HOCHSCHULE NORDHAUSEN
University of Applied Sciences

Modulkatalog des Masterstudiengangs

Renewable Energy Systems

Inhalt

Stand: 23.03.2018

1. Modulübersicht

Modularten:

P Pflichtmodul

WP Wahlpflichtmodul

Nr.	Modulbezeichnung	verantwortlich	Modulart
851	Wind Power Plants	Link	P
852	Photovoltaic Systems	Wesselak	P
854	Bioenergy Systems I - Solid Biomass	Fischer	P
855	Bioenergy Systems II - Biogas and Liquid Biofuels	Fischer	P
856	Life Cycle Analysis of Renewable Energy Systems	Fischer	P
857	1st Scientific Project	Fischer	P
858	2nd Scientific Project	Fischer	P
859	Solar Thermal Laboratory	Leibbrandt	P
860	Master Thesis Module Renewable Energy Systems	Fischer	P
861	Ocean energy and Hydropower	Fischer	WP
862	Renewable Energies in Rural Areas	Fischer	WP
863	Fuel cell technologies	Fischer	WP
864	Bioengineering	Breuer	WP
866	Climate Change	Fischer	WP
867	Numerical Methods in Heat and Mass Transfer	Leibbrandt	WP
910	Deutsch als Fremdsprache	Marx-Tilp	P

Studienverlaufsplan Renewable Energy Systems (M. Eng.)

Semester**W**ochen**S**tunden
Vorlesung oder Seminar/**Ü**bung/**Pr**aktikum oder Projektarbeit
Credit **P**oints
Prüfungs**A**rt: P = Prüfungsleistung / V = Prüfungsvorleistung / S = Studienleistung

Pflichtbereich

1. Semester (Spring Semester)	**SWS** V/Ü/Pr	**CP**	**PA**	**2. Semester** (Autumn Semester)	**SWS** V/Ü/Pr	**CP**	**PA**
Bioenergy Systems I **(854)** Solid Biomass	4/0/0	5	P	Bioenergy Systems II **(855)** Biogas and Liquid Biofuels	4/0/0	5	P
Photovoltaic Systems **(852)**	4/0/0	5	P	Solar Thermal Lab **(859)**	2/0/2	5	P
Wind Power Plants **(851)**	3/0/1	5	P	Lifecycle Analysis of Renewable Energy Systems **(856)**	4/0/0	5	P
1st Scientific Project **(857)**	0/0/4	5	P	2nd Scientific Project **(858)**	0/0/8	10	P
Deutsch als Fremdsprache **(910)**	0/0/4	5	P				
Obligatory Elective Course	4	5	P	Obligatory Elective Course	4	5	P
Summe	**24**	**30**			**24**	**30**	

3. Semester (Spring Semester)	**CP**
Masterthesis **(860**A**)**	26
Presentation and Defence **(860**B**)**	4
Summe	**30**

Obligatory Elective Courses / Wahlpflichtfächer

	SWS V/Ü/Pr	**CP**	**PA**
Renewable Energies in Rural Areas **(862)**	4/0/0	5	P
Bioengineering **(864)**	4/0/0	5	P
Climate Change **(866)**	4/0/0	5	P
Ocean Energy and Hydropower **(861)**	4/0/0	5	P
Numerical Methods in Heat and MassTransfer **(867)**	2/2/0	5	P
Fuel Cell Technologies **(863)**	4/0/0	5	P

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		851		Mandatory module
Module name		**Wind Power Plants**		
Module coordinator		Prof. Dr.-Ing. Thomas Link		
Title		Wind Power Plants		
Title of examination		Wind Power Plants		
Semester		1		
Course type	Language	Lecture		English
SWS/ ECTS/ Workload		3 V / 1 P	5	150
Requirements for attendance		No		

1. Content and objectives

Content:

- Classification of Wind Turbines
- Aerodynamics of Wind Turbines
- Betz's Theory and Schmitz's Design rules
- Aerodynamic of the Darrieus Turbine
- Control of Wind Turbines
- Wind Turbine Design
- Wind Characteristics and Resources
- Hands-on-Training with an Aero-Elastic-Code

Learning goals:

The participants know the fundamental physical procedures that are vital for the usage of wind energy. They can use lift diagrams and calculate lift and resistance for given diagrams. The students are able to evaluate the optimal shapes for predefined profiles using Betz's law and determine efficiency and the power coefficient of wind turbines under idealized conditions. They are familiar with the different regulation concepts used in wind energy systems and are able to show the constructive peculiarities of the installations. The students know the advantages and disadvantages of applied construction variants of wind turbines. They are able to work with probability density functions and capable of calculating wind velocity for given roughness lengths to then estimate the power output of wind turbines using power curves.

Due to their internship, the participants are able to utilize the basic functions of the software Bladed. They can design a wind turbine with predefined features and select different design options using Bladed.

2. Method(s) of instruction

3 SWS Lecture and 1 SWS practical training.

3. Requirements for attendance

There are no formal requirements for participation. A successful degree in the module of fluid dynamics is recommended.

Literature:

[1] R. Gasch, J. Twele, Wind Power Plants, Springer, 2012

[2] J.-P. Molly, Windenergie: Theorie, Anwendung, Messung, Verlag C. F. Müller, 1990

[3] E. Hau, Wind Turbines, Springer, 2006

[4] J. F. Manwell, et. al., Wind Energy Explained: Theory, Design and Application, Wiley, 2009

4. Usability of this module

The module is offered as mandatory module in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

Requirement for earning credit points is a test performance rated at least „sufficient“ in the module exam (written exam, 90 min) and a completed internship as a prerequisite.

6. ECTS credits

The grade corresponds to the grading of the exam. When completing the unit successfully, students are granted 5 credit points (ECTS).

7. Frequency of offer

The module is lectured in the spring semester

8. Work load

The workload consists of visiting lectures (33,75 h), participation in the presence internship (11,25 h), preparation and debriefing of the subject matters (45 h), processing of internship tasks (30 h) as well as preparation of the written exam (30 h). The total workload amounts to 150 h which corresponds to 5 ECTS.
9. Duration of module
The module is lectured in one semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		852		Mandatory module
Module name		**Photovoltaic Systems**		
Module coordinator		Prof. Dr.-Ing. Viktor Wesselak		
Title		Photovoltaic Systems		
Title of examination		Photovoltaic Systems		
Semester		1		
Course type	Language	Lecture		English
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Content:

The students should achieve consolidated knowledge about installation, dimensioning and application of photovoltaic systems. In addition, the students get a profound introduction to the physics of solar cells.

1. Introduction

History of photovoltaics - current trends and actors

2. Basics

Introduction to semiconductor theory - generation and recombination processes - the solar cell as a p-n junction - modelling a real solar cell - thermodynamics of solar energy conversion

3. Technology

Production process for silicon solar cells - production process for thin-film solar cells – measuring in photovoltaics

4. System technology

From the single solar cell to a solar generator – control of solar generators - operation of grid-connected photovoltaic systems - operation of off-grid photovoltaic systems

5. System design

Irradiation analysis - shading effects - mounting and interconnection - converters – grid connection – energy yield forecast - operation and maintenance of photovoltaic systems - economics

Learning goals:

After successfully completing the module, the students have a deeper knowledge about solar cells as a semiconductor. They confidently deal with cell and module characteristics and use them, for example, to understand phenomena in interconnecting single modules to generators. Furthermore, the students are able to plan a photovoltaic system using standard design software and estimate the energy yield.

2. Method(s) of instruction

The module consists of two courses: Contents 1 to 4 are taught in a lecture with integrated exercises and active involvement of the students. Content 5 will be held as a separate lecture with a high fraction of practical and computer-based exercises.

3. Requirements for attendance

No course specific requirements

Literature:

[1] Wesselak/Voswinckel: Photovoltaik, Springer 2016 (introducing – only in german)

[2] Luque/Hegedus: Handbook of Photovoltaic Science and Engineering, Wiley, Chichester, 2011 (deepening)

[3] Würfel: Physics of Solar Cells, Wiley, Chichester, 2009 (deepening)

4. Usability of this module

The module is offered as mandatory module in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

Assessment is performed either as written (60 minutes) or oral examination

6. ECTS credits

5 ECTS credits

7. Frequency of offer

The module is lectured in the spring semester

8. Work load

The total workload for this module is 150 hours; this corresponds to 5 ECTS credits. This workload results from the presence at the lectures with an active participation of the students (about 45 hours). As part of the self-study, the lecture material should be reworked and discrete computer exercises should be carried out (about 75 hours). The preparation and execution of the examination is about. 30 hours.
9. Duration of module
The module is lectured in one semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		854		Mandatory module
Module name		**Bioenergy Systems I - Solid Biomass**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Bioenergy Systems I - Solid Biomass		
Title of examination		Bioenergy Systems I - Solid Biomass		
Semester		1		
Course type	Language	Lecture with excursion	English	
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

The objective of this course is to understand state of-the-art technologies for thermal biomass conversion. Based on the properties of different biofuels and the fundamentals of thermal conversion processes the course covers conversion processes as combustion, gasification, torrefaction and pyrolysis. Furthermore, emissions from thermal biomass conversion are addressed; methods for their reduction are explained. Additionally, economical aspects of solid biofuel systems are covered.

Module content:

- Biomass for thermal processes: origins and properties
- Fundamentals of thermal biomass conversion processes
- Combustion of biomass: technologies
- Gaseous and particulate emissions: formation processes and abatement technologies
- Power generation from solid biomass, technologies and plant layout
- Synthesis gas production: Biomass gasification
- Mastering the tar problem in biomass synthesis gas
- Pyrolysis and torrefaction: additional pathways for solid biomass conversion
- Hydrothermal conversion processes
- Economical aspects of thermal bioenergy conversion processes

On-line Lecture notes and training material will be available.

Recommended Literature:

John Love (Editor): Biofuels and Bioenergy , Wiley Blackwell 2017

Andreas Hornung: Transformation of Biomass: Theory to Practice, Wiley, 2014

Learning goals:

Students acquire competent knowledge in modern technologies of thermal biomass conversion.

In addition to fundamental knowledge of the physical and chemical properties, students are familiar with the formation of gaseous emissions and particulate matter and their abatement. Students are enabled to recognize and evaluate the application and limitations of solid biomass technologies compared to conventional technologies and to draw appropriate conclusions considering technical and economic aspects.

2. Method(s) of instruction

Lecture in combination with an excursion to a biomass- CHP - plant

3. Requirements for attendance

No course specific requirements

4. Usability of this module

The module is offered as mandatory course in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

- Participation in the the integrated excursion is mandatory
- Assessment is performed either as written examination (90 minutes) or oral examination
- Students need to pass the module examination, which encompasses all contents of the lecture.

6. ECTS credits

- 5 ECTS credits
7. Frequency of offer
- Annually in the spring semester.
8. Work load
150 h of total work load, therefrom - 80 h of presence at lectures - 40 h of self-study - 30 h preparation for examination
9. Duration of module
1 semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		855		Mandatory module
Module name		**Bioenergy Systems II - Biogas and Liquid Biofuels**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Bioenergy Systems II - Biogas and Liquid Biofuels		
Title of examination		Bioenergy Systems II - Biogas and Liquid Biofuels		
Semester		2		
Course type	Language	Lecture with excursion	English	
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

This lecture deals with technologies for biogas generation and utilization and conversion processes for liquid biofuels.

Module content:

BIOGAS

- Microbiological fundamentals of anaerobic digestion
- Biogas substrates: handling and gas yields
- Components of biogas plants
- Plant layout
- Utilization of Biogas: decentralized heat and power generation
- Processing of biogas: biomethane and biogas liquefaction

LIQUID BIOFUELS

- First generation Biofuels: Processes for Biodiesel and Bioethanol production- technologies, raw materials and costs
- Application of first generation biofuels in combustion engines
- Second generation Biofuels: Cellulosic Ethanol and synthetic biofuels conversion technologies, technical challenges, costs
- Application of second generation biofuels in combustion engines
- Third generation Biofuels: biofuels from algae

On-line Lecture notes and training material will be available.

Recommended Literature:

John Love (Editor): Biofuels and Bioenergy , Wiley Blackwell 2017

Arthur Wellinger, Jerry D. Murphy: Biogas Handbook , Woodhead Publishing Series in Energy, 2013

Ram Sarup Singh, Ashok Pandey (Editors): Biofuels: Production and Future Perspectives, Taylor & Francis Inc, 2016

Learning goals:

After attending the lecture, students have a competent knowledge in modern technologies of biogas generation and biofuel production. They know various conversion pathways and application of biogas and biofuels in different markets. They can identify and apply the appropriate technology for different situations. In addition, they are able to assess critically the limitations of these bioenergy systems from a technical and economic viewpoint.

2. Method(s) of instruction

Lecture in combination with an excursion to a biogas plant

3. Requirements for attendance

No Course specific requirements. However, knowledge on bioenergy systems as addressed in the module Bioenergy Systems I is advantageous.

4. Usability of this module

The module is offered as mandatory module in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

Participation in the integrated excursion is mandatory. - Assessment is performed either as written examination (90 minutes) or oral examination - Students need to pass the module examination, which encompasses all contents of the lecture.
6. ECTS credits
- 5 ECTS credits
7. Frequency of offer
- Annually in the autumn semester
8. Work load
150 h of total work load, therefrom - 80 h of presence at lectures - 40 h of self-study - 30 h preparation for examination
9. Duration of module
1 semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		856		Mandatory module
Module name		**Life Cycle Analysis of Renewable Energy Systems**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Life Cycle Analysis of Renewable Energy Systems		
Title of examination		Life Cycle Analysis of Renewable Energy Systems		
Semester		2		
Course type	Language	Lecture including exercises	English	
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

This lecture deals with the methodological basics and application of various environmental assessment tools in the field of renewable energy systems

Module contents:

- Introduction to Sustainability Concepts and Life Cycle Analysis
- Methods: material flow analysis, risk assessment, carbon footprint and life cycle assessment
- Risk and Life Cycle Framework for sustainable energy systems (Introduction, Risk, Environmental Risk Assessment)
- Overview of LCA Methodology - Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools - UMBERTO)
- Life Cycle Assessment – Detailed Methodology and ISO Framework
- Life Cycle Inventory and Impact Assessments (Unit Processes and System Boundary, Data Quality, Procedure for Life Cycle Impact Assessment, LCIA in Practice with Examples, Interpretation of LCIA Results)
- Case Studies

On-line Lecture notes and training material will be made available.

Recommended Literature:

Michael Z. Hauschild, Ralph K. Rosenbaum, Stig Irving Olsen: Life Cycle Assessment: Theory and Practice, Cham: Springer International Publishing, 2018.

Learning goals:

After attending the lecture, students know environmental assessment tools, such as material flow analysis, risk assessment, and life cycle assessment. They can identify and apply the appropriate tool in a given situation. In addition, they are able to assess critically existing studies. They understand the general background of the methods as well as the basics of the corresponding tools. Furthermore, they also have knowledge on the limitations of the methods.

2. Method(s) of instruction

Interactive lecture in combination with exercises, using the LCA software UMBERTO.

3. Requirements for attendance

No Course specific requirements

4. Usability of this module

The module is offered as mandatory course in the master study course „Renewable Energy Systems“ (M.Eng.) as well as elective course in the master course „Energiesysteme“ (M. Eng.).

5. Requirements for assessment

Assessment is performed either as written examination (90 minutes) or oral examination. Students need to pass the module examination, which encompasses all contents of the lecture.

6. ECTS credits

- 5 ECTS credits

7. Frequency of offer

- Annually in the autumn semester

8. Work load

150 h of total work load, therefrom - 80 h of presence at lectures/exercises - 40 h of self-study - 30 h preparation for examination
9. Duration of module
1 semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		857		Mandatory module
Module name		**1st Scientific Project**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Scientific Project I		
Title of examination		Scientific Project I		
Semester		1		
Course type	Language	Project		English
SWS/ ECTS/ Workload		4 P	5	150
Requirements for attendance		No		

1. Content and objectives

Content:

In the first semester, the students should complete a project in a small group, which runs over the entire semester. The topics of the project are a complex assignment out of renewable energy engineering. Subject are combined photovoltaic and wind power plants, combined heat and power facilities or decentralized energy systems for example.
The project work is done in small groups of 3 – 5 students and concludes with an oral presentation of the project results and a written project documentation. In order to take the system approach of renewable energies into account, at least two professors from different fields should offer and organize a project topic.

Learning goals:

The students should learn within a small team to structure complex tasks, define reasonable work packages and to process them in a limited time. Periodical milestone discussions with the supervising lecturers help the project team and the individual student to complete the task in an efficient and goal-oriented manner. The final documentation and presentation of the project results prepares the prospective Master of Engineering for a project-oriented work in industry and economy.

2. Method(s) of instruction

Project work

3. Requirements for attendance

No course specific requirements

4. Usability of this module

The module is offered as mandatory module in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

Assessment is performed with the submission and presentation of the project; both will be graded.

6. ECTS credits

5 ECTS credits

7. Frequency of offer

The module is lectured in the spring semester

8. Work load

The total workload for this module is 150 hours; this corresponds to 5 ECTS credits. This workload results mainly from the independent and self-responsible handling of the project (100 hours), the participation in the milestone meetings (20 hours) as well as from the preparation of the final report and presentation (30 hours).

9. Duration of module

The module is lectured in one semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		858		Mandatory module
Module name		**2nd Scientific Project**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Scientific Project II		
Title of examination		Scientific Project II		
Semester		2		
Course type	Language	Project		English
SWS/ ECTS/ Workload		8 P	10	300
Requirements for attendance		successful completion of Module 857 – 1st Scientific Project		

1. Content and objectives

Content:

In the second semester, the students in this course should complete one scientific project, which runs over the entire semester. The topic of the project is a complex assignment out of renewable energy engineering. Subject are the design of a district energy system, combined heat and power facilities or the simulation of a power plant for example.
The project work is done in groups of 10 - 15 students and concludes with an oral presentation of the project results and a written project documentation. In order to take the system approach of renewable energies into account, at least two professors from different fields should offer and organize the project topic.

Learning goals:

The students should learn within a team to structure complex tasks, define reasonable work packages and to process them in a limited time. Periodical milestone discussions with the supervising lecturers help the project team and the individual student to complete the task in an efficient and goal-oriented manner.
The final documentation and presentation of the project results prepares the prospective Master of Engineering for a project-oriented work in industry and economy.

2. Method(s) of instruction

Project work

3. Requirements for attendance

Successful completion of the module 857 – „1st Scientific Project“

4. Usability of this module

The module is offered as mandatory module in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

Assessment is performed with the submission and presentation of the project; both will be graded.

6. ECTS credits

10 ECTS credits

7. Frequency of offer

The module is annually lectured in the autumn semester

8. Work load

The total workload for this module is 300 hours; this corresponds to 10 ECTS credits. This workload results mainly from the independent and self-responsible handling of the project (220 hours), the participation in the milestone meetings (40 hours) as well as from the preparation of the final report and presentation (40 hours).

9. Duration of module

The module is lectured in one semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		859		Mandatory module
Module name		**Solar Thermal Laboratory**		
Module coordinator		Pascal Leibbrandt, M.Eng.		
Title		Solar Thermal Laboratory		
Title of examination		Solar Thermal Laboratory		
Semester		2		
Course type	Language	Tutorial/Laboratory		English
SWS/ ECTS/ Workload		4 P	5	150
Requirements for attendance		none		

1. Content and objectives

Content:

1. Solar collectors, components and systems
   - Collector types, characteristics
   - Collector loop, operating mode
   - Heat storage, heat exchanger, controls
2. System design, economics
   - System types, characteristics
   - Solar heat costs, economics
3. Laboratory experiments
   - Pump hydraulics and pressure drop
   - Collector test (QDT)
   - Collector front glazing
4. Current research

Learning goals:

The students have knowledge about the various solar thermal collector types, design and function. They can dimension various solar loop types and design them using typical key figures. The economic viability of the investments and the basics of investment calculation is known to the students. By using typical and standardizes test methods (test rig design, data acquisition and evaluation) the students are able to test solar collectors and solar loop components in laboratory.

2. Method(s) of instruction

The module consists of a lecture with integrated exercises and an active involvement of the students in the laboratory.

3. Requirements for attendance

There are no formal requirements for participation. Basics in physics, mathematics and mechanics are recommend-ed. Basic knowledge in renewable energies and heat transfer is useful.

Literature:

[1] Duffie; Beckman: Solar Engineering of Thermal Processes. 4th Edition. Wiley & Sons, Hoboken (2013)

[2] Schabbach; Leibbrandt: Solarthermie – Wie Sonne zu Wärme wird. Springer, Berlin (2017)

[3] Nellis; Klein: Heat Transfer. 1st Edition. Cambridge University Press, Cambridge (2008)

[4] Wesselak, Schabbach; Link; Fischer: Regenerative Energietechnik. Springer Vieweg, Berlin (2017)

4. Usability of this module

The module is offered as mandatory module in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

Assessment is performed as written examination (120 minutes).

6. ECTS credits

5 ECTS credits

7. Frequency of offer

The module is lectured annually in the autumn semester

8. Work load

The total workload for this module is 150 hours; this corresponds to 5 ECTS credits. This workload results from the presence at the lectures with an active participation of the students in the laboratory (about 45

hours). As part of the self-study, the lecture material should be reworked (about 55 hours). The preparation and execution of the examination is about. 50 hours.
9. Duration of module
The module is lectured in one semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		**860**		**Mandatory module**
Module name		**Master Thesis Module Renewable Energy Systems**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		A: Master Thesis B: Presentation and Defence		
Title of examination		A: Master Thesis B: Presentation and Defence		
Semester		3		
Course type	Language	A: Scientific Project B: Colloquium		English
SWS/ ECTS/ Workload		-	A: 26 B: 4	900
Requirements for attendance		see §21 and §23 of the examination regulations		

1. Content and objectives

Content:

A: Master Thesis:
With the master thesis the students develop an independent scientific work. The results are usually derived from the practical activity to a given topic in a company or in another enterprise of professional scientific experience.

B: Presentation and Defence
In the Colloquium, students should present the results of their master thesis in an oral presentation and answer the questions of the supervisors and the audience.

Learning goals:

By completing the master thesis module, the students prove their professional qualification, to solve a practice-relevant engineering problem within a given time limit independently and with scientific methods, to present the results succinctly in a professional manner and to defend it in a colloquium.

2. Method(s) of instruction

A: Preparation of a scientific work supervised by an examiner of the university and a supervisor of the company/enterprise
B: Independent presentation of the results during a colloquium

3. Requirements for attendance

A: The requirements are documented in §21 of the examination regulations.
B: The requirements are documented in §23 of the examination regulations.

4. Usability of this module

The module is mandatory in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

A: Assessment is performed with an at least sufficient graded master thesis.
B: Assessment is performed with an at least sufficient graded colloquium.

6. ECTS credits

A: 26 ECTS credits
B: 4 ECTS credits

7. Frequency of offer

The module is lectured in any semester

8. Work load

The total workload for this module is 900 hours; this corresponds to 30 ECTS credits. This workload results mainly from the independent and self-responsible handling of the master thesis project (700 hours), the preparation of the master thesis (100 hours) and the presentation (100 hours).

9. Duration of module

One semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		861		Compulsory module
Module name		**Ocean energy and Hydropower**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Ocean energy and Hydropower		
Title of examination		Ocean energy and Hydropower		
Semester		2		
Course type	Language	Lecture	English	
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

This lecture discusses the theory, technology and engineering associated with hydropower, tidal and ocean energy.

Module content:

Ocean energy

- Ocean as an energy resource
- Wave energy, fundamentals and application
- Tidal energy, tidal theory and prediction; barrage generation; turbines
- Ocean thermal energy conversion
- Ocean currents as an energy resource – fundamentals and technologies
- Economic assessment of ocean energies

Hydropower

- Hydro power potentials
- Types of hydro power stations
- Hydro turbines: turbine types, application ranges, fundamentals
- Stream turbines: fundamentals, turbine types, application range
- Hydro power without dams and weirs

On-line Lecture notes and training material will be available.

Recommended Literature:

Deborah Greaves, Gregorio Iglesias; Wave and Tidal Energy, Wiley , 2018

Victor Lyatkher: Tidal Power: -Harnessing Energy from Water Currents, Wiley-Scrivener,2014

Edwin Parks; Hydropower Engineering, Larsen and Keller Education, 2017

Learning goals:

After successfully completing the module, students understand the established and new technologies of hydropower and ocean energy generation. They are able to evaluate the properties of those technologies. They can analyse potentials of ocean energy and hydropower based on meteorological, geomorphic and topographical conditions. They are capable to assess the basic economic feasibility of hydro power and ocean energy plants

2. Method(s) of instruction

Lecture with integrated exercises

3. Requirements for attendance

No course specific requirements

4. Usability of this module

The module is offered as compulsory course in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

- Assessment is performed either as written examination (90 minutes) or oral examination
- Students need to pass the module examination, which encompasses all contents of the lecture.

6. ECTS credits
- 5 ECTS credits
7. Frequency of offer
- Annually in the autumn semester
8. Work load
150 h of total work load, therefrom - 80 h of presence at lectures - 40 h of self-study - 30 h preparation for examination
9. Duration of module
1 semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		862		Compulsory module
Module name		**Renewable Energies in Rural Areas**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Renewable Energies in Rural Areas		
Title of examination		Renewable Energies in Rural Areas		
Semester		2		
Course type	Language	Lecture		English
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

This lecture discusses the basic energy needs in rural areas and the issues associated with increasing energy access. It examines the role of renewable energies for decentralized power and heat generation, the technologies available and policy instruments for improving energy services in rural areas, including the role of intermediation, the role of subsidies and pricing. Case studies from different countries are presented.

Module content:

Renewable Energy Technologies for Decentralized Heat and Power Generation

- Overview of Renewable Energy Technologies
- Overview of Costs of Different Renewable Technologies
- Common Barriers and Issues Limiting Widespread Use/Dissemination of Renewable Energy

Electricity Supply

- Utility network grid-connection
- Stand-alone systems
- Distributed-grid (mini-grid) systems

Options for Mini-Grid Systems

- General considerations
- Mini-hybrid powered systems Hybrid powered systems Biomass powered systems

Planning the Approach

- Technical issues
- Non-technical issues

Institutional Issues

- Government policy
- Effective implementing agencies Attracting investment/reducing risk
- Local institutional structures

On-line Lecture notes and training material will be available.

Recommended Literature:

Valeriy Kharchenko, Pandian Vasant (Eds.): Handbook of Research on Renewable Energy and Electric Resources for Sustainable Rural Development (Advances in Environmental Engineering and Green Technologies), Engineering Science Reference, 2018

Subhes Bhattacharyya: Rural Electrification Through Decentralised Off-grid Systems in Developing Countries (Green Energy and Technology) Springer; 2013

Learning goals:

After successfully completing the module, students are able to show the links between rural development and energy access and progress. They understand the basic energy needs in rural areas and some of the barriers preventing improved energy access to rural populations. They are able to assess the role of renewable energies in developing energy access in rural areas and they understand appropriate business models and private sector participation schemes for improving renewable energy services in a sustainable way.

2. Method(s) of instruction

Lecture with integrated case studies

3. Requirements for attendance
No course specific requirements
4. Usability of this module
The module is offered as compulsory course in the master study course „Renewable Energy Systems“ (M.Eng.)
5. Requirements for assessment
- Assessment is performed as a group work (Case Study) with a final oral presentation and a written essay. - Students need to pass the module examination, based on the presentation and the written essay.
6. ECTS credits
- 5 ECTS credits
7. Frequency of offer
- Annually in the autumn semester
8. Work load
150 h of total work load, therefrom - 80 h of presence at lectures - 30 h of self-study - 40 h preparation for examination (essay and presentation)
9. Duration of module
1 semester

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		863		Obligatory elective module
Module name		**Fuel cell technologies**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Fuel cell technologies		
Title of examination		Fuel cell technologies		
Semester		1		
Course type	Language	Lecture		English
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

The objective of this course is to understand the electrochemical fundamentals of fuel cells and their operation, the differences between cells types and the design of fuel cell systems. Additionally, aspects of manufacturing fuel cells, their application and the economy of fuel cell systems are addressed.

Module contents:

- Introduction to fuel cells, types of fuel cells and historical aspects
- Electrochemistry basics; double layer phenomena, electrochemical equilibrium, reaction kinetics
- Mass transport
- Steady-state behaviour of fuel cells
- Overview of fuel cell systems
- Fuel processing; fuels, handling and production of hydrogen
- Fuel Cell Characterization
- Manufacturing of fuel cells
- Fuel cell systems for combined heat and power generation and transport, application and economical aspects
- Environmental Impact of Fuel Cells

On-line Lecture notes and training material will be available.

Recommended Literature:

Andrew Dicks, David A J Rand: Fuel Cell Systems Explained, Wiley, 2018

Ryan O'Hayre,, Suk-Won Cha , Whitney Colella, Fritz B. Prinz :Fuel Cell Fundamentals Wiley, 2016

Learning goals:

Students have acquired competent knowledge in state of the art fuel cell technologies.

In addition to fundamental knowledge of fuel cell systems, students are familiar with the design of fuel cell systems and their application in combined heat and power generation as well as in transportation, considering technical and economic aspects. Students are enabled to recognize and evaluate the application and limitations of of fuel cell systems compared to conventional technologies and to draw appropriate conclusions.

2. Method(s) of instruction

Lecture

3. Requirements for attendance

No formal requirements. Basic knowledge on thermodynamics, and chemistry is advantageous.

4. Usability of this module

The module is offered as elective course in the master study course „Renewable Energy Systems“ (M.Eng.) as well as elective course in the master course „Energiesysteme“ (M. Eng.).

5. Requirements for assessment

Assessment is performed either as written examination (90 minutes) or oral examination. Students need to pass the module examination, which encompasses all contents of the lecture.

6. ECTS credits

- 5 ECTS credits

7. Frequency of offer

- Annually in the spring semester
8. Work load
150 h of total work load, therefrom - 80 h of presence at lectures - 40 h of self-study - 30 h preparation for examination
9. Duration of module
1 semester

Master study course Renewable Energy Systems (M. Eng.)

Module – Number		864		Compulsory
Name of Module		**Bioengineering**		
Person Responsible		Prof. Dr. Uta Breuer		
Title of the Course		Biological Engineering		
Trial Identification		Biological Engineering		
Semester		1		
Form of Course	Language	Lecture		English
SWS/ ECTS/ Workload		4 V	5	150
Formal Conditions		for graduates holding a Bachelor of Engineering degree		

1. Contents and Qualification Objectives

I **Microbiology and Physiology of Microorganisms**: cell biology, biochemical basic processes in the microbial metabolism, enzyme kinetics, microbial growth (kinetic and process management)

II **Bioprocess Engineering**: bioreactors, sterilization and sterile technology, measurement and regulation technology at bioreactors, upstream and downstream processing

III **Biotechnological Syntheses**:

biomass (feed and food, agriculture, pharmacy),

low-molecular products (methane, alcohols, organic acids, amino acids, lipids and fatty derivatives, nucleotides und coenzymes, vitamins, sweeteners)

macromolecules (microbial enzymes, Insulin, recombinant drugs, products of secondary metabolism)

IV **Biotechnological Remediation Procedures**: aerobic and anaerobic degradation, composting and special systems, anaerobic processes and process variants, liquid and gaseous emissions as well as treatments of wastes, bioremediation of pollutants in soil and ground water, bioleaching, phytoremediation

V **Biodegradables Materials**: biologically degradable materials, renewable biomass, PHA – PHB

VI **Environmental Microbiology**: C-, S-, N-, Fe-cycles, biosensors

Learning goals:
Students acquire in-depth knowledge in bioengineering with a microbial and biochemical-biotechnological focus. In addition to scientific and engineering knowledge, which reflects the link between microbial performance and technical implementation, historical and up-to-date engineering processes especially considering the economic and ecological feasibility are familiar to the students. Thus students are enabled to recognize and evaluate application possibilities and limitations of bioengineering as well as to make comparisons with conventional technologies and to draw appropriate conclusions.

2. Forms of Teaching

Lecture

3. Prerequisites for Participating

Theoretical and practical knowledge acquired in lectures on bioenergy, biogas and bioengineering. These prerequisites can also be acquired through individual studies of appropriate textbooks.

Bibliographical References: For preparation and follow-up the following text books are recommended:

- Colin Ed. Ratledge and Björn Kristiansen, Basic Biotechnology, Cambridge University, 3rd ed. 2006, ISBN13: 9780521549585
- Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, David A. Stahl: Brock Biology of Microorganisms, Pearson Education, 15th ed. 2017, ISBN 978-0134261928
- D.L. Nelson, M.M. Cox: Lehninger Principles of Biochemistry: International Edition, WH Freeman, 7th ed. 2017, ISBN 978-1319108243
- J.L. Slonczewski, J.W. Foster: Microbiology: An Evolving Science, WW Norton & Co Inc., 2013, ISBN 978-0393123678

A literature list for further reading will be handed out in the lecture.

4. Usability of the Module

This module is a compulsory module in the Master Program Renewable Energy Systems (M. Eng.).

5. Requirements for the Award of Credits

Students need to pass the module examination, which encompasses all contents of the lecture.
Type of examination: written examination with a duration of 90 min. Alternative types of examination are possible.

6. Credits and Grades

Modules are assessed by a module examination, which is credited by 5 credit points according to the ECTS (European Credit Transfer and Accumulation System).
7. Frequency of the Module
The module is offered annually in the spring semester.
8. Workload
Participation in the course = 50 h Preparation and follow-up (of the lecture) = 55 h Preparation for examination = 45 h The entire workload encompasses 150 hours, which equals 5 ECTS credit points.
9. Duration of Module
The module is performed within one semester.

Master study course Renewable Energy Systems (M. Eng.)

Module – No.		866		Compulsory module
Module name		**Climate Change**		
Module coordinator		Prof. Dr.-Ing. Joachim Fischer		
Title		Climate Change		
Title of examination		Climate Change		
Semester		1		
Course type	Language	Lecture	English	
SWS/ ECTS/ Workload		4 V	5	150
Requirements for attendance		Successfully completed technical study course (e.g. Bachelor of Engineering)		

1. Content and objectives

Objective

This lecture looks at the issue of climate change. It discusses the phenomenon of climate change and the underlying scientific, ecological, and economic issues. It also analyses climate change processes, and asses proposed policy measures.

Module content:

- Our climate system - Fundamentals
- Physics of the climate system
- Climatic dynamics
- Climate Modelling and Types of Climate Models
- Natural and anthropogenic climate change
- The climate of the future
- Impacts, vulnerability, adaptation

On-line Lecture notes and training material will be available.

Recommended Literature:

Andrew Dessler: Introduction to Modern Climate Change, 2nd ed., Cambridge University Press; 2015

William Ruddiman: Earth's Climate: Past and Future, 3rd ed., WH Freeman, 2013

Learning goals:

After successfully completing the module, students have a deeper knowledge about the natural scientific fundamentals of our climate system. They learn about the significant effects influencing this system and the impacts linked with climate change. In addition, they are able to assess critically policy measures and existing studies on climate change.

2. Method(s) of instruction

Lecture

3. Requirements for attendance

No course specific requirements

4. Usability of this module

The module is offered as compulsory course in the master study course „Renewable Energy Systems“ (M.Eng.)

5. Requirements for assessment

- Assessment is performed as a group work with a final oral presentation and a written essay.
- Students need to pass the module examination, based on the presentation and the written essay.

6. ECTS credits

- 5 ECTS credits

7. Frequency of offer

- Annually in the spring semester

8. Work load
150 h of total work load, therefrom - 80 h of presence at lectures - 30 h of self-study - 40 h preparation for examination (essay and presentation)
9. Duration of module
1 semester

Module – No		867		Compulsory module
Module name		**Numerical Methods in Heat and Mass Transfer**		
Module coordinator		M.Eng. Pascal Leibbrandt		
Title		Numerical Methods in Heat and Mass Transfer		
Title of examination		Numerical Methods in Heat and Mass Transfer		
Fachsemester		2		
Course type	Language	Tutorial/Laboratory		English
SWS/ ECTS/ Workload		4 P	5	150
Requirements for attendance		none		

1. Content and objectives

Content:

1. Introduction, applications
2. Basics on heat transfer
3. CFD-workflow, basic software components (CAD-modeller, mesher, physics, plots and reports)
4. Basics on CFD, mesh generation and diagnostics, physics models
5. Optimization of heat transfer problems, automation

Learning goals:

The students have knowledge about the phenomena of heat transfer and the simulation of heat transfer processes. They are able to use a commercial CFD software and interpret the simulation results. They understand the problems of residual and discretization convergence. The students can solve engineering problems like investigation and optimization of heat transfer problems.

2. Method(s) of instruction

The module consists of a lecture with integrated exercises.

3. Requirements for attendance

There are no formal requirements for participation. Basics in physics, mathematics and mechanics are recomended. Basic knowledge in renewable energies and heat transfer is useful.

Literature:

[1] Baehr; Stephan: Wärme- und Stoffübertragung. 7. Auflage. Springer, Heidelberg, Dordrecht, London, New York (2010)

[2] Duffie; Beckman: Solar Engineering of Thermal Processes. 4th Edition. Wiley & Sons, Hoboken (2013)

[3] Kreith; Bohn: Principles of Heat Transfer. 6th Edition. Brooks/Cole, Pacific Grove (2001)

[4] Polifke; Kopitz: Wärmeübertragung. 2. Auflage. Pearson Studium, München (2009)

[5] Ferziger; Peric: Numerische Strömungsmechanik. 1. Auflage. Springer, Berlin, Heidelberg (2008)

[6] Hirsch: Numerical Computation of Internal & External Flows. 2nd Edition. Butterworth-Heinemann, Burlington (2007)

4. Usability of this module

The module is offered as Compulsory module in the master study courses „Renewable Energy Systems“ (M.Eng.) and “Energiesysteme”

5. Requirements for assessment

Assessment is performed as written examination (120 minutes).

6. ECTS credits

The grade corresponds to the grading of the exam. When completing the unit successfully, students are granted 5 credit points (ECTS).

7. Frequency of offer

The module is lectured annually in the autumn semester

8. work load

The total workload for this module is 150 hours; this corresponds to 5 ECTS credits. This workload results from the presence at the lectures with with integrated exercises (about 45 hours). As part of the self-study, the lecture material should be reworked (about 55 hours). The preparation and execution of the examination is about 50 hours.

9. Duration of module

The module is lectured in one semester.

Master study course Renewable Energy Systems (M. Eng.)

Module – Number		910		Mandatory
Name of Module		**Deutsch als Fremdsprache**		
Person Responsible		Gabriele Marx-Tilp MA		
Title of the Course		German as a Foreign Language A1		
Trial Identification		German as a Foreign Language		
Semester		1		
Form of Course	Language	Seminar (I) and practice (II)		German
SWS/ ECTS/ Workload		4	5	150
Formal Conditions		for graduates holding a Bachelor of Engineering degree		

1. Contents and Qualification Objectives

I (seminar) and II (practice): vocabulary

Students are able to introduce themselves and know how to communicate in a simple manner. They can use short sentences and understand familiar expressions, which address the satisfaction of concrete needs.

I (seminar) and II (practice): grammar

Learners are expected to have a basic knowledge of the following grammar items when reaching A1 level:

- sentence: statement, question and command
- word order/sentence structure: verb in first, second and last position
- details of time, manner and place
- verb forms: infinitive, imperative, indicative
- tenses: present, perfect and preterite of auxiliary and modal verbs
- verbs with prefixes – separable and inseparable
- nouns: gender, singular and plural: nominative, accusative and dative
- definite and indefinite articles
- pronouns: personal, possessive and demonstrative (accusative and dative)
- prepositions: with accusative and dative
- conjunctions: *und, aber, oder, sondern, denn, dann*
- numerals : cardinal and ordinal numbers
- negations: *nicht, kein, nie*
- adjectives, comparative adjectives, and adverbs: *gern, lieber, am liebsten*

2. Forms of Teaching

I seminar: face-to-face teaching and blended learning

II practice: Students prepare and give short presentations on diverse yet familiar topics (e.g. life at university, home town or country and comparison to Germany), dialogues for everyday situations, specific grammar focuses (e.g. adjectives, adverbs, false friends) and receive feedback on their performances.

3. Prerequisites for Participating

Bibliographical References: For preparation and follow-up the following text books are recommended:

- Billina, Anneli and Lilli Marlen Brill: Deutsch üben. Wortschatz & Grammatik A1. Ismaning: Hueber, 2010.
- Jin, Friederike and Ute Voss: Grammatik aktiv: A1 –B1. Üben, Hören, Sprechen. Berlin: Cornelsen, 2013.
- Müller et. al.: Optimal A1 – Lehrwerk für Deutsch als Fremdsprache. München: Langenscheidt bei Klett, 2013.

A literature list for further language acquisition will be handed out in the lecture.

4. Usability of the Module

This module is a compulsory elective module in the Master's Program Systems Engineering (M. Eng.).

5. Requirements for the Award of Credits

Students need to pass the module examination, which encompasses all contents of the seminar.
Type of examination: written examination … Alternative types of examination are possible.

6. Credits and Grades

Module is assessed with a module examination, which is credited by 5 credit points according to the ECTS (European Credit Transfer and Accumulation System).

7. Frequency of the Module

The module is scheduled for the first academic year.
8. Work Load
Participation in the course = 50 h Preparation and follow-up (of the lecture) = 55 h Preparation for examination = 45 h **The entire workload encompasses 150 hours, which equals 5 ECTS credit points.**
9. Duration of Module
The module is performed within one semester.