UNI FREIBURG

Module handbook

REM M.Sc. Renewable Energy Engineering and Management

Academic year 2015/2016

State of 14.03.2015

Table of contents

Module handbook
Master of Science
Renewable Energy Engineering and Management

1. Introductory comments

According to § 4 of the examination regulation of the MSc Renewable Energy Engineering and Management a module handbook lists the module contents. The module handbook refers to the academic year and gives information about the time schedule, type and scope of the module related courses and examinations.

The MSc Renewable Energy Engineering and Management is a two-year course. In the first part the time schedule for the students in their respective semester (first or third semester, second or fourth semester) is given. In the second part the module descriptions (listed accordingly to the time schedule given in the first part) inform about the contents and course prerequisites of the individual modules.

The module handbook is available on the website of the MSc Renewable Energy Engineering and Management (www.rem.uni-freiburg.de). Thus students have access to the module handbook before and during their studies.

2. Schedule

	Winter term 2015/16 First Semester																										
	October				**November**					**December**				**January**				**February**				**March**					
CW				**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**CW**
	17.10.			19.10 – 18.12.									- 6.01.		07.01–23.01.			26.01. – 12.02.			15.02. – 04.03.						
REM (1st Sem.)	**Introductory day**			Module **Energy & Sustainable Development**									**Christmas Break**		Module **Natural Resources and Conversion Technologies**						Module **Climate & Energy Policy**						**REM (1st Sem.)**
				Pauliuk																							
				Module **Scientific Framework for REM**																							
				Baumgärtner											**Jaeger**						**Ragwitz**						

	Summer term 2016 – Second Semester							
	April	May	May	June	June / July	July	August	
CW	14 15 16	17 18 19	20	21 22 23	24 25 26	27 28 29	30 31 32 ...	CW
	04.04 –22.04.	25.04.- 13.05.	16.5-22.5	23.05. - 10.06.	13.06 – 01.07.	04.07 - 22.07.	25.07 -	
REM (2nd Sem.)	Module **Generation and Distribution of Energy**	Module **Manage-ment I**	**Pentecoast Break**	Module **Society & Economy**	Module **Research Skills**	Module **Elective Bioenergy I, Wind energy**	Module **Internship**	REM (2nd Sem.)
	Reindl	**Hanewinkel**		**Baumgärtner**	**Baumgärtner**	**Ragwitz, Jaeger**	**Baumgärtner**	

Winter term 2015/16 Third Semester

	October				November					December				January				February				March				
CW				43	44	45	46	47	48	49	50	51	52	01	02	03	04	05	06	07	08	09	10	11	12	13	CW

REM (3rd Sem.)	19.10 – 06.11.	09.11. - 27.11.	30.11. – 18.12.	- 6.01.	07.01. – 22.01.	25.01. – 12.02.	15.02. - 04.03.
	Module	Modules Elective Tracks	Modules Elective Tracks		Modules Elective Tracks	Modules Elective Tracks	Module
	Internship	**Energy Systems Hardware and Control**	**Smart Grids**	**Christmas Break**	**Energy Efficiency**	**Energy Informatics**	**Project**
		Photovoltaics 1	**Low Temperature Solar Thermal Energy**		**Photovoltaics 2**	**High Temperature Solar Thermal Energy**	
		Energy communities	**Management 2**		**Landscape, Nature Protection, Landuse Conflicts**	**Bioenergy 2**	
	Baumgärtner	**Diehl** **Wittwer** **Ruppert-Winkel**	**Wittwer** **Wittwer** **Hanewinkel**		**Reindl** **Wittwer** **Koch**	**Thiemann** **Wittwer** **Jaeger**	**Baumgärtner**

3. Module descriptions

3.1. Winter term 2015/2016 – first semester

- **Energy and Sustainable Development**
- **Scientific Framework for REM**
- **Natural resources and Conversion Technologies**
- **Climate and Energy Policy**

3.2. Winter term 2015/2016 – third semester

- **Internship**
- **Elective Track "Energy Systems Technology"**
  - ❖ **Energy Systems Hardware and Control**
  - ❖ **Smart Grids**
  - ❖ **Energy Efficiency**
  - ❖ **Energy Informatics**
- **Elective Track "Energy Conversion"**
  - ❖ **Photovoltaics 1**
  - ❖ **Low Temperature Solar Thermal Energy**
  - ❖ **Photovoltaics 2**
  - ❖ **High Temperature Solar Thermal Energy**
- **Elective Track "Environmental Planning and Management"**
  - ❖ **Energy Communities**
  - ❖ **Management 2**
  - ❖ **Landscape, Nature Protection, Landuse conflicts**
  - ❖ **Bioenergy 2**
- **Project**

3.3. Summer term 2016 – second semester

- **Generation and Distribution of Energy**
- **Management I**
- **Society and Economy**
- **Research Skills**
- **Elective Bioenergy I**
- **Elective Wind Energy**
- **Internship**

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
----</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93110</td><td colspan="2">Module name
Energy and sustainable development</td><td>Semester/return
1st Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
Max. 55</td></tr>
<tr><td>Teaching form
Lectures, group work, excursion</td><td>Examination form
Written exam</td><td>Start date
19.10.2015</td><td>Location
tba</td></tr>
<tr><td colspan="4">Module coordinator: Stefan Pauliuk, PhD (stefan.pauliuk@indecol.uni-freiburg.de)</td></tr>
<tr><td colspan="4">Additional teaching staff
Prof. Dr. Jürgen Huss, Philipp Thapa, Prof.Dr.Dr. Ernst Ulrich von Weizsäcker</td></tr>
</table>

Syllabus

An excursion on the first day of the course helps the newly arrived students to form a group and introduces them to the historic development of the relationship between humans and natural resources, exemplified by the forestry and mining activities around Freiburg.

The core of the module has three parts with clearly defined interfaces. The first part provides the theoretical basis for large parts of the rest of the program. We present the systems approach to human-environment interactions and introduce the central interdisciplinary concepts of system science. These concepts include socio-ecological systems and the separation of their biophysical and social aspects, boundary objects to describe objects and concepts across disciplines, socioeconomic metabolism and the biophysical structures of society, and industrial ecology and the circular economy. We describe the metabolism of historic societies and discuss its constraints. We study the socio-metabolic transitions that have occurred in the past and the transition to a sustainable energy supply that is about to occur. We then present two main systems approaches to quantify and assess material and energy flows in society: Material flow analysis and life cycle sustainability assessment. At the end of the first part we apply these methods to conduct two case studies, one for each method, on sustainable energy supply projects in different parts of the world.

The second part of the module adds a normative and utopian perspective to the idea of socio-metabolic transitions. The focal double question is: "What future do we want, and why?" Working with case studies, including those from the first part of the module, students develop awareness for the diversity both of possible future visions and of the reasons and criteria that can be used to support or criticise their pursuance. They learn to distinguish between factual claims and normative appeals and to analyse their intertwinement in concepts such as development, economic growth, sustainability, biodiversity, or nature. They practise making normative arguments of their own and questioning those of others. Together, we discuss the main conceptions of sustainability and ethics and offer an introduction into environmental ethics, including the question whether we owe respect to (some) non-human beings. Students learn to consider "social technologies", including ethics and lifestyles, as potential tools for sustainable development in addition to engineering solutions.

The third part focusses on climate change mitigation as major aspect of sustainable development. Aside from renewable energies, the most powerful strategy in this regard is a massive increase of energy productivity. Similarly, a sustainable strategy of dealing with increasing non-energy resource scarcity (water, metals, phosphorus etc.) is a massive increase of resource productivity. Examples of large productivity gains will be shown from a wide range of industrial sectors, transport, buildings, and agriculture. Also, policy options will be discussed to steer technologies and investments in the right direction. One strategy deserves special consideration: a gradual and steady increase of prices of the use of energy and the extraction of mineral resources.

The module is interactive and encourages strong student participation. Lectures, offering a detailed introduction, are complemented by different didactical methods, such as autonomous group work with short presentations, panel discussions etc. On the basis of the acquired knowledge, student groups (5-6) conduct small case studies on different topics concerning the ethical and biophysical aspects of sustainability and climate change.

Learning goals and qualifications

- Knowledge about historic limitations of socio-metabolic regimes and historic socio-metabolic transitions
- Systems theory and quantitative analysis of human-environment systems, basics of material flow analysis and life cycle sustainability assessment
- Resource productivity and new political frameworks as central aspects of sustainable development
- Awareness of the ethical aspects of socio-ecological development
- Basic knowledge of the main ethical approaches and normative argumentation skills
- Soft skills: rhetoric, discussion and presentation skills, capacity for team work

Recommended reading

- Saarinen, Thomas F.: ***Environmental perception and behaviour: an inventory and prospect*** / Thomas F. Saarinen , eds.. - Chicago, Ill.: Univ. of Chicago, Dep. of Geography, 1984. - X, 263 p.;
- Simmons, Ian G.:***Global environmental history: 10,000 BC to AD 2000/I***. G. Simmons.-Edinburgh: Edinburgh Univ. Press, 2008. – XVI, 271 p. (eng)
- Von Weizsäcker, E., Hargroves K., Smith M.H., Desha C.: ***"Factor Five"*** (Earthscan, London, 2009)
- Ott, Konrad: ***Essential components of Future Ethics***. In: Döring, Ralph / Rühs, Michael (eds.): Ökonomische Rationalität und praktische Vernunft. P. 83-108.
- Pauliuk, S. and Müller, D.B. ***The role of in-use stocks in the social metabolism and in climate change mitigation***, Global Environmental Change 2014, Vol. 24, pp. 132-142

Course prerequisites

None.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93950</td><td colspan="2">Module name
Scientific Framework for REM</td><td>Semester/return
1st Sem. / annual</td></tr>
<tr><td>Workload/presence
10 ECTS (300h/100h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
max. 55</td></tr>
<tr><td>Teaching form
Lectures, tutorials</td><td>Examination form
Written exam</td><td>Start date
19.10.2015</td><td>Location
tba</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Stefan Baumgärtner</td></tr>
<tr><td colspan="4">Additional teaching staff: Prof. Dr. Daniela Kleinschmit, Dr. Roderich von Detten, Dr. Oswald Prucker, Dr. Michael Henze, Dr. Adnan Yousaf Kathrin Drozella,</td></tr>
</table>

Syllabus

This module is designed to harmonize the heterogeneous background knowledge due to the interdisciplinary and internationality nature of the M.Sc. REM course by providing fundamental knowledge about diverse subjects relevant for this course. At the beginning, the current knowledge in physics, chemistry, biology, engineering, politics, economics, business, and law will be tested and recommendations will be given to the student, which lectures with a total workload of 10 ECTS they should take to fill their knowledge gaps

1. Introduction in Physics, Chemistry, Biology and Engineering

In this module, the basics of mechanics, thermodynamics, electro statics and dynamics, as well as optics are discussed in a physics class. An overview over the chemistry (e.g. assembly of elements, chemical bindings, chemical reactions, organic molecules, polymers) and biology (e.g. photosynthesis, cells in a perspective of biomass) is given. An engineering class provides the students with the fundamental knowledge on electricity (e.g. basics of electronics, electric components, Kirchhoff's laws, diodes, three-phase current)

2.Introduction into Politics, Economics, Business and Law

The course gives an overview on basic concepts of policy and economic sciences. This includes basics of the political system, multilevel governance, the policy process, the use of political and market instruments and the management of enterprises. Regulative instruments are in focus.

Basics of business economics: Classical & modern theories & approaches of Organization & Management, Context of Management (interactions between firms and the business environment), Strategic Aspects of Management; Organisation Structures and Processes; Decision Making in organizations

Learning goals and qualifications

1. Introduction in Physics, Chemistry, Biology, and Engineering

The students acquire basic knowledge in physics and engineering to provide the required prerequisites for advanced technology classes. The students understand the concepts of thermodynamics, mechanics, electro statics and dynamics, and optics as well as the electric engineering, which consists of electrical components, electrical circuits and conduction. The students learn fundamental concepts of chemistry and biology providing a basis for understanding biomass and conversion into bioenergy. This includes the classifications and properties of basic elements of the periodic table and survey the different bonding mechanisms and resulting chemical species, the fundamentals of chemical reactions including stoichiometry with a specific emphasis on reactions relevant to biomass such as acid / base reactions.

2.Introduction into Politics, Economics, Business and Law Participants will have a basic knowledge of policy, economic and management theory. They understand the principles of the legal framework of land use as well as the role of organizations as bottlenecks for the implementation of sustainability strategies. Students understand the rational of social and economic sciences (methodology, methods). They are able to adopt theoretical concepts to practical questions and use them as a tool to understand the formulation and implementation of energy policy.
Recommended reading Tipler, Mosca: Physics for Scientists and Engineers; Freeman, 6th edition, 2007 (Part I, II, III, IV, V) Boylestad, Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall, 7th edition Orrrest M. Mims, Getting Started in Electronics, 12th edition (1994) – *soft copy for the students will be provided*. Economy & Management: Selected chapters from : Cole, G. a. 2003. Management. Theory and Practice. 6th edition. Cengage Learning (UK) & Parkin, M., Powell, M. and Matthews, K. 2003 Economics, 5th Edition, Harlow: Addison-Wesley; during the module materials will be made available via the learning platform ILIAS
Course prerequisites **-**

Course M.Sc. Renewable Energy Management			
Availability to other courses ---			**Instruction Language** English
Module No. **93951**	**Module name** **Natural Resources and Conversion Technologies**		**Semester/return** 1st Sem. / annual
Workload/presence 10 ECTS (300 h/100 h)	**Prerequisite module(s)** Scientific Framework for REM	**Follow-up module(s)** Generation and Distribution of Energy	**No. of participants** Max. 55
Teaching form Lectures, Exercises, Seminar, lab experiments	**Examination form** Written exam	**Start date** 07.01.2016	**Location** tba

Module coordinator: Prof. Dr. Dirk Jaeger

Additional teaching staff

PD Dr. Dirk Schindler (solar radiation & wind), Dr. Werner Platzer (solar thermal, solar power), Dr. Ralf Preu (photovoltaics), Stefan Baehr (wind energy), Prof. Dr. Markus Weiler (water & hydropower), Prof. Dr. Stefan Hergarten (geothermics & geothermal energy), Dr. Sebastian Paczkowski (biomass & bioenergy)

Syllabus

This module gives the students an overview and the fundamental knowledge of different renewable energy sources and their potentials as well as basics of the underlying conversion technologies.

1. Solar Radiation, Photovoltaics & Solar heat (2 weeks)

Solar radiation: Meteorological aspects of the utilization of solar radiation as a renewable energy source: processes, phenomena, solar radiation spectrum, spatial and temporal patterns of radiative fluxes in the atmosphere and at the earth's surface. Calculation of solar irradiation on inclined collectors; methods for determining diffuse and direct solar radiation

Photovoltaics: Basics of solar cell principles and characterisation silicon photovoltaics value chain with focus on cell technology, overview over other photovoltaic technologies, simple design of photovoltaic systems, and calculation of energy gain.

Solar Thermal Energy: Basics of solar thermal energy conversion are given, which includes: flat plate and vacuum tube solar collector design, black and selective absorbers, basics of optical gains and calculation of conductive, radiative and convective heat transfer in solar collectors and piping, solar thermal system concepts for solar domestic hot water and solar assisted heating, hot water storage types. System concepts are addressed, such as forced circulation and natural circulations systems, with low and high flow. Overview on solar concentrating collectors is given. High temperature applications are addressed, such as solar process heat and concentrated solar thermal power (CSP). Eventually, simple economics and system comparison with conventional alternatives are discussed.

2. Wind & Wind Energy (1 week)

Meteorological aspects of the utilization of wind as a renewable energy source are discussed, such as processes, phenomena, spatial and temporal patterns of kinetic energy and airflow in the atmospheric boundary layer.
Furthermore, this part of the module gives an applied overview about wind technology, focusing on performance and feasibility. Main topics are: the evolution of the wind turbine (capacity, components) and the role of electric grids. Additionally, key factors of wind-project development will be analysed: construction pre-requisites, steps, methods and costs. Wind technology perspectives around the world will be part of the module as well.

3. Water & Hydropower (1 week)

This part of the module gives a broad overview about the large number of different technologies and applications for producing hydropower and hydroelectricity. The state of hydropower worldwide and in certain countries will be addressed and calculations for hydropower and hydroelectricity output will be done. Further topics are: hydropower and environment, river ecology scientific discussion on dams (Internet: Hydro Association), aspects of hydropower economics, sustainable management of hydropower and case studies around the world. Hydropower as subject in the German EEG will be introduced as a model.

4. Geothermics & Geothermal Energy (1 week)

The potential of geothermal energy conversion is addressed, particularly of geothermal energy resources (Bucher): earth's thermal regime, energy budget of the earth, heat storage, heat transport, hot water in the heat reservoirs, hydraulic properties of fractured hard rock, geothermal potentials (distribution and assessment), geothermal energy resources

5. Biomass & Bioenergy (1 week)

This part of the module aims to provide general knowledge about standard biomass conversion technologies. Therefore basics in biomass chemistry and biomass composition will be given. Based on this, the three fundamental technologies of biomass conversion processes will be introduced to the students.

- thermo-chemical processing
- physical-chemical processing
- bio-chemical processing

The different biomass conversion technologies require a more or less specific kind of biomass. The students will learn about the requirements on biomass with respect to the conversion technologies. Advantages and disadvantages of each technology will be highlighted and suitability of each technology to produce power, heat or fuel will be discussed. To evaluate and to compare the different conversion processes, mainly aspects of energy efficiency and carbon balance are questioned and analysed based on a process oriented approach (LCA)

Learning goals and qualifications

The diversity of renewable energy harvesting is mediated to the students. They understand the potentials with respect to the spatial availability, the general technologies, the sustainability of renewable energy conversion at given conditions, challenges and risks, as well as solution strategies of many different kinds of renewable energy sources. The students learned the basic concepts of the different conversion technologies and know how the different renewable energy sources can be utilized in order to produce electric power, heat and/or fuel.

1. Solar Radiation, Photovoltaics & Solar heat (2 weeks)

Solar radiation: Comprehension of radiative processes in the atmosphere and at the Earth surface, application of knowledge about solar radiation at the earth's surface within the context of site assessment, analysis of methods used to quantify solar radiation incident at the earth's surface.

Photovoltaics: The students will understand the working principles of photovoltaics. They will understand the basic mechanisms of the generation of carriers by photon absorption. The focus will be on standard semi-conductor based photovoltaics. They will learn how a solar cell can be described by its characteristic current-voltage-dependence. They will learn about the different optical and electrical loss mechanisms, which limit the maximum efficiency of a photovoltaic device. They will gain a rough overview on the different technologies how to manufacture photovoltaic modules as well as the most important characterization methods. Finally they will get insight into cost issues and scenarios for the different technologies.

Solar Heat: The students will understand the working principles of solar collector systems and the main factors of the solar energy utilization. They will learn to estimate approximately the solar gains of solar thermal systems. The main factors influencing the output of system can be judged qualitatively. Within exercises optical solar gains and heat losses as part of the overall energy balance of a collector will be calculated. Based on that quantitative simple estimations of collector performance will be practised. They will understand the main features and the basic differences between concentrating and non-concentrating systems.

2. Wind & Wind Energy (1 week)

Comprehension of airflow patterns in the atmospheric boundary layer, application of knowledge about near-surface airflow within the context of site assessment, analysis of methods used to quantify the wind resource near the ground
The students will be able to understand the role of wind energy from the management perspective and to deduce future scenarios for this technology according to the natural conditions and legal framework of each country/region.

3. Water & Hydropower (1 week)

The students will get general and specific knowledge about principles, technologies, applications, problems and solutions regarding hydropower, ranging from micro to large systems, and the use of hydropower optimized towards sustainability. The students will be able to calculate the output and economics of hydropower. They will be able to compare, evaluate and manage different aspects of hydropower with the goal of sustainability.

4. Geothermics & Geothermal Energy (1 week)

The students acquire basic knowledge about the physics of the earth, the principles concepts of using geothermal energy, the technologies, the applications, the challenges as well as the solution strategies for geothermal energy conversion. They know how to evaluate potential of geothermal energy conversion at given local conditions with respect to sustainability and economics.

5. Biomass & Bioenergy (1 week)

Within this part of the module, the students will get an understanding on the principals of biomass conversion processes and the related requirements on biomass. Based on presented advantages and disadvantages of different conversion technologies, the students will be able to compare and evaluate these technologies. This basic knowledge on the conversion techniques will enable them to evaluate the different technologies with regard to production of power, heat or fuel. Furthermore competences in evaluation methods will be learned.

Recommended reading

- Duffie-Beckman: Solar Engineering of Thermal Processes.
- Martin Green: Solar Cells: Operating Principles, Technology, and System Applications.
- Richardson, J.: Bioenergy from sustainable forestry : guiding principles and practice: Kluwer Academic, 2002. 344 p.
- Ostergard,H.: Bioenergy and emerging biomass conversion technologies. Short paper based on presentation at the AG2020 Expert Workshop in Denmark, 8th May 2007.
- I. Stober and K. Bucher, 2009: Geothermal Energy, Geothermal Exploration. Springer Verlag, Heidelberg.
- Additional relevant literature will be presented in the module
-

Course prerequisites

Content of the module "Scientific Framework for REM"

Module No.	Module name		Semester/return
93140	**Climate and Energy Policy**		1st semester / annual
Workload/presence	**Prerequisite module(s)**	**Follow-up module(s)**	**No. of participants**
5 ECTS-P (150h/60h)	--	---	Max. 55
Teaching form	**Examination form**	**Start date**	**Location**
Lectures + group work assignments	Written test + group work presentations	15.02.2016	tba

Module coordinators: Prof. Dr. Mario Ragwitz

Additional teaching staff: Dr. Sibylle Braungardt, Dr. Till Pistorius, Barbara Schlomann

Syllabus

The prevailing focus of the module is on the governance of climate and energy issues and corresponding policies at different levels (international, national, regional), as well as on their interrelation to other policy fields. After a short introduction to the basics of political science, students will be confronted with the wide range of climate and energy issues as well as the resulting conflicts and their role in the international efforts to mitigate climate change. Targets of climate and energy policy will be presented as well as the broad range of related instruments, policy processes, involved stakeholders and their interests.
In particular the module will cover the fundamentals of:

- international climate policy, including different concepts of effort sharing and the role of different countries / world regions in international negotiations of mitigation targets,
- energy policy, incl. instruments targeted at security of supply, energy efficiency, environmental sustainability,
- electricity markets and the impact of energy policy on these markets,
- renewable energy policy including basic economic characterization of renewable energies in energy modelling,
- the energy transition in Germany.

The module is designed in a very interactive manner and encourages strong participation of the students. After detailed introductions and presentations to the different topics they will be asked to elaborate issues and present the results in a self-organized manner (group work), i.e. by

- conducting country case studies,
- preparation of short presentations on case studies conducted.

Furthermore, various guest speakers and experts from different fields and institutions will be invited to provide expert views and insights on the respective topics.

Learning goals and qualifications

The main goal of this interdisciplinary module is to provide in-depth knowledge and insights into concepts of energy policy and the international climate regime; the focus of the module is on the connection to strongly related issues and processes, e.g., national and international climate, energy and land use policies. Different scientific disciplines are merged, with the objective to foster an understanding of complex multi-level political issues. This includes

- the presentation of different types of instruments and the role of the policy mix
- the role of different actors and institutional aspects
- different governance levels of energy and climate policy (local, regional, national, international)
- steps in the policy process (design, implementation, monitoring, evaluation, etc)
- role of scenarios (normative, explorative, projective), dealing with uncertainties
- cost aspects (system analytic, distributional effects, external costs)

Development of the following skills

- ability to analyze complex contextual knowledge
- interdisciplinary work
- ability to evaluate policy programmes and instruments
- rhetoric, discussion and presentation skills
- team work
- fostering of problem solving competences

Recommended reading
Metz, B. (2010): Controlling climate change. Cambridge university press. 350 p http://www.iea.org/policiesandmeasures/climatechange/ http://www.worldenergyoutlook.org/ http://unfccc.int/resource/process/guideprocess-p.pdf http://www.uneptie.org/energy/publications/pdfs/EmissionsTrading-Feb03.pdf http://www.bmu.de/files/pdfs/allgemein/application/pdf/reccs_endbericht_kurz_en.pdf http://www.grida.no/publications/rr/natural-fix/ebook.aspx http://www.bmu.de/files/english/renewable_energy/downloads/application/pdf/broschuere_ee_zahlen_en.pdf
Course prerequisites
- Teaching context of module “Energy and sustainable development” - Basic knowledge regarding environmental issues associated to climate change

Course M.Sc. Renewable Energy Management			
Availability to other courses ---			**Instruction Language** English
Module No. **6900**	**Module name** **Internship (Praktikum)**		**Semester/return** 2nd - 3rd Sem. / annual
Workload/presence 10 ECTS-P (300 h)	**Prerequisite module(s)** ---	**Follow-up module(s)** ---	**No. of participants** max. 30
Teaching form Practical work	**Examination form** Written report	**Start date** 25.08.2015	**Location** t.b.a.
Module coordinators: Prof. Dr. Stefan Baumgärtner			
Additional teaching staff Academic experts of the respective internship institution			

Syllabus

The MSc. programmes at the Faculty of Environment and Natural Resources Freiburg as a rule include a practical training in accordance with the examination regulations for the degree programme Master of Science. The practical training is completed in institutions and companies outside the faculty or in research departments of the ZEE and his partners.

Possible internship providers include:

- Renewable energy and power supply companies
- Planning and Engineering companies
- Consultancy and information services (energy agencies, technology transfer institutions) and public relation
- Science and research dealing with renewable energies
- Financing and Investment companies specialising in financing environmental projects, as well as investment and development banks

Learning goals and qualifications

The internship should provide students with a first insight into potential employment sectors; in all sectors this is primarily achieved by practical work. Apart from gaining an overview of the subject, students should experience typical work processes and the human interactions in an organization. The assigned work should give students an idea of the daily work procedure at their workplace (‘everyday life experiences’). Additionally, students should become familiar with the structures within the institution, as well as the interconnections with external systems.
Furthermore, the expert knowledge gained in the course of the studies should be intensified and to a certain degree, applied during the practical training.

Recommended reading

To be suggested individually by coordinator and internship institution

Course prerequisites

None.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97000</td><td colspan="2">Module name
Energy Systems Hardware and Control</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS (150 h / 60 h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)
Generation and distribution of energy</td><td>No. of participants
Max. 20</td></tr>
<tr><td>Teaching form
Lectures and Exercises</td><td>Examination form
Written exam</td><td>Start date
9.11.2015</td><td>Location
Room 103</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Moritz Diehl, (moritz.diehl@imtek.uni-freiburg.de), PD Rüdiger Quay (ruediger.quay@iaf.fraunhofer.de)</td></tr>
<tr><td colspan="4">Additional teaching staff
Dr. Michael Erhard</td></tr>
</table>

Syllabus

In this module the students will learn about high power electronics with a particular emphasis on control.

The compact course is split in two parts:

- A) The hardware of high-power electronics
- B) Systems Theory and Feedback Control

In Part A of this module building hardware aspects of power electronics will be introduced. The course starts with the fundamentals and concepts of power devices and circuits. It comprises three aspects: fundamental power conversion-concepts with focus on DC-DC and –AC conversion, more complex power circuitry, and actual power conversion systems. At the interface of modern electronics, circuit design, and control theory, advanced analysis and characterisation techniques are introduced in order to bridge the gap from modern power conversion to the understanding of systems and network systems with all aspects of power conversion. Students will carry out study examples using the simulation software QUCS.

In Part B of this module, students are introduced to the design and analysis of feedback control systems. We start with regarding general ordinary differential equations (ODE) and then focus on linear time invariant systems in continuous time. Conditions for stability are discussed, and performance measures for feedback control systems defined. We then discuss state space control design in more detail, covering topics such as Luenberger Observer, Kalman Filter, the Linear Quadratic Regulator (LQR) and Model Predictive Control (MPC).

Learning goals and qualifications

In Part A, the students will be enabled to understand materials, concepts, functioning, and design of modern power devices, circuits, and converter systems. This includes the understanding of basic concepts of power conversion (AC theory), of passive and active semiconductor devices, high-voltage operation, converter-, and control concepts, device protection, and aspects of system and power network theory. The students will be competent to analyse and design passive and active power devices such as MOSFET, Insulated Gate Bipolar IGBT, and thyristors, and circuits, full converter functions, integration, and analyze full system concepts. Circuits and system concepts for power conversion, such as half and full bridges, aspects high voltage operation, and design for robustness are presented, and several examples are discussed in detail.

In Part B the students will learn how to mathematically model a given dynamical system with control inputs and sensor outputs in form of ordinary differential equation models, and how use state space estimation and control techniques to design suitable feedback controllers.

Recommended reading Everything provided in lecture and exercise.
Course prerequisites Undergraduate mathematics (calculus, linear algebra) and basics in systems theory.
Additional information Electronic manuscripts are provided for the lecture. Visit to Fraunhofer IAF

Course M.Sc. Renewable Energy Engineering and Management			
Availability to other courses			**Instruction Language** English
Module No. **97001**	**Module name** **Smart Grids**		**Semester/return** 3rd Sem. / annual
Workload/presence 5 ECTS (150 h/60 h)	**Prerequisite module(s)**	**Follow-up module(s)**	**No. of participants** Max. 20
Teaching form Lectures, Exercises, Seminar, lab experiments	**Examination form** Presentation and speech	**Start date** 30.11.2015	**Location** University of Freiburg; Fraunhofer ISE

Module coordinator:

Prof. Dr. Christof Wittwer (christof.wittwer@ise.fraunhofer.de)

Additional teaching staff

Dr. Bernhard Wille-Haussmann; Dr. Robert Kohrs, NN

Syllabus

1. Energy transport and grids
   - 1.1. Energy and power definition;
   - 1.2. Grid bounded transport: gas; heat; electricity
   - 1.3. Power analysis: sankey; efficiency; duration curves;
2. Distributed and centralized generation
   - 2.1. Transformation into renewable energy system
   - 2.2. Grid structure; distribution and transmission grid
   - 2.3. Components; power plants; storage, loads
   - 2.4. Grid integration; flexibility; cross energy management
   - 2.5. Economics: liberalized energy market; grid operation
   - 2.6. Demand Responce, micro grids
   - 2.7. Control and communication system: smart grid architecture models
3. System theory
   - 3.1. System modeling and simulation: application domains
   - 3.2. Linear and differential equations:
   - 3.3. Thermal-electric energy system simulation: examples
   - 3.4. Controls and Optimization of grid integrated energy systems
4. Grid theory
   - 4.1. DC and AC Circuit calculation;
   - 4.2. Transient and stationary power flow
   - 4.3. Grid integration: reactive and active power flow contol

Learning goals and qualifications

Students will learn to use the basics of designing grid integrated energy systems; fundamental aspects of power and energy definition, overview on plant and smart grid technologies, calculation and simulation of energy systems; fundamental aspects of power flow calculation and grid theory.

Recommended reading

Duffie and Beckman: Solar Engineering of Thermal Processes. ISBN: 978-0-470-87366-3
Volker Quaschning: Renewable Energy and Climate Change: ISBN 978-0-470-74707-0.
European SmartGrids technology platform: http://ec.europa.eu/research/energy/pdf/smartgrids_en.pdf
Smart Grid Communications and Networking; Ekram Hossain isbn: 9781107014138
Modelling and Analysis of Electric Power Systems: Göran Andersson:
http://www.eeh.ee.ethz.ch/uploads/tx_ethstudies/modelling_hs08_script_02.pdf

Course prerequisites: “Generation and Distribution of Energy”

Course			
M.Sc. Renewable Energy Engineering and Management			
Availability to other courses			**Instruction Language** English
Module No. **97002**	**Module name** **Energy Efficiency**		**Semester/return** 3rd Sem. / annual
Workload/presence 5 ECTS (150 h/60 h)	**Prerequisite module(s)**	**Follow-up module(s)** Elective II Energy Efficiency	**No. of participants** Max. 20
Teaching form Lectures, Exercises, Seminar, lab experiments	**Examination form** Lab Report, Assignments and Oral Presentation	**Start date** 07.01.2016	**Location** Uni Freiburg Room 103, University of Applied Sciences Offenburg

Module coordinator:

Prof. Dr. Leo Reindl (reindl@imtek.uni-freiburg.de)

Additional teaching staff

Prof. Elmar Bollin (bollin@hs-offenburg.de), Dr. Dipl.-Ing. Doreen Kalz (Doreen.kalz@ise.fraunhofer.de)

Syllabus

In this module the students will learn about general aspects of energy efficiency technologies in buildings.

The compact course is split in two parts:

- Building Automation
- Building and HVAC Concepts

In Part 1 of this module building automation will be introduced as an important tool to analyse building energy performance and to operate building technologies by means of advanced building automation tools like remote control and weather forecasting. Basics of control technics including PID Controller will be introduced.

At Hochschule Offenburg students will operate different trails on building automation for the case of an realistic sized air conditioning unit. By setting the controller students are forced to go in detail with Building Automation Technologies and discuss the energy saving potentials by optimization. In a written lab report the students will summarise their learning outcomes and present the trails result.

In Part 2 of this module, students are introduced to the design and analysis of concepts for heating, cooling and ventilation of buildings. First, students are introduced to national and international building codes and standards. The lecture will give an overview of energy consumption in buildings and building-related CO_2 emissions. Students will research the state-of-the art of buildings and their energy consumption, building codes and requirements on building design in their home country. Results are presented and discussed in class by a short presentation.

Second, fundamental heat transfer processes in buildings are described and quantified including conduction, convection, and radiation. The sensible and latent loads as well as the energy demand for heating, ventilating, and air-conditioning in buildings is calculated. The study includes the physical interaction of climate and buildings and the thermal comfort as well as indoor air quality requirements.

Third, different components and concepts for an energy efficient heating and cooling of buildings are introduced. In particular, focus is given to novel and sustainable concepts using environmental heat sources and sinks as well as renewable energy.

Students will carry out an individual case study using the simulation software Therakles. A typical non-residential building will be modelled and calculated considering the particular location of the building.

Learning goals and qualifications
Students will learn to use building automation to optimize building operation, to analyse structural plans of digital building control and to parameterize control cycles of systems for building services. Students are able to evaluate energy saving potentials in optimizations of HVAC systems for daily operation. Students know the existing building control technologies and their applications.
Recommended reading
Everything provided in lecture and lab
Course prerequisites

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97003</td><td colspan="2">Module name
Energy Informatics</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS (150 h/60 h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)</td><td>No. of participants
Max. 20</td></tr>
<tr><td>Teaching form
Lectures, Exercises, Seminar</td><td>Examination form
Assignments and Oral Presentation</td><td>Start date
25.01.2016</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinator:
Prof. Dr. Peter Thiemann (Thiemann@informatik.uni-freiburg.de)</td></tr>
<tr><td colspan="4">Additional teaching staff
Prof. Dr. Georg Lausen (lausen@informatik.uni-freiburg.de), Prof. Dr. Christian Schindelhauer (schindel@informatik.uni-freiburg.de), NN</td></tr>
<tr><td colspan="4">Syllabus
1. Networks
1.1. Smart grid
1.2. Topologies
1.3. Technologies
2. Distributed systems
2.1. Terminologies, concepts and problems
2.2. Modeling techniques
2.3. Game Theory
3. System design
3.1. Data modeling
3.2. Behavioral modeling
3.3. Interfaces
4. Security
4.1. Information flow control
4.2. Access control</td></tr>
<tr><td colspan="4">Learning goals and qualifications
Students will learn to use basic techniques for modelling and design of distributed systems in the application domain of energy systems. Students will be able to apply these techniques on basic examples. Students will be familiar with the underlying principles of tools for modelling and will know how to use them.</td></tr>
<tr><td colspan="4">Recommended reading
Everything provided in lecture</td></tr>
<tr><td colspan="4">Course prerequisites</td></tr>
</table>

Course			
M.Sc. Renewable Energy Engineering and Management			
Availability to other courses			**Instruction Language** English
Module No. **97010**	**Module name** **Photovoltaics 1**		**Semester/return** 3rd Sem. / annual
Workload/presence 5 ECTS (150 h/60 h)	**Prerequisite module(s)** Natural Resources and Conversion Technologies	**Follow-up module(s)** Photovoltaics 1	**No. of participants** Max. 20
Teaching form Lectures, Exercises, Seminar, lab experiments	**Examination form** Written exam	**Start date** 09.11.2015	**Location** t.b.a.

Module coordinator: Prof. Dr. Christof Wittwer

Additional teaching staff: Dr. Ralf Preu (ralf.preu@ise.fraunhofer.de)

Syllabus

In this module, fundamental concepts and a deeper understanding of photovoltaic technology are presented to the students

- Basics of semiconductor physics
- Photogeneration and recombination, carrier transport
- pn- Junction and IV-characteristics
- Silicon: Quartz, metallurgical silicon, crystallization, wafer cutting
- Industrial silicon solar cell production
- Module technology
- Cost of ownership
- Characterization of cells / material
- Loss mechanisms and improvements
- High efficiency cell concept

Learning goals and qualifications

As the first step in this course the student will get an overview about the basic concepts of semiconductors. This is the prerequisite for the understanding of the principles of solar cell physics which is one of the main topics of this course. Subsequently the student will study the whole production chain of silicon solar cells starting from quartz via solar cell production to module fabrication. This will be accompanied by an in-depth cost analysis of the solar cell production. The students will understand main loss mechanisms of silicon solar cells and the advantages of high-efficiency cell concepts

Recommended reading

1. B. Streetman, Solid State Electronic Devices
2. S.M. Sze, Physics of Semiconductor Devices
3. Martin A. Green, Solar Cells: Operating Principles, Technology, and System Applications
4. Peter Würfel, Physics of Solar Cells
5. Goetzberger, B. Voß, J. Knobloch, Crystalline Silicon Solar Cells: Technology and Systems Applications
6. Jenny Nelson, The Physics of Solar Cells

Course prerequisites

Basic knowledge of semiconductor physics, “Natural Resources and Conversion Technologies - Photovoltaics”

Course M.Sc. Renewable Energy Engineering and Management			
Availability to other courses			**Instruction Language** English
Module No. **97011**	**Module name** **Low Temperature Solar Thermal Energy**		**Semester/return** 3rd Sem. / annual
Workload/presence 5 ECTS (150 h/60 h)	**Prerequisite module(s)** Natural Resources and Conversion Technologies	**Follow-up module(s)** High Temperature Solar Thermal Energy	**No. of participants** Max. 20
Teaching form Lectures, Exercises, Seminar, lab experiments	**Examination form** Written exam	**Start date** 30.11.2015	**Location** t.b.a.
Module coordinator: Prof. Dr. Christof Wittwer			
Additional teaching staff: Dr. Werner Platzer, Dr. Peter Schossig, Dr. Andreas Georg, Dr. Korbinian Kramer, Doreen Kalz (t.b.d.)			

Syllabus

In this module the students will learn about low temperature solar thermal energy applications and combinations with energy efficiency measures in buildings. The module focuses on the use of solar in typical heating dominated climates like Central and Northern Europe:

- Solar availability on different part of the building envelope
- Demand profiles for domestic hot water, solar assisted heating, preheating of air
- Materials and coatings for glazings, absorbers (antireflex, low-emissivity, selectivity)
- Passive solar concepts and components (windows, transparent insulation)
- Design and performance of flat-plate and vacuum-tube collectors
- Special collector developments e.g. air-collectors, hybrid collectors
- Building physics of solar-active buildings
- Building integration concepts for solar thermal
- Hydraulics and design of collector fields (stagnation, flow-regimes, pressure drop, flow distribution)
- Thermal storage concepts (short term and seasonal storage, sensible, latent heat, sorption and chemical storage)
- Control issues for active solar systems
- System concepts, performance and economics for small and large solar thermal systems
- Market overview

Learning goals and qualifications

In this course, students will learn about the use of active and passive solar thermal systems, components used and specifications with respect to the application for heating water, air and buildings. They will learn temperature and efficiency limitations, how to improve thermal systems by specific material design and selection. System analysis with respect to storage concepts, hydraulic flow regimes and flow control will be intensified. Students will be able afterwards to design active and passive solar systems, perform simulations and assess the performance and economics of projects. The students should be able to understand the interrelations between system components know different system concepts and approximately calculate the solar gains of different systems.

Recommended reading

Duffie-Beckman: Solar Engineering of Thermal Processes
Volker Quaschning, Understanding Renewable Energy, Earthscan, 2005
Siegel, Howell, *Thermal Radiation Heat Transfer*, 4th ed., Taylor and Francis, New York, 2001.
Peuser FA, Remmers K, Schnauss M. Solar thermal systems. Beuth; 2010

Course prerequisites

“Natural Resources and Conversion Technologies - Solar Thermal Energy”

- Basic knowledge of solar thermal systems and solar radiation calculation
- Knowledge of heat transfer mechanisms (radiation, convection)
- Knowledge of thermodynamic cycles (heat pumps)

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97012</td><td colspan="2">Module name
Photovoltaics 2</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS (150 h/60 h)</td><td>Prerequisite module(s)
Photovoltaics 1</td><td>Follow-up module(s)</td><td>No. of participants
Max. 20</td></tr>
<tr><td>Teaching form
Exercises, Seminar</td><td>Examination form
Seminar Presentation, Report / Written exam</td><td>Start date
07.01.2016</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Christof Wittwer</td></tr>
<tr><td colspan="4">Additional teaching staff: Dr. Ralf Preu (ralf.preu@ise.fraunhofer.de)</td></tr>
<tr><td colspan="4">Syllabus
A seminar about specific topics of PV technology, systems and costs thereof (e.g. review of different approaches for the calculation of levelized cost of PV electricity or Review of PV Technology for industrial high efficiency solar cells). The three week course will be distributed into 3 phases.
1st week: topic collection, group definition (up to 5 groups min. 2 person per group), introduction to the topic by a tutor including distribution of literature and work within the group, study of literature, one additional appointment with tutor at the end of the week to discuss open points and structure of the presentation and report.
2nd week: preparation of final presentation, two-day seminar with presence requested by all, each individual member of a group has to give a sub-presentation.
3rd week: Groups will have to hand in a report on the review (max. 10 pages) at the beginning of the week. At the end of the week a short exam will be written on all presented topics.</td></tr>
<tr><td colspan="4">Learning goals and qualifications
Based on the knowledge acquired in Photovoltaics 1 this course will deepen the knowledge of the students in PV. Furthermore students will study group work and learn to review a scientific topic in a short given time.</td></tr>
<tr><td colspan="4">Recommended reading
See Photovoltaics 1 – specific literature will be distributed at the beginning of the course</td></tr>
<tr><td colspan="4">Course prerequisites
Successful participation in Photovoltaics 1.</td></tr>
</table>

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97013</td><td colspan="2">Module name
High Temperature Solar Thermal Energy</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS (150 h/60 h)</td><td>Prerequisite module(s)
Low Temperature Solar Thermal Energy</td><td>Follow-up module(s)</td><td>No. of participants
Max. 20</td></tr>
<tr><td>Teaching form
Lectures, Exercises, Seminar, lab experiments</td><td>Examination form
Written exam</td><td>Start date
25.01.2016</td><td>Location
Room 211</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Christof Wittwer</td></tr>
<tr><td colspan="4">Additional teaching staff: Dr. Werner Platzer, Dr. Peter Schossig, Dr. Andreas Georg, Dr. Thomas Fluri (t.b.d.)</td></tr>
</table>

Syllabus

In this module the students will learn about high-temperature solar thermal systems with respect to:
- Solar availability and demand profiles for solar thermal power, process heat and cooling
- Concentration of solar radiation
- Solar thermal conversion for temperatures above 100°C using non-concentrating and concentrating collectors
- Concentrating collector technologies (collector concepts, design, materials, manufacturing and assembly)
- Hydraulics and design of collector fields
- Heat-transfer fluids (steam/water, oil, molten salt, etc.)
- High-temperature thermal energy storage (TES) and its role in systems
- Integration of solar thermal heat into industrial processes
- Concentrated solar thermal power (CSP): Solar field concepts, system aspects
- Heat engines and thermodynamic cycles (Rankine, Organic Rankine etc.) in CSP
- Plant control and operation
- Combining of CSP with process steam generation, heating, cooling and desalination
- Project planning, financing and implementation for CSP and solar process heat
- Markets and prospects

Learning goals and qualifications

In this course, students will learn about high-temperature solar thermal systems, components used and specifications with respect to the application for process heat, cooling, climatization and electricity generation. Principles and different concentrating collector types shall be understood and the basic design features known. The conversion of solar radiation to high temperature heat with limitations and aspects will be taught. System analysis with respect to storage concepts, integration of auxiliary sources and flow control will be intensified. Students will learn how to design active solar systems for production of steam, hot fluids and electricity as end product. They will perform simulations and assess the performance and economics of projects. Especially the aspects of steam generation and molten salt technology will be detailed. The students will learn about the interrelations between system components, will get to know different system concepts and will calculate the solar gains of different systems with various methods.

Recommended reading

Duffie-Beckman: Solar Engineering of Thermal Processes.
Lovegrove, K., Stein, W. (Eds.): Concentrating solar Power Technology, Woodhead, 2012
Vogel W, Kalb H. Large-scale solar thermal power: Technologies, costs and development. Wiley-VCH Verlag & Co. KGaA; 2010.
Kreith F, Goswami DY. Handbook of energy efficiency and renewable energy. CRC Press; 2007.
Dinçer İ, Rosen M. Thermal energy storage systems and applications. New York: Wiley; 2002.

Course prerequisites

Content of the module “Natural Resources and Conversion Technologies”

- Basic knowledge of solar thermal systems and solar radiation calculation
- Knowledge of heat transfer mechanisms (radiation, convection)
- Thermodynamic properties of fluids
- Knowledge of thermodynamic cycles (heat engines)

It is recommended to participate in the module “Low Temperature Solar Thermal Energy”

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Engineering and Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
97020</td><td colspan="2">Module name
Energy communities</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150/60h)</td><td>Prerequisite module(s)</td><td>Follow-up module(s)</td><td>No. of participants
Max. 20</td></tr>
<tr><td>Teaching form
Case study teaching (reading, lectures, exercises, group work)</td><td>Examination form
Presentation (group work with individual parts),written report (group work)</td><td>Start date
09.11.2015</td><td>Location
Room 103</td></tr>
<tr><td colspan="4">Module coordinators: Sören Becker (soeren.becker@irs-net.de)</td></tr>
<tr><td colspan="4">Additional teaching staff:
Prof. Dr. Peter Schmuck (University of Göttingen), Tobias Haas (University of Tübingen), N.N.</td></tr>
</table>

Syllabus

Community energy and energy communities play an important role in political and scientific discussion on the transformation of the existing energy system. Strongly connected to the rise of decentralised renewable energy technologies, energy communities are worldwide portrayed as ensuring a better participation of citizens and as increasing the potential of villages, cities and regions to decide upon their own energy future. Meanwhile decentralised forms of organisations and businesses challenge the traditional lines of power in the energy sector. **This module will provide students with knowledge about different types of energy communities; an understanding of the processes how these communities and project are realized; and the crucial role socio-economic and other contextual factors play. An emphasis is put on how difficult circumstances and obstacles can be overcome by local solutions.** After a theoretical introduction, different exercises, and an excursion in the first week, students will research and interpret different case studies of energy communities in changing groups. A list of possible cases will be provided.

1st week
The first week will be focussed on questions and indicators to get a broad understanding of factors influencing the establishment and development of energy communities. A series of introductory lectures, readings and exercises will give an overview over the topic. Students will choose one research topic to deepen their own empirical research. Possible research topics may consist of the following:

- actors, political decision-making and policy contexts
- the confluence of technological solutions and social organisation
- economic actors, strategies and structures
- citizen participation and prospect for behaviour change

Friday: Excursion to energy community Schönau im Schwarzwald

2nd week
In week two students will prepare a group presentation that discusses one real-world case of energy communities. In this presentation, each student will focus on their specific research topic and question. Students will gain a detailed understanding how one specific energy community became established and obstacles were overcome. Material will be provided and will have to be complemented by own research. There will be two opportunities for consultation while groups are expected to work individually.

3rd week
The third week of the module is devoted to the final discussion. Each group will present their case-study in a marked presentation; afterwards the students will be regrouped according to their research topics. The aim is now to develop theses from the comparison of different cases and write a short comparative report (also graded).

Learning goals and qualifications

The main goals are:

1) to gain in-depth knowledge on different forms of energy communities, the contextual factors influencing their development and different social, technological, political and economic solutions

2) to structure acquired knowledge from interdisciplinary scientific sources

3) to integrate acquired knowledge in different groups with different aims and to enhance problem-solving competency

4) learn to abstract from the single case through basic skills in social science comparisons and to assess the limits and opportunities of different research methods

Recommended reading

Readings will be distributed during the course.

Sociotechnical transitions

Geels, Frank W. (2002): Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. In: Research Policy 31 (8-9), S. 1257–1274.

Rotmans, Jan; Kemp, René; van Asselt, Marjolein (2001): More evolution than revolution: transition management in public policy. In: Foresight 3 (1), S. 15–31. DOI: 10.1108/14636680110803003.

Shove, Elizabeth; Walker, Gordon (2007): CAUTION! Transitions ahead: politics, practice, and sustainable transition management. Commentary. In: Environment and Planning A 39 (4), S. 763–770. DOI: 10.1068/a39310.

Energy transitions

Kern, Florian; Smith, Adrian (2008): Restructuring energy systems for sustainability? Energy transition policy in the Netherlands. In: Energy Policy 36 (11), S. 4093–4103.

Schmid, Eva; Knopf, Brigitte; Pechan, Anna (2015): Who puts the German Energiewende into action? Characterizing arenas of change and implications for electricity infrastructure. http://eeg.tuwien.ac.at/eeg.tuwien.ac.at_pages/events/iewt/iewt2015/uploads/fullpaper/P_119_Schmid_Eva_30-Jan-2015_21:57.pdf

Verbong, Geert; Geels, Frank (2007): The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). In: Energy Policy 35 (2), S. 1025–1037.

Energy communities

Busch, Henner; McCormick, Kes (2014): Local power: exploring the motivations of mayors and key success factors for local municipalities to go 100% renewable energy. In: Energy, Sustainability and Society 4 (1), S. 5. DOI: 10.1186/2192-0567-4-5.

Rae, C.; Bradley, F. (2012): Energy autonomy in sustainable communities: a review of key issues. Renewable and Sustainable Energy Review 16, p. 6497–6506.

Hoppe, Thomas; Graf, Antonia; Warbroek, Beau; Lammers, Imke; Lepping, Isabella (2015): Local Governments supporting local energy initiatives: lessons from the best practices of Saerbeck (Germany) and Lochem (The Netherlands). In: Sustainability 7, S. 1900-1931. http://www.mdpi.com/2071-1050/7/2/1900

Success stories Karpenstein-Machan, M.; Schmuck, P.; Wilkens, I.; Wüste, A (2014): The power of a vision: pioneers and success stories of the regional energy transformation. Working Paper (German/ English). http://www.idee-regional.de/files/Kraft_der_Visionen_web_korr.pdf Ruppert-Winkel, C.; Hauber, J.; Aretz, A.; Funcke, S.; Kress, M.; Noz, S.; Salecki, S.; Schlager, P; Stablo, J.: Cooperative Local Energy Transitions. A Guide for Socially Just and Ecologically Sound Renewable Energy Self-Sufficiency - with an Emphasis on Bioenergy. ZEE Working Paper 06 – 2013.
Course prerequisites Basic research skills and interest in social science approaches.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93220</td><td colspan="2">Module name
Management II</td><td>Semester/return
2nd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60 h)</td><td>Prerequisite module(s)
--</td><td>Follow-up module(s)
Management II</td><td>No. of participants
max. 30</td></tr>
<tr><td>Teaching form
Lectures, Exercises, Seminar</td><td>Examination form
Seminar presentation, written exam</td><td>Start date
19.05.2014</td><td>Location
Room 103</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Marc Hanewinkel</td></tr>
<tr><td colspan="4">Teaching staff: Dr. Roderich von Detten (r.v.detten@ife.uni-freiburg.de)</td></tr>
</table>

Syllabus

1. Basics of economics
   1.1 Fundamental terms of economic activity
   (Allocation, distribution, division of labour, exchange, micro- and macroeconomic flow of goods and money).
   1.2 Typology of economic units
   (Households - firms - organisations in the so-called tertiary sector)
   1.3 Typology of economic systems
   - overview
   - focus: social and ecological committed market economy
   - normative underpinnings: efficiency, ecological sustainability, justice
   - coordination mechanisms: state - market – civil society
   1.4 About the interplay of the political and the economic system
2. Basics of management
   2.1 Overview: What is management about?
   2.2 Economical dimension – added value in firms (Business Simulation Game “TOPSIM”)
   2.3 Social dimension – the firm is an organisation
   2.4 Ecological consequences of commercial action
   2.5 Goals and decisions in the focus of entrepreneurial action
   2.6 Management cycle – planning, organisation, human resources, accounting, controlling
3. Project management
4. Strategic Management

Learning goals and qualifications

- ➢ Knowledge of fundamental economic concepts as a basis for the application of business instruments
- ➢ Ability to apply strategic management concepts
- ➢ Additional general skills: rhetoric, discussion and presentation skills, competence for team work

Recommended reading

There are several introductions to economy:

- e.g. for management: Cole, G. a. 2003. Management. Theory and Practice. 6th edition. Cengage Learning (UK).
- e.g. for economics: Parkin, M., Powell, M. and Matthews, K. 2003 Economics, 5th Edition, Harlow: Addison-Wesley

During the module materials will be made available via the learning platform ILIAS

Course prerequisites

None.

Course

M.Sc. Renewable Energy Engineering and Management

Availability to other courses			**Instruction Language**
---			English
Module No.	**Module name**		**Semester/return**
97022	**Landscape, Nature Protection, Landuse conflicts**		3rd Sem. / annual
Workload/presence	**Prerequisite module(s)**	**Follow-up module(s)**	**No. of participants**
5 ECTS-P (150/60h)			Max. 20
Teaching form	**Examination form**	**Start date**	**Location**
Project work	Project report and presentation	07.01.2016	Room 201

Module coordinator: Prof. Dr. Barbara Koch

Additional teaching staff: t.b.a.

Syllabus

Introduction to the significance renewable energy projects for environment and landscapes

An introduction to the interrelation of the renewable energy and the impact on environment how renewable energy strategies change landscapes. Students actively will identify practical examples to study the changes in environment and landscapes related to renewable energy projects and policies. An outline is given between the difference of Life Cycle Assessment (LCA) and Environmental Impact Assessment (EIA) what is the meaning of LCA compared to EIA.

How to assess the impacts and interdependencies with the environment.

The data needs and methods for performing an EIA, are described. The scheme of an EIA process is presented and discussed. Tools for data assessment and performing (GIS) the EIA introduced. They study a real case. They reflect the situation for the EIA implementation in reference to their home countries.

Case study

The students select a case from the renewable energy field for an EIA study. They collect data and information supported by the lecturer team. They perform a simplified EIA for one case. They present the result in the group and discuss the problems reflecting the situation in different regions of the world.

Learning goals and qualifications

Knowledge about environmental and landscape problems connected with renewable energy. Information about EIA and the EIA process. Students will be able to apply the tools for data assessment and EIA performance. They will reflect the problems on international basis.

Recommended reading

Calvert K., Pearce J.M., Mabee: Toward renewable energy geo-information infrastructures: Applications of GIScience and remote sensing that build institutional capacity, Renewable and Sustainable Energy Reviews, doi: 10.1016/j.rser.2012.10.024

Course prerequisites:

-

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93932</td><td colspan="2">Module name
Elective II - Bioenergy</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150 / 60h)</td><td>Prerequisite module(s)
Technology I,II</td><td>Follow-up module(s)
none</td><td>No. of participants
Max. 15</td></tr>
<tr><td>Teaching form
Lectures, excursions</td><td>Examination form
Written Exam</td><td>Start date
26.01.2015</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Dirk Jaeger</td></tr>
<tr><td colspan="4">Additional teaching staff: Dr. Sebastian Paczkowski (sebastian.paczkowski@foresteng.uni-freiburg.de)</td></tr>
</table>

Syllabus

The module focuses on the conversion of non-wood (agriculture) biomass as well as on their availability and suitability for different conversion technologies.

In a first step conversion technologies, which are mainly suitable for non-woody biomass, will be presented and discussed in detail. The chemical background and progress will be elaborated for the following conversion technologies:

- bio-gas from anaerobe digestion
- bio-oil from pressing and extraction
- bio-methanol from transesterfication
- bio-ethanol from alcoholic fermentation

Additionally new developments for fuel cell concepts based on bio-technology will be touched.

In a second step the question of biomass availability will be raisin. Therefore the cultivation and production technologies of energy crops (e.g. corn, miscanthus) in agriculture systems will be presented and discussed. Following this, the supply logistic chains, including harvesting and transportation will be presented on selected examples. Furthermore alternative organic resources (e.g. organic waste) will be in the focus of the lecture. In this context, concepts of an integrated organic waste management will be presented.

Excursion within the module will provide practical background information and give examples on some of these technologies.

A project work, reflecting and integrating the lecture content, will be part of the last week within the module. The project work will handle an actual topic, e.g. energy potential of different resources (organic waste vs. corn) for a certain region. Sustainability and energy efficiency will be compared for different conversion technologies / raw material options.

Learning goals and qualifications

The students will learn about the techniques of non-wood biomass conversion. They will be able to distinguish between the technologies by assessing the advantages and disadvantages.

Furthermore the students will learn about biomass on agricultural land systems. Techniques of cultivation, harvesting and logistics will be explained, so the students will be able to design a sustainable concept of using non-wood biomass.

The students will be able to make a critical analysis of profitability, efficiency and sustainability, reflecting biomass production and alternative purposes, including environmental side-effects.

The students will learn how to summarize essential information and to present them in written and oral form.

Recommended reading:

- Biomass and Agriculture , Sustainability, Markets and Policies (2004). 568 pp. ISBN: 9789264105546; OECD Code: 512004011E1.
- Guidelines for Life-Cycle Assessment: A "Code of Practice„ Consoli, F.; Allen, D.; Boustead, I.; Fava, J.; Franklin, W.; Jensen, A.; Oude, N.; Parrish, R.; Perriman, R.; Postlethwaite, D.; Quay, B.; Seguin, J.; Vigon, B. SETAC-Society of Environmental Toxicology and Chemistry, 1993.

Additional literature will be given within the module.

Course prerequisites

The students should bring the teaching contents of the modules “Technology I and II”.
Basic knowledge in statistics, economy and life cycle assessment are required.
The recommended reading gives a basic knowledge about the issues discussed in this part of the module.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93340</td><td colspan="2">Module name
Project</td><td>Semester/return
3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60h)</td><td>Prerequisite module(s)
Research Skills, Elective I</td><td>Follow-up module(s)
---</td><td>No. of participants
Max. 55</td></tr>
<tr><td>Teaching form
Seminar, self study, students presentation</td><td>Examination form
Written report</td><td>Start date
16.02.2015</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Stefan Baumgärtner</td></tr>
<tr><td colspan="4">Additional teaching staff: All lecturers of REM study programme</td></tr>
<tr><td colspan="4">Syllabus
• During REM study programme – especially the modules “internship”, “Elective I” and “Elective II” research related projects are being identified by the students and the associate professor.
• The goal of the module is that each student identifies the research topic of own interest. Using the knowledge acquired in the module “Research Skills”, each student should develop a research proposal that meets the standards for a master thesis proposal at ZEE.
• The proposal should describe at least the problem statement, research questions, literature review (state of the art), methodology, expected results, time and budget plan and a proposed table of content of the thesis.
Milestones:
• At the beginning: selection/identification of research topic
• Searching the supervisor (professor)
• At the end of the module: presentation of the proposal and project report</td></tr>
<tr><td colspan="4">Learning goals and qualifications
Students will
• get an introduction on how to work scientifically with an real world example
• deepen their knowledge in the specialisation chosen during Elective I and II (“Learning by doing”)
• learn to work in a team
• practice to manage a project</td></tr>
<tr><td colspan="4">Recommended reading
Information about recommended reading will be provided by supervising professor individually.</td></tr>
<tr><td colspan="4">Course prerequisites
Content of modules Research Skills and Elective I.</td></tr>
</table>

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93952</td><td colspan="2">Module name
Generation and Distribution of Energy</td><td>Semester/return
2nd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS/(100h/50h)</td><td>Prerequisite module(s)
Natural Resources and Conversion Technologies</td><td>Follow-up module(s)
Elective modules</td><td>No. of participants
Max. 55</td></tr>
<tr><td>Teaching form
Lectures, excursions, seminar, lab experiments</td><td>Examination form
Exam</td><td>Start date
04.04.2016</td><td>Location
t.b.a</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Leonard Reindl</td></tr>
<tr><td colspan="4">Additional teaching staff: Prof. Dr. Christof Wittwer</td></tr>
</table>

Syllabus

To understand the role of renewable energies for sustainable energy systems, it is essential to know how our today's electricity system actually works. In this module, today's energy systems are discussed from the energy production via the distribution of the electricity to the socket of the end user. This includes the technological view of energy production by classical power plants; transformation of energy and the different voltage levels, as well as the stabilisation of and the distribution by the electricity grid.

The distribution of renewable energy sources is discussed and the geographic information systems introduced. Geographical presentation and analyses of electricity networks in Geographical Information Systems (GIS) helps to understand current distribution grids and optimize planning for future demands. Basics in data formats, data bases, creation of data and modelling will be taught.

Learning goals and qualifications

The students acquired fundamental knowledge of today's electricity systems, which is essential to integrate renewable energy power supplies effectively in existing electricity systems in terms of technology, economics and sustainability. The students understand how electricity is distributed by the electricity grid and know what can be done to solve challenges in the system stability and the security of supply.

The students get hands on information on managing, analyses and presentation of data in electricity networks.

Recommended reading

- Relevant literature will be given to the student in advance and also presented in the module

Course prerequisites

Content of the module "Scientific Framework for REM" and "Natural Resources and Conversion Technologies".

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93220</td><td colspan="2">Module name
Management I</td><td>Semester/return
2nd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150h/60 h)</td><td>Prerequisite module(s)
--</td><td>Follow-up module(s)
Management II</td><td>No. of participants
max. 55</td></tr>
<tr><td>Teaching form
Lectures, Exercises, Seminar</td><td>Examination form
Seminar presentation, written exam</td><td>Start date
25.04.2016</td><td>Location
t.b.a</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Marc Hanewinkel</td></tr>
<tr><td colspan="4">Additional teaching staff: Dr. Roderich von Detten (r.v.detten@ife.uni-freiburg.de)</td></tr>
</table>

Syllabus

1. Basics of economics
   1.1 Fundamental terms of economic activity
   (Allocation, distribution, division of labour, exchange, micro- and macroeconomic flow of goods and money).
   1.2 Typology of economic units
   (Households - firms - organisations in the so-called tertiary sector)
   1.3 Typology of economic systems
   - overview
   - focus: social and ecological committed market economy
   - normative underpinnings: efficiency, ecological sustainability, justice
   - coordination mechanisms: state - market – civil society

   1.4 About the interplay of the political and the economic system
2. Basics of management
   2.1 Overview: What is management about?
   2.2 Economical dimension – added value in firms (Business Simulation "Factory")
   2.3 Social dimension – the firm is an organisation
   2.4 Ecological consequences of commercial action
   2.5 Goals and decisions in the focus of entrepreneurial action
   2.6 Management cycle – planning, organisation, human resources, accounting, controlling
3. Project management
4. Strategical Management

Learning goals and qualifications

- Knowledge of fundamental economic concepts as a basis for the application of business instruments
- Ability to apply strategic management concepts
- Additional general skills: rhetoric, discussion and presentation skills, competence for team work

Recommended reading

There are several introductions to economy:

- e.g. for management: Cole, G. a. 2003. Management. Theory and Practice. 6th edition. Cengage Learning (UK).
- e.g. for economics: Parkin, M., Powell, M. and Matthews, K. 2003 Economics, 5th Edition, Harlow: Addison-Wesley

During the module materials will be made available via the learning platform ILIAS

Course prerequisites

None.

Course M.Sc. Renewable Energy Management			
Availability to other courses ---			**Instruction Language** English
Module No. 93953	**Module name** **Society & Economy**		**Semester/return** 2^{nd} Sem. / annual
Workload/presence 5 ECTS-P (150/60h)	**Prerequisite module(s)** Management I, Climate & energy policy	**Follow-up module(s)** Management II	**No. of participants** max. 55
Teaching form Lectures, Exercises, Excursions, Seminar	**Examination form** Excursion Reports, Seminar presentation, Written Exam	**Start date** 23.05.2016	**Location** t.b.a
Module coordinator: Prof. Dr. Stefan Baumgärtner			
Additional teaching staff: Dr. Tanvir Hussain			

Syllabus

- Introduction to the economics of renewable energy management
  - Energy Markets: Competitive vs. Oligopolistic Markets
  - Environmental Economics: Externalities, Governmental Policies, and the Case of Global CO_2 Emissions
- The socio-cultural setting – consumer behaviour
- Levels of legal regulation – energy law, contract law
- Interdisciplinary conditions of societal development:
  - Society and responsible handling of environmental protection
  - Society and technological progress – innovations, diffusion, risk assessment of technologies, handling of environmental risks
  - Society and corporate social responsibility (CSR)
  - International political framework and conflict management
  - Economical behaviour in the so called tertiary sector.
  - Governance of modern societies

Learning goals and qualifications

Related to energy efficiency and renewable energy technologies:

- Understanding the working and failures of markets, especially with respect to energy provision and environmental effects
- Understanding the relations and interdependencies between different societal sectors
- Understanding the responsibilities and options
- Understanding the role and effects of company's behaviour on the society

Recommended reading

Different material will be provided on the learning platform ILIAS

Course prerequisites

Content of the modules "Management I" and "Climate and Energy Policy".

Course M.Sc. Renewable Energy Management			
Availability to other courses ---			**Instruction Language** English
Module No. 93320	**Module name** Research Skills		**Semester/return** 1st Sem. / annual
Workload/presence 5 ECTS-P (150h/60 h)	**Prerequisite module(s)** --	**Follow-up module(s)** ---	**No. of participants** max. 55
Teaching form Lecture/ group work	**Examination form** Poster presentation and paper submission	**Start date** 13.06.2016	**Location** t.b.a.
Module coordinator: Prof. Dr. Stefan Baumgärtner			
Additional teaching staff: Dr. Simone Ciuti, PD Dr. Dirk Schindler			

Syllabus

This module deals with the introduction of sciences and scientific methodology. There are no prerequisites required for this course.

In the first part of the module, students will be familiarized with the process of research including research strategy and cycle, literature review but also scientific misconducts and fraud. Students will get familiar with scientific citation and bibliography.

In the second part of the module, students will learn the main goals and methods of qualitative and quantitative research process. This part includes details about research design, data collection and data analysis.

At the end of the module, students will be prepared for scientific communication and scientific publications, such as writing papers, presenting posters, etc.

Learning goals and qualifications

- Students will be able to understand the main goals and common methods of qualitative and quantitative research (including empirical methods and statistics)
- Students will be able to develop meaningful research questions (hypothesis) and to design studies to evaluate their hypothesis (including research design, data collection and analysis)
- Students will be able to communicate their research results among scientific community via publications

Recommended reading

Curd, M. and Cover, J. A (1998): Philosophy of science - the central issue. W. W. Norton & Company, New York

McCaskill, M. K. (1998): Grammar, punctuation and capitalization: A handbook for technical writers and editors (NASA SP-7084). Langley Research Centre, Hampton, Virginia

Popper, Karl (2004): The logic of scientific discovery. London: Routledge-Classic

Strauss, A. and Corbin, J. (1990): Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications

Others: to be announced in class

Course prerequisites

None.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
93931</td><td colspan="2">Module name
Elective Bioenergy I</td><td>Semester/return
2nd Sem. / annual</td></tr>
<tr><td>Workload/presence
5 ECTS-P (150 / 60h)</td><td>Prerequisite module(s)
Scientific Framework for REM, Natural Resources and Conversion</td><td>Follow-up module(s)
Elective II</td><td>No. of participants
Max. 25</td></tr>
<tr><td>Teaching form
Lectures, excursions</td><td>Examination form
Written Exam</td><td>Start date
04.07.2016</td><td>Location
T.b.a.</td></tr>
<tr><td colspan="4">Module coordinator: Prof. Dr. Dirk Jaeger</td></tr>
<tr><td colspan="4">Additional teaching staff: Dr. Sebastian Paczkowski (sebastian.paczkowski@foresteng.uni-freiburg.de)</td></tr>
<tr><td colspan="4">Syllabus
The module will introduce into the most relevant energy conversion technologies related to wood biomass. Furthermore the important aspects of raw material procurement (production, harvesting, logistic) will be explained. Cross-dependency to alternative uses of wood (industrial processing) will be distinguished. It starts with detailed presentation of the principal conversion processes
- pyrolysis
- technical gasification
- combustion
Specifications of these processes are going to lead to different kind of energy products (solid, liquid or gas). These primary energies may be used direct or further processed into added value energy products. Within the lecture the production of synthetic fuels (BtL) and High Temperature Carbonisation (HTC) will be presented. Advantages and disadvantages of these processes will be discussed in terms of technology, products, energy efficiency and biomass resources. Lectures will also give attention to the production and characteristics of pellets.
To understand and evaluate the material base for the wood based bioenergy processes, biomass potentials from forests, saw mill residues and short rotation coppice (SRC) will be assessed. Also production potentials of biomass forest plantations will be part of the lecture. The topic of harvesting and supply concepts will be touched as well.
Excursion within the module will give practical background information and present examples of these technologies.
A case study, which deals with actual topics -- e.g. economic and energy efficient production of pellets from SRC; energy concepts for an integrated energy supply -- will be part of the third week of the module.</td></tr>
</table>

Learning goals and qualifications

The students will achieve basic knowledge about conversion processes and technologies of woody biomass. They will be able to assess different technologies by knowing the advantages and disadvantages.

Furthermore the students will learn to assess the potentials of woody biomass supply and the production of intermediate products like wood chips and pellets. Based on the knowledge from the production side, the supply systems and knowing the principals of the conversion processes, the students will be able to analyse, evaluate and develop suitable, regional and sustainable wood energy concepts. They will be able to understand competition and integration between energy products (heat, power, fuel) and industrial wood based materials from the economic and ecologic point of view.

The students will learn how to summarize essential information and to present them in written and oral form.

Recommended reading

- Richardson, J.. Bioenergy from sustainable forestry: guiding principles and practice: Kluwer Academic, 2002. 344 S.
- Brenes, MD. Biomass And Bioenergy: New Research (2006): Chapter 2. Nova Science Pub Inc.
- Klugman,S.; Karlsson,M. and Moshfegh,K. (2007): A Scandinavian chemical wood-pulp mill. Part 2. International and model mills comparison. Applied Energy, Volume 84, Issue 3, Pages 340-350.

Additional literature will be given within the module.

Course prerequisites

The students should have joined the modules “Natural Resources”, “Technology of renewable energy Management” and “Societal Framework”.
The students should have basic knowledge in plant genetics to understand the mechanisms of genetic improvement of trees used in short rotation plantation for bio-energy. Also basic knowledge in biotic and abiotic risk management in forests and forest plantations is required.
For understanding the part of terrestrial and remote sensing inventory of semi-natural and planted forests as well as production modelling basic knowledge in descriptive and applied statistics are required.
For the case study the basic principles of energy cycles of wood processing industries are required. The readings recommended give a basic overview about the required knowledge in the module.

Course M.Sc. Renewable Energy Management			
Availability to other courses ----			**Instruction Language** English
Module No. **93933**	**Module name** **Elective Wind energy**		**Semester/return** 3rd Sem. / annual
Workload/presence 5 ECTS-P (150h/60h)	**Prerequisite module(s)** Elective I	**Follow-up module(s)** ---	**No. of participants** Max. 45
Teaching form Lectures, Excursion	**Examination form** Written exam	**Start date** 04.07.2016	**Location** t.b.a.
Module coordinator: Prof. Dr. Mario Ragwitz			
Additional teaching staff: Dr. Marian Klobasa, Daniel Kowalski, Dr. Martin Pudlik			

Syllabus

The Wind Energy module will give the students a brief but thorough introduction to the science and technology of wind turbines and utilization of wind energy for power generation.
The module will be structured into the following components:

- Introduction and motivation: Development of wind energy in Europe and globally
- Consolidating basic knowledge of wind energy technology already provided in module “Technology II”
- Potential assessment and geo-modeling of sites including environmental aspects
- Economics of wind power and wind energy project development
- Integration of wind power into the electricity system
- Policy design for the future development of wind energy

The first component will present the past and present status of wind energy and its contribution to the overall energy mix, introduce recent economic and technical developments and challenges of wind energy, main drivers and barriers as well as future scenarios of wind energy development.

The second component will review the fundamentals of wind and wind harvesting incl. the stochastic nature of the wind and the statistic parameters, the aerodynamics of wind turbines and the technological characterisation of wind turbines / system components. This will include statistical tools used to describe the wind (Weibull, etc.), the physics of a wind turbine including the Betz limit, the aerodynamics of turbine blades and the mechanics of wind turbines and turbine types (power curve, capacity factor, stall vs. pitch wind turbines, direct drive vs. geared turbine).

The third component will start with an introduction to geographical information systems (GIS) to allow the presentation of techniques of geo-modelling of wind sites and GIS-based assessment of wind potentials. This will include the consideration of environmental constraints of wind park planning.

The fourth component will cover the practical realisation and economics of wind power projects. From a project developers perspective the following aspects will be presented:

- Acquisition of a project, technical project management, wind park planning
- Due Diligence of the entire project
- Financial Issues/Business Models

The fifth component concentrates on the integration of wind energy in the energy system based on the challenges of fluctuating electricity generation It contains key approaches to facilitate system and grid integration of wind energy incl. network expansion requirements as well as strategies for increasing the flexibility of the power system.

The final component will present best practices of policy design for wind energy in the context of different energy economic framework conditions incl. approached for improved market introduction of wind energy.

If possible the Wind Energy Module will also include a field trip to a local wind turbine in Baden-Württemberg.

The lessons learned from the module components will be utilized by the students in the final project.

Learning goals and qualifications

- Knowledge on main drivers and barriers for wind energy development in the EU and globally
- Understanding of the stochastic nature of the wind and the statistic parameters used to summarize the wind.
- Introduction to the physics and mechanics of wind power and the physical limits.
- Basic understanding of the various turbine typologies and economic reasoning behind the types.
- Understanding the methodology of GIS based assessment of wind energy potentials
- Fundamental understanding of the issues involved with wind park planning, including the necessity to understand local conditions, including social/political/environmental issues.
- Knowledge on the practical realization of wind projects from a technical and economic perspective
- Basic understanding of approaches to system and market integration of wind energy
- Insights into the design of effective and economically efficient policies for wind energy
- Additional general skills: rhetoric, discussion and presentation skills, capacity for team work

Recommended reading (*available at www.ub.uni-freiburg.de)

Wind Energy – the Facts: Technology, Economics, grid integration, industry and markets and environmental issues of wind power **(http://www.wind-energy-the-facts.org/)**

Wind energy explained* : theory, design and application / J. F. Manwell and J. G. McGowan ; A. L. Rogers. - 2. ed.. - Chichester : Wiley, 2009

Wind turbines* : fundamentals, technologies, application, economics; Erich Hau. - 2. ed.. - Berlin ; Heidelberg [u.a.] : Springer, 2006

Wind Energy Handbook – Burton et al.

Wind Power Plants: Fundamentals, Design, Construction and Operation– Gasch, Twele

http://windpower.org/en/

Course prerequisites

None.

<table>
<tr><td colspan="4">Course
M.Sc. Renewable Energy Management</td></tr>
<tr><td colspan="3">Availability to other courses
---</td><td>Instruction Language
English</td></tr>
<tr><td>Module No.
6900</td><td colspan="2">Module name
Internship (Praktikum)</td><td>Semester/return
2nd - 3rd Sem. / annual</td></tr>
<tr><td>Workload/presence
10 ECTS-P (300 h)</td><td>Prerequisite module(s)
---</td><td>Follow-up module(s)
---</td><td>No. of participants
max. 55</td></tr>
<tr><td>Teaching form
Practical work</td><td>Examination form
Written report</td><td>Start date
25.07.2016</td><td>Location
t.b.a.</td></tr>
<tr><td colspan="4">Module coordinators: Prof. Dr. Stefan Baumgärtner</td></tr>
<tr><td colspan="4">Additional teaching staff
Academic experts of the respective internship institution</td></tr>
<tr><td colspan="4">Syllabus
The MSc. programmes at the Faculty of Environment and Natural Resources Freiburg as a rule include a practical training in accordance with the examination regulations for the degree programme Master of Science. The practical training is completed in institutions and companies outside the faculty or in research departments of the ZEE and his partners.
Possible internship providers include:
▪ Renewable energy and power supply companies
▪ Planning and Engineering companies
▪ Consultancy and information services (energy agencies, technology transfer institutions) and public relation
▪ Science and research dealing with renewable energies
▪ Financing and Investment companies specialising in financing environmental projects, as well as investment and development banks</td></tr>
<tr><td colspan="4">Learning goals and qualifications
The internship should provide students with a first insight into potential employment sectors; in all sectors this is primarily achieved by practical work. Apart from gaining an overview of the subject, students should experience typical work processes and the human interactions in an organization. The assigned work should give students an idea of the daily work procedure at their workplace (‘everyday life experiences’). Additionally, students should become familiar with the structures within the institution, as well as the interconnections with external systems.
Furthermore, the expert knowledge gained in the course of the studies should be intensified and to a certain degree, applied during the practical training.</td></tr>
<tr><td colspan="4">Recommended reading
To be suggested individually by coordinator and internship institution</td></tr>
<tr><td colspan="4">Course prerequisites
None.</td></tr>
</table>