars Andren
Solar Energy: Fundamentals, Design, Modelling And Applications	Narosa	G.N. Tiwari
Time to Shine: Applications of Solar Energy Technology	Wiley	Michael Grupp
Energy: Management, Supply and Conservation	Butterworth-Heinemann	Clive Beggs
The Future for Renewable Energy 2: Prospects and Directions	James & James	EUREC
Thermal Energy Storage: Systems and Applications	Wiley	Ibrahim Dincer
Flexible Solar Cells	Wiley	Mario Pagliaro
Solar Energy Storage: A Combat of Energy Crisis: Photochemical Conversion and Storage of Solar Energy	Lambert	Arsi Ameta
Solar house : a guide for the solar designer	Elsevier	Terry Galloway

VII. Course Outline

The following topics will be covered in this course:

	Topics	**Number of Hours**
1	**Fundamentals:** Physics – Components - Collector Loop	15
2	**Design and Installation:** System design and configuration- System Installation	10
3	**Fields of Application for Solar Thermal Systems:** Basics of Solar Thermal technologies - Kinds of solar thermal collectors - Applications in the residential sector - Industrial applications - Solar assisted heat networks: Local and district heating - Energy storing possibilities	15
4	**Concentrating Solar Power:** Conventional Steam Power Plant technology - CSP	10