Module Handbook

Renewable Energy and Energy Efficiency - Management, Engineering and Application

Master

PO-2026

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Table of Content

Abbreviations

-	B	Basic
-	C	Cairo
-	DDKH	Double Degree Kassel-Cairo
-	DDKM	Double Degree Kassel-Monastir
-	E	Elective
-	ECTS	European Credit Transfer System
-	GUC	German University in Cairo
-	H	Hyderabad
-	JNTUH	Jawaharlal Nehru Technological University Hyderabad
-	K	Kassel
-	M	Monastir
-	REMENA	Renewable Energy and Energy Efficiency - Management, Engineering, and Application
-	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

The 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 basic modules are listed in Sect. **Fehler! Verweisquelle konnte nicht gefunden werden.**. 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. 2** 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 Germany or worldwide during the fourth semester.

The study modes of the REMENA master's program include four versions based on the sites where the studies are accomplished. Recently, the REMENA master program has established a network called REMENA university network (RUN) including three main partner-universities, namely, the University of Monastir (UM) in Monastir (M), Tunisia, the Jawaharlal Nehru Technological University Hyderabad (JNTUH) in Hyderabad (H), India, and the University of Kassel (UKAS) in Kassel (K), Germany. 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

The schematic of the overall view of ***all*** modules ***offered*** in each site based on different modes are shown in **Table 1- Table 4**.

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	H	16	30	-
2	SS	K	16	49	
3	WS	RUN	-	> 30	
4	SS	Germany/worldwide	-		30

Table 1: The schematic of mode "1" starting in the winter semester.

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	RUN	-	> 30	
4	SS	Germany/worldwide	-		30

Table 2: The schematic of mode "2" starting in the winter semester.

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	H	16	30	
3	SS	RUN	-	> 30	
4	WS	Germany/worldwide	-		30

Table 3: The schematic of mode "3" starting in the summer semester.

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	RUN	-	> 30	
4	WS	Germany/worldwide	-		30

Table 4: The schematic of mode "4" starting in the summer semester.

The student can choose from two kinds of **double** degrees, namely, double degree Kassel-Hyderabad (DDKH) obtained from both UKAS and JNTUH:

DDKH: Double Degree Kassel-Hyderabad

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

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 **Sect. 2**. as well as the module Thesis Project of 30 ECTS credits to be conducted worldwide during the fourth semester as discussed in **Sect. 2.7**.

Table 5 - Table 8 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	H	B	E	-		30	DDKH
2	SS	March - August	K	B	E	-		30	
3	WS	September - February	RUN	-		E	-	30	
4	SS	March - August	Germany/worldwide	-			T	30	

Table 5: Credits distributions of mode "1" with DDKH.

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	RUN	-		E	-	30	

4	SS	March - August	Germany/worldwide	-	T	30	

Table 6: 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	DDKH
2	WS	September - February	H	B	E	-		30	
3	SS	March - August	RUN	-		E	-	30	
4	WS	September - February	Germany/worldwide	-			T	30	

Table 7: Credits distributions of mode “3” with DDKH.

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	RUN	-		E	-	30	
4	WS	September - February	Germany/worldwide	-			T	30	

Table 8: Credits distributions of mode “4” with DDKM.

2. Basic Modules

In this section, all basic modules are listed. The modules comprise three groups, namely modules in **Table 9** conducted in Hyderabad (H) during WS, modules in **Table 10** conducted in Monastir (M) during WS and modules in **Table 11** conducted in Kassel (K) during SS, respectively.

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

- *Thermodynamic Basics 1*
- *Thermodynamic Basics 2*
- *Language and Presentation*

Thermodynamic Basics 1	ECTS site	Thermodynamic Basics 2	ECTS site	Language and Presentation	ECTS site
Engineering Thermodynamics	2 H	Fluid Mechanics	3 H	German Language Course	3 H
Heat Transfer	3 H	Material Science	2 H	Presentation and Moderation Techniques	3 H

Table 9: Basic modules conducted in Hyderabad 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 1*, given in JNTUH, is composed by the courses *Engineering Thermodynamics* and *Heat Transfer.*

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

- *Energy and Thermodynamic Basics 1*
- *Energy and Thermodynamic Basics 2*
- *Language and Communication Competencies*

Energy and Thermodynamic Basics 1	ECTS site	Energy and Thermodynamic Basics 2	ECTS site	Language and Communication Competencies	ECTS site
Thermodynamics Fundamentals	2 M	Fluid Mechanics Fundamentals	4 M	German and Arab Language Courses	3 M
Heat Transfer Fundamentals	4 M			English Presentation and Communication Techniques	3 M

Table 10: 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 1*
- *Engineering Basics 2*
- *German Competencies*

Engineering Basics 1	ECTS site	Engineering Basics 2	ECTS site	German Competencies	ECTS site
Electrical Engineering Fundamentals	3 K	Engineering Mathematics	3 K	German Energy Transition - Politics and Policies	3 K
Control Systems	2 K	Technical Mechanics	2 K	German Course Kassel	3 K

Table 11: 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. 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.

2.1. Basic Modules Kassel

Engineering Basics 1

Module number / code	P-UK-01
Module name	Engineering Basics 1
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	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) 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
Course types	VLmP (3 SWS); VLmP (2 SWS)
Content	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 Control Systems • Fundamental definitions in control circuits

	• Signal flow charts • Basic elements of block diagram models • Simulation of systems using MATLAB • Linear system overlay techniques • Step response • Feedback performance, stability of linear feedback control systems • Frequency response of control circuits • Industrial PID controllers
Title of courses	Electrical Engineering Fundamentals Control Systems
Teaching and learning methods	lecture (Electrical Engineering Fundamentals) lecture (Control Systems)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance; 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Electrical Engineering Fundamentals - written exam (90 min) Grade weighting P1: 60% Examination P2: Control Systems - written exam (90 min) Grade weighting P2: 40%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Dirk Dahlhaus, Ayman El-Badawy
Media used	black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs
Recommended 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. • Further literature will be announced by the lecturers.
Comments	5 cp (3 cp - Electrical Engineering Fundamentals; 2 cp - Control Systems)

Engineering Basics 2

Module number / code	P-UK-02
Module name	Engineering Basics 2
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	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) 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
Course types	VLmP (2 SWS); VLmP (3 SWS)

Content	Technical Mechanics
	• Fundamental definitions in technical mechanics
	• Flow of forces in static systems
	• Simple dynamic problems e.g. between turbines and ground
	
	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)

Title of courses	Technical Mechanics Engineering Mathematics
Teaching and learning methods	lecture (Technical Mechanics) lecture (Engineering Mathematics)
Usabilitiy in other programs	

Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance; 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Technical Mechanics - written exam (90 min) Grade weighting P1: 40% Examination P2: Engineering Mathematics - written exam (90 min) Grade weighting P2: 60%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Ammar Abid, Nour Mansour
Media used	black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs
Recommended literature	• Lecture notes on Techniocal Mechanics. • 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.
Comments	5 cp (2 cp - Technical Mechanics; 3 cp - Engineering Mathematics)

German Competencies

Module number / code	P-UK-03
Module name	German Competencies
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **German Energy Transition - Politics and Policies** the students are enabled to: • understand the institutional set-up of the German Energy Transition

	• work with political, economic and cultural objectives and instruments After the successful participation in the course **German Language Cours Kassel** the students are able to: • communicate with elaborated formulations and expressions for use in daily life
Course types	VLmP+Ex (3 SWS); VLmP (3 SWS)
Content	**German Energy Transition - Politics and Policies** • Institutional set-up of bilateral and multilateral development cooperation: ○ Role of German parliament, ministries for development, environment and economy w.r.t. energy transition • Socio-political objectives and instruments of the German Energy Transition. **German Language Course Kassel** • basic phrases and short sentences for everyday use • technical terms and expressions in electrical engineering and RE • basic concepts in High German grammar
Title of courses	German Energy Transition - Politics and Policies German Language Course Kassel
Teaching and learning methods	visit to organisations in Berlin, lecture, discussions lecture (German Language Course Kassel)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English, German
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (90 h course attendance, 90 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: German Energy Transition - Politics and Policies - written report (5-6 pages) Grade weighting P1: 50% Examination P2: German Language Course Kassel - written exam (90 min) and oral exam (30 min) Grade weighting P2: 50%
Credit points (ECTS)	6 cp

Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Marc Selig, International Study Centre / Language Centre
Media used	black board and beamer; visiting energy sector organisations in Germany and discussions with planners and decision makers; slide show and power point presentations
Recommended literature	• Literature will be announced by the lecturers.
Comments	6 cp (3 cp - German Energy Transition - Politics and Policies; 3 cp - German Language Course Kassel)

2.2. Basic Modules Monastir

Energy and Thermodynamics Basics 1

Module number / code	P-UM-01
Module name	Energy and Thermodynamics Basics 1
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **Thermodynamics Fundamentals** the students: • 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 After the successful participation in the course **Heat Transfer Fundamentals** the students: • 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 condition • 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
Course types	VLmP+Ü (2 SWS); VLmP+Ü (4 SWS)
Content	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.
Title of courses	Thermodynamics Fundamentals Heat Transfer Fundamentals
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (90 h course attendance; 90 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Thermodynamics Fundamentals - midterm assignments (1/3), final written exam (90 min) (2/3); Grade weighting P1: 33% Examination P2: Heat Transfer Fundamentals - midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 67%

Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. El Alimi
Lecturer(s)	Khalifa Mejbri, Walid Hassen, Ameni Mokni
Media used	black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs
Recommended 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.
Comments	6 cp (2 cp - Thermodynamics Fundamentals; 4 cp - Heat Transfer Fundamentals)

Energy and Thermodynamics Basics 2

Module number / code	P-UM-02
Module name	Energy and Thermodynamics Basics 2
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **Fluid Mechanics Fundamentals** the students: • 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
Course types	VLmP+Ü (4 SWS)
Content	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.
Title of courses	Fluid Mechanics Fundamentals
Teaching and learning methods	lecture, exercise

Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance; 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	midterm assignments (1/3), final written exam (90 min) (2/3)
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. El Alimi
Lecturer(s)	Abdelmajid JEMNI
Media used	black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs
Recommended literature	• Yunus Cengel, John Cimbala, Fluid Mechanics Fundamentals and Applications, McGraw-Hill Higher Education.

Language and Communication Competencies

Module number / code	P-UM-03
Module name	Language and Communication Competencies
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	VLmP+Ü (3 SWS); VLmP+Ü (3 SWS)
Content	German and Arab Language Courses Monastir • Basic phrases and short sentences for everyday use • Technical terms and expressions in electrical engineering and RE • Basic concepts in grammar 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
Title of courses	German and Arab Language Course Monastir English presentation and communication techniques
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English, German, Arabic
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (90 h course attendance, 90 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: German and Arab Language Course Monastir - oral and written assignments (50 %); final written exam (90 min)(50 %) Grade weighting P1: 50% Examination P2: English presentation and communication Techniques - oral and written assignments (50 %); final written exam (90 min) (50 %) Grade weighting P2: 50%

Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. El Alimi
Lecturer(s)	Anis Ben Amor, Yosr Mustapha, Saad Borghol Kmar Hadded, Nadia Douki, Abir Mili, Sonia Ouada
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises and video feedback, case studies in groups; formal and interactive
Recommended literature	• Cambridge English for Job hunting/ Presentations in English/ English For Presentation / Market Leader. • Lecture notes and course material in Arabic and German language courses.
Comments	6 cp (3 cp - German and Arab Language Course Monastir; 3 cp - English presentation and communication techniques)

2.3. Basic Modules Hyderabad

Thermodynamic Basics 1

Module number / code	P-JNTUH-01
Module name	Thermodynamic Basics 1
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	VLmP (3 SWS); VLmP (3 SWS)

Content	Engineering Thermodynamics
	• Fundamental concepts and definitions: unit systems, (pure) substances, 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
	
	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
Title of courses	Engineering Thermodynamics Heat Transfer
Teaching and learning methods	lecture (Engineering Thermodynamics) lecture (Heat Transfer)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (60 h course attendance; 120 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Engineering Thermodynamics - written exam (90 min) Grade weighting P1: 50% Examination P2: Heat Transfer - written exam (90 min) Grade weighting P2: 50%
Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Naik
Lecturer(s)	S.Naga Sarada, K.V.Sharma
Media used	black board and beamer, lectures and presentations, problem based teaching
Recommended 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.
Comments	6 cp (3 cp - Engineering Thermodynamics; 3 cp - Heat Transfer)

Thermodynamic Basics 2

<table>
<tr><td>Module number / code</td><td>P-JNTUH-02</td></tr>
<tr><td>Module name</td><td>Thermodynamic Basics 2</td></tr>
<tr><td>Type of module</td><td>Compulsory module</td></tr>
<tr><td>Learning outcomes, acquired competencies and qualification goals</td><td>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.
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>Course types</td><td>VLmP (2 SWS), VLmP (2 SWS)</td></tr>
<tr><td>Content</td><td>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
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</td></tr>
<tr><td>Title of courses</td><td>Fluid Mechanics
Material Science</td></tr>
<tr><td>Teaching and learning methods</td><td>lecture (Fluid Mechanics)
lecture (Material Science)</td></tr>
<tr><td>Usabilitiy in other programs</td><td></td></tr>
</table>

Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (60 h course attendance; 120 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Fluid Mechanics - written exam (90 min) Grade weighting P1: 50% Examination P2: Material Science - written exam (90 min) Grade weighting P2: 50%
Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Naik
Lecturer(s)	K.V.Sharma, Ch.Anjamma
Media used	black board and beamer, lectures and presentations
Recommended literature	• Lecture notes on Fluid Mechanics and Material Science.
Comments	6 cp (3 cp - Fluid Mechanics; 3 cp - Material Science)

Language and Presentation

Module number / code	P-JNTUH-03
Module name	Language and Presentation
Type of module	Compulsory module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **German Language Course Hyderabad** the students are able to: • implement basic formulations and expressions of German for use in daily life 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
Course types	VLmP (2 SWS); VLmP (1 SWS)
Content	German Language Course Hyderabad • basic phrases and short sentences for everyday use • technical terms and expressions in electrical engineering and RE • basic concepts in High German grammar 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
Title of courses	German Language Course Hyderabad Presentation and Moderation Techniques
Teaching and learning methods	lecture (German Language Course Hyderabad) lecture (Presentation and Moderation Techniques)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (45 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: German Language Course Hyderabad - written exam (60 min) and oral exam (30 min) Grade weighting P1: 75% Examination P2: Presentation and Moderation Techniques - presentations (2x15 min) Grade weighting P2: 25%

Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Naik
Lecturer(s)	N.N., N V S Lakshmi, M.T.Naik
Media used	black board and beamer; introductory class meetings, power point presentations, discussions
Recommended literature	• Lecture notes and course material 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.
Comments	4 cp (3 cp - German Language Course Hyderabad; 1 cp - Presentation and Moderation Techniques)

3. Elective Modules

In this section, all elective modules being conducted in Cairo, Monastir, Kassel are listed **in Table 12** - **Table 14** as well as the elective module offered by the RUN and called “Present Challenges in REEE” with 30 ECTS **in** Fehler! Verweisquelle konnte nicht gefunden werden. such that the student can study the elective modules according to the modes defined in Sec. **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Develop-ment of RE Projects	**ECTS site**	**Fundamentals of REEE**	**ECTS site**	**Ecological Aspects of REEE**	**ECTS site**
Project Planning and Tendering	3 H	Renewable Energy Technologies	3 H	Environmental Pollution and Control	3 H
Project Commis-sioning, Operation and Maintenance	4 H	Solar Power Engineering	4 H	Waste Management and Recycling	4 H

Table 12: Elective modules conducted in Hyderabad during WS (21 ECTS credits).

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

Table 13: Elective modules conducted in Monastir during WS (30 ECTS credits).

REEE in Buildings	ECTS site	International Project Management	ECTS site	Social Aspects of RE	ECTS site	Smart Power Systems	ECTS site	Solar Thermal Systems	ECTS site
Photovoltaic Systems	2 K	International Project Management	2 K	Project Management in Development Cooperation	2 K	Smart Grids	3 K	Solar Thermal Cooling	2 K
Energy Efficiency in Buildings	3 K	Intercultural Communication	2 K	Energy and Society	2 K	Grid Integration	2 K	Concentrated Solar Thermal Systems	2 K
Economic Aspects of RE Projects	**ECTS site**	**Wind Energy Technology**	**ECTS site**	**Energy Efficiency**	**ECTS site**	**Scientific Programming and Publishing**	**ECTS site**	**Bio Power**	**ECTS site**
Business Economic Aspects of RE	2 K	Mechanical Aspects of Wind Energy	3 K	Energy Efficiency in Cross-Sectional Technologies	3 K	Introduction to MATLAB	4 K	Bio Gas	2 K
Entrepreneurship in Germany	2 K	Electrical Aspects of Wind Energy	3 K	Energy Efficiency Through Process Integration	3 K	Introduction to LaTeX	2 K	System Aspects of Bio Power Generation	2 K
Energy Storage 1	**ECTS site**	**Energy Storage 2**	**ECTS site**						
Introduction to Energy Storage	2 K	Battery Energy Storage Systems	2 K						
Hydrogen and Power-to-Chemical Technologies	3 K	Flexible Generation and Demand Side Management	2 K						

Table 14: Elective modules conducted in Kassel during SS (57 ECTS credits).

The tables below show the detailed elective modules at JNTUH, UM, UKAS.

3.3. Elective Modules Hyderabad

Fundamentals of REEE

Module number / code	W-JNTUH-01
Module name	Fundamentals of REEE
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	After their successful participation in the course **Renewable Energy Technologies**, students will be able to: • Understanding national and international regulations and framework conditions for renewable energy systems. • Explain the characteristics of solar radiation and its global distribution. • Outline the ▯ecture▯iza of renewable resources, including wind, biomass, hydrogen, fuel cells, ocean, and geothermal energy in domestic and industrial applications. • Analyse the energy potential of renewable energy resources. • Understand the principles and applications of sustainable energy solutions. After their successful participation in the course **Solar Power Engineering**, students will be able to: • Explain the constructional features and performance criteria of solar thermal energy collectors. • Evaluation of Flat Plate Collector and Evacuated Tube Collector systems' performance and their applications, such as solar drying, air heating, and process heating. • Performance and constructional features of Concentrated Solar Power (CSP) and Distributed Solar Power (DSP) systems for steam turbine operation, reducing fossil fuel reliance. • Analyse high-temperature thermal energy generation from concentrating systems in solar distributed power plants. • Offer high-temperature applications for heating, drying, ▯ecture▯izati, chemical production, and power production.
Course types	VLmP (2 SWS), VLmP (3 SWS)
Content	Renewable Energy Technologies • Fundamentals of Energy • Renewable Energy scenario • Solar radiation and measurement • Sun-earth relations • Wind Energy • Wind turbine operational characteristics • Biomass Energy • Biogas

	• Hydrogen energy • Ocean Energy • Geothermal power plants • Fuel cell Principle Solar Power Engineering • Basics of Solar Radiation • Flat Plate Collectors (FPC) • FPC Performance • Solar Concentrators • Central Receiver Power Plant • CSC Performance • Distributed Thermal Power Plant • Solar Energy Applications • Low-Temperature Applications • Energy Conversion and Storage • Solar Energy Storage
Title of courses	Renewable Energy Technologies Solar Power Engineering
Teaching and learning methods	lecture (Renewable Energy Technologies) lecture (Solar Power Engineering)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	210 hours (75 h course attendance, 135 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Renewable Energy Technologies – written exam (90 min) Grade weighting P1: 43% Examination P2: Solar Power Engineering – written exam (90 min) Grade weighting P2: 57%
Credit points (ECTS)	7 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Naik
Lecturer(s)	M.T.Naik
Media used	black board and beamer, lectures and presentations

Recommended literature	• Renewable Energy Sources, Twidell, J.W. and Weir, A., EFN Spon Ltd., 1986. • Renewable Energy Sources, Basic principles and applications N Tiwari& M K Ghoshal. • Renewable Energy Engineering and Technology, Kishore VVN, Teri Press, New Delhi, 2012. • Renewable Energy Power for a Sustainable Future, Godfrey Boyle, Oxford University, Press, U.K., 1996. • Duffie, J.A., Beckman, W.A. "*Solar Engineering of Thermal Processes"*, 3rd ed., Wiley, 2006. • Kalogirou, S, "*Solar Energy Engineering",* Processes and Systems, Elsevier, 2009. • Yogi Goswami, Frank Kreith, Jan F. Kreider, "*Principles of Solar Engineering"*, Second Edition, Taylor & Francis, 2003.
Comments	7 cp (3 cp – Renewable Energy Technologies; 4 cp – Solar Power Engineering)

Ecological Aspects of REEE

Module number / code	W-JNTUH-02
Module name	Ecological Aspects of REEE
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	After their successful participation in the course **Environmental Pollution and Control,** students will be able to: • Identify pollutant types and their source and monitor their environmental effects. • Outline the technologies for pollution control. • Construct the framework of environmental legislation and policies. • Develop strategies for pollution prevention and sustainable environmental management. After successful participation in the course **Waste Management and Recycling**, students will be able to: • Understand integrated solid waste management principles: reuse, recycling, and energy recovery.

	• Analyse landfill planning, including siting, design, operation, and post-closure maintenance with a focus on gas and leachate management. • Explain the necessity of integrated solid waste management and apply strategies for reduction, reuse, recycling, recovery, and disposal. • Classify and manage hazardous wastes, addressing regulatory and policy aspects of dangerous and e-waste management in India. • Discuss agricultural environmental issues and demonstrate knowledge of hazardous waste classification, treatment, and regulatory compliance.
Course types	VLmP (2 SWS); VLmP (3 SWS)
Content	Environmental Pollution and Control • Introduction to Environmental Pollution • Environment and Ecosystems • Air Pollution • Indoor air pollution • Air Pollution Control • Noise Pollution • Solid Waste • Solid Waste Management • Water Pollution • Industrial Wastewater Management Waste Management and Recycling • Integrated Solid Waste Management • Sources of Waste Generation and Characterisation • Landfills • Landfill Method of Solid Waste Disposal • Process Effluents • Separation and Processing of Solid Waste • Wastewater Treatment • Environmental Issues in Agriculture • Management of Hazardous Wastes Found in Municipal Solid Waste • Hazardous waste management and treatment
Title of courses	Environmental Pollution and Control Waste Management and Recycling
Teaching and learning methods	lecture (Environmental Pollution and Control) lecture (Waste Management and Recycling)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	

Required prerequisites for participation	none
Student workload	210 hours (75 h course attendance, 135 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Environmental Pollution and Control – written exam (90 min) Grade weighting P1: 43% Examination P2: Waste Management and Recycling – written exam (90 min) Grade weighting P2: 57%
Credit points (ECTS)	7 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Naik
Lecturer(s)	N.N.
Media used	black board and beamer, lectures and presentations
Recommended literature	• Goel, P.K. Water pollution: causes, effects, and control. New Age International, 2006. • Environmental Pollution Control Engineering, C. S. Rao, Wiley Eastern Ltd., Delhi, 1991. • Municipal Solid Waste Management Manual Part I and II: An Overview, Central Public Health and Environmental Engineering Organisation (CPHEEO), 2016. • Industrial Solid Waste Management and Landfilling Practice, M. Dutta, B.P. Parida, B.K. Guha and T. R. Sur Krishnan. Narosa Publishing House, New Delhi (1999). • Control Engineering, C.S. Rao, Wiley Eastern Ltd. New Delhi (1995). • Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel (2014), 2nd Ed., CRC Press, USA
Comments	7 cp (3 cp – Environmental Pollution and Control; 4 cp – Waste Management and Recycling)

Development of Renewable Energy Projects

Module number / code	W-JNTUH-03
Module name	Development of Renewable Energy Projects
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 After the successful participation in the course P**roject Commissioning, Operation and Maintenance** the students are able to: • perceive commissioning processes, operation and maintenance practice in RE/EE projects
Course types	VLmP (2 SWS); VLmP+S (3 SWS)

Content	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
	
	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.
	  ○ environmental codes and standards
	  ○ Wind turbine maintenance (schedules for different components, power regulation, electric shielding, cleaning of components)
	• Case studies to be prepared by students based on the wind energy example:
	  ○ solar thermal power plants
	  ○ bio fuels power plants
	  ○ PV power plants

Title of courses	Project Planning and Tendering Project Commissioning, Operation and Maintenance
Teaching and learning methods	lecture (Project Planning and Tendering) lecture, seminar (Project Commissioning, Operation and Maintenance)

Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	210 hours (75 h course attendance, 135 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Project Planning and Tendering – written exam (90 min) Grade weighting P1: 43% Examination P2: Project Commissioning, Operation and Maintenance – written exam (90 min) Grade weighting P2: 57%
Credit points (ECTS)	7 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Naik
Lecturer(s)	N.N.
Media used	black board, beamer
Recommended literature	• Presentations and reports on major RE/EE projects • Local and international tendering and procurement regulations • Commissioning and O&M standards codes of practice
Comments	7 cp (3 cp – Project Planning and Tendering; 4 cp – Project Commissioning, Operation and Maintenance)

3.2. Elective Modules Kassel

REEE in Buildings

Module number / code	W-UK-01
Module name	REEE in Buildings
Type of module	Elective module

Learning outcomes, acquired competencies and qualification goals	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. 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
Course types	VLmP (2 SWS); VLmP (3 SWS)
Content	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) 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
Title of courses	Photovoltaic Systems Energy Efficiency in Buildings
Teaching and learning methods	lecture (Photovoltaic Systems) lecture (Energy Efficiency in Buildings)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Photovoltaic Systems – written exam (90 min) Grade weighting P1: 40% Examination P2: Energy Efficiency in Buildings – written exam (90 min) or or report (5-6 pages) Grade weighting P2: 60%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Mohamed Ibrahim, Ron-Hendrik Hechelmann, Florian Schlosser, Diana Khripko
Media used	black board and beamer, power point presentations, experiments
Recommended literature	• M.A. Green, *Third Generation Photovoltaics: Advanced Solar Energy Conversion*, Springer, 2005. • 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
Comments	5 cp (2 cp – Photovoltaic Systems; 3 cp – Energy Efficiency in Buildings)

Economic Aspects of RE Projects

Module number / code	W-UK-02
Module name	Economic Aspects of RE Projects
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 After the successful participation in the course **Entrepreneurship in Germany** the students are able to: • reflect key factors, methods and the necessary framework to set up successfully a company in the market of a country.
Course types	VLmP+S (2 SWS); VLmP+S (2 SWS)

Content	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
	
	Entrepreneurship in Germany
	• Presenting a company with their actual activities in Germany
	• Framework and necessary steps to set up a company in Germany

Title of courses	Business economic aspects of RE Entrepreneurship in Germany
Teaching and learning methods	lecture, seminar
Usabilitiy in other programs	

Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Business economic aspects of RE – presentation (15 min) and report (3-4 pages) Grade weighting P1: 50% Examination P2: Entrepreneurship in Germany – presentation (15 min) and report (3-4 pages) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Wesly Urena Vargas, Alireza Taheri
Media used	black board and beamer
Recommended literature	• F.E. Banks, Energy Economics: A Modern Introduction, Springer, 1st stedition, 1999. • D.L. Cleland and R. Gareis, Global Project Management Handbook: Planning, Organizing and Controlling International Projects, McGraw-Hill Professional, 2nd 2006.
Comments	4 cp (2 cp – Business economic aspects of RE; 2 cp – Entrepreneurship in Germany)

International Project Management

Module number / code	W-UK-03
Module name	International Project Management
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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.
Course types	VLmP+S (2 SWS); S (2 SWS)
Content	International Project Management • Defining the terms project and project management • Cases where project management is necessary and reasonable • Project objectives, - �ecture�izat, - execution • Exemplary international projects: ○ forms, specifics and success factors ○ preparation ○ team building 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
Title of courses	International Project Management Intercultural Communication
Teaching and learning methods	seminar, lecture (International Project Management) seminar (Intercultural Communication)
Usabilitiy in other programs	

Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: International Project Management – presentations, assignments, written exam (90 min) Grade weighting P1: 50% Examination P2: Intercultural Communication – written report (3-4 pages) and written exam (60 min) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Rao Aamir Ali Khan, Anke Aref
Media used	black board and beamer, case studies in groups
Recommended 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. • 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.
Comments	4 cp (2 cp – International Project Management; 2 cp – Intercultural Communication)

Solar Thermal Systems

Module number / code	W-UK-04

<table>
<tr><td>Module name</td><td>Solar Thermal Systems</td></tr>
<tr><td>Type of module</td><td>Elective module</td></tr>
<tr><td>Learning outcomes, acquired competencies and qualification goals</td><td>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

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>Course types</td><td>VLmP (2 SWS); VLmP (2 SWS)</td></tr>
<tr><td>Content</td><td>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, □ecture□ization 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
</td></tr>
</table>

	• Application: jet-cycle systems, double-effect absorption cycle, examples of installed systems
	
	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

Title of courses	Solar Thermal Cooling Concentrated Solar Thermal Systems
Teaching and learning methods	lecture (Solar Thermal Cooling) lecture (Concentrated Solar Thermal Systems)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)

Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Solar Thermal Cooling – written exam (90 min) Grade weighting P1: 50% Examination P2: Concentrated Solar Thermal Systems – written exam (90 min) or report (5-6 pages) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Salman Ajib, Adel Khalil
Media used	black board and beamer, lectures and power point presentations
Recommended 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.
Comments	4 cp (2cp – Solar Thermal Cooling; 2 cp – Concentrated Solar Thermal Systems)

Wind Energy Technology

Module number / code	W-UK-05
Module name	Wind Energy Technology
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 After the successful participation in the course **Electrical Aspects of Wind Energy** the students are able to: - 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
Course types	VLmP+Ex (3 SWS), VLmP (3 SWS)
Content	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 - 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

<table>
<tr><td></td><td>

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
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

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

</td></tr>
<tr><td>Title of courses</td><td>Mechanical Aspects of Wind Energy
Electrical Aspects of Wind Energy</td></tr>
<tr><td>Teaching and learning methods</td><td>lecture (Mechanical Aspects of Wind Energy)
lecture (Electrical Aspects of Wind Energy)</td></tr>
<tr><td>Usabilitiy in other programs</td><td></td></tr>
<tr><td>Duration</td><td>1 Semester</td></tr>
<tr><td>Frequency of module offer</td><td>annually in summer semester</td></tr>
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Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (90 h course attendance, 90 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Mechanical Aspects of Wind Energy – written exam (90 min) Grade weighting P1: 50% Examination P2: Electrical Aspects of Wind Energy – written exam (90 min) Grade weighting P2: 50%
Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Michael Beyer, Siegfried Heier
Media used	black board and beamer, power point presentations
Recommended 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.
Comments	6 cp (3 cp – Mechanical Aspects of Wind Energy; 3 cp – Electrical Aspects of Wind Energy)

Energy Efficiency

Module number / code	W-UK-06
Module name	Energy Efficiency
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course E**nergy efficiency (EE) in cross-sectional technologies** the students are able to: • analyze energetically industrial processes • examine energy efficiency potentials 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
Course types	VLmP (3 SWS); VLmP (3 SWS)

Content	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
	
	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

Title of courses	Energy efficiency in cross-sectional technologies Energy efficiency through process integration
Teaching and learning methods	lecture (Energy efficiency in cross-sectional technologies) lecture, group work (Energy efficiency through process integration)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 h (90 h course attendance, 90 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Energy efficiency in cross-sectional technologies – written exam (90 min) Grade weighting P1: 50% Examination P2: Energy efficiency through process integration – written exam (90 min) or oral exam (60 min) Grade weighting P2: 50%

Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Ron-Hendrik Hechelmann, Florian Schlosser, Jannik Oetzel
Media used	black board and beamer, computer models, experimental measurements
Recommended literature	• 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.
Comments	6 cp (3 cp – Energy efficiency in cross-sectional technologies; 3 cp – Energy efficiency through process integration)

Energy Storage 1

Module number / code	W-UK-07
Module name	Energy Storage 1
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **Introduction to Energy Storage** the students are able to: • distinguish different storage technologies and their role for the RE system • decide on the application of Energy Storage solutions for given storage tasks and compare costs and potentials of storage systems After the successful participation in the course **Hydrogen and Power-to-Chemical Technologies** the students are able to: • ○ Identify role of hydrogen and Power-to-chemicals in sustainable energy systems ○ Get acquainted with the different hydrogen production technologies ○ Conversion of Hydrogen with CO2 or N2 to PtX molecules ○ Evaluate simply PtX process chain from energy and economic perspectives

	○ Get a glimpse on the recent research and development trend in this value chain
Course types	VLmP (2 SWS), VLmP (3 SWS)

Content	Introduction to Energy Storage
	• Description of energy storage technologies:
	  ○ power to gas
	  ○ battery technologies
	  ○ pumped hydro storage
	  ○ compressed air energy storages
	  ○ thermal energy storages
	• Efficiency of energy storage systems
	• Economics of different energy storage solutions
	• Energy Storage Solutions including sector coupling, especially Power-to-Heat and Power-to-Mobility
	
	Hydrogen and Power-to-Chemical Technologies
	• Description of different hydrogen production technologies
	• Thermodynamics fundamentals for electrochemical hydrogen production and storage
	• Chemical reaction engineering fundamentals for hydrogen conversion to PtX
	• Based on stoichiometric or ideal approach, identify the efficiency of the PtX value chain
	• Evaluate the cost of production of Hydrogen and PtX based on short-cut methods

Title of courses	Introduction to Energy Storage Hydrogen and Power-to-Chemical Technologies
Teaching and learning methods	lecture (Introduction to Energy Storage) lecture (Hydrogen and Power-to-Chemical Technologies)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Introduction to Energy Storage – written exam (90 min) or report (5-6 pages)

	Grade weighting P1: 40% Examination P2: Hydrogen and Power-to-Chemical Technologies – report (5-6 pages) Grade weighting P2: 60%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Ingo Stadler, Matteo Genovese
Media used	Black board and beamer, presentations, computer models, PC based software development
Recommended literature	• Stadler: Handbook of Energy Storage: Demand, Technologies, Integration. ISBN-13: 978-3662555033, ISBN-10: 3662555034 • Lecture notes on Energy Storage. • Ouda M. et al. (2019) Power-to-Methanol: Techno-Economical and Ecological Insights. In: Maus W. (eds) Zukünftige Kraftstoffe. ATZ/MTZ-Fachbuch. Springer Vieweg, Berlin, Heidelberg. DOI: 10.1007/978-3-662-58006-6_17 • Olah, G. A. (2005). Beyond oil and gas: the methanol economy. Angewandte Chemie International Edition, 44(18), 2636-2639. • CRABTREE, George W.; DRESSELHAUS, Mildred S.; BUCHANAN, Michelle V. The hydrogen economy. Physics today, 2004, 57. Jg., Nr. 12, S. 39-44. • O'CONNELL, John P.; HAILE, James M. Thermodynamics: Fundamentals for applications. Cambridge University Press, 2005.
Comments	5 cp (2 cp – Introduction to Energy Storage; 3 cp – Hydrogen and Power-to-Chemical Technologies)

Smart Power Systems

Module number / code	W-UK-08
Module name	Smart Power Systems
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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.
Course types	VLmP+Pr (3 SWS); VLmP (2 SWS)
Content	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 - 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 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
Title of courses	Smart Grids Grid Integration
Teaching and learning methods	lecture, lab (Smart Grids) lecture (Grid Integration)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English

Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Smart Grids – presentations (4 x 15 min) Grade weighting P1: 60% Examination P2: Grid Integration – written exam (90 min) or report (5-6 pages) Grade weighting P2: 40%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Marc Selig, Reinhard Mackensen
Media used	black board and beamer, lab experiments, measurements
Recommended literature	• Vadari, S., *Smart Grid Redefined: Transformation of the Electric Utility*, Artech House, 2018 • 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.
Comments	5 cp (3 cp – Smart Grids; 2 cp – Grid Integration)

Scientific Programming and Publishing

Module number / code	W-UK-09
Module name	Scientific Programming and Publishing
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	Pr (2 SWS); VLmP+Pr (1 SWS)
Content	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 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
Title of courses	Introduction to MATLAB Introduction to LaTeX
Teaching and learning methods	lab, training (Introduction to MATLAB) lecture and training (Introduction to LaTeX)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (45 h course attendance, 135 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Introduction to MATLAB – lab training attendance, programming, oral exam (30 min) Grade weighting P1: 67%

	Examination P2: Introduction to LaTeX – writing a scientific report Grade weighting P2: 33%
Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Nour Mansour, Dirk Dahlhaus
Media used	beamer, black board (mathematical notation, explanations), paper (exercises), PC based software development (lab training)
Recommended literature	• P. Venkataraman, Applied Optimization with MATLAB Programming, 2009. • H. Moore, MATLAB for Engineers, 2007. • S. Boyd, L. Vandenberghe, Convex Optimization, Cambridge University Press,2014.
Comments	6 cp (4 cp – Introduction to MATLAB; 2 cp – Introduction to LaTeX)

Social Aspects of RE

Module number / code	W-UK-10
Module name	Social Aspects of RE
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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. 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.
Course types	VLmP+S (2 SWS); S+Ex (2 SWS)

Content	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,

	○ indicator development. 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 • Visit to a citizen energy cooperative.
Title of courses	Project Management in Development Cooperation Energy and Society
Teaching and learning methods	lecture, seminar, excursion
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Project Management in Development Cooperation – presentation (15 min) and report (3-4 pages) Grade weighting P1: 50% Examination P2: Energy and Society – presentation (15 min) and report (2-3 pages) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik

Responsible person	Prof. Dahlhaus
Lecturer(s)	Wolfgang Dewald, Kristina Bayer
Media used	black board and beamer, case studies in groups
Recommended literature	• 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 • World Commission on Dams, Dams and Development: A New Framework for Decision-Making, Earthscan Ltd, 2000. • Further literature will be announced by the lecturers.
Comments	4 cp (2 cp – Project Management in Development Cooperation; 2 cp – Energy and Society)

Energy Storage 2

Module number / code	W-UK-11
Module name	Energy Storage 2
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **Battery Energy Storage Systems** the students are able to: • distinguish different battery technologies and their role for the RE system • decide on the application of battery storage solutions for given tasks and compare costs and potentials of battery systems. 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.
Course types	VLmP (2 SWS), VLmP (2 SWS)
Content	Battery Energy Storage Systems • Introduction to BESS and Applications • Evolution of Energy Storage Technologies • Battery Cell Fundamentals and Chemistries • System Design – Modules, Racks & Manufacturing

	• Power Conversion & Balance of Plant
	• Control Architecture and SCADA Systems
	• Project Development & Site Engineering
	• Project Finance and Engineering Procurement Construction (EPC)
	• Operations, Maintenance & Safety
	• Workforce, Trends & Real Project Case Studies
	
	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

Title of courses	Battery Energy Storage Systems Flexible Generation and Demand Side Management (DSM)
Teaching and learning methods	lecture
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Battery Energy Storage Systems – written exam (90 min) or oral exam (30 min) Grade weighting P1: 50% Examination P2: Flexible Generation and Demand Side Management – written exam (90 min) or oral exam (30 min) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik

Responsible person	Prof. Dahlhaus
Lecturer(s)	Ahmed Abdelrasoul, John Sievers
Media used	Black board and beamer, presentations
Recommended literature	• 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. • Further literature will be announced by the lecturers.
Comments	4 cp (2 cp – Battery Energy Storage Systems; 2 cp – Flexible Generation and Demand Side Management (DSM))

Bio Power

Module number / code	W-UK-12
Module name	Bio Power
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	After the successful participation in the course **Bio Gas** 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. 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.
Course types	VLmP+Ex (2 SWS), VLmP+Pr (2 SWS)

Content	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

	◦ ecture 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 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
Title of courses	Bio Gas System Aspects of Bio Power Generation
Teaching and learning methods	lecture, excursion, lab
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Bio Gas – written exam (90 min) Grade weighting P1: 50% Examination P2: System Aspects of Bio Power Generation – written exam (90 min) or

	oral exam (30 min) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Bernd Krautkremer, John Sievers
Media used	Black board and beamer, lab experiments, measurements.
Recommended literature	• 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. • R. Frischknecht and N. Jungbluth (eds.), *Overview and Methodology, Ecoinvent report No. 1*, 2007. • Further literature will be announced by the lecturers.
Comments	4 cp (2 cp – Bio Gas; 2 cp – System Aspects of Bio Power Generation)

3.3. Elective Modules Monastir

Advanced Energy Engineering

Module number / code	W-UM-01
Module name	Advanced Energy Engineering
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	VLmP+Ü (3 SWS); VLmP+Ü (3 SWS)
Content	Applied Heat Transfer • Heat radiation: introduction to thermal radiationblackbody 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 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
Title of courses	Applied Heat Transfer Advanced Fluid Mechanics
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 hours (90 h course attendance, 90 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Applied Heat Transfer – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 50% Examination P2: Advanced Fluid Mechanics – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 50%
Credit points (ECTS)	6 cp
Teaching unit	Elektrotechnik

Responsible person	Dr. El Alimi
Lecturer(s)	Hacen DHAHRI, Walid HASSEN, Ameni MOKNI, Zouhour ARAOUD
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive
Recommended literature	• CENGEL Y.A. Heat Transfer: Practical Approach, McGraw-Hill, 1997 • HOLMAN J.P. Heat Transfer, McGraw-Hill, Inc.,1990 • 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
Comments	6 cp (3 cp – Applied Heat Transfer; 3 cp – Advanced Fluid Mechanics)

Energy and Environment

Module number / code	W-UM-02
Module name	Energy and Environment
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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 14001certification
Course types	VLmP+Ü (2 SWS); VLmP+Ü (2 SWS)
Content	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; CO_2 issue; energy optimization in the refinery; CO_2 capture and storage; H_2 (new energy vector); energy transition and global responsibility; economic estimates 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
Title of courses	Energy and Environmental Context, Energy Transition and Sustainable Development Energy and Environmental Management Systems
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Energy and Environmental Context, Energy Transition and Sustainable Development – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 50% Examination P2: Energy and Environmental Management Systems – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Dr. El Alimi

Lecturer(s)	Chiheb BOUDEN, Bassem TRIKI
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive
Recommended literature	• Energy and the challenge of sustainability, United Nations Development Programme • www.iea.org • www.iso.org
Comments	4 cp (2 cp – Energy and Environmental Context, Energy Transition and Sustainable Development; 2 cp – Energy and Environmental Management Systems)

Management and Engineering Mathematics

Module number / code	W-UM-03
Module name	Management and Engineering Mathematics
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	VLmP+Ü (3 SWS); VLmP+Ü (2 SWS)
Content	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 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

Title of courses	Numerical Methods and Optimization Project Management and Industrial Marketing
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Numerical Methods and Optimization – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 60% Examination P2: Project Management and Industrial Marketing – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 40%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Dr. El Alimi
Lecturer(s)	Souheil EL ALIMI, Sadok ZAYEN
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive
Recommended literature	• 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
Comments	5 cp (3cp – Numerical Methods and Optimization; 2 cp – Project Management and Industrial Marketing)

Solar Energy Subsystems

Module number / code	W-UM-04
Module name	Solar Energy Subsystems
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	VLmP+Ü (3 SWS); VLmP+Ü (2 SWS)
Content	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.
Title of courses	Solar Energy Collectors PV Solar Energy Materials
Teaching and learning methods	Lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English

Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 h (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Solar Energy Collectors – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 60% Examination P2: PV Solar Energy Materials – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 40%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Dr. El Alimi
Lecturer(s)	Chiheb BOUDEN, Souheil EL ALIMI
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive
Recommended literature	Soteris A Kalogirou, Solar energy engineering processes and systems, Academic Press
Comments	5 cp (3 cp – Solar Energy Collectors; 2 cp – PV Solar Energy Materials)

Geothermal Energy

Module number / code	W-UM-05
Module name	Geothermal Energy
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 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
Course types	VLmP+Ü (2 SWS); VLmP+Ü (3 SWS)

Content	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.
	
	Geothermal Applications
	
	• Electricity generation
	  ○ technical features of plant options: atmospheric and condensing exhaust conventional steam turbines; binary plant; biphase rotary separator turbo-alternator.
	  ○ 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.

Title of courses	Geothermal Resource Identification and Development Geothermal Applications
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none

Student workload	150 hours (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Geothermal Resource Identification and Development – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 40% Examination P2: Geothermal Applications – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 60%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Dr. El Alimi
Lecturer(s)	Hacen DHAHRI
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal and interactive
Recommended literature	Ronald DiPippo, Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact Geothermal energy: utilization and technology, Elsivier.
Comments	5 cp (2 cp – Geothermal Resource Identification and Development; 3 cp – Geothermal Applications)

Combined Cooling, Heating and Power (CCHP)

Module number / code	W-UM-06
Module name	Combined Cooling, Heating and Power (CCHP)
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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. 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
Course types	VLmP+Ü (2 SWS); VLmP+Ü (3 SWS)
Content	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, steamTurbines; combined and steam injection cycles; controlling prime movers; renewable and alternative power technologies 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
Title of courses	Theory and Technology of Combined Heating, Cooling & Power Applications of Combined Heating, Cooling & Power
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	150 hours (75 h course attendance, 75 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Theory and Technology of Combined Heating, Cooling & Power – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 40%

	Examination P2: Applications of Combined Heating, Cooling & Power – midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 60%
Credit points (ECTS)	5 cp
Teaching unit	Elektrotechnik
Responsible person	Dr. El Alimi
Lecturer(s)	Souheil EL ALIMI, Abdelmajid JEMNI
Media used	black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises, case studies in groups; formal & interactive
Recommended literature	Neil Petchers, Combined Heating, Cooling & Power Handbook: Technologies & Applications, the Fairmont press, INC, Marcel Dekker, INC.
Comments	5 cp (2 cp – Theory and Technology of Combined Heating, Cooling & Power; 3 cp – Applications of Combined Heating, Cooling & Power)

3.4. REMENA University Network (RUN) Courses

The REMENA master program has established a network called REMENA university network (RUN) including three core partner universities, namely, JNTU Hyderabad (JNTUH) in Hyderabad (H), University of Monastir (UM) in Monastir (M) and University of Kassel (UKAS) in Kassel (K).

In the course catalog below, different elective modules offered by the RUN partner universities, i.e., the University of Sfax (US) in Sfax (S) and the German University in Cairo (GUC) in Cairo (C), are listed. The modules below can also be chosen as elective modules to reach the total amount of 58 ECTS.

Project Work	**ECTS site**	**Optimization, Regression and Forecasting**	**ECTS site**	**Power Systems**	**ECTS site**	**Contracts and Projects Administration**	**ECTS site**	**Design, Testing and Control**	**ECTS site**
Project	15 C	Linear and Non-Linear Optimization	5 C	Power Electronics	4 C	Legislation, Contracts and Engineering Ethics	2 C	Design of Experiments and Measuring Techniques	5 C
		Production and Operations Management	5 C	Distributed Power Systems	5 C	Construction Contracts and Project Administration	2 C	Heating, Ventilation and Air Conditioning (HVAC) Systems and Control	5 C
								Quality Control	5 C

Table 15: Elective modules conducted at GUC during WS (53 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	Rules of Writing Research Documents	ECTS site
Induction Machine Modelling	2 S	Electric System Modelling	2 S	Linear Static Magnetic Analyses	2 S	Storage Systems: Case Studies	2 S	The Scientific Paper: From Reading to Writing	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	Writing Process	1 S
Special AC Actuators	**ECTS site**	**Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives**	**ECTS site**	**Control Strategies of Electric Drives**	**ECTS site**	**Power Electronic Converters**	**ECTS site**	**Embedded Generating Systems**	**ECTS site**
Switched Reluctance Machines	1 S	Faults in Electric Machine Drives	1 S	Rotor Flux Oriented Control of Three-Phase Induction Motor	1 S	PWM Control Strategies of Two-Level Inverters	1 S	Generating Systems Embedded on Board of Road Vehicles	1 S
Axial Flux Machines	1 S	Faults Detection and Isolation Techniques and Methods	1 S	Direct Torque Control of Three- Phase Induction Motor	1 S	PWM Control Strategies of Three-Level Inverters	1 S	Modelling of Claw Pole Alternators	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	Design Improvement of the CPA-Based Generating Systems	1 S
								Avionic Generating Systems	1 S

Table 16: Elective modules conducted in Sfax during WS (34 ECTS credits).

The tables below show the detailed elective modules at GUC and US.

Optimization, Regression and Forecasting

Module number / code	W-GUC-01
Module name	Optimization, Regression and Forecasting
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Fundamental theories and computational methodologies used in (computer aided) optimization analysis, productivity analysis, forecasting techniques, regression and correlation analysis, management, scheduling and aggregate planning After the successful participation in the course **Linear and Non-Linear Optimization** the students are able to: • Knowledge and Understanding: ○ identify the objective function, the holonomic and nonholonomic constrains

	○ form the Lagrangian function and solve for the optimal variables and Lagrange multipliers ○ form the Hessian matrix and analyze the second order sufficiency conditions of the optimization problem ○ compare between optimization techniques such as the gradient descent method, Gauss-Newton method and the Levenberg-Marquardt method • Intellectual Skills: ○ formulation of the optimization problem through the ability to distinguish between the objective functions and the constrains ○ ability to solve the optimization numerically ○ ability to select the appropriate optimization problem based on the constrains and the dynamics of the process After the successful participation in the course **Production and Operations Management** the students are able to: • Knowledge and Understanding: ○ define productivity analysis and its application ○ describe different forecasting techniques ○ describe regression techniques ○ describe inventory techniques ○ explain aggregate planning ○ define project scheduling • Professional and Practical skills: ○ predict new demands of the globally competitive business environment emphasize the importance of change, facilitation of learning, cross-functional teamwork, knowledge capture, and analysis in manufacturing organizations ○ submit a course project, in which the project process of initiating, planning, executing, controlling and closing the project is applied through case studies • Intellectual Skills: ○ develop an understanding of the strategic importance of manufacturing systems, production and operations systems ○ recognize the relationship between manufacturing and related service providers and other business functions, such as human resources, purchasing, marketing, finance, etc. ○ calculate forecasts using different techniques ○ apply qualitative and quantitative methods of inventory models ○ apply proactive and reactive planning strategies ○ calculating the timing of the use of different resources in an organization • General and Transferrable skills: ○ employ critical thinking to solve problems in area of quality control ○ practice independent learning required to build up knowledge base ○ work in teams
Course types	VLmP+Ü (4 SWS); VLmP+Ü (4 SWS)
Content	Linear and Non-Linear Optimization • Optimization analysis • Lagrangian function and Hessian matrix • Gradient descent method

	• Gauss-Newton method and the Levenberg-Marquardt method • Different non linear optimization methods Production and Operations Management • Productivity analysis • Forecasting techniques • Regression and correlation analysis • Inventory • Management • Aggregate planning • Materials requirements planning (MRP) • Scheduling • It also allows more emphasis on computer solutions with excel spreadsheets
Title of courses	Linear and Non-Linear Optimization; Production and Operations Management
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	300 hours (120 h course attendance; 180 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Linear and Non-Linear Optimization - midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P1: 50% Examination P2: Production and Operations Management - midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 50%
Credit points (ECTS)	10 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Eberhard Roos
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	

Comments	10 cp (5 cp - Linear and Non-Linear Optimization; 5 cp - Production and Operations Management)

Power Systems

Module number / code	W-GUC-02
Module name	Power Systems
Type of module	Elective module

Learning outcomes, acquired competencies and qualification goals	Fundamentals of power electronics switches and their applications and analyzing the operation of traditional and distributed power systems and study power different generation technologies
	
	After the successful participation in the course **Power Electronics** the students are able to:
	
	• Knowledge and Understanding:
	  ○ name types of power converters
	  ○ list different topologies of each power electronic converter
	  ○ discuss the operation of different power electronic converters
	• Professional and Practical skills:
	  ○ practice their knowledge with power electronics for advanced applications (practical applications) like electric drives and renewable energy
	• Intellectual Skills:
	  ○ analyze different circuit configurations used in different converters
	  ○ solve problems related to DC-DC choppers, AC-AC choppers, and AC-DC converters
	  ○ operate different power electronic circuits
	  ○ propose suitable power converters for different applications
	
	After the successful participation in the course **Distributed Power Systems** the students are able to:
	
	• demonstrate knowledge and understanding of power system analysis under steady state and faulty conditions
	• represent the multi-port power system using impedance and admittance matrices
	• recognize and calculate the different types of power system faults
	• formulate and solve the load flow problem using approximate and numerical techniques
	• assess the different generation technologies and be able to select the size and the location of the distributed generators to support the system steady state performance

Course types	VLmP+Ü (2 SWS); VLmP+Ü (4 SWS)
Content	Power Electronics • Solid-state switches • Controlled and uncontrolled single phase rectifiers • Controlled single phase full wave rectifiers • Three phase uncontrolled half wave & full wave rectifiers • Single phase AC voltage controllers • DC-to-DC converters Distributed Power Systems 1. Power system Representation: • Power system components • Modelling of system components • The per-unit system 2. Power flow analysis: • System performance measures; system losses and voltage profile • Formulation of the Load flow equations • Approximate solution of Load flow equations • Numerical solution of Load flow equations 3. Distributed generation systems: • Terminology of distributed generation systems • Different distributed generation technologies • Benefits of distributed generation systems • Analysis of distributed generation systems
Title of courses	Power Electronics; Distributed Power Systems
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	270 hours (90 h course attendance, 180 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Power Electronics - midterm assignments 35%, final written exam (90 min) 45%, quiz 15%, report 5%

	Grade weighting P1: 44% Examination P2: Distributed Power Systems - midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 56%
Credit points (ECTS)	9 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Frank Gunzer, Mostafa Soliman
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	9 cp (4 cp - Power Electronics; 5 cp - Distributed Power Systems)

Contracts and Projects Administration

Module number / code	W-GUC-03
Module name	Contracts and Projects Administration
Type of module	Elective module

Learning outcomes, acquired competencies and qualification goals	Laws and legislations concerning engineering works, contracts, industrial safety and security, relation between owner and tenant and engineering Ethics
	
	After the successful participation in the course **Legislation, Contracts and Engineering Ethics** the students are able to:
	
	• Knowledge and Understanding:
	    ○ define, describe, identify and explain the Engineering profession and what it implies in terms of technicality, legally and ethics-wise
	    ○ undergo proper contract drafting and/or engaging in a contractual relationship with clients/fellow engineers
	    ○ relate to the diversity of ethics' codes, worldwide, within different venues such as environmental and computer ethics
	• Professional and Practical skills:
	    ○ operate as a professional engineer whether in engineering practice or conduct
	    ○ manage to mitigate the course content to junior engineers of the profession, upon reaching a senior stage
	• Intellectual Skills:
	    ○ differentiate between business organizations
	    ○ use, properly, the laws and regulations within the country of residence to avoid adverse circumstances/conflicts
	    ○ exhibit ethical conduct in light of the made-available ethical codes and guidelines
	
	After the successful participation in the course **Construction Contracts and Project Administration** the students are able to:

	• be aware of the importance of legal and contractual issues and due administration on and around construction projects and of the consequences if contractual issues are not taken serious
Course types	VLmP+Ü (2 SWS); VLmP+Ü (2 SWS)
Content	Legislation, Contracts and Engineering Ethics • General overview on the legal systems worldwide • Business Organizations • Hierarchy of the Syndicate of Engineers • Fundamentals and development of tort Law • Contracts and contractual relations • Tendering Issues • Breach of Contracts • Regulatory Aspects and Ethics • Ethical Problems in Engineering management and private practice • Environmental Ethics/Computer Ethics Construction Contracts and Project Administration • Main contractual terms and conditions of standard contract forms • Analysing and evaluating real case issues • Different areas will be introduced with its basic application tools as well as its cross links to contract administration
Title of courses	Legislation, Contracts and Engineering Ethics, Construction Contracts and Project Administration
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Legislation, Contracts and Engineering Ethics - midterm assignments 30%, final written exam (90 min) 60%, quiz 10% Grade weighting P1: 50% Examination P2: Construction Contracts and Project Administration - midterm

	assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Yasser Hegazy, Tarik Youssef
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	4 cp (2 cp - Legislation, Contracts and Engineering Ethics; 2 cp - Construction Contracts and Project Administration)

Design, Testing and Control

Module number / code	W-GUC-04
Module name	Design, Testing and Control
Type of module	Elective module

Learning outcomes, acquired competencies and qualification goals	Measurement instrumentations and applications, statistical concepts, basic techniques in experimental and randomized block design, full and fractional factorial design, design an HVAC system and get familiar with air conditioning standards, tables and charts and tackle concepts of energy utilization; improve quality, reliability and design in a manufacturing environment and implement effective quality systems
	
	After the successful participation in the course **Design of Experiments and Measuring Techniques** the students are able to:
	• analyse significant testing results and learn the concepts and techniques of design of experiments
	• appreciate the value of variance reduction in process design and control
	• design full and fractional factorials and acquire a working knowledge of statistical software programs
	• measure several physical and mechanical quantities using simple and/or specialized instrumentations
	• learn about general characteristics of sensors and measurement systems, measurement of force, torque, motion, speed, strain, temperature, pressure and flow
	
	After the successful participation in the course **Heating, Ventilation and Air Conditioning (HVAC) Systems and Control** the students are able to:
	• Knowledge and Understanding:
	    ○ define different types of cooling/heating loads
	    ○ define different types of air conditioning systems and differentiate between them
	    ○ identify the concepts of refrigerators and heat pumps and how to measure their performance

	○ recall different properties of moist air ○ identify the psychometric chart and how to deal with it. • Intellectual Skills: ○ calculate the different components of the cooling load for the conditioned space ○ decrease the cooling/heating load in order to establish most efficient cooling system ○ choose the machine suitable for the conditioned space ○ design an efficient and effective air conditioning system ○ classify modes of heat transfer that affect the conditioned space (conduction, convection or radiation) ○ calculate the cooling load for any space (their homes, lecture halls, class rooms…etc.) ○ categorize the cooling load and the construction of the conditioned space into categories according to their materials and their effect on the cooling load ○ distribute the air and select the proper duct and air distribution system for a defined space • Professional and Practical Skills: ○ estimate the cooling load for a defined space ○ determine the duct sizing and air distribution in a defined space ○ select machines (air-conditioning system selection) ○ select the appropriate control method for the selected air conditioning system After the successful participation in the course **Quality Control** the students are able to: • improve quality, reliability, and design in a manufacturing environment by learning some practical and statistical engineering methods • learn sampling techniques and fundamental test strategies designed to identify controllable factors and their effects on quality measures as well as the foundations of robust design and its application to design, manufacturing and customer service
Course types	VLmP+Ü (4 SWS); VLmP+Ü (4 SWS); VLmP+Ü (4 SWS)
Content	Design of Experiments and Measuring Techniques • Statistical concepts, basic techniques in experimental design, comparison of • K-variables • Randomized block design • Latin squares, matrix theory, full and fractional factorial design, confounding & blocking and response surface methodology • Measurement instrumentations and applications • General characteristics of sensors and measurement systems. Measurement force, torque, motion, speed, strain, temperature, pressure and flow Heating, Ventilation and Air Conditioning (HVAC) Systems and Control • Refrigerating machine and the reversed Carnot cycle • Gas, vapor mixture and air • Conditioning • Psycrometric chart • Air conditioning processes • Principles of air conditioning and comfort conditions

	• Cooling load estimation • Air conditioning systems and control Quality Control • Basic definitions, concepts and terminology used in quality control systems • Analytical, practical and statistical engineering tools to improve quality, reliability and design in a manufacturing environment and implement effective quality systems
Title of courses	Design of Experiments and Measuring Techniques, Heating, Ventilation and Air Conditioning (HVAC) Systems and Control, Quality Control
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	450 hours (180 h course attendance, 270 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Design of Experiments and Measuring Techniques - midterm assignments 35%, final written exam (90 min) 45%, quiz 15%, report 5%; Heating, Ventilation and Air Conditioning (HVAC) Systems and Control - midterm assignments 35%, final written exam (90 min) 40%, quiz 15%, project 10% Grade weighting P1: 67% Examination P2: Quality Control - midterm assignments (1/3), final written exam (90 min) (2/3) Grade weighting P2: 33%
Credit points (ECTS)	15 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	El Sayed Imam Morgan, Mohammed Salama Abdelhady
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	

Comments	15 cp (5 cp - Design of Experiments and Measuring Techniques; 5 cp - Heating, Ventilation and Air Conditioning (HVAC) Systems and Control; 5 cp - Quality Control)

Project Work

Module number / code	W-GUC-05
Module name	Project Work
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Scientific analysis of the present challenges in REEE After the successful participation in the course **Project Work** the students are able to: • conduct literature and internet based investigation • sole a problem in a structured approach • conduct independent scientific work • work in a team and to exchange ideas • present results in the framework of a project • write a scientific report and presentation of the project results • investigate literature and internet based sources • work independently and scientifically
Course types	PrM (9 SWS)
Content	• Topics in REEE with a specific focus on issues related to the MENA region • Fundamentals and present challenges in REEE
Title of courses	Project Work
Teaching and learning methods	project work
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	450 hours (135 h course attendance, 315 h self-study)
Required course work	none
Prerequisites for examination(s)	none

Module examination(s)	report (20-30 pages) and presentation (20-25 minutes)
Credit points (ECTS)	15 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	GUC team
Media used	
Recommended literature	

Control Oriented Modelling of AC Actuators

Module number / code	W-Sfax-01
Module name	Control Oriented Modelling of AC Actuators
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Electromagnetic modeling of AC actuators 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 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
Course types	VLmP+Ü (1 SWS); VLmP+Ü (1 SWS)
Content	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 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
Title of courses	Induction Machine Modelling Synchronous Machine Modelling
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 h (30 h course attendance, 90 h tutored project)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Induction Machine Modelling - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P1: 50% Examination P2: Synchronous Machine Modelling - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Ahmed Masmoudi, Badii Bouzidi
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	4 cp (2 cp - Induction Machine Modelling; 2 cp - Synchronous Machine Modelling)

FEA Modelling of AC Actuators (level 1)

Module number / code	W-Sfax-02
Module name	FEA Modelling of AC Actuators (level 1)
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Design oriented machine modelling using the finite element method 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 After the successful participation in the course **Finite System 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
Course types	VLmP+Ü (2 SWS); VLmP+Ü (1 SWS)
Content	Electric System Modelling: • Magnetic and electric laws • Maxwell's equations • Electrostatic model • Magneto-static model • Electro-magnetic model • Cases studies Finite System Modelling: • Fundamentals of FEM • Approximating potentials with shape functional finite elements • Edge finite elements • Application of the finite element method
Title of courses	Electric System Modelling Finite System Modelling
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester

Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 hours (45 h course attendance, 45 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Electric System Modelling - written exam (90 min) Grade weighting P1: 60% Examination P2: Finite System Modelling - written exam (90 min) Grade weighting P2: 40%
Credit points (ECTS)	3 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Imen Abdennadher
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	3 cp (2 cp - Electric System Modelling; 1 cp - Finite System Modelling)

FEA Modelling of AC Actuators (level 2)

Module number / code	W-Sfax-03
Module name	FEA Modelling of AC Actuators (level 2)
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Sizing oriented machine modelling using the finite element method 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 After the successful participation in the course **Non-Linear Static Magnetic Analyses** 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
Course types	VLmP+Ü (1 SWS); VLmP+Ü (1 SWS)
Content	Linear Static Magnetic Analysis • Examples description • Linear material definition • Meshing • Boundary conditions • Loads definition • Review results Non-Linear Static Magnetic Analyses • Examples description • Non-linear material definition • Meshing • Boundary conditions • Loads definition • Review results
Title of courses	Linear Static Magnetic Analysis Non-Linear Static Magnetic Analyses
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (30 h course attendance, 90 h tutored project)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Linear Static Magnetic Analysis - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P1: 50% Examination P2: Non-Linear Static Magnetic Analyses - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P2: 50%
Credit points (ECTS)	4 cp

Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Imen Abdennadher, Amal Souissi
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	4 cp (2 cp - Linear Static Magnetic Analysis; 2 cp - Non-Linear Static Magnetic Analyses)

Embedded Energy Storage Systems

Module number / code	W-Sfax-04
Module name	Embedded Energy Storage Systems
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Storage systems analysis and sizing 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 After the successful participation in the course **Sizing of Storage Systems** the students are able to: • choose the best 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
Course types	VLmP+Ü (1 SWS); VLmP+Ü (1 SWS)
Content	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 Sizing of Storage Systems • Hydrogen storage system • Super capacitor • Battery electric storage system
Title of courses	Storage Systems: Case Studies Sizing of Storage Systems
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (30 h course attendance, 90 h tutored project)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Storage Systems:Case Studies - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P1: 50% Examination P2: Sizing of Storage Systems - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Lotfi Krichen, Achraf Abdelkafi
Media used	Black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	4 cp (2 cp - Storage Systems: Case Studies; 2 cp - Sizing of Storage Systems)

Special AC Actuators

Module number / code	W-Sfax-05
Module name	Special AC Actuators
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Analysis and design of non-conventional AC 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 After the successful participation in the course **Axial Flux Machine** the students are able to: • understand the principle of operation of axial flux machines • understand the principle of torque production in axial flux machines After the successful participation in the course **Transvers 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
Course types	VLmP+Ü (1 SWS), VLmP+Ü (1 SWS), VLmP+Ü (1 SWS)
Content	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 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 Transvers 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
Title of courses	Switched Reluctance Machines, Axial Flux Machine, Transvers Flux Machines
Teaching and learning methods	lecture (Switched Reluctance Machines); lecture (Axial Flux Machine); lecture, exercise (Transvers Flux Machines)
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 hours (45 h course attendance, 45 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Switched Reluctance Machines - written exam (90 min), Axial Flux Machine - written exam (90 min) Grade weighting P1: 67% Examination P2: Transvers Flux Machines - written exam (90 min) Grade weighting P2: 33%
Credit points (ECTS)	3 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Ahmed Masmoudi
Media used	black board and beamer, case studies in groups, lab experiments, measurements.
Recommended literature	
Comments	3 cp (1 cp - Switched Reluctance Machines; 1 cp - Axial Flux Machine; 1 cp - Transvers Flux Machines)

Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives

Module number / code	W-Sfax-06
Module name	Diagnosis, Monitoring and Reconfiguration of Electric Machines Drives

Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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 faults whether they are mechanically- or electrically- caused • predict faults on the different electric drive components 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 Fault detection and isolation and the synthesis of 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
Course types	VLmP+Ü (1 SWS), VLmP+Ü (1 SWS), VLmP+Ü (1 SWS)
Content	Faults in Electric Machine Drives • Faults in AC drives • Voltage supply inverter faults • Sensor faults Faults Detection and Isolation Techniques and Methods • Diagnosis: general procedure • FDI methods classification • Faults detection: model-based method • Faults detection: signal processing techniques • Faults detection: motor current signature analysis (MCSA) technique • Faults detection: Artificial Intelligent Based Methods Fault-Tolerant Control Strategies • Principle of fault tolerant control • Fault tolerant control: passive technique • Fault tolerant control: active technique • Fault tolerant control: hybrid technique

Title of courses	Faults in Electric Machine Drives, Faults Detection and Isolation Techniques and Methods, Fault-Tolerant Control Strategies
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 hours (45 h course attendance, 45 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Faults in Electric Machine Drives - written exam (90 min), Faults Detection and Isolation Techniques and Methods - written exam (90 min) Grade weighting P1: 67% Examination P2: Fault-Tolerant Control Strategies - written exam (90 min) Grade weighting P2: 33%
Credit points (ECTS)	3 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Houda Ben Attia-Sethom
Media used	black board and beamer, case studies in groups, lab experiments, measurements.
Recommended literature	
Comments	3 cp (1 cp - Faults in Electric Machine Drives; 1 cp - Faults Detection and Isolation Techniques and Methods; 1 cp - Fault-Tolerant Control Strategies)

Control Strategies of Electric Drives

Module number / code	W-Sfax-07
Module name	Control Strategies of Electric Drives

Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Synthesis and implementation of control strategies dedicated to electric drives After the successful participation in the course **Rotor Flux Oriented Control of Three-phase Induction Motor** the students are able to: • make the synthesis and the implementation of the RFOC strategy of the IM After the successful participation in the course **Direct Torque Control of Three-phase Induction Motor** the students are able to: • make the synthesis and the implementation of the DTC strategy of the IM After the successful participation in the course **Direct Power Control 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
Course types	VLmP+Ü (1 SWS), VLmP+Ü (1 SWS), VLmP+Ü (1 SWS)
Content	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
Title of courses	Rotor Flux Oriented Control of Three-phase Induction Motor, Direct Torque Control of Three-phase Induction Motor, Direct Power Control Strategies of Three-Phase PWM Rectifiers
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	
Teaching language	English
Recommended (knowledge) prerequisites	

Required prerequisites for participation	none
Student workload	90 hours (45 h course attendance, 45 h tutored project)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Rotor Flux Oriented Control of Three-phase Induction Motor - written exam (90 min) (70%), tutored project defense (15 min) (30%); Direct Torque Control of Three-phase Induction Motor - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P1: 67% Examination P2: Direct Power Control Strategies of Three-Phase PWM Rectifiers - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P2: 33%
Credit points (ECTS)	3 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Bassem EL BADSI
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	3 cp (1 cp - Rotor Flux Oriented Control of Three-phase Induction Motor; 1 cp - Direct Torque Control of Three-phase Induction Motor; 1 cp - Direct Power Control Strategies of Three-Phase PWM Rectifiers)

Power Electronic Converters

Module number / code	W-Sfax-08
Module name	Power Electronic Converters
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Control strategies of three-phase inverters and matrix converters 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 (PWM) techniques for the control of three-phase two-level voltage source inverter 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 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
Course types	VLmP+Ü (1 SWS); VLmP+Ü (1 SWS); VLmP+Ü (1 SWS)
Content	PWM Control Strategies of Two-Level Inverters • Sinusoidal PWM • Third Harmonic Injection PWM • Conventional Space Vector PWM • Bus-Clamping Space Vector PWM PWM Control Strategies of Three-Level Inverters • Modelling of Three-Level Inverter • Sinusoidal PWM Technique • Space Vector PWM Technique Matrix Converters and their Control Strategies • Modelling of Matrix Converters • Venturini's Modulation Technique • Venturini's Optimum Modulation Technique
Title of courses	PWM Control Strategies of Two-Level Inverters, PWM Control Strategies of Three-Level Inverters, Matrix Converters and their Control Strategies
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 hours (45 h course attendance, 45 h tutored project)
Required course work	none
Prerequisites for examination(s)	none

Module examination(s)	Examination P1: PWM Control Strategies of Two-Level Inverters - written exam (90 min) (70%), tutored project defense (15 min) (30%); PWM Control Strategies of Three-Level Inverters - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P1: 67% Examination P2: Matrix Converters and their Control Strategies - written exam (90 min) (70%), tutored project defense (15 min) (30%) Grade weighting P2: 33%
Credit points (ECTS)	3 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Bassem EL BADSI, Badii Bouzidi
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	3 cp (1 cp - PWM Control Strategies of Two-Level Inverters; 1 cp - PWM Control Strategies of Three-Level Inverters; 1 cp - Matrix Converters and their Control Strategies)

Embedded Generating Systems

Module number / code	W-Sfax-09
Module name	Embedded Generating Systems
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Design, modelling, and analysis of embedded generating systems 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 After the successful participation in the course **Modelling of Claw Pole Alternators** the students are able to: • establish the magnetic equivalent circuit of CPAs • predict the no- and load features of CPAs After the successful participation in the course **Design Improvement of the CPA-Based Generating Systems** the students are able to: • rethink the design of CPAs • design hybrid excited CPAs 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
Course types	VLmP+Ü (1 SWS); VLmP+Ü (1 SWS); VLmP+Ü (1 SWS); VLmP+Ü (1 SWS)
Content	**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 **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 **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 **Avionic Generating Systems** • Reason behind the use of 400Hz networks in aircrafts • Case study: the primary three-stage power generator of the Airbus A380
Title of courses	Generating Systems Embedded on Board of Road Vehicle, Modelling of Claw Pole Alternator, Design Improvement of the CPA-Based Generating Systems, Avionic Generating Systems
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	120 hours (60 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: Generating Systems Embedded on Board of Road Vehicle - written exam (90 min); Modelling of Claw Pole Alternator - written exam (90 min) Grade weighting P1: 50%

	Examination P2: Design Improvement of the CPA-Based Generating Systems - written exam (90 min); Avionic Generating Systems - written exam (90 min) Grade weighting P2: 50%
Credit points (ECTS)	4 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Amina Ibala, Rabeb Rebhi
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	4 cp (1 cp - Generating Systems Embedded on Board of Road Vehicle; 1 cp - Modelling of Claw Pole Alternator; 1 cp - Design Improvement of the CPA-Based Generating Systems; 1 cp - Avionic Generating Systems)

Rules of Writing Research Documents

Module number / code	W-Sfax-10
Module name	Rules of Writing Research Documents
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Ability of writing different scientific documents (paper, dissertation, report) 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 After the successful participation in the course **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
Course types	VLmP+Ü (1 SWS); VLmP+Ü (1 SWS)
Content	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 Writing Process • Pre-writing • Organizing • Drafting • Revising and editing • The final copy
Title of courses	The Scientific Paper: from Reading to Writing, Writing Process
Teaching and learning methods	lecture, exercise
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in summer semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 hours (30 h course attendance, 60 h self-study)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Examination P1: The Scientific Paper: from Reading to Writing - written exam (90 min) Grade weighting P1: 67% Examination P2: Writing Process - written exam (90 min) Grade weighting P2: 33%
Credit points (ECTS)	3 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus
Lecturer(s)	Abdelmajid Damak, Rabeb Rebhi
Media used	black board and beamer, case studies in groups, lab experiments, measurements
Recommended literature	
Comments	3 cp (2 cp - The Scientific Paper: from Reading to Writing; 1 cp - Writing Process)

3.5. Imported Modules Master "Wind Energy Systems"

Through an internal cooperation with the master's program "Wind Energy Systems (WES)" also taught at UKAS it is possible to take a limited selection of modules related to wind energy.

Design of Mechanical and Electrical Components	**ECTS site**	**Theoretical Fluid Mechanics**	**ECTS site**	**Control and Operational Management for Wind Turbines and Wind Farms**	**ECTS site**	**Energy Storage**	**ECTS site**
Design of Mechanical and Electrical Components	6 K	Theoretical Fluid Mechanics	6 K	Control and Operational Management for Wind Turbines and Wind Farms	6 K	Energy Storage	6 K
		Energy Law	**ECTS site**	**Occupational Safety On- and Off-shore**	**ECTS site**	**Project Management**	**ECTS site**
		Energy Law	3 K	Occupational Safety On- and Off-shore	3 K	Project Management	3 K

Table 17: Elective modules conducted in Kassel (WES) during WS (33 ECTS credits).

The tables below show the detailed elective modules given in the WES master program at UKAS.

Design of Mechanical and Electrical Components

Module number / code	W-WES-01
Module name	Design of Mechanical and Electrical Components
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Die Studierenden sind am Ende des Kurses in der Lage, - einzelne Windenergieanlagen (WEA) – Komponenten prinzipiell auszulegen, - die optimale aerodynamische Rotor-Auslegung prinzipiell zu berechnen und die optimalen Blattwinkel für die Auslegungswindgeschwindigkeit zu bestimmen, - Schub- und Leistungskennlinien für die WEA zu berechnen, - die grundlegenden Geometrie einer WEA zu bestimmen, - verschiedene Auslegungskonzepte von Triebstrangsystemen zu bewerten, - verschiedene Getriebearten und mechanische Antriebe im Maschinenhaus zu bewerten, - die Funktion von Sicherheits- und Bremsensystemen im Maschinenhaus zu verstehen, - verschiedene Nachführsysteme prinzipiell auszulegen, - die verschiedenen aerodynamischen, strukturellen und dynamischen Lasten auf die Rotorblätter und den Turm zu ermitteln, - funktionslasten auf die WEA Komponenten abzuschätzen, - unterschiedliche Rotorblattmaterialien unterschieden zu können, - zu entscheiden, welche verfügbaren Rotorblattmaterialien zu verwenden sind, - unterscheiden zu können, welche Turmbauarten und Fundament-typen für entsprechende WEA geeignet sind, - einen prinzipiellen Entwurf für einen Rohrturm, Betonturm oder Fachwerkturm mit einem geeigneten Fundament zu beschreiben, - die unterschiedlichen gesetzlichen Anforderungen und Transportmöglichkeiten zu kennen, die für den Bau, die Aufstellung und den Betrieb von WEA und Windparks notwendig sind, - einen neuen Windpark prinzipiell zu planen und ein Gantt-Diagramm mit den wichtigsten Planungsabschnitten für Auslegung, Aufbau, Inbetriebnahme und Betrieb zu entwickeln, - die notwendigen Sicherheitsanforderungen und notwendige Wartungsmaßnahmen für den

	Betrieb von WEA zu kennen und zu verstehen, - die notwendigen Schritte für den Zertifizierungsprozess eines Windparks zu kennen. Die Studierenden - haben die Funktionsweisen unterschiedlicher WEA Typen verstanden, - können die verschiedenen Komponenten von WEA beschreiben, - können aus einer Blattauslegung und -einstellung eine Leistungskennlinie ermitteln, - können einen geeignetes Generatorkonzept für einen vorgegebenen Rotor aussuchen, - können einen geeigneten Antriebsstrang für eine WEA beschreiben, - können die verschiedenen Anforderungen an die Netzeinbindung von WEA beschreiben und verstehen, - kennen und verstehen die verschiedenen Arten von Netzen, - kennen und verstehen unterschiedliche Modelle zur Netzregelung, können unterschiedliche Regelungskonzepte für Inselnetze, Netze und deren Verbunde beschreiben.
Course types	BL und/oder EL
Content	
Title of courses	Design of Mechanical and Electrical Components
Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 Stunden (30 Std. Online-Kontaktstudium, 150 Std. Selbststudium)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Schriftliche Klausur (120 Minuten) oder mündliche Prüfung (30 Minuten) oder schriftliche Hausarbeit (25 Seiten) mit Abgabegespräch und Präsentation der Hausarbeit (30 Minuten). Die Prüfungsleistungen gehen zu den Anteilen 75% (schriftliche Hausarbeit) und 25% (Abgabegespräch und Präsentation) in die Gesamtnote des Moduls ein.
Credit points (ECTS)	6 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. habil. Detlef Kuhl
Lecturer(s)	Dr.-Ing. Siegfried Heier; Dr. Matthias Günther

Media used	
Recommended literature	

Theoretical Fluid Mechanics

Module number / code	W-WES-02
Module name	Theoretical Fluid Mechanics
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Am Ende des Kurses wissen die Studierenden wie sie komplexe sowie 3D Fluidströmungen in Windenergiesystemen modellieren und analytisch berechnen können.
Course types	BL und/oder EL
Content	
Title of courses	Theoretische Fluidmechanik/Theoretical Fluid Mechanics
Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 Stunden (30 Std. Online-Vorlesungen, 60 Std. Übungen, 90 Std. Selbststudium)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Multiple Choice Test (30 Minuten) und mündliche Online-Prüfung (30 Minuten) oder E-Klausur (120 Minuten). Die Prüfungsleistungen gehen zu den Anteilen 25% (Multiple Choice Test) und 75% (mündliche Prüfung oder E-Klausur) in die Gesamtnote des Moduls ein.
Credit points (ECTS)	6 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. Olaf Wünsch
Lecturer(s)	Prof. Dr.-Ing. Olaf Wünsch, Prof. Dr. Andreas Meister

Media used	
Recommended literature	

Control and Operational Management for Wind Turbines and Wind Farms

Module number / code	W-WES-03
Module name	Control and Operational Management for Wind Turbines and Wind Farms
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Am Ende dieses Moduls haben die Studierenden regelungstechnische Aufgabenstellungen für Windenergieanlagen und Windparks erarbeitet. Am Ende des Moduls haben die Studierende einen Einblick in die wichtigsten regelungstechnischen Probleme im Bereich der Windenergietechnik erhalten, und beherrschen dazu gängige Lösungswege. Dies beinhaltet die folgenden Felder: • Ziele der Regelung und wichtige Wechselwirkungen, z. B. Anlagenregelung-Strukturlasten, Parkregelung-Netzverhalten, etc. • Systematischer Regelungsentwurf • Einblick in aktuelle Forschungsthemen Weiterhin haben die Studierenden die Modellierung von Windenergieanlagen und Wind Parks für die Zwecke der Regelungstechnik, die Grundlagen der Netzregelung und Netzanschlussbedingungen und die Strategien zur Regelung von Windenergieanlagen im Teillast- und Vollastbereich und Wind Parks für Wirk- und Blindleistungsregelung sowie Zertifizierungsrichtlinien und gängige Simulationswerkzeuge kennengelernt.
Course types	BL und/oder EL
Content	
Title of courses	Regelung und Betriebsführung für Windkraftanalgen und Windparks/ Control and Operational Management for Wind Turbines and Wind Farms
Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none

Student workload	180 h (30 h Online-Kontaktstudium, 60 h Hausarbeit/Seminarvortrag, 90 h Selbststudium)
Required course work	S1: Seminarvortrag, Hausarbeit (12-15 Seiten)
Prerequisites for examination(s)	none
Module examination(s)	Multiple-Choice-Test (30min), mündliche Prüfung (20min), Gewichtung der Gesamtnote 1:2
Credit points (ECTS)	6 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. habil. Detlef Kuhl
Lecturer(s)	Dipl.-Ing. Melanie Hau; Dr.-Ing. WeiWei Shan
Media used	
Recommended literature	

Energy Storage

Module number / code	W-WES-04
Module name	Energy Storage
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	• Die Studierende kennen die Anforderungen der Energiespeicherung in Energiesystemen. • Die Studierenden sind in der Lage, die Anforderungen von Energiespeicherung innerhalb der Energiesysteme zu unterscheiden. • Die Studierenden sind mit den Theorien der Technologien der Energiespeicherung in den verschiedenen Zeitebenen vertraut und wissen, wie sie diese Technologien auf verschiedenen Ebenen in das Energiesystem integrieren. • Die Studierenden sind in der Lage, Energiespeicherung nach den Systemanforderungen und der Wirtschaftlichkeit zu vergleichen.
Course types	BL und/oder EL
Content	
Title of courses	Energiespeicherung/Energy Storage
Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester

Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	180 Stunden (30 Std. Online-Kontaktstudium, 60 Std. Übung, 90 Std. Selbststudium)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Schriftliche Prüfung (90 Minuten) oder schriftliche Hausarbeit (25 Seiten)
Credit points (ECTS)	6 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. habil. Detlef Kuhl
Lecturer(s)	Prof. Dr.-Ing. Aleksandra Sasa Bukvic-Schäfer
Media used	
Recommended literature	

Energy Law

Module number / code	W-WES-05
Module name	Energy Law
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Dieses Modul hat das Ziel, den Studierenden anhand Beispielen aus verschiedenen Rechtsordnungen vertiefte Kenntnisse über bei der Planung und Durchführung internationaler Windenergieprojekten typischerweise zu beachtende rechtliche und regulatorische Aspekte und mögliche Risiken zu vermitteln. **Erzielte Wissen**: Die Studierenden kennen rechtliche und regulatorische Aspekte und Risiken, die bei der Planung und Durchführung von internationalen Windenergieprojekten typischerweise zu beachten sind und damit verbundene Risiken. **Erzielte Kompetenz**: Die Studierenden sind in der Lage bei der Planung und Durchführung internationaler Windenergieprojekte bestehende rechtliche und regulatorische Rahmenbedingungen zu beurteilen und potentiell bestehende Risiken angemessen bei der Planung und Durchführung zu berücksichtigen.
Course types	BL und/oder EL
Content	
Title of courses	Energierecht/Energy Law

Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 Stunden (5 Std. Online-Vorlesung, 45 Std. Selbststudium, 40 Std. Hausarbeit)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	schriftliche Hausarbeit (10 Seiten) und Kurzpräsentation der Hausarbeit (15 Minuten). Die Prüfungsleistungen gehen zu den Anteilen 75% (schriftliche Hausarbeit) und 25% (Präsentation) in die Gesamtnote des Moduls ein.
Credit points (ECTS)	3 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. habil. Detlef Kuhl
Lecturer(s)	Jian Bani
Media used	
Recommended literature	

Occupational Safety On- and Off-shore

Module number / code	W-WES-06
Module name	Occupational Safety On- and Off-shore
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	Dieses Modul hat das Ziel, den Studierenden das Verständnis und das Wissen für die bestehenden rechtlichen und regulatorischen Vorgaben für Windenergieprojekte nach aktuellem Stand der Technik zu vermitteln. Sowie Arbeits- und Umweltschutzbestimmung und der gültigen Gesetze, die bei der Entwicklung von Offshore Windenergieprojekten zu berücksichtigen sind. **Erzieltes Wissen:** Die Studierenden kennen am Ende des Modules die gesetzlichen und regulatorischen Vorgaben in allen Stufen, bei der Entwicklung von Windenergieprojekte, einbringen und umsetzen.

	Erzielte Kompetenz: Die Studierenden sind am Ende des Modules in der Lage, die allgemeinen Anforderungen der bestehenden rechtlichen und regulatorischen Bedingungen zu erkennen und diese im Projektmanagement einbringen und umsetzen.
Course types	BL und/oder EL
Content	
Title of courses	Arbeitssicherheit On- und Offshore/Occupational Safety On- and Off-shore
Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 Stunden (10 Std. Online-Vorlesung, 60 Std. Selbststudium inklusive Übungen)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Multiple-Choice-Test (20 Minuten)
Credit points (ECTS)	3 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. habil. Detlef Kuhl
Lecturer(s)	Michael Mucha
Media used	
Recommended literature	

Project Management

Module number / code	W-WES-07
Module name	Project Management
Type of module	Elective module

Learning outcomes, acquired competencies and qualification goals	Am Ende des Moduls sind die Studierenden in der Lage, geeignete Strukturen zu entwickeln, um ein Windpark-Projekt als Ganzes oder in einzelnen Teilprojekten zu managen. Die Studierenden sind zudem in der Lage, diese Pläne an die Bedürfnisse und Gegebenheiten der Projektveränderungen anzupassen. Die Teilprojekte beinhalten die Ortsauswahl, die Entwicklung, die Umweltverträglichkeitsprüfung, die Ausschreibung, den Bau, den Betrieb und die Wartung. Die Studierenden werden mit allen Aufgaben vertraut sein, welche in den Teilprojekte enthalten sind, und lernen Strategien diese zu managen.
Course types	BL und/oder EL
Content	
Title of courses	Projektmanagement/Project Management
Teaching and learning methods	
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	annually in winter semester
Teaching language	Englisch
Recommended (knowledge) prerequisites	
Required prerequisites for participation	none
Student workload	90 Stunden (15 Std. Online-Kontaktstudium, 45 Std. Selbststudium, 30 Std. Übung)
Required course work	none
Prerequisites for examination(s)	none
Module examination(s)	Schriftliche Hausarbeit (15 Seiten) und Präsentation der Ergebnisse sowie mündliche Prüfung (zum allgemeinem Wissen und zur schriftlichen Arbeit) (10 Minuten). Die Prüfungsleistungen gehen zu den Anteilen 50% (schriftliche Hausarbeit) und 20% (Präsentation) und 30% (mündliche Prüfung) in die Gesamtnote des Moduls ein.
Credit points (ECTS)	3 cp
Teaching unit	Bauingenieurwesen
Responsible person	Prof. Dr.-Ing. habil. Detlef Kuhl
Lecturer(s)	Daniel Meier
Media used	
Recommended literature	

4. Master Thesis Module

The module Thesis Project, comprising 30 credits is to be conducted in Germany or worldwide during the fourth semester.

Thesis Project

Module number / code	T-01
Module name	Thesis Project
Type of module	Elective module
Learning outcomes, acquired competencies and qualification goals	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
Course types	MA_A (20 SWS)

Content	Master Thesis
	• Topics in the area of renewable energies and energy efficiency
	• Independent work including
	  ○ literature research
	  ○ definition of thesis structure
	  ○ elaboration of report
	  ○ conducting measurements etc.

Title of courses	REMENA Master Thesis
Teaching and learning methods	independent research
Usabilitiy in other programs	
Duration	1 Semester
Frequency of module offer	Summer und winter semester
Teaching language	English
Recommended (knowledge) prerequisites	
Required prerequisites for participation	84 CP Basismodule Kassel + Monastir ODER Kassel + Hyderabad Successful completion of the modules: Engineering Basics 1 German Competencies Thermodynamic Basics 1 Language and Presentation Energy and Thermodynamics Basics 1 Language and Communication Competencies Engineering Basics 2 Energy and Thermodynamics Basics 2 Thermodynamic Basics 2
Student workload	900 hours (740 h independent research; 160 h writing thesis)

Required course work	S1: Kolloquium (30 - 50 min)
Prerequisites for examination(s)	Successful completion of the modules: Engineering Basics 1 German Competencies Thermodynamic Basics 1 Language and Presentation Energy and Thermodynamics Basics 1 Language and Communication Competencies Engineering Basics 2 Energy and Thermodynamics Basics 2 Thermodynamic Basics 2
Module examination(s)	REMENA Master Thesis report (30 - 200 pages)
Credit points (ECTS)	30 cp
Teaching unit	Elektrotechnik
Responsible person	Prof. Dahlhaus/Prof. Naik; Prof. Dahlhaus/Dr. El Alimi
Lecturer(s)	Supervisor from institutions or companies together with supervisor from university
Media used	PC based software development and/or hardware development, beamer (presentation of results), report (electronic form and hard copy)
Recommended literature	Literature depends on the thesis topic and is to be gathered by the student upon discussion with the supervisor