Module handbook of the master's program in

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

at the Dept. of Electrical Engineering/Computer Science at the University of Kassel

and the Faculty of Engineering at Cairo University

Status: October 24, 2010

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1 Qualification Modules

In this section, all modules which have to be attended for qualification are listed. The modules totalling 14 ECTS credits cover the areas of

- *Thermodynamic Basics*
- *Electrical Engineering Basics*

and are shown in **Tab. 1.**

Thermodynamic Basics	**ECTS site**	**Electrical Engineering Basics**	**ECTS site**
Engineering Thermodynamics	2 C	Electrical Engineering Fundamentals	3 C
Heat Transfer	2 C	Engineering Mathematics	3 C
Fluid Mechanics	2 C	Control Systems	2 C

Tab. 1: Qualification modules (first semester).

Tab. 1 contains the credits for the corresponding course according to the European Credit Transfer System (ECTS) as well as the site (C = Cairo, K = Kassel) where the course is conducted. All qualification modules are conducted in Cairo in the first semester.

The modules being composed by a number of courses are described separately for each module below.

As an example, the module *Thermodynamic Basics* is composed by the courses *Engineering Thermodynamics*, *Heat Transfer* and *Fluid Mechanics*.

In the tables, the German “Semesterwochenstunde” (SWS) defines the time of a course unit where 1 SWS corresponds to fifteen units of 45 minutes each so that 1 SWS totals 675 minutes = 11 hours and 15 minutes.

<table>
<tr><td>Module title</td><td colspan="5">Thermodynamic Basics</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Engineering Thermodynamics</td><td>lecture, exercise</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Heat Transfer</td><td>lecture, exercise</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Fluid Mechanics</td><td>lecture, exercise</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">first semester (months 1-3)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Hendawi Salem, Abd-El-Maged Hafiz
Adel Khalil
Mahmoud Fouad</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
90 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Ability to apply the first and second laws of thermo dynamics on thermal systems, to use property tables and charts, to perform energy balances, to calculate power and refrigeration cycle performance
• Understand the basic principles of heat transfer and its basic modes; apply the governing differential equation and perform simple energy balance on energy systems; be able to calculate the temperature distribution and heat flow in simple geometries; sizing and performance evaluation of heat exchangers and insulation; use the basic measuring devices associated with the subject; generate and systematically analyze real engineering problems; correct use of software and data analysis; working in groups.
• Ability to characterise different types of flows (laminar vs turbulent), to apply conservation equations to fluid flow and perform momentum and mass balances, to apply dimensional analysis and to calculate pressure losses in ducts and calculate pumping power requirements.</td></tr>
<tr><td>Contents</td><td colspan="5">• Fundamental concepts and definitions; unit systems; thermodynamic properties; pure substances; first law of thermodynamics; thermodynamic relations; second law of thermodynamics; vapour power cycles; reversed cycles Introduction to different modes of 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
• Introduction to fundamental concepts of fluids; fluid statics; basic conservation equations; Bernoulli equation; viscous flow in ducts and pipes; turbulent flow; pressure loss calculation in pipes; dimensional similarity.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs.</td></tr>
<tr><td>Literature</td><td colspan="5">• G.J. van Wylen and R.E. Sonntag, Fundamentals of Classical Thermodynamics, 3rd edition, John Wiley and Sons, New York, 1985.
• J.P. Holman, Heat Transfer, McGraw-Hill Science/Engineering/Math, 9th edition, 2001.
• Lecture notes on Fluid Mechanics.</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Electrical Engineering Basics</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Electrical Engineering Basics</td><td>lectures, labs, project work in groups</td><td>3</td><td>3</td><td>written exam</td></tr>
<tr><td>Engineering Mathematics</td><td>lecture, group discussions</td><td>3</td><td>3</td><td>written exam</td></tr>
<tr><td>Control Systems</td><td>lecture</td><td>2</td><td>2</td><td>written exam</td></tr>
<tr><td>Semester</td><td colspan="5">first semester (months 1-3)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Ahmed Alaa El Kousy
Hany El-Gazaly, Magdy Abd El-Aty El-Tawil
Albert Claudi</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">120 hours course attendance
120 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">8</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">
Students know definitions related to electrical quantities and systems; they are able to
- analyse electrical circuits
- handle measuring instruments and sensors.
They know about the principles of energy conversion mechanical <=> electrical and how to apply them.
Ability to deal with
- functions and its differentiation and integration.
- functions of more than one variable.
- matrices, determinants and system of equations
- random variables in a probabilistic model
- data statistically
- sampling and making statistical decisions.
Ability to
solve some basic differential equations using some useful methods (analytically and numerically)
- Use MATLAB in solving some problems numerically
Ability to understand and calculate simple linear control systems; students understand the specific terms and problems of control theory. In a discussion with control experts they are able to define the parameters for control circuits.
</td></tr>
<tr><td>Contents</td><td colspan="5">
Fundamental definitions in electric circuits; basic loads; DC and AC circuit analysis; power electronics: DC/DC and DC/AC topologies; measurements; energy conversion; rotating machines; laboratories and exercises
Calculus: single variable calculus (differentiation, integration), multi-variable calculus (partial differentiation, multiple integration)
Linear algebra: vector spaces, matrices, determinants; linear system of equations, eigenvalue problem, matrix functions
Probability and statistics: random variables, distributions, expectations, joint distributions, computer simulation (project), statistics
Applied numerical methods using MATLAB (fundamentals, solutions of systems of equations, curve fitting, interpolation, numerical differentiation and integration)
Partial differential equations (PDE), ordinary differential equations, diffusion-type problems, wave-type problems, steady-state type problems, numerical techniques in solving PDE
Introduction to control circuits, signal flow charts, basic elements of block diagram models, the 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.
</td></tr>
</table>

Media	Black board and beamer, lectures and presentations, problem based teaching, experimental measurements, use of simple computer programs.
Literature	• U.A. Bakshi and V.U. Bakshi, *Basic Electrical Engineering*, 2^{nd} edition, Technical Publications Pune, 2009. • G.B. Thomas, M.D. Weir, J. Hass, F.R. Giordano, *Thomas' Calculus Early Transcendentals*, 12^{th} edition, Addison Wesley, 2009. • R. Larson and D.C. Falvo, *Elementary Linear Algebra*, Brooks Cole, 6^{th} edition, 2008. • R.E. Walpole, R.H. Myers, S.L. Myers and K. Ye, *Probability and Statistics for Engineers and Scientists*, Prentice Hall, 8^{th} edition, 2006. • D.G. Zill, *A First Course in Differential Equations with Modelling Applications*, Brooks Cole, 9^{th} edition, 2008. • S.J. Farlow, *Partial Differential Equations for Scientists and Engineers*, Dover Publications, 1993. • S.C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, Tata McGraw Hill, 2^{nd} edition, 2008. • P.H. Lewis, *Basic Control Systems Engineering*, Prentice Hall, 1997. • Lecture notes on *Control Systems*.

2 Compulsory Modules

In this section, all compulsory modules are listed. The modules comprise two groups, namely modules in **Tab. 2** conducted in Cairo in the first and second semesters as well as modules in **Tab. 3** conducted in Kassel in the third semester.

Intercultural Competencies I	**ECTS site**	**REEE I**	**ECTS site**	**Renewable Energy Resources**	**ECTS site**	**Economic and Ecological Aspects of REEE I**	**ECTS site**
German and Arab Language Courses I	2 C	Renewable Energies - Basics	4 C	Potentials of REEE in the MENA Region and Europe	2 C	Environmental Issues and Managing the Effects (Global Climate Change)	2 C
Presentation and Moderation Techniques	1 C	Energy Efficiency in Processes and Systems	3 C	Energy Meteorology	2 C	Energy Economics - Macro	2 C
Intercultural Communication I	1 C					Engineering Economics and Feasibility Studies for REEE	2 C

Tab. 2: Compulsory modules conducted in Cairo in the first and second semesters; here, *REEE* stands for *Renewable Energies and Energy Efficiency*.

Intercultural Competencies II	**ECTS site**	**REEE II**	**ECTS site**	**Economic and Ecological Aspects of REEE II**	**ECTS site**	**International Project Management**	**ECTS site**
German-Arab Relations	1 K	Grid Integration	2 K	Energy Economics - Micro	2 K	International Project Management Basics	2 K
Energy and Society	1 K	Energy Efficiency in Buildings	3 K	Potentials of Institutions and Companies for the MENA Region in Germany	2 K	Project Management in Development Cooperation	2 K
Intercultural Communication II	2 K			Economic and Ecological Figures	1 K		
German and Arab Language Courses II	2 K						

Tab. 3: Compulsory modules conducted in Kassel in the third semester.

In addition to the modules in **Tab. 2** and **Tab. 3** totalling 41 ECTS credits, the module *Thesis Project* comprising 30 ECTS credits is to be conducted in the Middle East and North Africa (MENA) region.

All compulsory modules totalling 71 ECTS credits are listed below:

- *Intercultural Competencies I*
- *Intercultural Competencies II*
- *REEE I*
- *REEE II*
- *Renewable Energy Resources*
- *Economic and Ecological Aspects of REEE I*
- *Economic and Ecological Aspects of REEE II*
- *International Project Management*
- *Thesis Project.*

As for the qualification modules in Section 1, different courses form different modules which are described below.

<table>
<tr><td>Module title</td><td colspan="5">Intercultural Competencies I</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>German and Arab Language Courses I</td><td>lecture, seminar</td><td>2</td><td>2</td><td>written exam and oral exam</td></tr>
<tr><td>Presentation and Moderation Techniques</td><td>lecture</td><td>1</td><td>1</td><td>presentation and moderation project</td></tr>
<tr><td>Intercultural Communication I</td><td>lecture</td><td>1</td><td>1</td><td>written exam and presentation</td></tr>
<tr><td>Semester</td><td colspan="5">first semester (months 1-3)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Helen Beshara, Abdel Rahman Nagi
Sayed Kaseb
Fouad Khalaf</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">
Students improve their language skills in German and Arab to be able to communicate with basic formulations and expressions for use in daily life.
Knowledge and understanding: to know the concepts of presentation and moderation, to understand the methods and techniques for efficient meeting organization, discussion and moderation techniques; intellectual skills: to be able to envisage the content and prepare the materials for an efficient presentation and to develop and optimize the personal presentation and moderation skills; professional and practical skills: to be able to employ professional presentation and moderation techniques; general and transferable skills: to improve discussion and moderation techniques
Self-awareness of strengths, weaknesses, prejudices, preconceptions, stereotypes; building better multiculture (MC) skills, confidence and trust of what has to be improved and in handling MC issues; knowledge how to motivate people to improve in MC issues; ability to think outside the box (which may belong to normal culture devoid approaches); better listening skills and positive attitude: focusing on common grounds rather than differences.
</td></tr>
<tr><td>Contents</td><td colspan="5">
Modern Standard Arabic (MSA) and Egyptian dialect (EA) equip students with a basic ability in Arabic reading, writing, and speaking skills while building a solid foundation in formal Arabic grammar (nahu) and morphology (sarf). The student will be supplied with a vocabulary of at least 1000 Arabic words and will learn to communicate in daily life as well as in academic discourse and business activities. The German language course introduces the students both to basic phrases and short sentences for everyday use as well as technical terms and expressions in electrical engineering and renewable eneries. The course contains basic concepts in German grammar and is held exclusively in High German.
Preliminary activities (classifying target groups, determining research topics), types and basic rules of different presentations, content structure and developing a strategy for presentation, planning and handling of presentation materials and facilities, efficient visualization, report writing, analyzing personal delivery habits recorded in video, advanced presentation and moderation techniques, training and improving delivery habits, training efficient meeting organization.
Multiculture (MC) diversity and the work place: race, nationality, religion, values, ethics, languages & communication, misconceptions and stereotypes, attitudes, world cultures; obstacles due to cross cultural environment: lack of synergy, communication, mindsets, managerial issues, human resource (HR) organizational issues; intercultural issues in the workplace: how to leverage cultural differences or difficulties, notion of time, prerequisites for MC environments, cultural orientation & preparedness, legal issues,
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	implementation; HR issues in MC environments: staffing, directing & controlling, competitiveness & competition, remuneration issues, measuring skills & competencies; recipes of ways, tips and tactics to handle cross cultural issues: brainstorming, systems approach (thinking), management of change, innovation & creativity models, feedback models, managerial models, HR specifics, models of behaviour; cross culture negotiation skills: the meeting etiquette, cross cultural negotiation styles, negotiation tactics, case by case approach; maximizing the potential of multicultural teams: case studies, visits, talks, assignments.
Media	Black board and beamer; introductory class meetings, power point presentations, discussions, practical exercises and video feedback, case studies in groups; formal & interactive: ABC cultural model, case studies, team work, role play, essays & reports, presentation.
Literature	• Lecture notes and course material in Arabic and German language courses • J.E. Rudd and D.R. Lawson, *Communicating in Global Business Negotiations: A Geocentric Approach*, Sage Publications, 2007. • C. McNamara, *Basic Guide to Conducting Effective Meetings*, 2008. • J. Rotondo and M. Rotondo Jr., *Presentation Skills for Managers*, McGraw Hill, 1st edition, 2001. • B.J. Streibel, *The Manager´s Guide to Effective Meetings*, McGraw Hill, 1st edition, 2002.

<table>
<tr><td>Module title</td><td colspan="5">REEE I</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Renewable Energies - Basics</td><td>lecture, presentation, project work</td><td>4</td><td>4</td><td>written exam, project</td></tr>
<tr><td>Energy Efficiency in Processes and Systems</td><td>lecture</td><td>3</td><td>3</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">second semester (months 4-7)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Adel Khalil
Osama El Bahar, Mohamed El Sobki</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">105 hours course attendance
105 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">7</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Knowledge of the basics of the different energy forms and conversion technologies; ability to calculate conversion efficiencies for different forms of energy
• Ability to analyse energy supply and demand patterns, to identify different energy conservation technologies, to perform energy balance and analysis on thermal systems, to perform energy auditing, to identify and evaluate energy conservation opportunities and to apply energy codes and standards.</td></tr>
<tr><td>Contents</td><td colspan="5">• Energy classification, sources, utilization, economics and terminology, principal fuels for energy conversion, conversion to thermal energy, conversion to electrical energy, conversion to mechanical energy, nuclear energy conversion, energy storage
• Energy supply and demand patterns, energy conservation technologies, supply and demand side management, energy balance and analysis of thermal systems, heat pumps, cogeneration/polygeneration, material/thermal insulation selection, air conditioning, combustion control steam systems, high efficiency lighting, power factor correction, identification of energy conservation opportunities, energy management systems, energy auditing procedure, energy codes and standards.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, measurements, use of simple computer programs.</td></tr>
<tr><td>Literature</td><td colspan="5">• A.W. Culp, Principles of Energy Conversion, McGraw-Hill College, 2nd sub edition, 1990.
• F. Kreith and R.E. West (Editors), CRC Handbook of Energy Efficiency; CRC Press, 1st edition, 1996.
• T.D. Eastop and D.R. Croft, Energy Efficiency for Engineers and Technologists, Longman Publishing Group, 1990.</td></tr>
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<table>
<tr><td>Module title</td><td colspan="5">Renewable Energy Resources</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Potentials of REEE in the MENA Region and Europe</td><td>seminar</td><td>2</td><td>2</td><td>presentation</td></tr>
<tr><td>Energy Meteorology</td><td>lecture, seminar</td><td>2</td><td>2</td><td>oral exam and presentation</td></tr>
<tr><td>Semester</td><td colspan="5">second semester (months 4-7)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Adel Khalil, Sayed Kaseb
Atef Sherif</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Knowledge of the basics of the different energy forms and conversion technologies; ability to calculate conversion efficiencies for different forms of energy
• Ability to analyse energy supply and demand patterns, to identify different energy conservation technologies, to perform energy balance and analysis on thermal systems, to perform energy auditing, to identify and evaluate energy conservation opportunities and to apply energy codes and standards.</td></tr>
<tr><td>Contents</td><td colspan="5">• Actual energy situation, in particular in MENA countries and in student’s home country with presentation, definitions of potentials, researching specific information sources, actual state and potentials of renewable energies in the different countries, presentation/discussion of actual projects for renewable energies
• Wind power: fundamentals of atmospheric flow, potential/resources, design conditions, spatio-temporal behaviour of wind; solar power: fundamentals of radiation and atmosphere, potential/resources, spatio-temporal behaviour of solar radiation</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer</td></tr>
<tr><td>Literature</td><td colspan="5">• Recent publications on renewable energies in the MENA region and Europe
• Lecture notes
• R.B. Stull, Meteorology for Scientists and Engineers, Brooks Cole, 2nd edition, 1999.</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Economic and Ecological Aspects of REEE I</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Environmental Issues and Managing the Effects (Global Climate Change)</td><td>seminar, lecture</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Energy Economics – Macro</td><td>lecture</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Engineering Economics and Feasibility Studies for REEE</td><td>lecture</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">second semester (months 4-7)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Osama Elbahar
Mohamed El Sobki
Sayed Kaseb, Mohamed Fawzi El-Refaie</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
90 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Students know about different effects of energy use on the environment, society and economy. They know methods of greenhouse gas balances and are able to analyse different energy concepts relating to their environmental impacts. Students shall see renewable energies and energy efficiency against the background of the danger of uncontrollable climate change on the one hand and a global economy on the other. Students know about concepts for mitigation and are able to understand necessary adaptation concepts.
• Students understand the quantitative basics of energy supply and demand. They are able to assess economic aspects of production, distribution, consumption of energy and energy trade (including sustainability aspects). They understand functions and structure of national, regional and international organisations involved in the energy sector. They understand the economic and administrative rules and regulations and the attitudes that control supply and demand of energy.
• Knowledge and understanding: use of spreadsheet application programs to systemize the feasibility studies problems, concepts of decision making, cost estimation techniques and funding requirements; intellectual skills: ability to perceive the environment economic status, demand supply equilibrium, risk analysis; professional and practical skills: costs and cost estimating concepts, methods of economic study, depreciation, income taxes and after tax consideration, price changes and exchange rates, preparing feasibility study; general and transferable skills: money-time relationship (interest and equivalence), replacement analysis and probabilistic economic analysis, financial accounting and feasibility study</td></tr>
<tr><td>Contents</td><td colspan="5">• Environmental consequences of energy use and production: climate change/global warming, air pollution, water use and pollution, natural disasters, sea level rise, migration and climate change; mitigation: political framework, Kyoto protocol, UNFCCC, technologies for mitigation such as renewable energies, energy efficiency, clean coal; adaptation: risk management, land use change; greenhouse gas balances: fundamentals, methods, calculation (example: GEMIS)
• Basics: the national energy balance (who produces what type of energy, where, and from which source, who consumes it, where, and for what purpose), energy related units, conversions and formulas; sustainability: economic, social, ecologic and political aspects, criteria and indicators of the concept of sustainable energy supply, global and European-Arab strategies of energy supply, trade, and security, “plan solaire”; policies: role of state, role of market, role of private sector, decentralisation, standardisation, policy options and mix, awareness building; regulations: laws, law enforcement, division of labour among organisations, feed-in, economic and social functions of tariffs; organisations: functions and structure of public and private organisations in the energy sector on the national, regional and international level (e.g. IEA, IAEO)</td></tr>
</table>

	• Economic decision, money-time relationship, cost and cost estimating, building the feasibility study, methods of economic studies and selection, depreciation, income taxes, after-tax considerations, price change and exchange rate, replacement analysis and probabilistic economic analysis, funding requirements, financial accounting and benefits analysis, complete feasibility study.
Media	Black board and beamer, visiting energy sector organisations in Egypt and discussions with planners and decision makers, slide show and power point presentations, open ended discussions initiated by the lecturer, case studies through team work ended by discussions, computer lab for spreadsheet applications and surveying issues, project work
Literature	• R.M. Auty and K. Brown, *Approaches to Sustainable Development, Global Development and the Environment*, Routledge, 1st edition, 1997. • *Renewables 2007: Global Status Report*, 2007, downloadable from http://www.scribd.com/doc/8116771/Global-Energy-Report-Renewables-2007. • U.R. Fritsche and K. Schmidt, *Schwerpunktanalyse Regenerative Energien für die RegionNordafrika/Naher Osten (MENA) mit Ergänzungen zur Energieeffizienz*, downloadable from http://www.scribd.com/doc/17317686/Regenerative-Energien-fur-die-MENARegion-mit-Erganzungen-zur-Energieeffizienz. • W.G. Sullivan, E.M. Wicks and J.T. Luxhoj, *Engineering Economy*, Pearson Education, 12th edition, 2002. • D.G. Newman, T.G. Eschenbach and J.P. Lavelle, *Engineering Economic Analysis*, New York, USA, Oxford University Press, 10th edition, 2008. • J. Matson, *Cooperative Feasibility Study Guide*, United States, Department of Agriculture, Rural Business–Cooperative Service (RBS Service), Report 58, downloadable from http://www.rurdev.usda.gov/rbs/pub/sr58.pdf, 2000

<table>
<tr><td>Module title</td><td colspan="5">Intercultural Competencies II</td></tr>
<tr><td rowspan="5">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>German-Arab Relations</td><td>visits to organisations in Berlin, lectures, discussions</td><td>1</td><td>1</td><td>group discussions, (quantity, quality); written report on organisations visited</td></tr>
<tr><td>Energy and Society</td><td>seminar</td><td>1</td><td>1</td><td>presentation</td></tr>
<tr><td>Intercultural Communication II</td><td>seminar</td><td>2</td><td>2</td><td>meta-cognitive reflection, references of the reading done</td></tr>
<tr><td>German and Arab Language Courses II</td><td>lecture, seminar</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Matthias Weiter
Dieter Gawora
Claudia Finkbeiner
Abed Ibrahim
Veronika Lewenstein</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
90 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">German and Arab Language Courses I</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Understanding political, economic and cultural objectives and instruments of German-Arab relations; understanding the institutional set-up of bilateral and multilateral development cooperation with special reference to the Arab world; acquiring the ability of critical assessment of instruments, institutions and results of cooperation.
• Ability in critical analysis of energy projects worldwide and regional:
– analysis of social effects
– analysis of ecological effects,
– analysis of economical effects;
responsibility of engineering, understanding that each technical project creates impacts for the society; mainly in the planning phase of a project, positive and negative effects have to be discussed in democratically form which includes all directly or indirectly affected social groups by a project; understanding the importance of participation by society; understanding the importance of environmental assessment studies
• Cultural Awareness and meta-cognitive reflection of factors such as socio-cultural contexts, personality, language and how language is used to do things with words; products will be: autobiography, biography, deep-level cross-cultural analysis.
• Students improve their language skills in German and Arab to be able to communicate with more elaborated formulations and expressions for use in daily life and professional contexts.</td></tr>
<tr><td>Contents</td><td colspan="5">• Role of German parliament, ministries for development, environment and economy, Arab embassies and other organisations of relevance for shaping and cultivating German-Arab relations; development cooperation between Germany and the Arab world; nature and volume of German-Arab trade and investments; historic and present cultural and political relations between Germany and the Middle East; information on objectives and content of German-Arab M.Sc. programmes
• Case studies about energy projects and their social, ecological and economical impacts, e.g. big waterpower projects, oil, gas, and coal exploration projects, wind energy, etc., case studies of energy projects which have been blocked, analysis of environmental assessment studies, study of international standards.
• The ABC's of cultural understanding and communication is an intercultural model that</td></tr>
</table>

	includes (a) autobiography, (b) biography, (c) cross-cultural analysis and (d) cultural self-analysis of differences. It aims at exploring cultural and intercultural similarities and differences in the life stories of individuals from different cultural backgrounds trough an intercultural exchange; focuses on issues that are important for communicating issues of renewable energy in a global world taking account both of local and global knowledge; goal: to make participants successful intercultural communicators; considering events, phenomena, people etc. as situated, contextualized and dynamic issues differing and changing along different cultures and different times; raise awareness of the perception of one self and of others and take both close and distant looks at subject matters relevant in the field; creative activities on intercultural communication competence as core topic; write an autobiography, a biography and participate in the cross-cultural analysis; all the writings will be coded so that the author or interviewee remain anonymous. • Continuation of language courses started in Cairo; the language level will be adapted to the participants' language proficiency.
Media	• Black board and beamer, visiting energy sector organisations in Egypt and discussions with planners and decision makers, slide show and power point presentations, open ended discussions initiated by the lecturer, case studies through team work ended by discussions, computer lab for spreadsheet applications and surveying issues, project work • Case studies in groups • Face to face and online sessions, action-oriented, holistic activities strongly relating to participants' experience to trigger their subjective prior-knowledge and making them become aware of how that knowledge is culturally determined and dynamically changed over time
Literature	• *The Charter of the United Nations*, 1945. • United Nations General Assembly, *United Nations Millennium Declaration*, Resolution adopted by the General Assembly, 2000; • *Arab Human Development Report 2002*, http://www.arab-hdr.org/publications/other/ahdr/ahdr2002e.pdf • *Arab Human Development Report 2003*, http://www.arab-hdr.org/publications/other/ahdr/ahdr2003e.pdf • *Arab Human Development Report 2004*, http://www.arab-hdr.org/publications/other/ahdr/ahdr2004e.pdf • *Arab Human Development Report 2005*, http://www.arab-hdr.org/publications/other/ahdr/ahdr2005e.pdf • World Commission on Dams, *Dams and Development: A New Framework for Decision-Making*, Earthscan Ltd, 2000 • P. Ruggiano Schmidt and C. Finkbeiner (eds.), *The ABC's of Cultural Understanding and Communication: National and International Adaptations*, Information Age Publishing, 2006. • Further literature will be announced by the lecturers.

<table>
<tr><td>Module title</td><td colspan="5">REEE II</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Grid Integration</td><td>lecture, seminar</td><td>2</td><td>2</td><td>written report, presentation, oral exam</td></tr>
<tr><td>Energy Efficiency in Buildings</td><td>lecture</td><td>3</td><td>3</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Siegfried Heier, Kurt Rohrig
Klaus Vajen</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
75 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Energy Meteorology, Renewable Energies - Basics</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Knowledge of integration of different renewable energy generation into a grid; understanding of advanced schemes like e.g. online-monitoring and forecasting; understanding the design, problems and operation of integrated grids with respect to the specific properties of renewable energies
• Knowledge of thermal/hygric and energetic building physics; understanding of the basics for competencies, to apply and evaluate physical and technical aspects of efficient energy use in buildings; students learn to estimate potentials of energy efficiency technologies in buildings, energy production and energy use.</td></tr>
<tr><td>Contents</td><td colspan="5">• Introduction; the spatio-temporal behaviour of wind and solar power: wind and solar power as energy sources, the spatio-temporal behaviour of wind and solar power; integration of 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
• Basics of building physics: heat transfer in building elements, shading devices, humidity and condensation effects, thermal comfort (radiation, air temperature, etc.), ventilation, global radiation on building.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, power point presentations.</td></tr>
<tr><td>Literature</td><td colspan="5">• M.B. Ferguson (ed.), Renewable Energy Grid Integration: Technical Performance and Requirements (Environmental Remediation Technologies, Regulations and Safety), Nova Science Publishers Inc, 2010.
• S. Heier and R. Waddington, Grid Integration of Wind Energy Conversion Systems, Wiley-Blackwell, 2nd edition, 2006.
• Energy Efficiency in Buildings (CIBSE Guide), Chartered Institution of Building Services Engineers, 2006.
• Further literature will be announced by the lecturers.</td></tr>
</table>

<table>
<tr><td>Module title</td><td colspan="5">Economic and Ecological Aspects of REEE II</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Energy Economics – Micro</td><td>lecture</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Potentials of Institutions and Companies for the MENA Region in Germany</td><td>lecture</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Economic and Ecological Figures</td><td>lecture</td><td>1</td><td>1</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Detlev Möller
Theda Kirchner
Siegfried Heier, John Sievers</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
75 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Understanding which factors influence the cost of energy and how energy pricing can influence supply and demand; ability to read and assess cost-benefit-analyses.
• Students should get in close contact with a company or institution with interest in the MENA region and learn from the perspective of a company to explore the economic potentials in a particular country. They learn about the key factors, methods and necessary framework for a company to get into the market of a country.
• Knowledge about institutions and companies working in the MENA region; knowledge of how to investigate energy costs; ability to roughly determine costs under different conditions (sizes, boundary conditions etc.) and knowledge about figures of power generation costs; understanding the basics of life cycle assessment for different renewable energy sources</td></tr>
<tr><td>Contents</td><td colspan="5">• Cost calculation for energy production and distribution; cost development prognoses (national and international level); pricing; 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.
• Presentation of companies, actual activities of companies/institutions in the MENA region, actual state and political framework for renewable energies in the different countries, political and economical conditions for companies in MENA countries.
• Cost and life cycle analysis for different renewable energy sources: photovoltaics, wind, solar thermal power plants, bio energy; hydro power; ecological figures; operation, production and removal of plants; differences in temporal availability of power; and environmental aspects of these different plant operations regarding coverage of residual load under present conditions of power generation; scientific data collection and allocations, bonuses and the problems of different assessments; presentations of companies and institutions about their engagement in the MENA region.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer</td></tr>
<tr><td>Literature</td><td colspan="5">• F.E. Banks, Energy Economics: A Modern Introduction, Springer, 1st edition, 1999.
• D.L. Cleland and R. Gareis, Global Project Management Handbook: Planning, Organizing and Controlling International Projects, McGraw-Hill Professional, 2nd edition, 2006.
• 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.</td></tr>
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<table>
<tr><td>Module title</td><td colspan="5">International Project Management</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>International Project Management Basics</td><td>seminar, lecture</td><td>2</td><td>2</td><td>presentation and oral exam</td></tr>
<tr><td>Project Management in Development Cooperation</td><td>lecture, workshop</td><td>2</td><td>2</td><td>written exam, group work results</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Konrad Spang
Theda Kirchner</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Basic knowledge in project management and specific knowledge in international project management for successful execution of renewable energy projects in the development cooperation between Germany and Arab countries; students should know about the basic elements of project management and be aware of the meaning and value of project management in professional life. Moreover they will be qualified for the specific needs and targets of international projects.
• The students are enabled to use the key elements of project cycle management; they elaborate a project proposal themselves in a final workshop.</td></tr>
<tr><td>Contents</td><td colspan="5">• What is project management? What is a project? In which cases project management is necessary and reasonable? Project objectives, project organisation, project execution; forms, specifics and success factors of international projects; teambuilding in international projects; how to prepare international projects.
• Key elements of project cycle management (PCM), the logical framework approach; various analysis instruments like situation analysis, stakeholder analysis, problem/objectives/risk analysis; monitoring and evaluation; indicator development.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer</td></tr>
<tr><td>Literature</td><td colspan="5">• K.H. Rose, Project Quality Management: Why, What and How, J. Ross Publishing, 2005.
• D.L. Cleland and R. Gareis, Global Project Management Handbook: Planning, Organizing and Controlling International Projects, McGraw-Hill Professional, 2nd edition, 2006.
• R. Zah, H. Böni, M. Gauch, R. Hischier, M. Lehmann and P. Wäger, Life Cycle Assessment of Energy Products: Environmental Assessment of Biofuels, Empa, Technology and Society Lab, 2007; downloadable from http://www.bfe.admin.ch/themen/00490/00496/index.html?lang=en&dossier_id=01273.
• R. Frischknecht and N. Jungbluth (eds.), Overview and Methodology, Ecoinvent report No. 1, 2007; downloadable from http://www.ecoinvent.org/fileadmin/documents/en/01_OverviewAndMethodology.pdf
• Further literature will be announced by the lecturers.</td></tr>
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Module title	**Thesis Project**				
Courses	**Title**	**Teaching Method**	**SWS**	**Credits**	**Performance requirements/ Examination**
	REMENA Master Thesis	lecture	20	30	Report and Colloquium
Semester	fourth semester (months 13-21)				
Responsible	Khalil/Dahlhaus				
Site	MENA Region				
Lecturer(s)	Supervisor from institutions or companies together with supervisor from university				
Language	English				
Workload	300 hours course attendance 600 hours self-study				
Credits	30				
Recommended Qualifications	Compulsory modules				
Learning Outcomes	• Independent approach to solve a problem in the area of renewable energies and energy efficiency with a specific focus on issues related to the MENA region. • Writing of a report and presentation of results in a colloquium. • Literature and internet based investigation. • Independent scientific work. • Compilation of a report, preparation of a talk and presentation of scientific results.				
Contents	• Topics in the area of renewable energies and energy efficiency with a specific focus on issues related to the MENA region. • Independent work including literature research, definition of thesis structure, elaboration of report, conducting measurements etc.				
Media	PC based software development and/or hardware development, beamer (presentation of results), report (electronic form and hard copy).				
Literature	Literature depends on the thesis topic and is to be gathered by the student upon discussion with the supervisor.				

3 Elective Modules

In this section, all elective modules being conducted in Cairo and Kassel are listed in **Tab. 4**.

Solar Energy Technology I	**ECTS site**	**Wind Energy and Biomass Basics**	**ECTS site**	**Solar Energy Technology II**	**ECTS site**	**Wind Energy Technology**	**ECTS site**	**REEE III**	**ECTS site**	**RE Integration**	**ECTS site**	**Advanced Topics in RE**	**ECTS site**
Solar Thermal Systems I	2 C	Bio Energy I	2 C	Solar Thermal Systems II	2 K	Mechanical Aspects of Wind Energy	3 K	Energy Economics Special	2 K	Smart Grids	3 K	Photo-voltaics II	2 K
Concentrated Solar Thermal Power I	2 C	Wind Energy Basics	2 C	Concentrated Solar Thermal Power II	2 K	Electrical Aspects of Wind Energy	3 K	Energy Efficiency and Conservation Special	2 K	Flexible Generation and Demand Side Manage-ment	2 K	Bio Energy II	2 K
Photovoltaics I	2 C							Fuel and Emissions	1 K				

Tab. 4: Elective modules conducted in Cairo (two left columns) and Kassel (five right columns) (RE = Renewable Energies).

The elective modules of **Tab. 4** conducted at both sites and totalling 34 ECTS credits are listed below:

- *Solar Energy Technology I*
- *Solar Energy Technology II*
- *Wind Energy and Biomass Basics*
- *Wind Energy Technology*
- *REEE III*
- *RE Integration*
- *Advanced Topics in RE*.

As for the qualification modules in Section 1 and the compulsory modules in Section 2, different courses form different modules which are described below.

<table>
<tr><td>Module title</td><td colspan="5">Solar Energy Technology I</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Solar Thermal Systems I</td><td>lecture, seminar</td><td>2</td><td>2</td><td>written exam, presentation</td></tr>
<tr><td>Concentrated Solar Thermal Power I</td><td>lecture, seminar</td><td>2</td><td>2</td><td>written exam, presentation</td></tr>
<tr><td>Photovoltaics I</td><td>lecture, project work in groups</td><td>2</td><td>2</td><td>presentation, report</td></tr>
<tr><td>Semester</td><td colspan="5">second semester (months 4-7)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Salman Ajib
Mohamed Fawzi El-Refaie
Ahmed Alaa El Kousy, Yehia Bahnas</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
90 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Basics of Thermodynamics, Mathematics
Energy Meteorology, Renewable Energies - Basics</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">Learning the use of solar thermal energy for domestic hot water, space heating, swimming pool heating and air conditioning; learning how to evaluate systems on the basis of calculating energy balance; learning how to design and dimension solar thermal plants for domestic hot water, space heating and air conditioning (as components and as total system) as well as how to plan the connection of the systems with one another and with the building; learning how to use planning tools and simulation programs
Realizing the operating limits of non-focusing collectors and the need for focusing collectors; understanding the basic theory of energy concentration; knowledge of the different components of a focusing collector; knowledge of the different types of solar concentrators and the relative merits of each type, the achieved concentration ratios and the possible levels of delivery temperature; knowledge of the common features and the differences between different types; ability to make the calculations to yield the output power, the delivery temperature (for specific types) and the performance indices
The students are able to estimate the solar radiation on a oriented surfaces; they have basic knowledge about the physics of photovoltaic cell materials, production and modules structure; they understand the basic electrical characteristics of the solar module and required power conditioning unit for grid operation; they are able to design grid connected PV systems and to estimate the performance criteria using simulation software tools.</td></tr>
<tr><td>Contents</td><td colspan="5">Solar thermal heating: recapitulation of basics of solar radiation including calculation of radiation on the inclined, adjusted area, solar radiation distribution, spatial and temporal solar radiation variations; components of solar thermal plants: collector loop, collectors, energy balance of solar collectors, simplified efficiency curve, collector types, collector materials, selective surfaces; heat carrier: thermophysical properties, pressure drop and heat transfer, chemical stability, solubility of gases; collector loop: deventing device, expansion device, pump group, stagnation of solar collectors, drain back system, natural circulation system, control system; components of solar thermal plants: heat storage; general tasks of heat storage, thermophysical properties of heat stores, heat stores for conventional systems, domestic hot water demand (DHW), space heating demand, hydraulics of conventional systems, passive heat stores; hot water stores, stores for natural circulation plants (double mantle tanks), stores for forced circulation plants, function of internal and external heat exchangers, stratification devices, legionella, limestone, hydraulics of series/parallel connected heat stores; solar combi stores: design, charging/discharging schemes, overview on seasonal storage, overview on latent heat/sorption; hydraulics, design and control of solar thermal plants; general rules of hydraulics, collector hydraulics (low flow/high flow/match flow), one way valve in</td></tr>
</table>

	collector loop, decoupling of hydraulic circuits, natural circulation plants, DHW plants, solar combisystems (DHW + space heating), compact units; large solar thermal plants: large solar thermal plants for multi family houses; large centralized solar thermal plants using district heating and long term stores; solar assisted swimming pools: collectors, hydraulics and control; solar assisted air conditioning; solar process heat: temperature levels of several industrial processes, collector types for different temperature levels, examples of designed systems; dimensioning of solar thermal plants: DHW plants, swimming pools, combisystems; simulation tools for solar thermal systems: Meteonorm (climate data generator), TSOL, POLYSUN, TRNSYS, others; monitoring and optimization: system failures, methods for long term monitoring, methods for system optimization • Fundamentals, introduction: basic theory of focusing collectors, range of concentration ratios, components of a focusing collector, complications, application problems, lack of a generalized treatment; theoretical and practical solar images; different classifications: line and point focusing collectors, different forms of concentrators, different positions and the use of heliostats, different shapes of receivers, orienting or tracking mechanisms, manual or mechanized operation of orienting mechanisms, typical concentration ratios required for various temperature levels; energy balance: general energy balance and explanation of different terms, variation of useful energy gain with concentration ratio; optical losses: specular reflectance, practical values, special considerations when calculating cover transmittance and receiver absorptance, intercept factor; evaluation of thermal losses; thermal inertia effects: storage effect and transient effect; analysis of specific types of reflective concentrators; examples: parabolic trough, axicon concentrator, concentration profile, temperature distributions, performance indices, stationary-reflector-tracking-absorber (SRTA), conical-bucket concentrator, central-tower receiver • Photovoltaics (PV) and grid connected PV systems, introduction to PV systems and applications, characteristics of the solar radiation (diffuse, direct, and albedo) and estimating the radiation on the PV module, physics of solar cells (photovoltaic effect), semiconductor material and their application in PV, PV materials and cell technologies (mono-crystalline, multi-crystalline, thin-film technology) and production technology for solar cells and modules, electrical characteristics of solar cells and modules, maximum power point (MPP), aim and techniques of MPP-tracking, basic components of grid connected PV-Systems (cabling, protection), inverter-concepts (with and without transformer), local requirements and legislation for integration of PV systems to the utility grid, PV systems evaluation criteria (energy yield, performance ratio), design of grid connected PV systems (sizing of PV generator, cabling protection, inverter), implementing simulation tools (e.g. PV*SOL or INSEL) for the design and forecast of PV system performance, project work
Media	Black board and beamer, lectures and power point presentations.
Literature	• J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, Wiley, 3rd edition, 2006. • H.-M. Henning, *Solar-Assisted Air-Conditioning in Buildings: A Handbook for Planners*, Springer; 2nd edition, 2007. • A.B. Meinel and M.P. Meinel, *Applied Solar Energy*, Addison-Wesley Publishing Company, 1977. • M. M. Elsayed, I.S. Taha and J.A. Sabbagh, *Design of Solar Thermal Systems*, Scientific Publishing Center, King Abdulaziz University, Jeddah, KSA, 1994. • Selection of published papers (will be handed out). • T. Markvart and Luis Castaner (ed.), *Practical Handbook of Photovoltaics, Fundamentals and Applications*, Elsevier Science, 1st edition, 2003. • A. Goetzberger and V.U. Hoffmann, *Photovoltaic Solar Energy Generation*, Springer, 1st edition, 2010. • R.A. Messenger and J. Ventre, *Photovoltaic Systems Engineering*, CRC Press, 3rd edition, 2010. • J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, John Wiley & Sons Inc., 3rd edition, 2006. • M.A. Green, *Third Generation Photovoltaics: Advanced Solar Energy Conversion*, Springer, 2005.

<table>
<tr><td>Module title</td><td colspan="5">Wind Energy and Biomass Basics</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Bio Energy I</td><td>lecture</td><td>2</td><td>2</td><td>lab work evaluation</td></tr>
<tr><td>Wind Energy Basics</td><td>lecture, seminar</td><td>2</td><td>2</td><td>oral exam, presentation, home work</td></tr>
<tr><td>Semester</td><td colspan="5">second semester (months 4-7)</td></tr>
<tr><td>Responsible</td><td colspan="5">Khalil</td></tr>
<tr><td>Site</td><td colspan="5">Cairo</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">F. Ashour, Hendawi Salem
Galal Khalafalla, Basman El Hadidi</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Engineering Thermodynamics, Engineering Mathematics, Electrical Engineering Fundamentals</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Be able to assess the different types of bio energy sources; understand the need for new energy sources; comprehend the role of bio energy in providing clean energy; awareness of engineers towards the society; ability to produce an economical bio fuel; skills to evaluate different bio fuels
• The students should be able to
– to differentiate between different types of wind turbines
– to understand the different structural components and associated problem
– to understand the different control mechanism (blade pitch, stall, etc.)
– to design different wind turbine components
– to compute the rotor-blade aerodynamics and determine the optimum blade setting angles for design mean flow speed
– to compute the forces and performance curves for the wind turbine
– to determine the basic wind turbine dimensions.
The students should
– know the state of the art in wind energy and wind farming
– understand the basic operation of electric generators and grid integration, mechanical drive trains and mechanical pumps.
– know the basic modes of operation for isolated, island and wind farms, and the basic control mechanisms associated with each
– know the different types of energy storage and are introduced to pump storage systems and electrochemical battery systems
– be able to calculate the cost of production and the economic benefit.</td></tr>
<tr><td>Contents</td><td colspan="5">• An overview of petroleum as fuel (reserves, production and consumption) as well as gas and oil prices, potential of renewable energy, carbon cycle, types of biomass, introduction to bio fuels (history, international applications and production, properties, specifications and environmental impact), bio diesel, feedstock selection (agricultural point of view), water consumption, weather, food edible or non edible, land use for biomass production, agricultural waste worldwide, vegetable oils, animal fats and waste oils, chemistry of alcohols, triglycerides, free fatty acids and the trans-esterification reaction, simple introduction to biochemistry, oilseed processing (oil expellers, solvent extraction), economics of bio fuels, engine testing
• Historical development and state of the art in wind turbines and wind farms; technology, prospects and overview of wind power applications; wind turbine output and physical fundamentals, systematics of wind turbines, structure and behaviour of system components, measures at the wind turbine to regulate the power, tower design, characteristic curves and characteristic diagrams; design of wind turbines: rotor blade calculation for HAWT, dimensioning of wind turbines, selection of number of wind turbine blades; wind energy conversion systems (WECS): synchronous generator, asynchronous generator, mechanical drive train and adjustment, grid connection; power</td></tr>
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	plants for electricity generation: application types, functional structure of a wind power plant, modes of operation, control concepts; storage: pump storage, electrochemical storage; economy: plant costs, cost of electricity generation of wind power plants, subsidy programs; field excursion to Zaafarana or Hurghada sites.
Media	Field visits to oilseed plantations and oil extraction facilities in Egypt; lab work: preparation of biodiesel from non-edible vegetable oil; evaluation of the physical properties of the produced fuel, engine testing.
Literature	• 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.

<table>
<tr><td>Module title</td><td colspan="5">Solar Energy Technology II</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Solar Thermal Systems II</td><td>lecture</td><td>2</td><td>2</td><td>written exam</td></tr>
<tr><td>Concentrated Solar Thermal Power II</td><td>lecture, project</td><td>2</td><td>2</td><td>oral exam, project work</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Salman Ajib
Franz Trieb</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">-</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Learning the use of solar thermal energy for air conditioning, learning how to evaluate and to size solar thermal plants for air conditioning (as components and as total system) as well as how to plan the connection of the systems with one another and with the building; learning how to use planning tools and simulation programs for the design of solar air conditioning systems
• Understand the fundamental characteristics and capabilities of concentrating solar power (CSP) stations within national electricity supply schemes; learn how to assess the technical and economic potential of CSP in a country and to identify the best sites for project development; learn to design a sustainable national electricity supply scheme and to create scenarios for its implementation; learn to apply CSP for sustainable supply of water; understand the fundamentals of international cooperation for solar electricity export and long-distance transmission; learn about the environmental impacts of CSP plants.</td></tr>
<tr><td>Contents</td><td colspan="5">• Solar thermal cooling and solar thermal assisted air conditioning; introduction, space cooling and refrigeration, cooling and dehumidification, energy demand for cooling and dehumidification; fundamentals and basics of absorption cooling, energy and mass balance of absorption cycle, solution field, thermodynamics and efficiency, working pairs, enthalpy-concentration chart; basics of cooling towers, humid air, cooling tower concepts: wet cooling towers/dry cooling towers, absorption cycles using LiBr-water or other working pairs like NH3-water and organic pairs, cycle schematic; balances of the components, evaporator, condenser, absorber, desorber, solution heat exchanger, pump, expansion valves, figures of merit, performance coefficient, pump work ratio, design and technical details; typical component design, crystallisation prevention, maintenance of vacuum; system integration, control, characteristic equation, buffer and storage tanks, solar fraction, primary energy rate, water consumption, economics; state of the art of absorption chillers 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; other thermally driven cooling systems, open desiccant systems, solid desiccant systems, basics, design, working pairs, application, liquid desiccant systems, basics, design, working pairs; application: jet-cycle systems, double-effect absorption cycle, examples of installed systems
• Fundamentals: 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,</td></tr>
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	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
Media	Black board and beamer, lectures and power point presentations.
Literature	• J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, Wiley, 3rd edition, 2006. • H.-M. Henning, *Solar-Assisted Air-Conditioning in Buildings: A Handbook for Planners*, Springer; 2nd edition, 2007. • Lecture notes on *Solar Thermal Systems I*. • *Concentrating Solar Power for the Mediterranean Region*, German Aerospace Center (DLR), Institute of Technical Thermodynamics, Section Systems Analysis & Technology Assessment, 2005, downloadable from www.dlr.de/tt/med-csp. • *Trans-Mediterranean Interconnection for Concentrating Solar Power*, German Aerospace Center (DLR), Institute of Technical Thermodynamics, Section Systems Analysis & Technology Assessment, 2006, downloadable from www.dlr.de/tt/trans-csp • *Concentrating Solar Power for Seawater Desalination*, German Aerospace Center (DLR), Institute of Technical Thermodynamics, Section Systems Analysis & Technology Assessment, 2007, downloadable from www.dlr.de/tt/aqua-csp • Selection of published papers on concentrated solar thermal power will be announced.

<table>
<tr><td>Module title</td><td colspan="5">Wind Energy Technology</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Mechanical Aspects of Wind Energy</td><td>lecture</td><td>3</td><td>3</td><td>written exam, home work</td></tr>
<tr><td>Electrical Aspects of Wind Energy</td><td>lecture</td><td>3</td><td>3</td><td>written exam, home work</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Siegfried Heier</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">90 hours course attendance
90 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">6</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Wind Energy Basics</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">

The students should be able

to design different wind turbine components
to compute the rotor-blade aerodynamics and determine the optimum blade setting angles for design mean flow speed
to compute the forces and performance curves for the wind turbine
to determine the basic wind turbine dimensions
to compare different design concepts for power delivery systems
to design the different gear boxes and mechanical drives in the machine house
to understand the safety and braking systems needed in the machine house
to design the different tracking mechanisms
to compute the different aerodynamic, structural and dynamic loads on the wind turbine blades and tower
to estimate the extra loads from the mechanical systems connected to the wind turbine
to distinguish between the different materials used to construct the rotor blades
to design rotor blades using different available materials and technology
to distinguish and know about the different types of towers and support used for wind turbines
to make a preliminary design for a tubular, concrete or lattice tower and suitable foundation
to understand the different legislation requirements and transportation facilities needed to build and operate a wind turbine/farm
to plan for a new wind farm and to develop a Gannt chart to define when the different design, construction, testing and operation will commence
to understand the different safety measures and necessary scheduled maintenance for wind turbines
to take appropriate steps to apply for wind farm certification.

The students should be able

to understand and know the different WEC devices and functions
to describe the different components of WECS
to calculate the blade setting and obtain the performance curves
to match the turbine to a suitable generator
to describe the suitable drive train
to understand the different problems related with grid integration
to understand and know the different types of grids
to understand schemes for control of the grid
to design wind turbine control concepts for island, grid and interconnected operation

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	– to design the control systems for the plant operation.
Contents	• 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, aesthetic criteria; loads and structural demands: static aerodynamic and structural loads on blades and towers, dynamic loads on blades and towers, modelling to calculate the loads and structural demands, mechanical components and control system loads; 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, foundation; planning, installation and operation: project planning, 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 • Construction and functional structures of WEC; main components of wind energy converters: rotor blade with pitch drive, input torque, generator, mechanical drive train; grid integration: different electrical networks, grid influences, 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, development of mathematical models for control and simulation, dimensioning of the controllers.
Media	Black board and beamer, power point presentations.
Literature	• S. Heier and R. Waddington, *Grid Integration of Wind Energy Conversion Systems*, Wiley-Blackwell, 2nd edition, 2006. • E. Hau and H. von Renouard, *Wind Turbines: Fundamentals, Technologies, Application, Economics*, Springer; 2nd edition, 2005.

<table>
<tr><td>Module title</td><td colspan="5">REEE III</td></tr>
<tr><td rowspan="4">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Energy Economics Special</td><td>lecture, (group) work</td><td>2</td><td>2</td><td>evaluation of (group) work</td></tr>
<tr><td>Energy Efficiency and Conservation Special</td><td>lecture</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Fuel and Emissions</td><td>lecture, lab</td><td>1</td><td>1</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Sayed Kaseb
Jürgen Schmid
John Sievers</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
75 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Wind Energy Basics, Energy Economics – Macro, Energy Economics – Micro, Engineering Thermodynamics</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Acquire specific knowledge and methodology in energy economics to be able to design a concept for a master thesis in this field, to do the necessary research for this thesis and accomplish it.
• Ability to design, analyze and model energy efficiency systems
• Ability to determine the heat value of fuels and to determine emissions of the burning process</td></tr>
<tr><td>Contents</td><td colspan="5">• Sector policies, laws and regulations; economic instruments and incentives; financing; tariff structure (cross subsidies, social aspects); decentralisation; energy system modelling; institutional set-up, international best practices; visiting energy sector organisations; holding discussions with planners and decision makers; writing an analytic paper (individually or in a group)
• Energy management systems, high efficiency motors and generators, variable speed drives, combustion control and monitoring, waste heat recovery exchangers, building management system, design of thermal storage (cooling/heating), demand controlled ventilation, steam systems
• Fundamentals of comprising calorimetric and exhaust gas measurements with thermodynamic calculations and an assessment of accuracy and environmental impacts.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, computer models, experimental measurements.</td></tr>
<tr><td>Literature</td><td colspan="5">• Lecture notes on Energy Economics Special.
• F.E. Banks, Energy Economics: A Modern Introduction, Springer, 1st edition, 1999.
• D.R. Wulfinghoff, Energy Efficiency Manual, Energy Institute Press, 2000.
• Lecture notes on Fuel and Emissions.
• The Adiabatic Constant Volume Twin Calorimeter, downloadable from http://fluidproperties.nist.gov/cvht.html.</td></tr>
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<tr><td>Module title</td><td colspan="5">RE Integration</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Smart Grids</td><td>lecture, lab</td><td>3</td><td>3</td><td>oral exam</td></tr>
<tr><td>Flexible Generation and Demand Side Management</td><td>lecture, lab</td><td>2</td><td>2</td><td>oral exam</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Dahlhaus, Lindenborn
Sievers</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">75 hours course attendance
75 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">5</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Electrical Engineering Basics</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Students are able to understand the design principles of smart grids and smart grid communications; energy efficiency and renewable energy generation are to be understood as key drivers of smart grids; future grids are to be designed from the beginning as smart ones including scalability, security, privacy, etc.; students should understand the fundamentals of communication infrastructure required to set up smart grids
• Understanding of the requirements for balancing fluctuating renewable power generation; assessment of the suitability of possible solutions for these different requirements.</td></tr>
<tr><td>Contents</td><td colspan="5">• 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; communication technologies used in SGC; power line communications; fiber optic communications; wireless devices; privacy issues in smart grids; utility companies and energy load management/reduction; factors for demand response (DR) programs; automation of DR as key concept which helps reduce human intervention and increases accuracy and responsiveness to the DR program; activities in standardization bodies on SGC; practical experience gained in SGC lab experiments
• Possibilities and potentials of flexible power generation and Demand Side Management; (DSM), definition of requirements; discussion of solutions; practical experience with flexible power generation under central European conditions.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, lab experiments, measurements.</td></tr>
<tr><td>Literature</td><td colspan="5">• C.W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press; 1st edition, 2009.
• M. Shahidehpour and Y. Wang, Communication and Control in Electric Power Systems: Applications of Parallel and Distributed Processing. John Wiley & Sons, 2003.
• J. Sievers, M. Puchta, S. Faulstich, I. Stadler and J. Schmid, Guidelines promoting CHP concepts with heat accumulators, the perspective of CHP plants and other technologies that use thermal energy storage and their implementation in the European Union, Deliverable 2.4, EU project Dissemination strategy on Electricity balancing large Scale Integration of Renewable Energy (DESIRE), University of Kassel, Kassel, 2007, downloadable from http://desire2.iset.uni-kassel.de/files/deliverables/del_2.4.pdf.</td></tr>
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<table>
<tr><td>Module title</td><td colspan="5">Advanced Topics in RE</td></tr>
<tr><td rowspan="3">Courses</td><td>Title</td><td>Teaching Method</td><td>SWS</td><td>Credits</td><td>Performance requirements/ Examination</td></tr>
<tr><td>Photovoltaics II</td><td>project, seminar</td><td>2</td><td>2</td><td>project report, presentation</td></tr>
<tr><td>Bio Energy II</td><td>lecture, group work</td><td>2</td><td>2</td><td>oral exam, report</td></tr>
<tr><td>Semester</td><td colspan="5">third semester (months 8-13)</td></tr>
<tr><td>Responsible</td><td colspan="5">Dahlhaus</td></tr>
<tr><td>Site</td><td colspan="5">Kassel</td></tr>
<tr><td>Lecturer(s)</td><td colspan="5">Mohamed Ibrahim
Bernd Krautkremer</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Workload</td><td colspan="5">60 hours course attendance
60 hours self-study</td></tr>
<tr><td>Credits</td><td colspan="5">4</td></tr>
<tr><td>Recommended Qualifications</td><td colspan="5">Photovoltaics I, Bio Energy I</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">• Knowledge of decentralized PV systems and their requirements; basic knowledge about the storage technologies and their rule in photovoltaic stand alone systems; understanding the basic concepts of energy management; ability to design stand alone PV system according to specific application and resources conditions; gaining the necessary knowledge about estimating the techno-economic performance criteria; implementing standard PV simulation software tools for system design.
• Knowledge of
– the methodology to determine bio mass potentials
– methodology of bio mass conversion
– existing conversion technologies
– necessity of specific boundary condition for the conversion individual technologies.
Capability to
– analyse the sustainability of the whole chain
– adapt technologies to local needs
– integrate bio energy in the energy supply systems.</td></tr>
<tr><td>Contents</td><td colspan="5">• 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; aupervisory control and energy management strategies for PV decentralized systems; atorage 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); PV economics and specific energy cost calculation; techno-economic performance criteria of stand-alone PV and hybrid systems; 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)
• Efficiency of biomass production, biomass in waste, different ways of using biomass, combustion basics with respect to biomass conversion, conversion paths (combustion of solid bio mass, thermo chemical gasification, anaerobic digestion, bio fuels), integration of bio energy in conventional and renewable energy systems, utilization of the specific characteristics of bio energy systems with other renewable energies, design methodology for the design of conversion paths.</td></tr>
<tr><td>Media</td><td colspan="5">Black board and beamer, power point presentations.</td></tr>
<tr><td>Literature</td><td colspan="5">• T. Markvart and Luis Castaner (ed.), Practical Handbook of Photovoltaics, Fundamentals and Applications, Elsevier Science, 1st edition, 2003.
• A. Goetzberger and V.U. Hoffmann, Photovoltaic Solar Energy Generation, Springer, 1st</td></tr>
</table>

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