UNI KASSEL VERSITÄT | ELECTRICAL ENGINEERING COMPUTER SCIENCE

Module handbook of the master's program in

Renewable Energies and Energy Efficiency for the Middle East and North Africa Region (REMENA)

Dept. of Electrical Engineering/Computer Science, University of Kassel

Faculty of Engineering, Cairo University

Faculty of Engineering, University of Monastir

Faculty of Engineering, University of Sfax

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Table of Contents

Abbreviations

- B Basic
- C Cairo
- CU Cairo University
- DDKC Double Degree Kassel-Cairo
- DDKM Double Degree Kassel-Monastir
- E Elective
- ECTS European Credit Transfer System
- K Kassel
- M Monastir
- MENA Middle East and North Africa
- REMENA Renewable Energies and Energy Efficiency for the Middle East and North Africa Region
- RE Renewable Energies
- REEE Renewable Energies and Energy Efficiency
- S Sfax
- SS Summer Semester
- SWS Semesterwochenstunde
- T Thesis
- UKAS University of Kassel
- UM University of Monastir
- US University of Sfax
- WS Winter Semester

1. Study Modes

REMENA master program offers three main types of modules offered in different universities. The modules include:

I. Basic (B) Modules
II. Elective (E) Modules
III. Thesis (T) Project Module (Master Thesis)

All the basic modules are listed in Sect. 2. The basic modules being taken during the first two semesters of the study in the REMENA master's program are **Compulsory**. Clearly, each student is free to select combinations from the elective modules listed in Sect. 3 complying with the examination rules and corresponding to the individual knowledge in the different areas. Finally, the module Thesis Project, comprising 30 credits according to the European Credit Transfer System (ECTS) is to be conducted in the Middle East and North Africa (MENA) region or in Germany during the fourth semester.

The study modes of the REMENA master's program include six versions based on the sites where the studies are accomplished, namely, Cairo university (CU), university of Monastir (UM), university of Kassel (UKAS) and university of Sfax (US). The study modes are listed below:

1) Mode "1": starting in the winter semester
2) Mode "2": starting in the winter semester
3) Mode "3": starting in the summer semester
4) Mode "4": starting in the summer semester
5) Mode "5": starting in the summer semester
6) Mode "6": starting in the summer semester.

The schematic of the overall view of ***all*** modules ***offered*** in each site based on different modes are shown in **Tab. 1-Tab. 6**.

Mode "1": starting in the winter semester					
semester	winter semester (WS)/ summer semester (SS)	site	credits (ECTS)		
			Total Basic	Total Elective	Thesis Project
1	WS	C	16	30	-
2	SS	K	16	49	
3	WS	M	16	30	
4	SS	MENA region/Germany	-		30

Tab. 1: The schematic of mode "1" starting in the winter semester, (C=Cairo, K=Kassel, M=Monastir).

Mode "2": starting in the winter semester					
semester	winter semester (WS)/ summer semester (SS)	site	credits (ECTS)		
			Total Basic	Total Elective	Thesis Project
1	WS	M	16	30	-
2	SS	K	16	49	
3	WS	C	16	30	
4	SS	MENA region/Germany	-		30

Tab. 2: The schematic of mode "2" starting in the winter semester, (C=Cairo, K=Kassel, M=Monastir).

Mode "3": starting in the summer semester					
semester	winter semester (WS)/ summer semester (SS)	site	credits (ECTS)		
			Total Basic	Total Elective	Thesis Project
1	SS	K	16	49	-
2	WS	C	16	30	
3	SS	K	16	49	
4	WS	MENA region/Germany	-		30

Tab. 3: The schematic of mode "3" starting in the summer semester, (C=Cairo, K=Kassel).

Mode "4": starting in the summer semester					
semester	winter semester (WS)/ summer semester (SS)	site	credits (ECTS)		
			Total Basic	Total Elective	Thesis Project
1	SS	K	16	49	-
2	WS	M	16	30	
3	SS	K	16	49	
4	WS	MENA region/Germany	-		30

Tab. 4: The schematic of mode "4" starting in the summer semester, (K=Kassel, M=Monastir).

Mode "5": starting in the summer semester					
semester	winter semester (WS)/ summer semester (SS)	site	credits (ECTS)		
			Total Basic	Total Elective	Thesis Project
1	SS	K	16	49	-
2	WS	C	16	30	
3	SS	S	-	36	
4	WS	MENA region/Germany	-		30

Tab. 5: The schematic of mode "5" starting in the summer semester, (C=Cairo, K=Kassel, S=Sfax).

Mode "6": starting in the summer semester					
semester	winter semester (WS)/ summer semester (SS)	site	credits (ECTS)		
			Total Basic	Total Elective	Thesis Project
1	SS	K	16	49	-
2	WS	M	16	30	
3	SS	S	-	36	
4	WS	MENA region/Germany	-		30

Tab. 6: The schematic of mode "6" starting in the summer semester, (K=Kassel, M=Monastir, S=Sfax).

The student can choose from two kinds of **double** degrees, namely, double degree Kassel-Cairo (DDKC) obtained from both UKAS and CU:

REMENA **DDKC: Double Degree Kassel-Cairo**

and the double degree Kassel-Monastir (DDKM) obtained from both UKAS and UM:

REMENA **DDKM: Double Degree Kassel-Monastir**

Studying according to one of the above-mentioned modes requires a successful passing of the basic modules during the first two semesters which in total are 32 ECTS credits, a minimum of 58 ECTS credits chosen from the elective modules discussed in details in Sec. 3. as well as the module Thesis Project of 30 ECTS credits to be conducted in the MENA region during the fourth semester as discussed in Sec. 4.

Tab. 7-Tab. 12 show the credits distributions of different modes with the corresponding obtained double degrees.

Mode "1": starting in the winter semester (WS)									
Semester	WS/SS	Duration	Site	ECTS				ECTS per Semester	Type of Double-Degree
				16	14	30	30		
1	WS	September - February	C	B	E	-		30	DDKC
2	SS	March - August	K	B	E	-		30	
3	WS	September - February	M	-		E	-	30	
4	SS	March - August	MENA-Region/Germany	-			T	30	

Tab. 7: Credits distributions of mode "1" with DDKC.

Mode "2": starting in the winter semester (WS)									
Semester	WS/SS	Duration	Site	ECTS				ECTS per Semester	Type of Double-Degree
				16	14	30	30		
1	WS	September - February	M	B	E	-		30	DDKM
2	SS	March - August	K	B	E	-		30	
3	WS	September - February	C	-		E	-	30	
4	SS	March - August	MENA-Region/Germany	-			T	30	

Tab. 8: Credits distributions of mode "2" with DDKM.

Mode "3": starting in the summer semester (SS)									
Semester	WS/SS	Duration	Site	ECTS				ECTS per Semester	Type of Double-Degree
				16	14	30	30		
1	SS	March - August	K	B	E	-		30	DDKC
2	WS	September - February	C	B	E	-		30	
3	SS	March - August	K	-		E	-	30	
4	WS	September - February	MENA-Region/Germany	-			T	30	

Tab. 9: Credits distributions of mode "3" with DDKC.

Mode "4": starting in the summer semester (SS)									
Semester	WS/SS	Duration	Site	ECTS				ECTS per Semester	Type of Double-Degree
				16	14	30	30		
1	SS	March - August	K	B	E	-		30	DDKM
2	WS	September - February	M	B	E	-		30	
3	SS	March - August	K	-		E	-	30	
4	WS	September - February	MENA-Region/Germany	-			T	30	

Tab. 10: Credits distributions of mode "4" with DDKM.

Mode "5": starting in the summer semester (SS)									
Semester	WS/SS	Duration	Site	ECTS				ECTS per Semester	Type of Double-Degree
				16	14	30	30		
1	SS	March - August	K	B	E	-		30	DDKC
2	WS	September - February	C	B	E	-		30	
3	SS	March - August	S	-		E	-	30	
4	WS	September - February	MENA-Region/Germany	-			T	30	

Tab. 11: Credits distributions of mode "5" with DDKC.

Mode "6": starting in the summer semester (SS)									
Semester	WS/SS	Duration	Site	ECTS				ECTS per Semester	Type of Double-Degree
				16	14	30	30		
1	SS	March - August	K	B	E	-		30	DDKM
2	WS	September - February	M	B	E	-		30	
3	SS	March - August	S	-		E	-	30	
4	WS	September - February	MENA-Region/Germany	-			T	30	

Tab. 12: Credits distributions of mode "6" with DDKM.

2. Basic Modules

In this section, all basic modules are listed. The modules comprise three groups, namely modules in **Tab. 13** conducted in Cairo (C) during WS, modules in **Tab. 14** conducted in Monastir (M) during WS and modules in **Tab. 15** conducted in Kassel (K) during SS, respectively.

The total basic modules conducted in Cairo are 16 credits and cover the areas of

- *Thermodynamic Basics*
- *Language and Presentation*

Thermodynamic Basics	ECTS site	Language and Presentation	ECTS site
Engineering Thermodynamics	2 C	German and Arab Language Courses Cairo	3 C
Heat Transfer	3 C	Presentation and Moderation Techniques	3 C
Fluid Mechanics	3 C		
Material Science	2 C		

Tab. 13: Basic modules conducted in Cairo during WS (16 ECTS credits).

The modules being composed by a number of courses are described separately for each module. As an example, the module *Thermodynamic Basics*, given in CU, is composed by the courses *Engineering Thermodynamics*, *Heat Transfer, Fluid Mechanics and Material Science.*

The total basic modules conducted in Monastir are 16 ECTS credits and cover the areas of

- *Energy and Thermodynamic Basics*
- *Language and Communication Competencies*

Energy and Thermodynamic Basics	ECTS site	Language and Communication Competencies	ECTS site
Thermodynamics Fundamentals	2 M	German and Arab Language Courses	3 M
Heat Transfer Fundamentals	4 M	English Presentation and Communication Techniques	3 M
Fluid Mechanics Fundamentals	4 M		

Tab. 14: Basic modules conducted in Monastir during WS (16 ECTS credits).

The total basic modules conducted in Kassel are 16 credits and cover the areas of

- *Engineering Basics*
- *Intercultural Competencies*

Engineering Basics	ECTS site	Intercultural Competencies	ECTS site
Electrical Engineering Fundamentals	3 K	German-Arab Relations	2 K
Control Systems	2 K	Intercultural Communication	2 K
Technical Mechanics	2 K	German and Arab Language Courses Kassel	2 K
Engineering Mathematics	3 K		

Tab. 15: Basic modules conducted in Kassel during SS (16 ECTS credits).

In the tables below, the details of each basic module are provided in addition to the module Thesis Project to be conducted in the MENA region. The German "Semesterwochenstunde" (SWS) defines the time of a course unit where 1 SWS corresponds to fifteen units of 45 minutes each so that 1 SWS totals 675 minutes = 11 hours and 15 minutes.

<table>
<tr><td>Module title</td><td colspan="5">Thermodynamic Basics</td></tr>
<tr><td>Module type</td><td colspan="5">B</td></tr>
<tr><td>Competency</td><td colspan="5">Understanding basic physical concepts used in engineering</td></tr>
<tr><td rowspan="5">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Engineering Thermodynamics</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (40%) assignments
- final exam (60%)</td></tr>
<tr><td>Heat Transfer</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (40%) assignments
- final exam (60%)</td></tr>
<tr><td>Fluid Mechanics</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (40%) group presentation
- final exam (60%)</td></tr>
<tr><td>Material Science</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (40%) group presentation
- final exam (60%)</td></tr>
<tr><td>Semester</td><td colspan="5">winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Hendawi Salem, Abd-El-Maged Hafiz
Adel Khalil
Mahmoud Fouad
Iman El Mahallawy</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">150 hours course attendance
100 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">10</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="4">Learning Outcomes</td><td colspan="5">a) Engineering Thermodynamics
After the successful participation in the course Engineering Thermodynamics the students are able to:
• implement the first and second law of thermodynamics on thermal systems
• interpret property tables and create energy balances
• analyze power and refrigeration cycle performance.</td></tr>
<tr><td colspan="5">b) Heat Transfer
After the successful participation in the course Heat Transfer the students are able to:
• conduct basic principles of heat transfer and its basic modes on energy systems
• assess temperature distribution and heat flow regarding heat exchangers and
• insulations.</td></tr>
<tr><td colspan="5">c) Fluid Mechanics
After the successful participation in the course Fluid Mechanics the students are able to:
• conduct conservation equations on fluid flow
• implement fluid flow dimensional analysis on pressure losses and pumping power requirements.</td></tr>
<tr><td colspan="5">d) Material Science
After the successful participation in the course Material Science the students are able to:
• perceive next generation photovoltaic and optoelectronics materials used in photovoltaic applications
• interpret advanced membrane materials.</td></tr>
<tr><td>Contents</td><td colspan="5">a) Engineering Thermodynamics
• Fundamental concepts and definitions:
✓ unit systems
✓ (pure) substances</td></tr>
</table>

	✓ thermodynamic properties and relations • First and second law of thermodynamics on thermal systems • Vapor power cycles • Reversed cycles • Power and refrigeration cycle performance • Introduction to different modes of heat transfer
	b) Heat Transfer • Heat transfer by thermal conduction: - 1D steady state conditions - heat transfer in composite walls and cylinders - internal heat generation; - extended surfaces • Heat transfer by convection: - natural and forced convection - principles, mechanisms and correlations • Heat transfer by thermal radiation: - principles - radiation properties - surface heat exchange • Heat transfer by boiling and condensation • Heat exchange types and basic sizing calculations
	c) Fluid Mechanics • Fundamental concepts of fluids and fluid statics • Basic equations: - conservation equations - momentum and mass balances - Bernoulli equation • Different flow types (laminar vs. turbulent) • Flow characteristics in ducts and pipes: - viscous flow - pressure loss calculation in pipes - calculation of pumping power requirements • Dimensional similarity
	d) Material Science • Electronic transport in semiconducting materials: - quantum wire and quantum dot nanostructures increasing PV technology efficiency - excitation, scattering and relaxation mechanisms • Advanced membrane materials • Fuel cell and batteries including polymers, ionic solids, and hybrid systems
Media	Black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs.
Literature	• G.J. van Wylen and R.E. Sonntag, *Fundamentals of Classical Thermodynamics*, 3rd edition, John Wiley and Sons, New York, 1985. • J.P. Holman, *Heat Transfer*, McGraw-Hill Science/Engineering/Math, 9th edition, 2001. • Lecture notes on *Fluid Mechanics and Material Science*.

<table>
<tr><th>Module title</th><th colspan="5">Language and Presentation</th></tr>
<tr><th>Module type</th><th colspan="5">B</th></tr>
<tr><th>Competency</th><th colspan="5">Implementing language skills and presentation techniques</th></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>German and Arab Language Courses Cairo</td><td>lecture, seminar</td><td>3</td><td>3</td><td>final (oral and written) exam (100%)</td></tr>
<tr><td>Presentation and Moderation Techniques</td><td>lecture</td><td>3</td><td>3</td><td>a) midterm (40%)
- individual presentation
b) final exam (60%)
- individual presentation
- group presentation</td></tr>
<tr><td>Semester</td><td colspan="5">winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Dr. Abdelrahman Nagi/ Dr. Anwar Badawi/ Dr. Basem Schoaib (Arab)
Amal Maghraby / Basma El-Feky/ Iman Saber (German)
Sayed Kaseb
Fouad Khalaf</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">a) German and Arab Language Courses Cairo
After the successful participation in the course German and Arab Language Courses Cairo the students are able to:
• implement basic formulations and expressions of German and Arabic for use in daily life.</td></tr>
<tr><td colspan="5">b) Presentation and Moderation Techniques
After the successful participation in the course Presentation and Moderation Techniques the students are able to:
• interpret the concepts of presentation and moderation for efficient meeting organization, discussion and moderation techniques
• implement presentation and moderation techniques (suitable material, personal presentation, moderation skills) on a professional level.</td></tr>
<tr><td>Contents</td><td colspan="5">a) German and Arab Language Courses Cairo
• Modern Standard Arabic (MSA) and Egyptian dialect (EA):
- basic reading, writing, and speaking skills
- solid foundation in formal Arabic grammar (nahu) and morphology (sarf)
- vocabulary of at least 1000 Arabic daily life words
• German:
- basic phrases and short sentences for everyday use
- technical terms and expressions in electrical engineering and RE
- basic concepts in High German grammar</td></tr>
</table>

	b) Presentation and Moderation Techniques • Preliminary activities (classifying target groups, determining research topics): - types and basic rules of different presentations - content structure - developing a presentation strategy - planning and handling of presentation materials and facilities - efficient visualization • Advanced presentation and moderation techniques: - analysing personal delivery habits recorded in video - training and improving delivery habits - training efficient meeting organization • Report writing
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises and video feedback, case studies in groups; formal & interactive.
Literature	• Lecture notes and course material in Arabic and German language courses • J.E. Rudd and D.R. Lawson, *Communicating in Global Business Negotiations: A Geocentric Approach*, Sage Publications, 2007. • C. McNamara, *Basic Guide to Conducting Effective Meetings*, 2008. • J. Rotondo and M. Rotondo Jr., *Presentation Skills for Managers*, McGraw Hill, 1st edition, 2001. • B.J. Streibel, *The Manager´s Guide to Effective Meetings*, McGrawHill, 1st edition, 2002.

Module title	Energy and Thermodynamics Basics				
Module type	**B**				
Competency	**Understanding basic physical concepts used in engineering**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Thermodynamics Fundamentals	lecture, exercise	2	2	- midterm (1/3) assignments - final exam (2/3)
	Heat Transfer Fundamentals	lecture, exercise	4	4	- midterm (1/3) assignments - final exam (2/3)
	Fluid Mechanics Fundamentals	lecture, exercise	4	4	- midterm (1/3) assignments - final exam (2/3)
Semester	Winter				
Responsible	El Alimi				
Site	Monastir				
Lecturer(s)	Abdelmajid Jemni, Habib Ben Aissia, Naceur Borgini, Naoual Daouas, Maher Ben chiekh, Hacen Dhahri, Khalifa Mejbri, Ramla Gheith				
Language	English				
Workload	150 hours course attendance 100 hours self-study				
Credits	10				
Recommended Qualifications	-				
Learning Outcomes	**Thermodynamics Fundamentals** After the successful participation in the course **Thermodynamics Fundamentals** the students are able to: • know the basic concepts, principles and the properties of thermodynamics and thermodynamic equilibria of pure fluids and mixtures • control the mass balance, energy and entropy and exergy analysis of thermodynamic systems and processes • master the wet air diagram and unit operations of the air treatment.				
	Heat Transfer Fundamentals After the successful participation in the course **Heat Transfer Fundamentals** the students are able to: • know the basic concepts of thermal laws and identify the three ways of heat transfer (conduction, convection, radiation) • set equation and solve a simple problem of heat transfer in the case of regular geometries subjected to different types of boundary conditions • understand, model and control analytical and numerical techniques for solving heat conduction problems • define and implement a heat conduction equation problem and choose the appropriate method to solve and interpret the numerical results.				
	Fluid Mechanics Fundamentals After the successful participation in the course **Fluid Mechanics Fundamentals** the students are able to: • measure the pressure and the velocity • calculate hydrostatic strength • determine the velocity profiles (in a pipe and inside the boundary layer) and determine the friction forces.				
Contents	**Thermodynamics Fundamentals** Students know fundamentals of thermodynamic e.g. open and closed systems, steady-state processing, state of matter, heat, molecular agitations, ideal gases, real gases; thermodynamic properties (internal energy, enthalpy, free energy, free enthalpy, entropy, specific heat); first and second law of thermodynamics for a closed system; thermodynamic relations (Gibbs equations, Maxwell's equations, characteristic functions, general expressions of S, U and H, general relationship between Cp and Cv); thermodynamic equilibrium phases (chemical potentials); state equations applied to pure fluids (state equation of ideal gases); thermodynamics of mixtures (mixture of ideal gases, ideal solutions); first law of thermodynamics for open systems (mass and energy balance); second				

	law of thermodynamics for open systems (entropy balance sheet); exergy analysis (generation of entropy and exergy destruction, application to steady flows and closed systems); gas turbine (operating principle, Brayton cycle, inverted Brayton cycle), steam turbine (block diagram, Rankine cycles); engines; refrigeration machines, single-stage and two-stage vapor compression (schematic diagrams, thermodynamic cycles in PH and TS diagrams, two-stage compression and expansion); cryogenic thermodynamic processes; liquefaction of air (Linde and Claude cycles); production of dry ice.
	Heat Transfer Fundamentals Students know • Heat transfer basics: specific terms (temperature, heat flux, heat, isothermal surfaces); thermo physical characteristics; heat transfer methods (mechanisms and Fourier's, Newton's and Stefan's laws); simultaneous heat transfers. • Problem resolution of heat transfer: heat balance concept; general equation of conduction; boundary conditions; electrical analogy; systems with internal heat source. • Thermal fins study: introduction to the fins (applications, forms, materials, ... etc.); heat balance; performance and efficiency. • Steady conduction: analytical solution of the Laplace equation; steady numerical methods. • Unsteady conduction: dimensionless numbers (Biot and Fourier); thermally thin systems (low Biot); analytical and numerical methods. • Introduction to convection: heat transfer by convection; the general equations of transfer; boundary layers. • Forced convection: external flows; the experimental and theoretical methods; flow around a cylinder, sphere and a tube bundle; internal flows; hydrodynamic and thermal considerations; laminar flow in circular tubes; correlation for turbulent flow in circular and non-circular tubes. • Natural convection: boussinesq Model; similarity; natural convection near a vertical wall; correlations for natural convection.
	Fluid Mechanics Fundamentals Students know fluid specifications, dimensions and units; the basic law of the hydrostatic; the applications (pressure variation, measuring pressure, hydrostatic force on a surface); fluid kinematics; dynamics of perfect incompressible fluids (Bernoulli equation, applications e.g. speed measurement); Euler theorem; dynamic of real incompressible fluids (Couette experience, laminar viscous flow, Poiseuille flow); concept of loss and singular linear load; boundary layer (concept of the boundary layer, local and global equations of the boundary layer, characteristics of the boundary layer, accurate and approximate solutions of the boundary layer); similitude and dimensional analysis; dynamics of elastic fluids (unidirectional flow); shockwave.
Media	Black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs.
Literature	• J. Morano, N. Shapiro, Fundamentals of Engineering Thermodynamics • Michael J. Moran, Howard N. Shapiro, Bruce R. Munson, David P. DeWitt, Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer. John Wiley & Sons, Inc. • CENGEL Y.A. Heat Transfer : Practical Approach, McGraw-Hill, 1997 • Yunus Cengel, John Cimbala, Fluid Mechanics Fundamentals and Applications, McGraw-Hill Higher Education

<table>
<tr><th>Module title</th><th colspan="5">Language and Communication Competencies</th></tr>
<tr><td>Module type</td><td colspan="5">B</td></tr>
<tr><td>Competency</td><td colspan="5">Implementing language skills and presentation techniques</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>German and Arab Language Course Monastir</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- oral and written assignments (50%)
- final exam (50%)</td></tr>
<tr><td>English presentation and communication Techniques</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- oral and written assignments (50%)
- final exam (50%)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">Monastir</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Anis Ben Amor, Yosr Mustapha, Saad Borghol
Kmar Hadded, Nadia Douki
Abir Mili, Sonia Ouada</td></tr>
<tr><td>Language</td><td colspan="5">English, German and Arabic</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">German and Arab Language Courses Monastir
After the successful participation in German and Arab Language Courses Monastir the students are able to:
• improve their language skills in German and Arabic to communicate with basic formulations and expressions for use in daily life.</td></tr>
<tr><td colspan="5">English presentation and Communication Techniques
After the successful participation in the course English presentation and Communication Techniques the students are able to:
• interpret the concepts of presentation for efficient meeting organization, discussion and moderation techniques.
• rule of different presentations, develop a strategy for presentation, plan and handle of presentation materials and facilities.
• provide advanced presentation and moderation techniques, improve delivery habits, achieve an efficient meeting organization.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">German and Arab Language Courses Monastir
Ability of students to know
• basic phrases and short sentences for everyday use.
• technical terms and expressions in electrical engineering and RE.
• basic concepts in grammar.</td></tr>
<tr><td colspan="5">English presentation and Communication Techniques
• preliminary activities (classifying target groups, determining research topics); know types and basic rules of different presentations; content structure; developing a presentation strategy; planning and handling of presentation materials and facilities; efficient visualization.
• advanced presentation and moderation techniques; analysing personal delivery habits recorded in video; training and improving delivery habits; training efficient meeting organization; providing a written report.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises and video feedback, case studies in groups; formal and interactive.</td></tr>
<tr><td>Literature</td><td colspan="5">• Cambridge English for Job hunting/ Presentations in English/ English For Presentation / Market Leader.
• Lecture notes and course material in Arabic and German language courses.</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Engineering Basics</td></tr>
<tr><td>Module type</td><td colspan="5">B</td></tr>
<tr><td>Competency</td><td colspan="5">Understanding fundamental engineering principles used in RE technologies</td></tr>
<tr><td rowspan="5">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Electrical Engineering Fundamentals</td><td>lectures, labs, project work in groups</td><td>3</td><td>3</td><td>- assignments
- written exam</td></tr>
<tr><td>Control Systems</td><td>lecture, group discussions</td><td>2</td><td>2</td><td>- assignments
- written exam</td></tr>
<tr><td>Technical Mechanics</td><td>lecture</td><td>2</td><td>2</td><td>- assignments
- written exam</td></tr>
<tr><td>Engineering Mathematics</td><td>lecture</td><td>3</td><td>3</td><td>- assignments
- written exam</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Dirk Dahlhaus
Martin Jilg, Konstantin Schaab
Nour Mansour
Ammar Abid</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">150 hours course attendance
100 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">10</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="4">Learning Outcomes</td><td colspan="5">a) Electrical Engineering Fundamentals
After the successful participation in the course Electrical Engineering Fundamentals the students are able to:
• analyze electrical circuits and using measuring instruments and sensors
• apply principles of energy conversion (mechanical / electrical).</td></tr>
<tr><td colspan="5">b) Control Systems
After the successful participation in the course Control Systems the students are able to:
• understand the specific terms and problems of control theory
• analyze simple linear control systems.</td></tr>
<tr><td colspan="5">c) Technical Mechanics
After the successful participation in the course Technical Mechanics the students are able to:
• calculate flow of forces in static systems
• solve simple dynamic issues (e.g. problems between turbines and ground).</td></tr>
<tr><td colspan="5">d) Engineering Mathematics
After the successful participation in the course Engineering Mathematics the students are able to:
• understand functions and their differentiation and integration
• describe systems based on linear and non-linear operators (deterministic and stochastic)
• analyze system design and simulation using numerical methods.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">a) Electrical Engineering Fundamentals
• Fundamental elements in electric circuits
• Basic loads
• DC and AC circuit analysis
• Power electronics (DC/DC and DC/AC topologies)
• Energy conversion
• Rotating machines
• Laboratories: measurements (with instruments and sensors), exercises</td></tr>
<tr><td colspan="5">b) Control Systems
• Fundamental definitions in control circuits
• Signal flow charts
• Basic elements of block diagram models
• Simulation of systems using MATLAB</td></tr>
</table>

	• Linear system overlay techniques • Step response • Feedback performance, stability of linear feedback control systems • Frequency response of control circuits • Industrial PID controllers
	c) Technical Mechanics • Fundamental definitions in technical mechanics • Flow of forces in static systems • Simple dynamic problems e.g. between turbines and ground
	d) Engineering Mathematics • Fundamentals of linear algebra, basics in probability and statistics • Functions and its differentiation and integration • Functions of more than one variable • System description based on linear / non-linear operators (deterministic and stochastic) • System design and simulation using numerical methods • Calculus - single variable calculus (differentiation, integration) - multi variable calculus (partial differentiation, multiple integration)
Media	Black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs.
Literature	• U.A. Bakshi and V.U. Bakshi, *Basic Electrical Engineering*, 2nd edition, Technical Publications Pune, 2009. • P.H. Lewis, *Basic Control Systems Engineering*, Prentice Hall, 1997. • Lecture notes on *Control Systems*. • S.C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, Tata McGraw Hill, 2nd edition, 2008. • A. Papoulis and S. U. Pilllai, Probabilty, Random Variables and Stochastic Processes, 4th ed., McGraw Hill, 2002. • Further literature will be announced by the lecturers.

<table>
<tr><td>Module title</td><td colspan="5">Intercultural Competencies</td></tr>
<tr><td>Module type</td><td colspan="5">B</td></tr>
<tr><td>Competency</td><td colspan="5">Recognizing and exploiting synergies in international teams</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>German-Arab Relations</td><td>visits to organisations in Berlin, lectures, discussions</td><td>2</td><td>2</td><td>group discussions, (quantity, quality); written report on organisations visited</td></tr>
<tr><td>Intercultural Communication</td><td>seminar</td><td>2</td><td>2</td><td>meta-cognitive reflection, references of the reading done, intercultural project; written report</td></tr>
<tr><td>German and Arab Language Courses Kassel</td><td>lecture, seminar</td><td>2</td><td>2</td><td>written/oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Matthias Weiter, Claus-Peter Haase
Anke Aref, Dirk Dahlhaus
Ismail Yassin (Arab); Beate Kahre (German)</td></tr>
<tr><td>Language</td><td colspan="5">English, German/Arab</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">a) German-Arab Relations
After the successful participation in the course German-Arab Relations the students are enabled to:
• understand the institutional set-up of bilateral and multilateral development cooperation with special reference to the Arab world
• work with political, economic and cultural objectives and instruments of German-Arab relations.</td></tr>
<tr><td colspan="5">b) Intercultural Communication
After the successful participation in the course Intercultural Communication the students are enabled to:
• meta-cognitively reflect communication relevant factors in perception and assessment of situations and critical incidents in every day- and project-related communication
• monitor the personal adaptation process
• Generate a portfolio of tools for an empathic approach to effectively communicate and work in intercultural teams.</td></tr>
<tr><td colspan="5">c) German and Arab Language Courses Kassel
After the successful participation in the course German and Arab Language Courses Kassel the students are able to:
• communicate with elaborated formulations and expressions for use in daily life.</td></tr>
<tr><td>Contents</td><td colspan="5">a) German-Arab Relations
• Institutional set-up of bilateral and multilateral development cooperation:
- Role of German parliament, ministries for development, environment and economy
- Arab embassies and other organisations shaping and cultivating German-Arab relations
• Socio-political objectives and instruments of German-Arab relations:
- development cooperation between Germany and the Arab world
- nature and volume of German-Arab trade and investments
- historic and present cultural and political relations between Germany and MENA
• Information on objectives and content of German-Arab M.Sc. programmes</td></tr>
</table>

	b) Intercultural Communication • Intercultural and communication models like E.T. Hall, Hofstede, Schulz von Thun, and others - (auto) biography - cross-cultural analysis - cultural self-analysis of differences • Situated, contextualized and dynamic issues: considering events, phenomena, people etc. as differing and changing along different cultures and different times, culture shock model • Learning and working in an intercultural environment: - perception, assessment, inference - learning diary - core topic: creative activities on intercultural communication competence - scientific writing (perspective of the self and other, testimonials, critical incidents) • Communicating issues of RE in a global world considering local and global knowledge
	c) German and Arab Language Courses Kassel • German: - basic phrases and short sentences for everyday use - technical terms and expressions in electrical engineering and RE - basic concepts in High German grammar • Modern Standard Arabic (MSA) and Egyptian dialect (EA): - basic reading, writing, and speaking skills - solid foundation in formal Arabic grammar (nahu) and morphology (sarf) - vocabulary of at least 1000 Arabic daily life words
Media	• Black board and beamer, visiting energy sector organisations in Egypt and discussions with planners and decision makers, slide show and power point presentations, open ended discussions initiated by the lecturer, case studies through team work ended by discussions, computer lab for spread sheet applications and surveying issues, project work. • Case studies in groups and individual work. • Face to face and online sessions, action-oriented, simulations, holistic activities strongly relating to participants' experience to trigger their subjective prior-knowledge and making them become aware of how that knowledge is culturally determined and dynamically changed over time.
Literature	• The Charter of the United Nations,1945. • United Nations General Assembly, *United Nations Millennium Declaration*, Resolution adopted by the General Assembly, 2000; • Arab Human Development Report 2002, http://www.arab-hdr.org/publications/other/ahdr/ahdr2002e.pdf • Arab Human Development Report 2003, http://www.arab-hdr.org/publications/other/ahdr/ahdr2003e.pdf • Arab Human Development Report 2004, http://www.arab-hdr.org/publications/other/ahdr/ahdr2004e.pdf • Arab Human Development Report 2005, http://www.arab-hdr.org/publications/other/ahdr/ahdr2005e.pdf • P. Ruggiano Schmidt and C. Finkbeiner (eds.), *The ABC's of Cultural Understanding and Communication: National and International Adaptations*, Information Age Publishing, 2006. • G. Hofstede, G.J. Hofstede, M. Minkov: *Cultures and Organizations. Software of the Mind. Intercultural Cooperation and its importance for survival*. McGraw-Hill books, 3rd Edition, 2010. • Further literature will be announced by the lecturers.

4. Elective Modules

In this section, all elective modules being conducted in Cairo, Monastir, Kassel as well as in Sfax (S) are listed in **Tab. 16-Tab. 19** such that the student can study the elective modules according to the modes defined in Sec. 1.

Bio Energy	**ECTS site**	**Develop-ment of RE Projects**	**ECTS site**	**Fundamentals of REEE**	**ECTS site**	**Solar Energy Devices**	**ECTS site**	**Economic and Ecological Aspects of REEE**	**ECTS site**
Bio Fuels	2 C	Project Planning and Tendering	3 C	Conversion Processes	4 C	Solar Thermal Heating	2 C	Environmental Issues and Managing the Effects (Global Climate Change)	2 C
Poten-tials of Bio Waste	2 C	Project Commis-sioning, Operation and Main-tenance	2 C	Fundamentals in Energy Efficiency	3 C	Concentrated Solar Thermal Devices	2 C	Macroeconomic Aspects of RE	2 C
						Photovoltaic Devices	2 C	Engineering Economics and Feasibility Studies for REEE	2 C
								Potentials of RE in the MENA Region and Europe	2 C

Tab. 16: Elective modules conducted in Cairo during WS (30 ECTS credits), RE = Renewable Energies.

Advanced Energy Engineering	ECTS site	Energy and Environment	ECTS site	Management and Engineering Mathematics	ECTS site
Applied Heat Transfer	3 M	Energy and Environmental Context, Energy Transition and Sustainable Development	2 M	Numerical Methods and Optimization	3 M
Advanced Fluid Mechanics	3 M	Energy and Environmental Management Systems	2 M	Project Management and Industrial Marketing	2 M
Solar Energy Subsystems	**ECTS site**	**Geothermal Energy**	**ECTS site**	**Combined Cooling, Heating and Power (CCHP)**	**ECTS site**
Solar Energy Collectors	3 M	Geothermal Resource Identification and Development	2 M	Theory and Technology of Combined Heating, Cooling & Power	2 M
PV Solar Energy Materials	2 M	Geothermal Applications	3 M	Applications of Combined Heating, Cooling & Power	3 M

Tab. 17: Elective modules conducted in Monastir during WS (30 ECTS credits).

Practical Aspects of REEE	ECTS site	Project Management	ECTS site	RE Integration	ECTS site	Solar Energy Systems	ECTS site	Energy Efficiency and Storage	ECTS site
Grid Integration	2 K	International Project Management	2 K	Smart Grids	3 K	Solar Thermal Cooling	2 K	Energy Storage	2 K
Energy Efficiency in Buildings	3 K	Project Management in Development Cooperation	2 K	Flexible Generation and Demand Side Manage-ment	2 K	Concentrated Solar Thermal Systems	2 K	Energy efficiency in cross-sectional technologies	3 K
System Aspects of Bio Power Generation	2 K	Energy and Society	1 K	Bio Gas	2 K	Photovoltaic Systems	2 K	Energy efficiency through process integration	3 K
Economic Activities of Germany in the MENA Region	**ECTS site**	**Wind Energy Technology**	**ECTS site**	**Scientific Programming and Publishing**	**ECTS site**				
Business Economic Aspects of RE	2 K	Mechanical Aspects of Wind Energy	3 K	Introduction to MATLAB	4 K				
Potentials of German Institutions and Companies for the MENA Region	2 K	Electrical Aspects of Wind Energy	3 K	Introduction to LaTeX	2 K				

Tab. 18: Elective modules conducted in Kassel during SS (49 ECTS credits).

Control Oriented Modelling of AC Actuators	**ECTS site**	**FEA Modelling of AC Actuators (level 1)**	**ECTS site**	**FEA Modelling of AC Actuators (level 2)**	**ECTS site**	**Embedded Energy Storage Systems**	**ECTS site**
Induction Machine Modelling	2 S	Electric System Modelling	2 S	Linear Static Magnetic Analyses	2 S	Storage Systems: Case Studies	2 S
Synchronous Machine Modelling	2 S	Finite Element Modelling	1 S	Non-Linear Static Magnetic Analyses	2 S	Sizing of Storage Systems	2 S
Special AC Actuators	**ECTS site**	**Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives**	**ECTS site**	**Control Strategies of Electric**	**ECTS site**	**Power Electronic Converters**	**ECTS site**
Switched Reluctance Machines	1 S	Faults in Electric Machine Drives	1 S	Rotor Flux Oriented Control of Three-Phase Induction Motor	2 S	PWM Control Strategies of Two-Level Inverters	1 S
Axial Flux Machines	1 S	Faults Detection and Isolation Techniques and Methods	1 S	Direct Torque Control of Three-Phase Induction Motor	2 S	PWM Control Strategies of Three-Level Inverters	1 S
Transvers Flux Machines	1 S	Fault-Tolerant Control Strategies	1 S	Direct Power Control Strategies of Three-Phase PWM Rectifiers	1 S	Matrix Converters and their Control Strategies	1 S
Embedded Generating Systems	**ECTS site**	**Rules of Writing Research Documents**	**ECTS site**				
Generating Systems Embedded on Board of Road Vehicles	1 S	The Scientific Paper: From Reading to Writing	2 S				
Modelling of Claw Pole Alternators	1 S	Writing Process	1 S				
Design Improvement of the CPA-Based Generating Systems	1 S						
Avionic Generating Systems	1 S						

Tab. 19: Elective modules conducted in Sfax during SS (36 ECTS credits).

The tables below show the detailed elective modules in CU, UM, UKAS and US.

Module title	Bio Energy				
Module type	**E**				
Competency	**Assessing different technologies of bio energy (mainly bio fuels and waste)**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Bio Fuels	lecture	2	2	a) midterm (40%) - lab work evaluation - presentation b) final exam (60%)
	Potentials of Bio Waste	lecture, seminar	2	2	a) midterm (40%) assignments b) final exam (60%)
Semester	winter				
Responsible	Khalil				
Site	Cairo				
Lecturer(s)	Fatma Ashour				
Language	English				
Workload	60 hours course attendance 40 hours self-study				
Credits	4				
Recommended Qualifications	–				
Learning Outcomes	**a) Bio Fuels** After the successful participation in the course **Bio Fuels** the students are able to: • assess different types of bio energy sources with focus on liquid fuels • evaluate different bio fuels.				
	b) Potentials of Bio Waste After the successful participation in the course **Potentials of Bio Waste** the students are able to: • perceive sources, potentials and possible energetic use of bio waste.				
Contents	**a) Bio Fuels** • Petroleum as fuel (reserves, production and consumption) as well as gas and oil prices • Potential of RE, carbon cycle • Biochemistry fundamentals: - chemistry of alcohols - triglycerides, free fatty acids, trans-esterification reaction - oilseed processing (oil expellers, solvent extraction) • Bio fuels fundamentals: - history - international applications and production - properties, specifications - environmental impact • Sustainability criteria: - feedstock planting (agricultural point of view, climate conditions, weather) - feedstock selection (food edible vs. non-edible, agricultural waste, vegetable oils, animal fats and waste oils) - water consumption - land use for biomass production • Economics of bio fuels • Engine modifications for bio fuels				
	b) Potential of Bio Waste • Bio waste potential in the MENA region • Possible ways of collecting bio mass • Energetic use in power generation • Problems in handling materials and emissions in the burning process • Assessment of different resources				
Media	Field visits to oilseed plantations and oil extraction facilities in Egypt; lab work: preparation of biodiesel from non-edible vegetable oil; evaluation of the physical properties of the produced fuel, engine testing.				

Literature	• A. Demirbas, *Biofuels: Securing the Planet's Future Energy Needs*, Springer, 2nd edition, 2008. • S. Khanal, *Bioenergy and Biofuel from Bio wastes and Biomass*, ASCE, 2010. • Further literature will be announced by the lecturer.

<table>
<tr><th>Module title</th><th colspan="5">Development of Renewable Energy Projects</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Implementing project management skills regarding renewable energy projects</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Project Planning and Tendering</td><td>lecture</td><td>2</td><td>3</td><td>a) midterm (40%)
- assignments
- group presentation
b) final exam (60%)</td></tr>
<tr><td>Project Commissioning, Operation and Maintenance</td><td>lecture, seminar</td><td>2</td><td>2</td><td>a) midterm (40%)
- assignments
- group presentation
b) final exam (60%)</td></tr>
<tr><td>Semester</td><td colspan="5">winter</td></tr>
<tr><td>Responsible</td><td colspan="5">El Mahdi</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Alia El Mahdi
Abu Arab
Adel Khalil</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
50 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">a) Project Planning and Tendering
After the successful participation in the course Project Planning and Tendering the students are able to:
• plan a renewable energy project, select site and technology
• conduct tendering process and licensing.</td></tr>
<tr><td colspan="5">b) Project Commissioning, Operation and Maintenance
After the successful participation in the course Project Commissioning, Operation and Maintenance the students are able to:
• perceive commissioning processes, operation and maintenance practice in RE/EE projects.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">a) Project Planning and Tendering
• Fundamentals of the construction industry
- project life cycle and organization
- project management process
- types and life cycle of construction projects
• Project contract strategy
• Delivery methods
• Cash flow and cost control
• Scheduling techniques, among others:
- bar charts
- line of balance
- critical path method and others</td></tr>
<tr><td colspan="5">b) Project Commissioning, Operation and Maintenance
• RE fundamentals:
- different renewable power generation techniques
- commissioning rules and standards
• Case study wind energy:
- basic meteorology, statistical analysis of wind
- type of wind turbines (components, power curve, wind turbine loads, losses)
- economical considerations
- computation of wind power of a site
- wind farm layouts, loss of wind energy, environmental codes and standards, etc.</td></tr>
</table>

	- environmental codes and standards - Wind turbine maintenance (schedules for different components, power regulation, electric shielding, cleaning of components) - experience values of wind farm in Zafaraana, Egypt) • Case studies to be prepared by students based on the wind energy example: - solar thermal power plants - bio fuels power plants - PV power plants
Media	Black board and beamer.
Literature	• Presentations and reports on major RE/EE projects • Local and international tendering and procurement regulations • Commissioning and O&M standards codes of practice

<table>
<tr><th>Module title</th><th colspan="5">Fundamentals of REEE</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Assessing opportunities of efficiency in the energy sector</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Conversion Processes</td><td>lecture, presentation, project work</td><td>4</td><td>4</td><td>a) midterm (40%) quizzes
b) final exam (60%)</td></tr>
<tr><td>Fundamentals in Energy Efficiency</td><td>lecture</td><td>3</td><td>3</td><td>a) midterm (40%) group presentation
b) final exam</td></tr>
<tr><td>Semester</td><td colspan="5">winter</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Adel Khalil
Mohamed El Sobki</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">105 hours course attendance
70 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">7</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">a) Conversion Processes
After the successful participation in the course Conversion Processes the students are able to:
• perceive the basics of the different energy forms and conversion technologies
• assess conversion efficiencies for different forms of energy.</td></tr>
<tr><td colspan="5">b) Fundamentals in Energy Efficiency
After the successful participation in the course Fundamentals in Energy Efficiency the students are able to:
• distinguish energy supply and demand patterns
• review different energy conservation technologies/opportunities.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">a) Conversion Processes
• Energy classification, sources and utilization
• Economics and terminology
• Principal fuels for energy conversion
• Conversion to thermal energy / electrical energy / mechanical energy
• Short introduction into nuclear energy conversion</td></tr>
<tr><td colspan="5">b) Fundamentals in Energy Efficiency
• Energy supply and demand patterns / management
• Energy balance and analysis on thermal systems
• Energy codes and standards
• Energy auditing procedure
• Energy conservation opportunities (e.g. high efficiency lighting)
• Energy codes and standards
• Power factor correction</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, measurements, use of simple computer programs.</td></tr>
<tr><td>Literature</td><td colspan="5">• A.W. Culp, Principles of Energy Conversion, McGraw-Hill College, 2nd sub edition, 1990.
• F. Kreith and R.E. West (Editors), CRC Handbook of Energy Efficiency; CRC Press, 1st edition, 1996.
• T.D. Eastop and D.R. Croft Energy Efficiency for Engineers and Technologists, Longman Publishing Group, 1990.</td></tr>
</table>

Module title	Solar Energy Devices				
Module type	E				
Competency	Reviewing different technologies of solar energy Competency				
Courses	Title	Teaching Method	SWS	Credits	Performance requirements/ Examination
	Solar Thermal Heating	lecture, seminar	2	2	a) midterm (40%) assignments b) final exam (60%)
	Concentrated Solar Thermal Devices	lecture, seminar	2	2	a) midterm (40%) assignments b) final exam (60%)
	Photovoltaic Devices	lecture, project work in groups	2	2	a) midterm (40%) assignments b) final exam (60%)
Semester	winter				
Responsible	Khalil				
Site	Cairo				
Lecturer(s)	Mohamed Fawzi El-Refaie Mohamed Fawzi El-Refaie Nadia Raafat				
Language	English				
Workload	90 hours course attendance 60 hours self-study				
Credits	6				
Recommended Qualifications	–				
Learning Outcomes	**a) Solar Thermal Heating** After the successful participation in the course **Solar Thermal Heating** the students are able to: • distinguish solar thermal devices for domestic hot water with respect to radiation circumstances and geographical position • assess design and dimensioning of different solar thermal energy devices for domestic hot water, space and swimming pool heating and air conditioning.				
	b) Concentrated Solar Thermal Devices After the successful participation in the course **Concentrated Solar Thermal Devices** the students are able to: • recognize operating limits of non-focusing collectors and the need for focusing collectors, the different types of solar concentrators and their relative merits • assign output power, delivery temperatures and performance indices for different kinds of solar concentrator technologies.				
	c) Photovoltaic Devices After the successful participation in the course **Photovoltaic Devices** the students are able to: • distinguish the solar radiation on oriented surfaces • perceive the physics of photovoltaic cell materials, production, modules structure and basic electrical characteristics of the solar module.				

Contents	**a) Solar Thermal Heating** • Basics of heat transfer and thermodynamics • Basics of solar radiation including - calculation of radiation on the inclined / adjusted area - solar radiation distribution - spatial and temporal solar radiation variations • Components - collector (types, material, collector loop, energy balance, efficiency) - heat carrier (thermo physical properties, pressure drop, heat transfer, chemical stability, solubility of gases) - heat storage (different types and tasks, thermo-physical properties) • Dimensioning of solar thermal plants according to its uses: - domestic hot water plants, swimming pools, air conditioning - district heating - industrial use • Planning the connection of the systems with one another and with the building • Using planning tools and simulation programs (Meteonormm TSOL, POLYSUN, ect.) • Monitoring and optimization: - system failures - methods for long term monitoring / system optimization
	b) Concentrated Solar Thermal Devices • Driving factors for solar concentration techniques • Mechanism of solar concentration • Components of a concentrating collector • Concentration ratio (theoretical vs. actual) • Types and thermal performance of concentrating collectors • Tracking • Choice of collector mount • Calculations to yield the - output power - delivery temperature (for specific types) - the performance indices
	c) Photovoltaic Devices • Basics of: - electrical engineering - characteristics of solar radiation (diffuse, direct, and albedo) • PV design: - solar cells physics (photovoltaic effect) and materials (mono-crystalline, multi-crystalline, thin-film technology) - estimating the radiation on PV modules - semiconductor material and their application in PV • Basic components of grid connected PV-Systems - sizing of PV-generator - cabling, protection - inverter-concepts (with and without transformer) • Estimating *performance criteria* - evaluation criteria (energy yield, performance ratio, maximum power point (MPP), aim and techniques of MPP-tracking - simulation tools (e.g. PV*SOL or INSEL) for the design and forecast of PV system performance, project work • Local requirements and legislation for integration of PV systems to the utility grid
Media	Black board and beamer, lectures and power point presentations.
Literature	• J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, Wiley, 3rd edition, 2006. • H.-M. Henning, *Solar-Assisted Air-Conditioning in Buildings: A Handbook for Planners*, Springer; 2nd edition, 2007. • A.B. Meinel and M.P. Meinel,*Applied Solar Energy*, Addison-Wesley Publishing Company, 1977. • M. M. Elsayed, I.S. Taha and J.A. Sabbagh, *Design of Solar Thermal Systems*, Scientific Publishing Center, King Abdulaziz University, Jeddah, KSA, 1994. • Selection of published papers (will be handed out). • T. Markvart and Luis Castaner (ed.), *Practical Handbook of Photovoltaics, Fundamentals and Applications*, Elsevier Science, 1st edition, 2003.

	• A. Goetzbergerand V.U. Hoffmann, *Photovoltaic Solar Energy Generation*, Springer, 1st edition, 2010. • R.A. Messenger and J. Ventre, *Photovoltaic Systems Engineering*, CRC Press, 3rd edition, 2010. • J.A. Duffieand W.A. Beckman, *Solar Engineering of Thermal Processes*, John Wiley & Sons Inc., 3rd edition, 2006. • M.A. Green, *Third Generation Photovoltaics: Advanced Solar Energy Conversion*, Springer, 2005.

Module title	**Economic and Ecological Aspects of REEE**				
Module type	**E**				
Competency	**Understanding the importance of renewable energies with regards to environmental and economic impact of energy industry and assessing potential alternatives**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Environmental Issues and Managing the Effects (Global Climate Change)	seminar, lecture	2	2	a) midterm (40%) - group report - individual assignment b) final exam (60%)
	Macroeconomic Aspects of RE	lecture	2	2	a) midterm (40%) group presentation b) final exam (60%)
	Engineering Economics and Feasibility Studies for REEE	lecture	2	2	a) midterm (40%) - feasibility study in group - home exam - calculation tasks b) final group presentation (60%)
	Potentials of RE in the MENA Region and Europe	seminar	2	2	a) midterm (40%) - group presentation - individual report b) final exam (60%)
Semester	Winter				
Responsible	Khalil				
Site	Cairo				
Lecturer(s)	Osama Elbahar Mohamed El Sobki Sayed Kaseb, Mohamed Fawzi El-Refaie Adel Khalil, Sayed Kaseb				
Language	English				
Workload	120 hours course attendance 80 hours self-study				
Credits	8				
Recommended Qualifications	-				
Learning Outcomes	**a) Environmental Issues and Managing the Effects (Global Climate Change)** After the successful participation in the course **Environmental Issues and Managing the Effects (Global Climate Change)** the students are able to: • recognize different effects of energy use on environment, society and economy, methods of greenhouse gas balances and concepts for mitigation • distinguish different energy concepts relating to their environmental impacts.				
	b) Macroeconomic Aspects of RE After the successful participation in the course **Macroeconomic Aspects of RE** the students are able to: • assess economic aspects of production, distribution, consumption of energy and energy trade (including sustainability aspects) • interpret economic and administrative rules and regulations, functions and structure of regional, national and international organisations involved in the energy sector.				

	c) Engineering Economics and Feasibility Studies for REEE After the successful participation in the course **Engineering Economics and Feasibility Studies for REEE** the students are able to: • interpret basic economic concepts (e.g. demand supply equilibrium, risk analysis, depreciation) • conduct feasibility studies, concepts of decision making, cost estimation techniques and funding strategies.
	d) Potentials of RE in the MENA Region and Europe After the successful participation in the course **Potentials of RE in the MENA Region and Europe** the students are able to: • assign conversion efficiencies for different forms of energy with special respect to implementation in MENA Region.
Contents	**a) Environmental Issues and Managing the Effects (Global Climate Change)** • Environmental consequences of energy use and production: - climate change / global warming - air pollution - water use and pollution - natural disasters - sea level rise - migration - climate change • Mitigation: - political framework (Kyoto protocol, UNFCCC) - technologies for mitigation such as RE, EE, clean coal • Adaptation: - risk management - land use change • Greenhouse gas balances: fundamentals, methods, calculation
	b) Macroeconomic aspects of RE • Basics: - the national energy balance (who produces what type of energy, where, and from which source, who consumes it, where, and for what purpose) - energy related units - conversions - formulas • Sustainability criteria: - economic, social, ecologic and political aspects - criteria and indicators of the concept of sustainable energy supply - global and European-Arab strategies of energy supply - trade and security - “plan solaire” • Policies: - role of state / market / private sector - decentralisation - standardisation - policy options and mix - awareness building • Regulations: - laws and law enforcement - division of labour among organisations - feed-in, economic and social functions of tariffs • Organisations: functions and structure of public and private organisations in the energy sector on the national, regional and international level (e.g. IEA, IAEO)

	c) Engineering Economics and Feasibility Studies for REEE • Economic decision, money-time relationship, cost and cost estimating • Feasibility study: detailed introduction into building and structuring • Methods of economic studies and selection • Calculating: - depreciation - income taxes, after-tax considerations, price change and exchange rate - replacement analysis and probabilistic economic analysis - funding requirements - financial accounting and benefits analysis - complete feasibility study
	d) Potentials of RE in the MENA Region and Europe • Actual energy situation in EU and MENA countries resp. student's home countries • Definitions of potentials • Researching specific information sources • Actual state and potentials of renewable energies in the different countries • Actual projects for renewable energies: DESERTEC, Aqua/MED CSP • Economics and calculating technical potentials of RE in the MENA region
Media	Black board and beamer, visiting energy sector organisations in Egypt and discussions with planners and decision makers, slide show and power point presentations, open ended discussions initiated by the lecturer, case studies through team work ended by discussions, computer lab for spread sheet applications and surveying issues, project work.
Literature	• R.M. Auty and K. Brown, *Approaches to Sustainable Development, Global Development and the Environment*, Routledge, 1st edition, 1997. • *Renewables 2007: Global Status Report*, 2007, downloadable from http://www.scribd.com/doc/8116771/Global-Energy-Report-Renewables-2007. • U.R. Fritsche and K. Schmidt, *Schwerpunkt*analyze *Regenerative Energien für die Region Nord Afrika/Naher Osten (MENA) mit Ergänzungen zur Energieeffizienz*, downloadable from http://www.scribd.com/doc/17317686/Regenerative-Energien-fur-die-MENARegion-mit-Erganzungen-zur-Energieeffizienz. • W.G. Sullivan, E.M. Wicks and J.T. Luxhoj, *Engineering Economy*, Pearson Education, 12th edition, 2002. • D.G. Newman, T.G. Eschenbach and J.P. Lavelle, *Engineering Economic Analysis*, New York, USA, Oxford University Press, 10th edition, 2008. • J. Matson,*Cooperative Feasibility Study Guide*, United States, Department of Agriculture, Rural Business–Cooperative Service (RBS Service), Report 58, downloadable from http://www.rurdev.usda.gov/rbs/pub/sr58.pdf, 2000 • Recent publications on renewable energies in the MENA region and Europe • Lecture notes

<table>
<tr><td>Module title</td><td colspan="5">Advanced Energy Engineering</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Understanding the radiative properties of the thermal system</td></tr>
<tr><td rowspan="3"></td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Applied Heat Transfer</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Advanced Fluid Mechanics</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td>Winter</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Responsible</td><td colspan="5">El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">Monastir</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Abdelmajid Jemni, Naceur Borgini
Naoual Daouas, Maher Ben chiekh
Ameni Mokni</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Applied Heat Transfer
After the successful participation in the course Applied Heat Transfer the students are able to:
• evaluate the radiative exchange in a thermal system; understand the effect of radiative properties, geometry and arrangement of surfaces on the involved radiative fluxes; size and choose different types of heat exchange and determine the thermal loads of the premises.</td></tr>
<tr><td colspan="5">Advanced Fluid Mechanics
After the successful participation in the course Advanced Fluid Mechanics the students are able to:
• calculate and size different elements of a hydraulic system
• study the forces and the resulting motions of the objects through the air.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Applied Heat Transfer
• Heat radiation: introduction to thermal radiation; blackbody radiation; radiative properties of real surfaces; radiative exchange between surfaces; radiation through a semi-transparent medium.
• Heat exchangers: classification of heat exchangers; thermal design methods of heat exchangers; tubular heat exchangers: double-pipe, shell and tube exchangers; plate heat exchangers; heat exchangers with finned surfaces; heat exchangers with phase change (condenser boiler and evaporator); design and simulation of heat exchangers using the calculation codes (HTFS, etc.).
• Thermal building: concept of thermal comfort; steady-state calculation of the building load; load in winter mode (losses surface and thermal bridges, internal intakes losses by infiltration and air change, solar contributions); load in summer mode (losses surface and thermal bridges, internal intakes losses by infiltration and air change, solar contributions); transient modelling.</td></tr>
<tr><td colspan="5">Advanced Fluid Mechanics
• Hydraulics: hydraulic basics and systems; pumps; hydraulic actuators; valves; circuit diagrams and troubleshooting; electrical devices (troubleshooting and safety).
• Aerodynamics.
• Lift: balloons (Buoyancy and Archimedes); airplanes (air foils and Bernoulli).
• Drag: profile drag; induced drag; effects of air foil geometry on lift and drag</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.</td></tr>
<tr><td>Literature</td><td colspan="5">• CENGEL Y.A. Heat Transfer: Practical Approach, McGraw-Hill, 1997
• HOLMAN J.P. Heat Transfer, McGraw-Hill, Inc.,1990</td></tr>
</table>

	• OZISIK M.N. Radiative Transfer, John Wiley & Sons, 1973 • E.L. Houghton, P.W. Carpenter, Steven H. Collicott, Daniel T. Valentine; Aerodynamics for Engineering Students • F. Brater, W. King, E. Lindell, Y. Wei, Handbook of Hydraulics, McGraw-Hill

<table>
<tr><td>Module title</td><td colspan="5">Energy and Environment</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Implementing energy management systems, energy transition and sustainable development</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Energy and Environmental Context, Energy Transition and Sustainable Development</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Energy and Environmental Management Systems</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">Monastir</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Habib Ben Aissia, Hacen Dhahri
Souheil El Alimi, Ramla Gheith</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
40 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Energy and Environmental Context, Energy Transition and Sustainable Development
After the successful participation in the course Energy and Environmental Context, Energy Transition and Sustainable Development the students are able to:
• recognize the effect of energy use on the environment
• drive a sustainable energy management
• identify the improvement areas and cost reduction
• implement an energy management system.</td></tr>
<tr><td colspan="5">Energy and Environmental Management Systems
After the successful participation in the course Energy and Environmental Management Systems the students are able to:
• drive a sustainable energy management
• identify the improvement areas and cost reduction
• implement an energy management system
• know and interpret the requirements of ISO 14001
• acquire the tools and measurement indicators for the successful ISO 14001 certification.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Energy and Environmental Context, Energy Transition and Sustainable Development
• Energy and environmental context: growth of energy consumption; energy and climate change; energy independence and security act; state of the world's energy resources; opening of energy markets and price trends; the energy context in MENA region.
• Energy transition and sustainable development: new energy technologies; biofuels (different production); biofuels (industrial processes); sustainable development and its limits; CO2 issue; energy optimization in the refinery; CO2 capture and storage; H2 (new energy vector); energy transition and global responsibility; economic estimates.</td></tr>
<tr><td colspan="5">Energy and Environmental Management Systems
• Energy Management Systems: initiate the optimizing energy consumption process; discover the ISO 50001; initiate an Energy Management System ISO 5000; implement an Energy Management System; monitoring and measurement; management review.
• Energy and environmental management systems: the challenges of environmental management system; establishment of an EMS according to ISO 14001; acquire the key tools to build EMS according to ISO 14001; continuous improvement; organize efficient management reviews.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.</td></tr>
<tr><td>Literature</td><td colspan="5">• Energy and the challenge of sustainability, United Nations Development Programme</td></tr>
</table>

	• www.iea.org • www.iso.org

<table>
<tr><td>Module title</td><td colspan="5">Management and Engineering Mathematics</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Opportunity to deal with constrained and unconstrained general energy optimization problem and understand the fundamentals of project management</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Numerical Methods and Optimization</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Project Management and Industrial Marketing</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">Monastir</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Sassi Ben Nasrallah, Souheil El Alimi, Souheil Bechir</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
50 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Numerical Methods and Optimization
After the successful participation in the course Numerical Methods and Optimization the students are able to:
• develop and use numerical simulation codes of flow and heat and mass transfer.
• optimize general energy problem.</td></tr>
<tr><td colspan="5">Project Management and Industrial Marketing
After the successful participation in the course Project Management and Industrial Marketing the students are able to:
• apply the selection criteria of project management.
• understand and acquire the necessary tools' aspects of industrial marketing.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Numerical Methods and Optimization
• Numerical methods: discretization and general formulation of flow phenomena and transfers; finite volume methods: solving diffusion and flow problems, resolution of convection-diffusion problems; finite element methods: approximation by finite elements, various types of elements, integral formulation; finite element methods based on finite volumes.
• Optimization: optimization problem, constrained and unconstrained optimization.</td></tr>
<tr><td colspan="5">Project Management and Industrial Marketing
Project management fundamentals: project planning; software implementation for the project management; definition of industrial markets; marketing strategy; the marketing mix; sales force management and sales teams, cultural differences, the cost of the sales team and marketing contribution.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.</td></tr>
<tr><td>Literature</td><td colspan="5">• Suhas. V. Patankar, Numerical Heat Transfer and Fluid Flow,
• Singiresu S. Rao. Engineering Optimization
• RRMILA DIWEKAR, Introduction to applied optimization, Springer
• Scott Berkun, Making Things Happen: Mastering Project Management,
• A Guide to the Project Management Body of Knowledge, Project Management Institute</td></tr>
</table>

Module title	Solar Energy Subsystems				
Module type	**E**				
Competency	**Reviewing different technologies of solar energy**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Solar Energy Collectors	lecture, exercise	3	3	- midterm (1/3) assignments - final exam (2/3)
	PV Solar Energy Materials	lecture, exercise	2	2	- midterm (1/3) assignments - final exam (2/3)
Semester	Winter				
Responsible	El Alimi				
Site	Monastir				
Lecturer(s)	Hacen Dhahri, Souheil El Alimi, Ameni Mokni				
Language	English				
Workload	75 hours course attendance 50 hours self-study				
Credits	5				
Recommended Qualifications	-				
Learning Outcomes	**Solar Energy Collectors** After the successful participation in the course **Solar Energy Collectors** the students are able to: • assign output power, delivery temperatures and performance indices for different kinds of solar collectors.				
	PV Solar Energy Materials After the successful participation in the course **PV Solar Energy Materials** the students are able to: • perceive the physics of photovoltaic cell materials, production and modules structure.				
Contents	**Solar Energy Collectors** • Solar energy: reckoning of time; solar angle; solar radiation; the solar resources. • Solar energy collectors: stationary collectors; sun-tracking concentrating collectors; thermal analysis of flat-plate collectors; thermal analysis of air collectors; practical consideration for flat-plate collectors; concentrating collectors; second law analysis; performances of solar collectors.				
	PV Solar Energy Materials • Semi-conductors. • Photovoltaic panels: PV arrays and types of PV technology. • Related equipment: batteries; inverters; charge controller; peak power trackers. • Applications: direct-coupled PV system; stand-alone application; grid and hybrid connected systems.				
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.				
Literature	Soteris A Kalogirou, Solar energy engineering processes and systems, Academic Press				

<table>
<tr><td>Module title</td><td colspan="5">Geothermal Energy</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Developing and understanding geothermal resources and applications</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Geothermal Resource Identification and Development</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Geothermal Applications</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">Monastir</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Hacen Dhahri, Souheil El Alimi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
50 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Geothermal Resource Identification and Development
After the successful participation in the course Geothermal Resource Identification and Development the students are able to:
• identify and characterize the geothermal prospects and the techniques for drilling wells into geothermal formations to extract hot fluids.</td></tr>
<tr><td colspan="5">Geothermal Applications
After the successful participation in the course Geothermal Applications the students are able to:
• discuss the general concepts of geothermal power plants.
• define the main characteristics of the geothermal fluids used in space or district heating.
• describe the main features of the absorption cycles used for air conditioning and industrial refrigeration in geothermal applications.
• discuss the factors influencing greenhouse climate.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Geothermal Resource Identification and Development
• Geology of geothermal regions: the earth and its atmosphere; active geothermal regions; model of a hydrothermal geothermal resource and other types of geothermal resources; exploration strategies and techniques; objectives and phases of an exploration program; synthesis and interpretation.
• Geothermal well drilling: site preparation and drilling equipment; drilling operations; safety precautions.
• Reservoir engineering: reservoir and well flow; well testing; calcite scaling in well casings; reservoir modelling and simulation.</td></tr>
<tr><td colspan="5">Geothermal Applications
• Electricity generation
o technical features of plant options: atmospheric and condensing exhaust conventional steam turbines; binary plant; biphase rotary separator turbo-alternator.
o well-head generating units: economic considerations regarding small geothermal plants.
• Space and district heating: resource considerations; space heating (or cooling) needs; hot water collection and transmission system; equipment selection; economical and environmental considerations; tariffs; integrated uses.
• Space cooling: air conditioning; commercial refrigeration; absorption research; materials.
• Greenhouse heating: energy aspects of protected crop cultivation; characteristics of heat consumption; technical solutions for geothermal greenhouse heating; geothermal greenhouse heating installations; factors influencing the choice of heating installation; final considerations.</td></tr>
</table>

Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal and interactive.
Literature	Ronald DiPippo, Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact Geothermal energy: utilization and technology, Elsivier.

<table>
<tr><th>Module title</th><th colspan="5">Combined Cooling, Heating and Power (CCHP)</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Reviewing the applications and the different technologies of CCHP</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Theory and Technology of Combined Heating, Cooling & Power</td><td>lecture, exercise</td><td>2</td><td>2</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Applications of Combined Heating, Cooling & Power</td><td>lecture, exercise</td><td>3</td><td>3</td><td>- midterm (1/3) assignments
- final exam (2/3)</td></tr>
<tr><td>Semester</td><td colspan="5">Winter</td></tr>
<tr><td>Responsible</td><td colspan="5">El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">Monastir</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Hacen Dhahri, Souheil EL Alimi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
50 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Theory and Technology of Combined Heating, Cooling & Power
After the successful participation in the course Theory and Technology of Combined Heating, Cooling & Power the students are able to:
• provide the basic building blocks of CCHP.</td></tr>
<tr><td colspan="5">Applications of Combined Heating, Cooling & Power
After the successful participation in the course Applications of Combined Heating, Cooling & Power the students are able to:
• provide potential solutions.
• define the steps to choose and implement such solutions.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Theory and Technology of Combined Heating, Cooling & Power
• Optimizing heat and power resources: heat and power resources overview; expressing power cycle performance; localized vs. central station power generation; selection of power generation systems.
• Thermal technologies: heating value and combustion of fuel; properties and value of the steam; boilers; heat recovery.
• Prime mover technologies: reciprocating engines; combustion Gas Turbines, steam Turbines; combined and steam injection cycles; controlling prime movers; renewable and alternative power technologies.</td></tr>
<tr><td colspan="5">Applications of Combined Heating, Cooling & Power
• Localized electric generation: localized electric generation applications overview; electricity; electric generators; generator driver (applications and selection); electric generator switchgear and controls; interconnecting electric generators.
• Mechanical drive services.
• Mechanical drive applications overview: air compressors; pumps; fans.
• Refrigeration and air conditioning: refrigeration cycles and performance ratings; psychometrics; heat extraction – evaporators, chilled water, economizers and thermal storage; heat rejection – condensers, cooling towers, heat pumps and heat recovery; vapor compression- cycle systems; absorption cooling systems; desiccant dehumidification technologies.
• Integrated approach to energy resource optimization projects: technical analysis; evaluating the financial potential of the project; contracting and financing options of the project; implementing and operating the program.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive.</td></tr>
<tr><td>Literature</td><td colspan="5">Neil Petchers, Combined Heating, Cooling & Power Handbook: Technologies & Applications, the Fairmont press, INC, Marcel Dekker, INC.</td></tr>
</table>

Module title	**Economic Activities of Germany in the MENA region**				
Module type	**E**				
Competency	**Extracting success factors of German businesses in the MENA region**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Business economic aspects of RE	lecture	2	2	group presentation
	Potentials of German Institutions and Companies for the MENA Region	lecture	2	2	report
Semester	summer				
Responsible	Dahlhaus				
Site	Kassel				
Lecturer(s)	Thomas Adams, Wesly Urena Vargas Marc Selig				
Language	English				
Workload	60 hours course attendance 40 hours self-study				
Credits	4				
Recommended Qualifications	-				
Learning Outcomes	**a) Business Economic Aspects of RE** After the successful participation in the course **Business Economic Aspects of RE** the students are able to: • understand the driving factors of energy costs and how energy pricing can influence supply and demand • read and assess cost-benefit- analyzes.				
	b) Potentials of German Institutions and Companies for the MENA Region After the successful participation in the course **Potentials of German Institutions and Companies for the MENA Region** the students are able to: • reflect key factors, methods and the necessary framework for a company to get into the market of a country.				
Contents	**a) Business economic aspects of RE** • Cost calculation for energy production and distribution • Cost development prognoses (national and international level) • Metering, meter reading, billing • Fee collection (in public sector, industry, and households) • Analysing feasibility studies in the energy sector: - elements - calculation methods - risk assessment - critical analysis				
	b) Potentials of German Institutions and Companies for the MENA Region • Presenting companies and institutions with their actual activities in the MENA region • Excursions to selected companies (e.g. CUBE, Viessmann, Enercon) with presentations about their engagement in the MENA region and visits of production lines				
Media	Black board and beamer				
Literature	• F.E. Banks, *Energy Economics: A Modern Introduction*, Springer, 1st edition, 1999. • D.L. Cleland and R. Gareis, *Global Project Management Handbook: Planning, Organizing and Controlling International Projects*, McGraw-Hill Professional, 2nd edition, 2006.				

<table>
<tr><td>Module title</td><td colspan="5">Wind Energy Technology</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Analyzing the project management work flow for a wind farm (from the production resp. construction of turbine components to electricity generation and turbine maintenance)</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Mechanical Aspects of Wind Energy</td><td>lecture</td><td>3</td><td>3</td><td>written exam</td></tr>
<tr><td>Electrical Aspects of Wind Energy</td><td>lecture</td><td>3</td><td>3</td><td>written exam</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Henry Seifert
Siegfried Heier</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">–</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">a) Mechanical Aspects of Wind Energy
After the successful participation in the course Mechanical Aspects of Wind Energy the students are able to:
• apply their gained knowledge about the design of different wind turbines resp. single components and their material requirements on specific locations
• identify the optimal location for a planned wind farm and to develop it after analyzing the requirements for construction, logistics and grid connection as well as national standards.</td></tr>
<tr><td colspan="5">b) Electrical Aspects of Wind Energy
After the successful participation in the course Electrical Aspects of Wind Energy the students are able:
• distinguish the design of different types of Wind Energy Converter and to analyze their function in different control concepts
• be aware of different electrical networks and possible problems related with grid integration and grid control
• apply mathematical models for control system design and plant simulation.</td></tr>
<tr><td>Contents</td><td colspan="5">a) Mechanical Aspects of Wind Energy
• Wind turbine components:
- different wind turbine designs and their components
- functional requirements
- aesthetic criteria.
• Mechanical drive train and machine house:
- comparison of different design concepts
- blade adjustment system, rotor brake
- step up gears, generator coupling tracking of wind direction
• Machine house design:
- different gear boxes and mechanical drives
- needed safety and braking systems
• Loads and structural demands:
- static aerodynamic and structural loads on blades and towers
- dynamic loads on blades and towers
- extra loads from the mechanical systems connected to the wind turbine,
- modeling to calculate the loads and structural demands
- mechanical components and control system loads
• Forces and performance curves for the wind turbine
• Rotor blades in composite construction:
- materials, composite material construction
- rotor blade construction
- rotor blade connection to the hub</td></tr>
</table>

	• Towers and foundation (design and varieties): - steel tube towers, concrete tower, lattice tower - suitable foundation • Planning, installation and operation: - planning wind farms - developing a Gantt chart to define when the different design / construction / testing and operation will commence - legislations for land and environmental operation - transport facilitations for wind farm - plant erection, testing and operation - safety aspects - service and maintenance - certification of wind power plants • Field excursion to German wind farm sites
	b) Electrical Aspects of Wind Energy • Components and functions of Wind Energy Converter (WEC): - main components of wind energy converters - rotor blade with pitch drive - input torque, generator - mechanical drive train • Calculation of blade setting and obtaining performance curves • Grid integration: - different electrical networks - grid influences - different problems related with grid integration - schemes for grid control • Control concepts and operational results: - island grid operation of WECs - grid operation, interconnection operation • Control system design and plant simulation: - plant components characteristics - control systems for the plant operation - development of mathematical models for control and simulation - dimensioning of the controllers
Media	Black board and beamer, power point presentations.
Literature	• S. Heier and R. Waddington, *Grid Integration of Wind Energy Conversion Systems*, Wiley-Blackwell, 2nd edition, 2006. • E. Hau and H. von Renouard, *Wind Turbines: Fundamentals, Technologies, Application, Economics*, Springer; 2nd edition, 2005.

Module title	Energy Efficiency and Storage
Module type	E
Competency	Analyzing energy storage technologies and EE measures for RE systems

Courses

Title	Teaching Method	SWS	Credits	Performance requirements/ Examination
Energy Storage	lecture, (group) work	2	2	written exam
Energy efficiency in cross-sectional technologies	lecture	3	3	written exam
Energy efficiency through process integration	lecture, (group) work	3	3	written/oral exam

Semester	summer
Responsible	Dahlhaus
Site	Kassel
Lecturer(s)	Ingo Stadler Alexander Schlüter, Henning Meschede, Ron-Hendrik Peesel, Florian Schlosser
Language	English
Workload	120 hours course attendance 80 hours self-study
Credits	8
Recommended Qualifications	– Basics in thermodynamics and heat transfer
Learning Outcomes	**a) Energy Storage** After the successful participation in the course **Energy Storage** the students are able to: • distinguish different storage technologies and their role for the RE system • compare costs and potentials of EE processes and storage systems.
	b) Energy efficiency in cross-sectional technologies After the successful participation in the course **Energy efficiency (EE) in cross-sectional technologies** the students are able to: • analyze energetically industrial processes • examine energy efficiency potentials.
	c) Energy efficiency through process integration After the successful participation in the course **Energy efficiency (EE) through process integration** the students are able to: • analyze and model industrial EE systems • evaluate EE potentials.
Contents	**a) Energy Storage** • Description of thermal storages: - power to gas - batteries - hydro power - air storages • Efficiency of the conversion • Costs for different technologies • Calculation of specific costs per storage capacity

	b) Energy efficiency in cross-sectional technologies
	• Basics in energy efficiency
	• Energy management systems
	• EE in cross-sectional technologies:
	  • Lightning
	  • Compressed air
	  • Drives and pumps
	  • Chillers
	  • Process heating
	  • HVAC
	• Energy monitoring and measuring technology
	• Economic assessment of EE measures

	c) Energy efficiency through process integration • Thermodynamic modelling of energy systems • Waste heat recovery

	• Combined heat and power • Design of thermal storage (cooling/heating) • Pinch methodology
Media	Black board and beamer, computer models, experimental measurements.
Literature	• Lecture notes on *Energy Storage.* • Hesselbach, J., 2012. Energie- und klimaeffiziente Produktion. Grundlagen, Leitlinien und Praxisbeispiele ; 34 Tabellen. Springer Vieweg, Wiesbaden. • Pehnt, M., 2010. Energieeffizienz. Ein Lehr- und Handbuch. Springer-Verlag Berlin Heidelberg, Berlin, Heidelberg. • Klemeš, J.J. (Ed.), 2013. Handbook of process integration (PI). Minimisation of energy and water use, waste and emissions. Woodhead Pub, Cambridge, U.K.

<table>
<tr><td>Module title</td><td colspan="5">Scientific Programming and Publishing</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Scientific Programming and Publishing</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Introduction to MATLAB</td><td>lab training</td><td>2</td><td>4</td><td>lab training attendance, programming, oral exam (30 minutes)</td></tr>
<tr><td>Introduction to LaTeX</td><td>lecture and training</td><td>1</td><td>2</td><td>writing a scientific report</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Nour Mansour</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
40 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">–</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">MATLAB
After the successful participation in MATLAB training the students are able to:
• understand approaches for numerical simulation in the field of renewable energy and energy efficiency
• write a code for different optimization problems</td></tr>
<tr><td colspan="5">Introduction to LaTeX
After the successful participation in the course LaTeX, the students are able to:
• gain a sophisticated structuring abilities
• use a very advanced math typesetting
• build a sophisticated report or presentation without caring of the outlook but only about the content
• build the main structure of the scientific report
• know the different steps in order to write a scientific report, from the brainstorming to the final version
• professionally customize the look of the report
• learn how to build a consistent and more easily and changeable report or presentation.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">MATLAB
Introduction to MATLAB and its most important commands, simulation of a simple chain based on energy efficiency, system modelling, cost minimization and applied different optimization problem using MATLAB programming</td></tr>
<tr><td colspan="5">Introduction to LaTeX
Drafting, organizing revising and editing, learning the mathematical notion required for writing the scientific report, sophisticated structuring and building and elaborating, consistent and changeable report.</td></tr>
<tr><td>Media</td><td colspan="5">Beamer, black board (mathematical notation, explanations), paper (exercises), PC based software development (lab training).</td></tr>
<tr><td>Literature</td><td colspan="5">• P. Venkataraman, Applied Optimization with MATLAB Programming, 2009.
• H. Moore, MATLAB for Engineers, 2007.
• S. Boyd, L. Vandenberghe, Convex Optimization, Cambridge University Press,2014.</td></tr>
</table>

<table>
<tr><th>Module title</th><th colspan="5">Practical Aspects of REEE</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Identifying opportunities for practical implementation of RE systems</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Grid Integration</td><td>lecture, seminar</td><td>2</td><td>2</td><td>written exam</td></tr>
<tr><td>Energy Efficiency in Buildings</td><td>lecture</td><td>3</td><td>3</td><td>- assignments
- written exam</td></tr>
<tr><td>System Aspects of Bio Power Generation</td><td>lecture/lab</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Kurt Rohrig
John, Sievers, Susanne Eckhardt-Kastner
John Sievers</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">105 hours course attendance
70 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">7</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">a) Grid Integration
After the successful participation in the course Grid Integration the students are able to:
• understand the design, problems and operation of integrated grids with respect to the specific properties of renewable energies
• apply advanced schemes like online-monitoring and forecasting.</td></tr>
<tr><td colspan="5">b) Energy Efficiency in Buildings
After the successful participation in the course Energy Efficiency in Buildings the students are able to:
• understand physical and technical aspects of energy flows in buildings
• identify heat gains, heat losses and cooling demand of rooms
• determine life cycle costs and life cycle assessment of environmental impacts in the building sector.</td></tr>
<tr><td colspan="5">c) System Aspects of Bio Power Generation
After the successful participation in the course System Aspects of Bio Power Generation the students are able to:
• understand the basics of life cycle assessment for different renewable energy sources
• Investigate energy costs and to determine roughly costs under different conditions (sizes, boundary conditions etc.)
• determine the heat value of fuels and to determine and assess emissions of the burning process.</td></tr>
<tr><td>Contents</td><td colspan="5">a) Grid Integration
• Spatio-temporal behaviour of wind and solar power:
- wind and solar power as energy sources
- the spatio-temporal behaviour of wind and solar power
• Integrating wind and solar power in the electricity grid:
- grid operation
- wind and solar power in electricity grids
- balancing of production and consumption
- grid connection and ancillary services for the grid
• Strategies and tools for the operation of the electricity supply system:
- online-monitoring and smoothing effects
- wind power and solar power forecasting
- control options for the renewable power plant
• Outlook: virtual power plant, storage, load management</td></tr>
</table>

	b) Energy Efficiency in Buildings • Basics of building physics: - heat transfer adapted to building elements like walls and windows - shading devices, humidity and condensation effects - global radiation on building • Conventional vs. unconventional energy use in buildings: - thermal comfort, ventilation - boilers, cogeneration of heat and electricity, heat pumps - passive houses • Economic aspects of EE in the building sector: - costs and savings of energy efficiency measures - life cycle costs and life cycle assessment of environmental impacts • Comparing conditions in Germany and the Mena countries
	c) System Aspects of Bio Power Generation • Introduction into life cycle assessment of environmental impacts: using Gemis and Ecoinvent. DIN ISO 14040 • Scientific cost and life cycle analysis for different renewable energy sources: - bio energy in comparison to PV, wind, solar thermal power plants, hydro Power - derivation of ecological figures for operation, production and removal of plants • Introduction into scientific data collection and allocations: - bonuses - problems of different assessments with focus on bio energy • Lab regarding fundamentals of: - calorimetric - exhaust gas measurements • Thermodynamic calculations • Environmental impacts: - assessment of accuracy - discussion of environmental impacts
Media	Black board and beamer, power point presentations, experiments.
Literature	• M.B. Ferguson (ed.), *Renewable Energy Grid Integration: Technical Performance and Requirements (Environmental Remediation Technologies, Regulations and Safety)*, Nova Science Publishers Inc, 2010. • S. Heier and R. Waddington, *Grid Integration of Wind Energy Conversion Systems*, Wiley-Blackwell, 2nd edition, 2006. • Energy Efficiency in Buildings (CIBSE Guide), Chartered Institution of Building Services Engineers, 2006. • European Standard DIN EN ISO 14040, Environmental management - Life cycle assessment - Principles and frame work • European Standard DIN EN ISO 14041, Environmental management - Life cycle assessment -Goal and scope definition and life cycle inventory analysis • Further literature will be announced by the lecturers: Introductory documents for the Ecoinvent and GEMIS data source • R. Zah, H. Böni, M. Gauch, R. Hischier, M. Lehmann and P. Wäger, *Life Cycle Assessment of Energy Products: Environmental Assessment of Biofuels*, Empa, Technology and Society Lab, 2007; downloadable from http://www.bfe.admin.ch/themen/00490/00496/index.html?lang=en&dossier_id=01273. • R. Frischknecht and N. Jungbluth (eds.), *Overview and Methodology*, Ecoinvent report No. 1, 2007; downloadable from • http://www.ecoinvent.org/fileadmin/documents/en/01_OverviewAndMethodology.pdf. • The Adiabatic Constant Volume Twin Calorimeter, downloadable from http://fluidproperties.nist.gov/cvht.html.

<table>
<tr><th>Module title</th><th colspan="5">Project Management</th></tr>
<tr><th>Module type</th><th colspan="5">E</th></tr>
<tr><th>Competency</th><th colspan="5">Breaking down a project into its basic elements and assessing its socio-economic effects</th></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>International Project Management</td><td>seminar, lecture</td><td>2</td><td>2</td><td>- group presentations
- assignments
- written exam</td></tr>
<tr><td>Project Management in Development Cooperation</td><td>lecture, workshop</td><td>2</td><td>2</td><td>- group work results
- written exam</td></tr>
<tr><td>Energy and Society</td><td>seminar</td><td>1</td><td>1</td><td>presentation resp. report</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Rao Aamir Ali Khan
Theda Kirchner
Dieter Gawora</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
50 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">a) International Project Management
After the successful participation in the course International Project Management the students are able to:
• break down a project into its basic elements
• identify specific needs and targets of international projects
• investigate success factors for executing RE projects, specifically in the development cooperation between Germany and Arab countries.</td></tr>
<tr><td colspan="5">b) Project Management in Development Cooperation
After the successful participation in the course Project Management in Development Cooperation the students are able to:
• use the key elements of project management cycle
• elaborate a project proposal themselves (in a final workshop).</td></tr>
<tr><td colspan="5">C) Energy and Society
After the successful participation in the course Energy and Society the students are able to:
• understand the importance of environmental assessment studies
• analyze critically socio-economic effects of RE projects, worldwide as well as regional.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">a) International Project Management
• Defining the terms project and project management
• Cases where project management is necessary and reasonable
• Project objectives, - organisation, - execution
• Exemplary international projects:
- forms, specifics and success factors
- preparation
- team building</td></tr>
<tr><td colspan="5">b) Project Management in Development Cooperation
• Key elements of project cycle management (PCM) for using RE
• Logical framework approach
• Various analysis instruments like
- situation analysis
- stakeholder analysis
- problem/objectives/risk analysis
- monitoring and evaluation</td></tr>
</table>

	- indicator development.
	c) Energy and Society • Case studies of energy projects and their social, ecological and economical impacts, e.g. big waterpower projects, oil, gas, and coal exploration projects, wind energy • Case studies of energy projects which have been blocked • Analysis of environmental assessment studies • Study of international environmental standards
Media	• Black board and beamer, case studies in groups.
Literature	• K.H. Rose, *Project Quality Management: Why, What and How*, J. Ross Publishing, 2005. • D.L. Cleland and R. Gareis, *Global Project Management Handbook: Planning, Organizing and Controlling International Projects*, McGraw-Hill Professional, 2nd edition, 2006. • R. Zah, H. Böni, M. Gauch, R. Hischier, M. Lehmann and P. Wäger, *Life Cycle Assessment of Energy Products: Environmental Assessment of Biofuels*, Empa, Technology and Society Lab, 2007; downloadable from http://www.bfe.admin.ch/themen/00490/00496/index.html?lang=en&dossier_id=01273. • R. Frischknecht and N. Jungbluth (eds.), *Overview and Methodology*, Ecoinvent report No. 1, 2007; downloadable from http://www.ecoinvent.org/fileadmin/documents/en/01_OverviewAndMethodology.pdf • Further literature will be announced by the lecturers. • World Commission on Dams, *Dams and Development: A New Framework for Decision-Making*, Earthscan Ltd, 2000

<table>
<tr><td>Module title</td><td colspan="5">Solar Energy Systems</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Selecting solar energy systems according to specific local conditions</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Solar Thermal Cooling</td><td>lecture</td><td>2</td><td>2</td><td>written exam</td></tr>
<tr><td>Concentrated Solar Thermal Systems</td><td>lecture, project</td><td>2</td><td>2</td><td>written exam</td></tr>
<tr><td>Photovoltaic Systems</td><td>project, seminar</td><td>2</td><td>2</td><td>- midterm
- assignments
- group report</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Salman Ajib
Franz Trieb
Mohamed Ibrahim</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">a) Solar Thermal Cooling
After the successful participation in the course Solar Thermal Cooling the students are able to:
• understand the use of solar thermal energy for air conditioning
• analyze the size of solar thermal plants for air conditioning (as components and as total system) and the connection of the system to the building.</td></tr>
<tr><td colspan="5">b) Concentrated Solar Thermal Systems
After the successful participation in the course Concentrated Solar Thermal Systems the students are able to:
• reflect the fundamental characteristics and capabilities as well as impacts of concentrating solar power (CSP) stations within national electricity supply schemes
• understand the fundamentals of international cooperation for solar electricity export and long-distance transmission
• assess the technical and economic potential of CSP in a country and to identify the best sites for project development.</td></tr>
<tr><td colspan="5">c) Photovoltaic Systems
After the successful participation in the course Photovoltaic Systems the students are able to:
• select optimal(standalone, decentralized) PV systems according to specific application and resources conditions
• estimate the techno-economic performance criteria
• implement standard PV simulation software tools for system design.</td></tr>
</table>

Contents	**a) Solar Thermal Cooling** • Solar thermal cooling and solar thermal assisted air conditioning: - space cooling and refrigeration - cooling and dehumidification - energy demand for cooling and dehumidification • Fundamentals and basics of absorption cooling: - energy and mass balance of absorption cycle, solution field - thermodynamics and efficiency - working pairs - enthalpy-concentration chart • Basics of cooling towers, humid air, cooling tower concepts: - wet cooling towers/dry cooling towers - absorption cycles using LiBr-water or other working pairs like NH3-water and organic pairs, cycle schematic • Balances of the components: - evaporator, condenser, absorber, desorber, solution heat exchanger, pump, expansion valves, figures of merit, performance coefficient, pump work ratio, design and technical details; - typical component design, crystallisation prevention, maintenance of vacuum • System integration, control, characteristic equation, buffer and storage tanks, solar fraction, primary energy rate, water consumption, economics; state of the art of absorption chilliers and new developments; • Solid sorption, basics of absorption cooling, energy and mass balance of absorption cycle, thermodynamics and efficiency; working pairs, Silicagel-water, Zeolite-water, Ammonium salts, state of the art and new developments; • Further thermally driven cooling systems: open desiccant systems, solid desiccant systems, basics, design, working pairs, application, liquid desiccant systems, basics, design, working pairs; • Application: jet-cycle systems, double-effect absorption cycle, examples of installed systems
	b) Concentrated Solar Thermal Systems • Fundamentals: - solar meteorology - principles of solar electricity generation - fluctuating and balancing power, storability - short and long-term reserve capacity - environmental impacts of CSP plants • Assessment of CSP potentials: - mapping and time series of direct-normal irradiance (DNI) - mapping of site characteristics with geographic information systems - simplified modelling of CSP performance - mapping and evaluation of CSP potentials; • Creating scenarios for sustainable electricity: - target definition and sustainability - quantify the perspectives of electricity demand - quantify renewable electricity potentials - other electricity sources - how to match time series of electricity load and supply, technical and economic learning curves - least cost optimization • Concentrating solar power for seawater desalination: - water demand perspectives in the Middle East and North Africa - concepts for solar powered seawater desalination - scenarios for sustainable freshwater supply - economic and environmental impacts • Trans-Mediterranean interconnection: - CSP in the European electricity mix - opportunities of the Union for the Mediterranean (UfM) - long-term perspectives of CSP in Europe - MENA and worldwide - economic and environmental impacts

	c) Photovoltaic Systems • Decentralized and stand-alone PV hybrid systems: - modular PV systems technology for decentralized AC-power supply - large decentralized PV systems (fixed mounted and tracking systems, power condition units and grid integration) - PV stand-alone and hybrid systems configurations and components performance; - supervisory control and energy management strategies for PV decentralized systems; - storage technology for PV stand-alone systems (super-capacitors, batteries, electrolysis and fuel cells); - power conditioning units for decentralized and stand-alone PV-Systems and components (battery charger, bidirectional converters, fuel cell inverters); • Economics: - specific energy cost calculation - techno-economic performance criteria of stand-alone PV and hybrid systems • Design aspects: - methodologies for sizing PV hybrid systems - design of stand-alone PV hybrid system (load demand synthesis, component sizing, evaluation of performance criteria) - implementing simulation tools for designing PV stand-alone systems case study via project work (design of stand-alone PV system).
Media	Black board and beamer, lectures and power point presentations.
Literature	• J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, Wiley, 3rd edition, 2006. • H.-M. Henning, *Solar-Assisted Air-Conditioning in Buildings: A Handbook for Planners*, Springer; 2nd edition, 2007. • Lecture notes on *Solar Thermal Systems I*. • *Concentrating Solar Power for the Mediterranean Region*, German Aerospace Center (DLR), Institute of Technical Thermodynamics, Section Systems Analysis & Technology Assessment, 2005, downloadable from www.dlr.de/tt/med-csp. • *Trans-Mediterranean Interconnection for Concentrating Solar Power*, German Aerospace Center (DLR), Institute of Technical Thermodynamics, Section Systems Analysis & Technology Assessment, 2006, downloadable from www.dlr.de/tt/trans-csp • *Concentrating Solar Power for Seawater Desalination*, German Aerospace Center (DLR), Institute of Technical Thermodynamics, Section Systems Analysis & Technology Assessment, 2007, downloadable from www.dlr.de/tt/aqua-csp • Selection of published papers on concentrated solar thermal power will be announced. • *Practical Handbook of Photovoltaics, Fundamentals and Applications*, Elsevier Science, 1st edition, 2003. • A. Goetzbergerand V.U. Hoffmann, *Photovoltaic Solar Energy Generation*, Springer, 1st edition, 2010. • R.A. Messenger and J. Ventre, *Photovoltaic Systems Engineering*, CRC Press, 3rd edition, 2010. • J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, John Wiley & Sons Inc., 3rd edition, 2006. • M.A. Green, *Third Generation Photovoltaics: Advanced Solar Energy Conversion*, Springer, 2005.

<table>
<tr><th>Module title</th><th colspan="5">RE Integration</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Analysis and synthesis of integration processes of RE systems</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Smart Grids</td><td>lecture,
lab</td><td>3</td><td>3</td><td>written/oral exam</td></tr>
<tr><td>Flexible Generation and Demand Side Management</td><td>lecture,
lab</td><td>2</td><td>2</td><td>written/oral exam</td></tr>
<tr><td>Bio Gas</td><td>lecture,
group work</td><td>2</td><td>2</td><td>written/oral exam, report</td></tr>
<tr><td>Semester</td><td colspan="5">summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Marc Selig
John Sievers
Bernd Krautkremer</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">105 hours course attendance
70 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">7</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">–</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">a) Smart Grids
After the successful participation in the course Smart Grids the students are able to:
• Understand the key drivers as well as design principles of the smart grid (communication)
• evaluate the communication infrastructure required to set up smart grids.</td></tr>
<tr><td colspan="5">b) Flexible Generation and Demand Side Management
After the successful participation in the course Flexible Generation and Demand Side Management the students are able to:
• understand the requirements for balancing fluctuating renewable power generation and select solutions for these different requirements
• estimate potentials and costs in the control of flexible generators and consumers in domestic and industrial applications.</td></tr>
<tr><td colspan="5">c) Bio gas
After the successful participation in the course Biogas the students are able to:
• determine bio mass potentials taking into account different bio mass conversion processes and local potentials
• analyze the sustainability of the whole value chain.</td></tr>
<tr><td>Contents</td><td colspan="5">a) Smart Grids
• Overview of smart grids and smart grid communications (SGC)
• Power generation:
equipment-conditioning information and load conditions of the generation equipment
• Transmission:
- state of high-voltage power lines
- devices in the transmission substations
- power lines and feeders
• Consumers:
- overall power-usage information (meter reading) and information about power usage by devices inside the home
- automatic meter reading
- advanced metering infrastructure
- privacy issues in smart grids
• Communication technologies used in SGC:
- power line communications
- fiber optic communications
- wireless devices</td></tr>
</table>

	• Demand Response Management (DR): - utility companies and energy load management/reduction; - factors for DR programs - automation of DR as key concept which helps to reduce human intervention and increases accuracy and responsiveness to the DR program; • SGC: - activities in standardization bodies on SGC - practical experience gained in SGC lab experiments
	b) Flexible Generation and Demand Side Management (DSM) • Possibilities and potentials of flexible power generation • Differences in temporal power availability • Defining requirements • Different plant operations to cover residual load under present conditions of power generation • Discussing possible flexible balancing solutions • DSM potentials: - classification - descripting actual DSM potentials by the state of charge • Lab for practical experience with flexible power generation under central European conditions
	c) Bio gas • Different types of biomass and the efficiency of their production: - energy plants - organic waste - agricultural residuals • Different ways of using biomass and conversion paths: - combustion of solid bio mass - thermo chemical gasification, - anaerobic digestion - bio fuels • Bio gas as energy source: - components and processes of gasification - combustion basics with respect to biomass conversion • Integration of bio energy in conventional and RE systems
Media	Black board and beamer, lab experiments, measurements.
Literature	• C.W. Gellings, *The Smart Grid: Enabling Energy Efficiency and Demand Response*, CRC Press; 1st edition, 2009. • M. Shahidehpour and Y. Wang, *Communication and Control in Electric Power Systems: Applications of Parallel and Distributed Processing*. John Wiley & Sons, 2003. • J. Sievers, M. Puchta, S. Faulstich, I. Stadler and J. Schmid, *Guidelines promoting CHP concepts with heat accumulators, the perspective of CHP plants and other technologies that use thermal energy storage and their implementation in the European Union*, Deliverable 2.4, EU project *Dissemination strategy on Electricity balancing large Scale Integration of Renewable Energy* (DESIRE), University of Kassel, Kassel, 2007, downloadable from http://desire2.iset.uni-kassel.de/files/deliverables/del_2.4.pdf.

<table>
<tr><td>Module title</td><td colspan="5">Control Oriented Modeling of AC Actuators</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Electromagnetic modeling of AC actuators</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Induction Machine Modelling</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>Synchronous Machine Modelling</td><td>lecture, exercise</td><td>1</td><td>2</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Ahmed Masmoudi</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Ahmed Masmoudi
Badii Bouzidi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">30 hours course attendance
40 tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Induction Machine Modelling
After the successful participation in the course induction machine modelling, the students are able to:
• make the synthesis and the implementation of induction machine vector control strategies,
• make the synthesis and the implementation of induction machine direct torque control strategies,
• make the synthesis and the implementation of induction machine direct power control strategies.</td></tr>
<tr><td colspan="5">Synchronous Machine Modelling
After the successful participation in the course synchronous machine modelling the students are able to:
• make the synthesis and the implementation of synchronous machine vector control strategies,
• make the synthesis and the implementation of synchronous machine direct torque control strategies,
• make the synthesis and the implementation of synchronous machine maximum torque per ampere control strategies</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Induction Machine Modelling
• Principle of Operation: Induction Phenomenon
• Model Simplification Hypothesis
• IM A-B-C Model
• Park Transform
• IM Park Model
• Park Model-Based Analysis of the IM Steady-State Operation</td></tr>
<tr><td colspan="5">Synchronous Machine Modelling
• Salient Pole SM A-B-C model
• SM Park Model
• Electromagnetic Torque Formulation
• Operation at Maximum Torque
• Operation at Unity Power Factor
• Flux Weakening Operation</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">• Stephen Chapman, Electric Machinery Fundamentals, Fourth Edition, McGraw-Hill Series in Electrical and Computer Engineering, 2005.
• Paul Krause, Oleg Wasynczuk, Scott Sudhoff, Steven Pekarek, Analysis of Electric Machinery and Drive Systems, Third Edition, Wiley Online Library, 2013.</td></tr>
</table>

<table>
<tr><th>Module title</th><th colspan="5">FEA Modelling of AC Actuators (level 1)</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Design oriented machine modelling using the finite element method</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Electric System Modelling</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">exam (100%)</td></tr>
<tr><td>Finite Element Modelling</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Imen Abdennadher</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Imen Abdennadher</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
30 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Electric System Modelling
After the successful participation in the course electric system modelling the students are able to:
• make the synthesis and the analytical resolution of the electrostatic model,
• make the synthesis and the analytical resolution of the magneto-static model,
• make the synthesis and the analytical resolution of the electro-magnetic system model.</td></tr>
<tr><td colspan="5">Finite System Modelling
After the successful participation in the course finite element modelling the students are able to:
• make the synthesis of finite element model,
• make the resolution of finite element mode,
• make the numerical resolution of the finite element method.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Electric System Modelling
• Magnetic and electric laws
• Maxwell's equations
• Electrostatic model
• Magneto-static model
• Electro-magnetic model
• Cases studies</td></tr>
<tr><td colspan="5">Finite System Modelling
• Fundamentals of FEM
• Approximating potentials with shape functional finite elements
• Edge finite elements
• Application of the finite element method</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">• Miklos Kuczmann, Potential Formulations in Magnetics Applying the Finite Element Method, Lecture notes, Széchenyi István" University Györ, Hungary, 2009.
• Guillaume Legendre, Introduction à l'Analyse Numérique et au Calcul Scientifique, University of Paris, 2017</td></tr>
</table>

<table>
<tr><th>Module title</th><th colspan="5">FEA Modelling of AC Actuators (level 2)</th></tr>
<tr><th>Module type</th><th colspan="5">E</th></tr>
<tr><th>Competency</th><th colspan="5">Sizing oriented machine modelling using the finite element method</th></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Linear Static Magnetic Analyses</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>Non-Linear Static Magnetic Analyses</td><td>lecture, exercise</td><td>1</td><td>2</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Imen Abdennadher</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Imen Abdennadher
Amal Souissi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">30 hours course attendance
40 tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Linear Static Magnetic Analysis
After the successful participation in the course linear static magnetic analysis the students are able to:
• establish the model and make the numerical resolution of the linear electrostatic model,
• establish the model and make the numerical resolution of the linear magneto-static model,
• establish the model and make the numerical resolution of the linear electro-magnetic model.</td></tr>
<tr><td colspan="5">Non-Linear Static Magnetic Analysis
After the successful participation in the course non-linear static magnetic analysis the students are able to:
• establish the model and make the numerical resolution of the non-linear electrostatic model,
• establish the model and make the numerical resolution of the non-linear magnetostatic model,
• establish the model and make the numerical resolution of the non-linear electromagnetic model.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Linear Static Magnetic Analysis
• Examples description
• Linear material definition
• Meshing
• Boundary conditions
• Loads definition
• Review results</td></tr>
<tr><td colspan="5">Non-Linear Static Magnetic Analysis
• Examples description
• Non-linear material definition
• Meshing
• Boundary conditions
• Load definition
• Review results</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">Conventional software packages tutorials</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Embedded Energy Storage Systems</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Storage systems analysis and sizing</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Storage Systems: Case Studies</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>Sizing of Storage Systems</td><td>lecture, exercise</td><td>1</td><td>2</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Lotfi Krichen</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Lotfi Krichen
Achraf Abdelkafi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">30 hours course attendance
40 tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">Storage Systems: Case Studies
After the successful participation in the course storage systems: case studies the students are able to:
• understand why we must store in an isolated system,
• understand why we should store in a system connected to the network,
• understand at what level we can store,
• understand the main electrical energy storage technologies.</td></tr>
<tr><td colspan="5">Sizing of Storage Systems
After the successful participation in the course sizing of storage systems the students are able to:
• choose the good electric storage system according to the application,
• size the chosen electric storage system taking into account the imposed constraints,
• evaluate the performances of the studied hybrid system,</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">Storage Systems: Case Studies
• General information on storage systems
• Study of a hydrogen storage system
• Super capacitor energy storage system
• Battery electric storage system
• Application 1: Electric power generation based on WECS-SC under load disturbance
• Application 2: BESS for smoothing load power curves in smart grid</td></tr>
<tr><td colspan="5">Sizing of Storage Systems
• Hydrogen storage system
• Super capacitor
• Battery electric storage system</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">• Sergio Faias, Jorge Sousa and Rui CastroEmbedded Energy Storage Systems in the Power Grid for Renewable Energy Sources Integration, Intech, 2009,
• Bernard MULTON, Stockage de l’énergie électrique pour la production décentralisée d’électricité (connecté au réseau ou en site isolé), 2010.
• Robert Huggins, Energy Storage, Springer 2010.</td></tr>
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<table>
<tr><th>Module title</th><th colspan="5">Special AC Actuators</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Analysis and design of non-conventional AC machines</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Switched Reluctance Machines</td><td>lecture</td><td>1</td><td>1</td><td rowspan="3">exam (100%)</td></tr>
<tr><td>Axial Flux Machines</td><td>lecture</td><td>1</td><td>1</td></tr>
<tr><td>Transvers Flux Machines</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Ahmed Masmoudi</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Ahmed Masmoudi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">Switched Reluctance Machines
After the successful participation in the course switched reluctance machines, the students are able to:
• understand the principle of operation of switched reluctance machines,
• understand the principle of torque production in switched reluctance machines.</td></tr>
<tr><td colspan="5">Axial Flux Machine
After the successful participation in the course axial flux machines, the students are able to:
• understand the principle of operation of axial flux machines,
• understand the principle of torque production in axial flux machines.</td></tr>
<tr><td colspan="5">Transverse Flux Machines
After the successful participation in the course transverse flux machines, the students are able to:
• understand the principle of operation of transverse flux machines,
• understand the principle of torque production of transverse flux machines,
• identify the advantages and limitations of different transverse flux machine topologies.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">Switched Reluctance Machines
• Switched reluctance machines: current automotive applications
• Switched reluctance machine basis
• Switched reluctance machines: associated converter
• Switched reluctance machines: torque production
• Case study: E-supercharger of Valeo</td></tr>
<tr><td colspan="5">Axial Flux Machine
• Axial flux machines: applications
• Single stator/single rotor topology
• Single stator/dual rotor topology
• Single stator/dual rotor torus topology
• Single stator/dual rotor coreless torus topologies</td></tr>
<tr><td colspan="5">Transverse Flux Machines
• Transverse flux machines: topologies
• Transverse flux machines: principle of the torque production
• Substitution of laminations by soft magnetic composites
• Problem of low power factor
• Sizing of double-sided transverse flux machines</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, simulation using conventional software packages.</td></tr>
<tr><td>Literature</td><td colspan="5">• Stephen Chapman, Electric Machinery Fundamentals, Fourth Edition, McGraw-Hill Series in Electrical and Computer Engineering, 2005.
• A. Masmoudi and A. Elantably, An Approach to Sizing High Power Density TFPM Intended for Hybrid Bus Electric Propulsion, Electric Machines and Power Systems, vol. 28, no. 4, pp. 341-354, 2000.</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Fault detection and isolation and the synthesis of fault-tolerant control strategies</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Faults in Electric Machine Drives</td><td rowspan="3">lecture, exercise</td><td>1</td><td>1</td><td rowspan="3">exam (100%)</td></tr>
<tr><td>Faults Detection and Isolation Techniques and Methods</td><td>1</td><td>1</td></tr>
<tr><td>Fault-Tolerant Control Strategies</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Houda Ben Attia-Sethom</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Houda Ben Attia-Sethom</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">Faults in Electric Machine Drives
After the successful participation in the course Faults in electric machine drives, the students are able to:
• have an overview on the most common faults occurring in AC electric drives (induction and synchronous machines),
• distinguish the different type of defaults weather they are mechanically- or electrically-caused,
• predict faults on the different electric drive components.</td></tr>
<tr><td colspan="5">Faults Detection and Isolation Techniques and Methods
After the successful participation in the course faults detection and isolation techniques and methods, the students are able to:
• know the diagnosis procedure when the data acquisition process may reveal abnormal operating conditions,
• distinguish between model-based and data-based diagnosis method and their cases of usage,
• determine the parameters and variables to diagnose and use the appropriate model to predict it.</td></tr>
<tr><td colspan="5">Fault-Tolerant Control Strategies
After the successful participation in the course Fault-tolerant control strategies, the students are able to:
• know the main factors to be considered in any fault-tolerant control system to automatically compensate the faults,
• distinguish between passive and active fault tolerant control techniques, acknowledge their characteristics and case of usage.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">Faults in Electric Machine Drives
• Defaults in AC drives
• Voltage supply inverter defaults
• Sensor defaults</td></tr>
<tr><td colspan="5">Faults Detection and Isolation (FDI) Techniques and Methods
• Diagnosis: general procedure
• FDI methods classification
• Defaults detection: model-based method
• Defaults detection: signal processing techniques
• Defaults detection: motor current signature analysis (MCSA) technique
• Defaults detection: Artificial Intelligent Based Methods</td></tr>
<tr><td colspan="5">Fault-Tolerant Control Strategies
• Principle of fault tolerant control
• Fault tolerant control: passive technique
• Fault tolerant control: active technique</td></tr>
</table>

	• Fault tolerant control: hybrid technique
Media	Black board and beamer, lectures and presentations, simulation using conventional software packages.
Literature	• M. Bourogaoui, I. Jlassi, S. Khojet El Khil, and H. Ben Attia Sethom, *An Effective Encoder Fault detection in PMSM Drives at Different Speed Ranges*, 2015 IEEE 10th International Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives (SDEMPED), pp. 90-96, Guarda, Portugal, Sptember 2015. • A. Bennani-Ben Abdelghani, H. Ben Abdelghani, F. Richardeau, J.-M. Blaquière, F. Mosser, and I. Slama-Belkhodja, *Versatile Three-Level FC-NPC Converter With High Fault-Tolerance Capabilities: Switch Fault Detection and Isolation and Safe Postfault Operation,* IEEE Trans. on Industrial Electronics, vol. 64, no. 8, pp. 6453-6464, 2017.

Module title	Control Strategies of Electric Drives				
Module type	**E**				
Competency	**Synthesis and implementation of control strategies dedicated to electric drives**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	Rotor Flux Oriented Control of three-phase Induction Motor	lecture, exercise	1	1	- exam (70%) - tutored project defense (30%)
	Direct Torque Control of three-phase Induction Motor	lecture, exercise	1	1	
	Direct Power Control Strategies of Three-Phase PWM Rectifiers	lecture, exercise	1	1	
Semester	Summer				
Responsible	Bassem EL BADSI				
Site	Sfax				
Lecturer(s)	Bassem EL BADSI				
Language	English				
Workload	45 hours course attendance 40 tutored project				
Credits	3				
Recommended Qualifications	-				
Learning Outcomes	**Rotor Flux Oriented Control of Three-Phase Induction Motor** After the successful participation in the course **rotor flux oriented control (RFOC) of three-phase induction motor (IM),** the students are able to make the synthesis and the implementation of the RFOC strategy of the IM.				
	Direct Torque Control of three-phase Induction Motor After the successful participation in the course **direct torque control (DTC) of three-phase Induction Motor,** the students are able to make the synthesis and the implementation of the DTC strategy of the IM.				
	Direct Power Control Strategies of Three-Phase PWM Rectifiers After the successful participation in the course **direct power control (DPC) strategies of three-phase PWM rectifiers,** the students are able to make the synthesis and the implementation of DPC strategies for the control of the three-phase PWM rectifiers.				
Contents	**Rotor Flux Oriented Control of Three-Phase Induction Motor** • Principle of *Park* Transform • RFOC of IM Using Current-Controlled VSI • RFOC of IM Using Voltage-Controlled VSI				
	Direct Torque Control of three-phase Induction Motor • Space Voltage Vectors of B6 Inverter • Implementation of Classical DTC Strategy • Bus-Clamping DTC Strategy				
	Direct Power Control Strategies of Three-Phase PWM Rectifiers • Modelling of Three-Phase PWM Rectifier • Line Voltage and Virtual Flux Estimation • Implementation of DPC Strategy				
Media	Lectures and presentations, simulation using MATLAB-Simulink.				
Literature	• G. Narayanan, D. Zhao, H. K. Krishnamurthy, R. Ayyanar, and V. T. Ranganathan, *Space Vector Based Hybrid PWM Techniques for Reduced Current Ripple*, IEEE Trans. on Industrial Electronics, vol. 55, no. 4, pp. 1614-1626, 2008. • A. Jidin, N. R. N. Idris, A. H. M. Yatim, T. Sutikno, and M. E. Elbuluk, *Simple Dynamic Over Modulation Strategy for Fast Torque Control in DTC of Induction Machines with Constant-Switching-Frequency Controller*, IEEE Trans. on Industry Applications, vol. 47, no. 5, pp. 2283-2291, 2011. • B. El Badsi, B. Bouzidi, and A. Masmoudi, *Bus-Clamping-Based DTC: An Attempt to Reduce Harmonic Distortion and Switching Losses*, IEEE Trans. on Industrial Electronics, vol. 60, no. 3, pp. 873-884, 2013.				

<table>
<tr><td>Module title</td><td colspan="5">Power Electronic Converters</td></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Control strategies of three-phase inverters and matrix converters</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>PWM Control Strategies of Two-Level Inverters</td><td>lecture, exercise</td><td>1</td><td>1</td><td rowspan="3">- exam (70%)
- tutored project defense (30%)</td></tr>
<tr><td>PWM Control Strategies of Three-Level Inverters</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Matrix Converters and Their Control Strategies</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Bassem El Badsi</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Bassem El Badsi
Badii Bouzidi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance
40 tutored project</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td colspan="5">PWM Control Strategies of Two-Level Inverters
After the successful participation in the course PWM control strategies of two-level inverters, the students are able to make the synthesis and the implementation of different pulse-width modulation techniques for the control of three-phase two-level voltage source inverter.</td></tr>
<tr><td colspan="5">PWM Control Strategies of Three-Level Inverters
After the successful participation in the course PWM control strategies of three-level inverters, the students are able to make the synthesis and the implementation of different PWM techniques for the control of three-phase three-level voltage source inverter.</td></tr>
<tr><td colspan="5">Matrix Converters and their Control Strategies
After the successful participation in the course matrix converters and their control strategies, the students are able to make the modelling and the implementation of different modulation techniques for the control of matrix converters.</td></tr>
<tr><td rowspan="3">Contents</td><td colspan="5">PWM Control Strategies of Two-Level Inverters
• Sinusoidal PWM
• Third Harmonic Injection PWM
• Conventional Space Vector PWM
• Bus-Clamping Space Vector PWM</td></tr>
<tr><td colspan="5">PWM Control Strategies of Three-Level Inverters
• Modelling of Three-Level Inverter
• Sinusoidal PWM Technique
• Space Vector PWM Technique</td></tr>
<tr><td colspan="5">Matrix Converters and their Control Strategies
• Modelling of Matrix Converters
• Venturini Modulation Technique
• Venturini's Optimum Modulation Technique</td></tr>
<tr><td>Media</td><td colspan="5">Lectures and presentations, simulation using MATLAB-Simulink.</td></tr>
<tr><td>Literature</td><td colspan="5">• H. Fang; X. Feng; W. Song; X. Ge; R. Ding, Relationship between Two-Level Space-Vector Pulse-Width Modulation and Carrier-Based Pulse Width Modulation in the Over-Modulation Region, IET Power Electronics, vol. 7, no. 1, pp. 189-199, 2014.
• R. Baranwal; K. Basu; N. Mohan, Carrier-Based Implementation of SVPWM for Dual Two-Level VSI and Dual Matrix Converter with Zero Common-Mode Voltage, IEEE Trans. on Power Electronics, vol. 30, no. 3, pp. 1471-1487, 2015.
• J. H.Seo; C. H. Choi; and D. S. Hyun, A New Simplified SV-PWM Method for Three-Level Inverters, IEEE Trans. on Power Electronics, vol. 16, no. 4, pp. 545-550, 2001.
• K. Gupta and A. M. Khambadkone, A Space Vector PWM Scheme for Multilevel Inverters Based on Two-Level Space Vector PWM, IEEE Trans. on Industrial Electronics, vol. 53, no. 5, pp. 1631-1639, 2006.</td></tr>
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<tr><th>Module title</th><th colspan="5">Embedded Generating Systems</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Design, modelling, and analysis of embedded generating systems</td></tr>
<tr><td rowspan="5">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Generating Systems Embedded on Board of Road Vehicles</td><td rowspan="4">lecture, exercise</td><td>1</td><td>1</td><td rowspan="4">exam (100%)</td></tr>
<tr><td>Modelling of Claw Pole Alternators</td><td>1</td><td>1</td></tr>
<tr><td>Design Improvement of the CPA-Based Generating Systems</td><td>1</td><td>1</td></tr>
<tr><td>Avionic Generating Systems</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Amina Ibala</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Amina Ibala
Rabeb Rebhi</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="4">Learning Outcomes</td><td colspan="5">Generating Systems Embedded on Board of Road Vehicles
After the successful participation in the course generating systems embedded on board of road vehicles, the students are able to:
• identify the components of embedded generating systems,
• classify the embedded generating systems.</td></tr>
<tr><td colspan="5">Modelling of Claw Pole Alternators
After the successful participation in the course finite modelling of claw pole alternators (CPAs), the students are able to:
• establish the magnetic equivalent circuit of CPAs,
• predict the no- and load features of CPAs.</td></tr>
<tr><td colspan="5">Design Improvement of the CPA-Based Generating Systems
After the successful participation in the course design improvement of the CPA-based generating systems, the students are able to:
• rethought the design of CPAs,
• design hybrid excited CPAs.</td></tr>
<tr><td colspan="5">Avionic Generating Systems
After the successful participation in the course avionic generating systems, the students are able to:
• identify the components of avionic generating systems,
• classify the avionic generating systems.</td></tr>
<tr><td rowspan="4">Contents</td><td colspan="5">Generating Systems Embedded on Board of Road Vehicles
• Claw pole alternator (CPA) topological description,
• Flux path through the CPA magnetic circuit,
• Road vehicle embedded generating chain.</td></tr>
<tr><td colspan="5">Modelling of Claw Pole Alternators
• Magnetic equivalent circuit (MEC) modelling,
• CMA MEC elaboration and resolution,
• Prediction of the CPA no-load characteristic,
• Prediction of the CPA load characteristic.</td></tr>
<tr><td colspan="5">Design Improvement of the CPA-Based Generating Systems
• Attempts to eradicate the CPA major limitations,
• Limitation caused by the slip rings-brushes system,
• CPA design rethought: hybrid excitation,
• Boosting the DC bus current.</td></tr>
<tr><td colspan="5">Avionic Generating Systems
• Reason behind the use of 400Hz networks in aircrafts,</td></tr>
</table>

	• Case study: the primary three-stage power generator of the Airbus A380.
Media	Black board and beamer, lectures and presentations, simulation using conventional software packages.
Literature	• D. Elloumi, A. Ibala, R. Rebhi, and A. Masmoudi, *Lumped Circuit Accounting for the Rotor Motion Dedicated to the Investigation of the Time-Varying Features of Claw Pole Topologies*, IEEE Trans. on Magnetics, vol. 51, no. 5, pp. 8105108, 2015. • R. Rebhi, A. Ibala, and A. Masmoudi, *MEC-Based Sizing of a Hybrid-Excited Claw Pole Alternator*, IEEE Trans. on Industry Applications, vol. 51, no. 1, pp. 211-223, 2015. • A. Ibala and A. Masmoudi, *Accounting for the Armature Magnetic Reaction and Saturation Effects in the Reluctance Model of a New Concept of Claw-Pole Alternator*, IEEE Trans. on Magnetics, vol. 46, no. 11, pp. 3955-3961, 2010.

<table>
<tr><th>Module title</th><th colspan="5">Rules of Writing Research Documents</th></tr>
<tr><td>Module type</td><td colspan="5">E</td></tr>
<tr><td>Competency</td><td colspan="5">Ability of writing different scientific documents (paper, dissertation, report)</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>The Scientific Paper: from Reading to Writing</td><td>lecture, exercise</td><td>1</td><td>2</td><td rowspan="2">exam (100%)</td></tr>
<tr><td>Writing Process</td><td>lecture, exercise</td><td>1</td><td>1</td></tr>
<tr><td>Semester</td><td colspan="5">Summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Abdelmajid Damak</td></tr>
<tr><td>Site</td><td colspan="5">Sfax</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Abdelmajid Damak</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">45 hours course attendance</td></tr>
<tr><td>Credits</td><td colspan="5">3</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td colspan="5">The Scientific Paper: from Reading to Writing
After the successful participation in the course the scientific paper: from reading to writing, the students are able to:
• learn efficient ways to organize the reading method with some useful hints for successful reading,
• distinguish between the different type of scientific writing,
• learn how to structure scientific writing and elaborate a work plan.</td></tr>
<tr><td colspan="5">Writing Process
After the successful participation in the course the writing process, the students are able to:
• know the different steps in order to write a scientific paper, from the brainstorming to the final version of the document,
• acknowledge the major difficulties in scientific writing and the possible solutions.</td></tr>
<tr><td rowspan="2">Contents</td><td colspan="5">The Scientific Paper: from Reading to Writing
• The reading process,
• The notion of scientific publication,
• Structuring the writing and respecting the writing plan,
• Elaborating the work plan.</td></tr>
<tr><td colspan="5">Writing Process
• Pre-writing,
• Organizing,
• Drafting,
• Revising and editing,
• The final copy.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations,</td></tr>
<tr><td>Literature</td><td colspan="5">J. Swales, Genre Analysis: English in academic and research settings, Cambridge University Press, 1990.</td></tr>
</table>

4. Thesis Project

The module Thesis Project, comprising 30 credits is to be conducted in the MENA region during the fourth semester.

<table>
<tr><th>Module title</th><th colspan="5">Thesis Project</th></tr>
<tr><td>Competency</td><td colspan="5">Scientific Analysis of a current RE resp. EE issue in the MENA region</td></tr>
<tr><td rowspan="2">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>REMENA Master Thesis</td><td>independent research</td><td>20</td><td>30</td><td>report and colloquium</td></tr>
<tr><td>Semester</td><td colspan="5">winter and summer</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus/Khalil
Dahlhaus/El Alimi</td></tr>
<tr><td>Site</td><td colspan="5">MENA Region</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Supervisor from institutions or companies together with supervisor from university</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Workload</td><td colspan="5">740 hours independent research
160 hours writing thesis</td></tr>
<tr><td>Credits</td><td colspan="5">30</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">–</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">a) Master thesis
After the successful development of the master thesis the student is able to:
• write a scientific report and presentation of results in a colloquium
• investigate literature and internet based sources
• work independently and scientifically.</td></tr>
<tr><td>Contents</td><td colspan="5">a) Master Thesis
• Topics in the area of renewable energies and energy efficiency with a specific focus on issues related to the MENA region
• Independent work including
- literature research
- definition of thesis structure
- elaboration of report
- conducting measurements etc.</td></tr>
<tr><td>Media</td><td colspan="5">PC based software development and/or hardware development, beamer (presentation of results), report (electronic form and hard copy).</td></tr>
<tr><td>Literature</td><td colspan="5">Literature depends on the thesis topic and is to be gathered by the student upon discussion with the supervisor.</td></tr>
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