Modules for Postgraduate Programme Renewable Energy

Mastermodule

pre011 - Fundamentals of Renewable Energy

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<td></td>
<td>Carsten Agert</td>
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<td>Andreas Günther</td>
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<td>Hans-Gerhard Holtorf</td>
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<td>Cuauhtemoc Adrian Jimenez Martinez</td>
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<td>Robin Knecht</td>
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<td>Herena Torio</td>
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<td>Simone Malz</td>
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<td>Paul Ziethe</td>
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Entry requirements

Skills to be acquired in this module

After successful completion of the module students should be able to:

- identify their competence and incompetence with respect to the study of renewable energies
- describe basic knowledge from a wide field of disciplines as required for renewable energies
- perform laboratory measurements in a university environment according to scientific standards
- analyse and interpret measurement results using relevant and widely used software tools
- work and communicate their results with international and interdisciplinary partners
- critically discuss basic principles of current mainstream economics
- distinguish between the classical, neo-classical and selected heterodox economics and relate those approaches to the historic economic development
- distinguish and evaluate the peculiarities of selected energy markets and its regulatory frameworks

Module contents

The module is designed to give students a solid foundation to successfully start the MSc programme. The content from the field of Physics, Mathematics as well as Electrical and Mechanical Engineering aims to provide a homogenous foundation for the study of renewable energies via lectures and laboratory experiments. With an introduction into Socio-economics students will learn about the principles of mainstream economics, the peculiarities of energy markets and will get insight into some selected heterodox economic perspectives.

Primers (Lecture & Exercises 60 h workload)

- Mathematics
- Programming
- Modelling
- Electronic Power Systems
- Semiconductor Physics
- Material Characterization
- Thermodynamics
- Fluid Dynamics

Laboratories (Theoretical/practical Seminar ? 120 h workload)
- Introductory Laboratory
- Interaction Light and Matter
- Heat Transfer
- Fluid Dynamics
- Storage Technologies

Introduction to Socio-economics (Lecture & Seminar ? 90 h workload)
- Scarcity, market
- Supply and demand
- Equilibrium
- Elasticity
- Incentives, free market, role of the state
- Peculiarities of energy markets and corresponding regulatory frameworks
- Limitations of mainstream economics
- Selected heterodox economics

Reader's advisory

Links

Languages of instruction German, English

Duration (semesters) 1 Semester

Module frequency

Module capacity unlimited

Module level MM (Mastermodul / Master module)

Module type Pflicht / Mandatory

Lern-/Lehrform / Type of program

Vorkenntnisse / Previous knowledge

Examination Time of examination Type of examination
Final exam of module 2 Prüfungsleistungen: Fachpraktische Übungen (Versuchspraktikum und Übungsaufgaben, Gewicht: 75%) und entweder Hausarbeit (10-15 Seiten) oder Präsentation (15-20 min, Gewicht: 25%)

Course type Comment SWS Frequency Workload attendance
Lecture 2.00 SuSe and WiSe 28 h
Exercises 4.00 SuSe and WiSe 56 h

Total time of attendance for the module 84 h
**pre021 - Energy Resources and Systems**

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<td></td>
<td>Herena Torio</td>
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**Entry requirements**

Skills to be acquired in this module

After successful completion of the module students should be able to:

- characterise the global energy system and analyse the structure and constraints of today’s energy system
- explain the availability and connection between solar and wind energy
- identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles
- relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology

**Module contents**

This module will give an overview on the global energy system and the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles.

Energy Meteorology (Lecture ? 90 h workload)

**Section I: Solar Irradiance**

- Radiation Laws
- Solar Geometry
- Interaction of solar irradiance with the atmosphere
- Radiation Climatology
- Solar Radiation Model
- Statistical Properties of Solar Irradiance
- Measuring devices to ascertain Solar Radiation balance
- Satellite-supported data acquisition to assess Solar Irradiance

**Section II: Wind Flow**

- Origin and Potential of atmospheric energy movements, Heat balance of the atmosphere
- Physical laws of atmospheric flow
- Wind circulation in the atmosphere, Local Winds
- Wind flow in atmospheric layers (Vertical Structure, Ekman Layer)
- Assessment of Wind potential (European Wind Atlas: Model, Concept
- Wind Measurements

Energy Systems (Lecture ? 90 h workload)
- Definitions, separation electrical - thermal energy use
- Resources & reserves
- Energy system analysis: Efficiencies at various levels of the energy chain; Exergy analysis
- Energy scenarios
- Climate Change
- Advanced (power plant) technologies for conventional fuels
- Electric power systems with large shares of renewables

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pre031 - Renewable Energy Technologies I

Module label  Renewable Energy Technologies I
Module code  pre031
Credit points  12.0 KP
Workload  360 h
Used in course of study  Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person
- Authorized examiners
  - Carsten Agert
  - Michael Hölling
  - Hans-Gerhard Holtorf
  - Robin Knecht
  - Herena Torio
  - Michael Wark
  - Alexandra Pehken
  - Robert Steinberger-Wilckens

Entry requirements

Skills to be acquired in this module

After successful completion of the module students should be able to:

- critically evaluate and compare three major Renewable Energy conversion processes and technologies: photovoltaics, wind energy and one out of three of solar thermal energy, biomass energy or hydro power.
- critically appraise various electrochemical storage processes and the respective storage techniques
- analyse various system components and their interconnections within a complex Renewable Energy supply system.
- evaluate the Renewable Energy supply systems' operational size and efficiency.
- critically evaluate non-technical impact and side effects when implementing renewable energy supply systems

Module contents

This module will give an overview over a selection of the major renewable energy technologies and some possibilities of their storage. The focus is on the scientific principles of components and the technical description of the components. Further detailed system analysis will be presented in other modules.

Photovoltaics (Lecture ? 90 h workload)

Physics of PV:

- Basic and most important properties of solar radiation related to photovoltaics
- PV cells basics: Fundamental physical processes in photovoltaic materials
- Characterisation and basic modelling of solar cells

Component Description:

- PV generator
- Charge controller
- Inverter
- Balance of system components

System Description
- Grid Connected System
- Stand Alone System

Basics of Wind Energy (Lecture ? 90 h workload)
- Wind characterization and anemometers
- Aerodynamic aspects of wind energy conversion
- Wind turbine performance
- Design of wind turbines
- Dimensional analysis and pi-theorem

Fuel Cells & Energy Storage (Lecture ? 90 h workload)
- Fundamentals of electrochemistry and thermodynamics, energy and environmental balances
- Basics of hydrogen production - starting materials, processes, efficiencies, environmental impacts
- Basics of fuel cells function, materials, construction, systems, applications
- Fundamental setup of most common battery types
- Fundamental chemical reactions in these batteries
- Operational characteristics, wear processes and service lives of these batteries.

Solar Thermal Energy, Biomass Energy, Hydro Power

Students select one out of the three units:

a. Solar Thermal Energy (90 h workload)
b. Biomass Energy (90 h workload)
c. Hydro Power (90 h workload)

In the third semester the other two of the three units will be selected in the module Renewable Energy Technology II.

Solar Thermal Energy (Seminar & Exercises ? 90 h workload)
- Assessment of solar thermal ambient parameters: regional global, diffuse, reflected solar radiation on horizontal and on tilted plane, ambient temperature
- Solar thermal collectors
- Solar thermal heat exchangers
- Solar thermal storages
- Solar thermal systems and their operation
- Characterization of solar thermal systems

Biomass Energy (Lecture ? 90 h workload)
- Energy mix overview; gas, heat, electricity, Pros & Cons of biomass
- Chemical composition of biomass: sugar, cellulose, starch, fats, Oils, proteins, lignin
- Natural photosynthesis in plants: chemical storage of solar energy; general mechanisms
- Chemistry & Biology (microorganism) of Biogas Technology
- Conversion processes of biomass: classification, main pathways
Introduction to catalysis used in biomass conversion
- Chemical fuels (chemical energy storage) from biomass, routes to platform chemicals and separation processes
- Technology concepts for bioenergy usage
- Introduction into economical and legal constraints

Hydro Power (Seminar & Exercises ? 90 h workload)
- Theoretical background: general hydraulic terms, Bernoulli Equation, Major Empirical Formulae and their backgrounds
- Water Resource: catchment area, seasonal precipitation, flow duration curve, dam, & run off river
- Powerhouse: penstock, water hammer, cavitation, tailrace
- Turbines: main types of turbines, their characteristics & their components
- Ocean Power Overview

Reader's advisory

Links

Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency:
Module capacity: unlimited
Module level:
- BC (Basisskriptum / Base curriculum)
- MM (Mastermodul / Master module)
Module type:
- Pflicht / Mandatory
- Wahlpflicht / Elective

Lern-/Lehrform / Type of program

Vorkenntnisse / Previous knowledge

Examination

Time of examination
Type of examination

Final exam of module
2 Prüfungsleistungen: Klausur (3h, Gewicht 75%) sowie Referat (15 min. Präsentation, 15 Seiten Bericht, Gewicht 25%).

Course type
Lecture
Exercises

Comment

SWS
4.00
4.00

Frequency
SuSe and WiSe
SuSe and WiSe

Workload attendance
56 h
56 h

Total time of attendance for the module
112 h
**pre041 - Sustainability of Renewable Energy**

**Module label**  
Sustainability of Renewable Energy

**Module code**  
pre041

**Credit points**  
6.0 KP

**Workload**  
180 h

**Used in course of study**  
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**  
Authorized examiners
- Carsten Agert
- Cuauhtemoc Adrian Jimenez Martinez
- Herena Torio

**Entry requirements**

**Skills to be acquired in this module**

After successful completion of the module students should be able to:

- analyse, and critically compare and evaluate selected sustainability concepts and strategies addressing renewable energy systems
- critically appraise and analyse the principles and implications of selected scientific methods and theories for a sustainable energy supply
- critically evaluate the suitability and meaningfulness of different sustainability indicators, theories, methods and practices regarding their role and impact for developed countries, on the one hand, and developing countries, on the other
- perform an integral assessment, involving several relevant aspects related to the sustainability of a particular real-life renewable energy project as well as identify the main barriers, potentials and driving factors for improving it
- perform a literature review on selected sustainability approaches to a professional standard and extract the main related conclusions, and arguing critically on them
- present data and information both verbally and in the written form, including quotation to a professional standard

**Module contents**

The module “Sustainability of RE Systems” provides the theoretical background for understanding main concepts and interdisciplinary scientific methods from the context as well as their role in the sustainability debate.

**Sustainability Seminar (Lecture & Seminar ? 180 h workload)**

- Strategies and dimensions in sustainability research and discussion: efficiency, consistency and sufficiency, as well as related concepts (e.g. rebound)
- Growth/De-growth and decoupling of growth and emission
- Life-cycle analysis
- Thermodynamic methods: exergy, EROI and related approaches
- Social indicators and their relation to energy use
- Economic indicators and related paradigms in the context of energy consumption
- Resilience and its operationalisation for energy systems
- Methods for developing and assess socio-technical scenarios

**Reader's advisory**

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**Lern-/Lehrform / Type of program**

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**Total time of attendance for the module**

56 h
pre051 - Renewable Energy Systems Laboratory and Modelling

Module label: Renewable Energy Systems Laboratory and Modelling

Module code: pre051

Credit points: 6.0 KP

Workload: 180 h

Used in course of study:
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
Authorized examiners:
- Andreas Günther
- Hans-Gerhard Holtorf
- Cuauhtemoc Adrian Jimenez Martinez
- Robin Knecht
- Herena Torio

Entry requirements:

Skills to be acquired in this module:

After successful completion of the module students should be able to:

- implement as well as critically analyse and discuss models and their limitations using various methods
- develop research questions and approaches to answer them
- perform laboratory measurements or simulations in a university environment
- analyse and interpret their results using relevant and widely used software tools
- work and communicate their results with international and interdisciplinary partners according to scientific standards

Module contents:

In this module the students obtain the knowledge and skills on programming, modelling and critically analysing simulations and apply those in a topic on renewable energies of their choice. Students have the choice to simulate specific renewable energy components or systems which are later investigated in hands-on laboratories. Through this students learn to critically discuss the results of their simulations and compare them to real measurements as well the results from differently implemented simulations from which they deduce the limits and validity of the respective models.

Modelling and Simulation of Renewable Energy Systems (Lecture & Seminar ? 90 h workload)

- numerical concepts
- differential equations
- discrete models
- statistical modeling
- algorithms to develop simulations
- building a simple model from the field of renewable energies
- various tools to implement and critically analyse the performance and limits of a model
- examples of various simulation approaches

Laboratory on Renewable Energy Systems (Theoretical?practical Seminar ? 90 h workload)

- Theory, Hands-on experience and reporting on either:
  - Improved Cook Stoves
  - Wind Energy Systems
  - Solar Home Systems
- Meteorological Resource Assessment
  - Student conference on the Performance of Renewable Energy Systems

**Reader’s advisory**

**Links**

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**Previous knowledge**

**Examination**

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**Total time of attendance for the module**

56 h
**pre071 - Internship**

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**Used in course of study**
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**
- Authorized examiners
  - Robin Knecht
  - Herena Torio

**Entry requirements**

**Skills to be acquired in this module**

After successful completion of the module students should be able to:
- evaluate and critically reflect on his/her two months working experience
- critically appraise and compare professional working in different working environments, i.e. business, research, development organisation
- conclude whether he/she intends to work further in this particular field of Renewable Energy for his/her master thesis
- present data and information both verbally and in the written form to a professional standard (i.e. scientific report writing, presentation and quotation)

**Module contents**

**External Internship (180 h workload)**

The ‘External Internship’ is an approximately two-month stay in companies, consultancies, international development organisations or research institutes, normally outside Oldenburg University. Students stay for and perform ? in accordance with some basic principles ? one or several tasks, related to the activities/business of the respective host organisation. The training, normally situated in the break between the first and second semester of the postgraduate programme, can either help to prepare for the six-month Master Thesis Project, which will follow after the third term. Otherwise, it can also be used as a supplementary or complementary experience in an additional field of interest. Organisations that take PPRE students for an internship may have their own regulations with respect to internships, which apply anyway. The external Internship will be concluded by a report (ca. 20 pages).

The University of Oldenburg requests to fulfil a few requirements for the internship:
- The university needs an acceptance letter (incl. contact details of local supervisor and topic of internship) from the host organisation prior to start the internship.
- The duration of the training should enable students to return to university at the beginning of summer term classes.
- Weekly full-time workload is required. However, it should not exceed local standards.
- Students are asked to hand in a report (approx. 20 pages) on their training, comprising a description of the host organisation, planned and performed tasks, perspectives for a thesis project, and give a presentation in the Internship Seminar in the summer term.
- If the host organisation demands a certain format of the report, the student has to comply.
- A short feedback by the local supervisor about the performance of the student during the internship is requested and recommended, but not compulsory.

**Internship Seminar (90 h workload)**

Presentation (20 minutes) of the host organisation, the task(s) and experiences
Reader's advisory

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Module frequency

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Course type

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Total time of attendance for the module 84 h
pre061 - Renewable Energy Complementary Topics

Module label
Renewable Energy Complementary Topics

Module code
pre061

Credit points
6.0 KP

Workload
180 h

Used in course of study
• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person

Authorized examiners
- Carsten Agert
- Levent Güay
- Detlev Heinemann
- Hans-Gerhard Holtorf
- Martin Kühn
- Laura Lukassen
- Bernd Siebenhüner
- Andreas Hermann Schmidt
- Bernhard Stoevesandt
- Sebastian Lehnhoff
- Heidemarie Altmuth-Düster
- Ulrich Kobusch
- Claudia Tjarks

Entry requirements

Skills to be acquired in this module

After completing the module students will be able to:

- describe basic knowledge in two of a wide field of disciplines (technical, scientific, social, political, transferrable, language) as required for the implementation of renewable energy
- critically discuss basic principles of the implementation of renewable energy
- justify their personal decision on educational fields for their career development

Module contents

The module is designed to give students an outlook on fields which have not been covered so far in their previous lectures and specialization modules. The content from the fields of technical, scientific, social, political, transferrable, language disciplines is offered for tailoring the personal education for the planned careers. All units are 3CP units.

- Advanced Solar Energy Meteorology (Dr. Detlev Heinemann) (Lecture ? 90 h workload)
- Advanced Wind Energy Meteorology (Dr. Detlev Heinemann) (Lecture ? 90 h workload)
- Photovoltaic Systems (Hans-Gerhard Holtorf PhD) (Lecture ? 90 h workload)
- Physical Basics of Photovoltaics (Dr. Michael Richter) (Lecture ? 90 h workload)
- Future Power Supply Systems (Prof. Dr. Carsten Agert) (Lecture ? 90 h workload)
- Biomass in Developing Countries (Andreas Günther) (Lecture ? 90 h workload)
- Smart Grids Lecture (Prof. Dr. Sebastian Lehnhoff) (Lecture ? 90 h workload)
- Smart Grids Seminar (Prof. Dr. Sebastian Lehnhoff) (Seminar ? 90 h workload)
- Fluid Dynamics II (Prof. Dr. Joachim Peinke) (Lecture ? 90 h workload)
- Computational Fluid Dynamics I (Dr. Bernhard Stoevesandt) (Lecture ? 90 h workload)
- Wind Physics Measurement Project (Prof. Dr. Martin Kühn, Andreas Hermann Schmidt) (Project ? 90 h workload)
- Wind Energy Applications ? from Wind Resource to Wind Farm Operations (Dr. Hans-Peter Waldl) (Lecture ? 90 h workload)
- Ecological Economics (Prof. Dr. Bernd Siebenhüner) (Lecture ? 90 h workload)
- International Environmental Governance (Prof. Dr. Bernd Siebenhüner) (Lecture ? 90 h workload)
- Project Management (Ulrich Kobusch) (Project ? 90 h workload)
- Language Course (Heidemarie Aßmuth-Düster) (Lecture ? 90 h workload)
- Conflict Management (Claudia Tjarks) (Seminar ? 90 h workload)
- Working in International Teams (Claudia Tjarks) (Seminar ? 90 h workload)
- German language courses

Reader's advisory

Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency

Module capacity
unlimited

Modullevel
BC (Basiscurriculum / Base curriculum)

Modullevel
MM (Mastermodul / Master module)

Modulart
Wahlpflicht / Elective

Lern-/Lehrform / Type of program

Vorkenntnisse / Previous knowledge

Examination
Time of examination
Type of examination

Final exam of module
2 Prüfungsleistungen: Das Modul ist unbenotet, jedoch müssen 2 der möglichen Kurse mindestens als 'bestanden' gewertet werden um das Modul zu bestehen. Mögliche Prüfungsformen sind: Klausur (1 h), mündliche Prüfung (20 min), Referat (10 Seiten Ausarbeitung + 10 Minuten Präsentation), Hausarbeit (max. 20 Seiten), Fachpraktische Übung (max. 8), Seminararbeit (max. 20 Seiten), Portfolio, Präsentation (15 min.) In Seminaren wird Aktive Teilnahme (siehe Ergänzung zu § 9 Abs. (6) ) gefordert..

Course type
Comment
SWS
Frequency
Workload attendance

Lecture
2.00
SuSe and WiSe
28 h

Seminar und Übung
2.00
SuSe and WiSe
28 h

Total time of attendance for the module
56 h
**Module label**
Renewable Energy Project

**Module code**
pre081

**Credit points**
9.0 KP

**Workload**
270 h

**Used in course of study**
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**

- Authorized examiners
  - Carsten Agert
  - Hans-Gerhard Holtorf

**Entry requirements**

**Skills to be acquired in this module**

In the module Renewable Energy Project students merge the acquired scientific knowledge on different RE technologies and the concepts and methodologies they have gained in the different related disciplines and they transfer their competences to solve a real life project.

After successful completion of the module students should be able to:

- appraise the challenge of a given energy service supply problem
- assess given data of the situation of the energy service supply problem
- discriminate between valuable and less valuable input data, necessary and unnecessary data
- judge and then decide on methodologies to apply to generate a solution
- develop and then recommend a technical, economic and social solution for an energy service supply system
- explain, justify and defend the developed solution

**Module contents**

This module trains students to apply the knowledge acquired in previous lectures to a real life problem.

**Case Study (Seminar ? 180 h workload)**

Students need to

- Evaluate the state of the art at the Case Study’s project site
- Describe the energy services demanded
- Determine the energy demand to supply these services in hourly and seasonal course of time
- Design the energy supply system based on different technologies for this energy demand
- Technically & economically optimise generator size, storage size, dumped energy and unmet energy
- Write a final report for the stakeholder involved
- Present the findings to the stakeholders involved
- Solve challenges of working in an international group in order to generate a solution (project management, conflict management, intercultural communication)

**Excursion (Excursion ? 90 h workload)**

The excursion refers to the case study project. Within the excursion, students collect necessary information for the completion of the Case Study itself.

Students prepare, manage and document the excursion by
- Setting up a list of institutions to be visited
- Plan the excursion route and excursion schedule
- Negotiate the necessary appointments
- Perform the excursion
- Prepare all participants for the appointments with the institutions
- Conduct the appointments
- Document the appointments
- Draw necessary conclusions for the Case Study from the excursion

**Reader's advisory**

**Links**

<table>
<thead>
<tr>
<th>Languages of instruction</th>
<th>German, English</th>
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<tr>
<td><strong>Duration (semesters)</strong></td>
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<td>Wahlpflicht / Elective</td>
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**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

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**Total time of attendance for the module** 84 h
Pre111 - Photovoltaic Physics

Module label: Photovoltaic Physics
Module code: pre111
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
- Authorized examiners:
  - Levent Gütay
  - Robin Knecht

Entry requirements:

Skills to be acquired in this module:

- describe schematically the events around the pn-junction under bias in the dark and under illumination
- calculate the width of the space charge region
- use solar cell data sheets in their professional career
- discuss the concepts of solar cell materials, design and optimization
- choose a PV technology for a given project

Module contents:

This specialization module covers the physics of photovoltaics. The behaviour of solar cells is discussed from a fundamental physical point of view to explain the differences in performance and limits of various photovoltaic materials. Students learn how solar cells function, are designed and optimized.

Physical Basics of Photovoltaics (Lecture & Exercises ? 180 h workload)

- Optical and electronical properties of semiconductors, light absorption
- Charge carrier generation/recombination/life time
- Charge carrier transport across the pn-junction in equilibrium and under light and voltage bias,
- Transport equations,
- Current-voltage characteristics, efficiency
- Quantum efficiency
- Design concepts to optimize the efficiency
- Overview of the most important PV technologies

Reader's advisory:

Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: unlimited
Module capacity: unlimited
Module level: BC (Basiscurriculum / Base curriculum)
Moduleart: Wahlpflicht / Elective

je nach Studiengang Pflicht oder Wahlpflicht
Lern-/Lehrform / Type of program

Vorkenntnisse / Previous knowledge

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Total time of attendance for the module: 56 h
pre112 - Photovoltaics Systems & Solar Energy Meteorology

<table>
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<th>Photovoltaics Systems &amp; Solar Energy Meteorology</th>
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<td>• Master's Programme Postgraduate Programme Renewable Energy (Master) &gt; Mastermodule</td>
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<td>Authorized examiners</td>
</tr>
<tr>
<td></td>
<td>● Carsten Agert</td>
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<td></td>
<td>● Detlev Heinemann</td>
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<td>● Hans-Gerhard Holtorf</td>
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<td>● Bernhard Stoevesandt</td>
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</table>

Entry requirements

Skills to be acquired in this module

- After successful completion of the module students should be able to:
  - explain the concepts of physical processes governing the surface solar irradiance available for solar energy applications
  - model the solar radiation and show their expertise in application, adaptation and development of models
  - discuss state-of-the-art-methods in satellite-based irradiance estimation and solar power forecasting
  - categorize and feature different PV systems (PV on-grid, PV off-grid, PV pumping, PV-hybrid)
  - explain concepts behind PV system design
  - explain the operation principles of PV systems

Module contents

This specialization module covers more in-depth topics concerning photovoltaics systems and solar energy meteorology. Based on their knowledge about the solar resource and photovoltaic behaviour students learn to design a photovoltaic system for various environmental conditions and predict its performance.

Solar Energy Meteorology (Lecture ? 90 h workload)

- Physics of radiative processes in the atmosphere
- Physical modelling of atmospheric radiative transfer (incl. computing tools)
- Solar irradiance modelling for solar energy applications
- Solar spectral irradiance: Theory & relevance for solar energy systems
- Satellite-based estimation of solar irradiance
- Solar irradiance (& solar power) forecasting
- Solar radiation measurements: Basics & setup of high-quality measurement system

Photovoltaic Systems (Lecture ? 90 h workload)

- Detailed description of involved balance of system components (e.g. inverter, charge controllers)
- System Operation
- Detailed System Design ? from meteorological input across component rating to energy service output

Reader's advisory
<table>
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<tr>
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pre121 - Wind Energy Converters & Fluid Dynamics

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Contact person

Authorized examiners
- Detlev Heinemann
- Hans-Gerhard Holtorf
- Martin Kühn
- Laura Lukassen
- Andreas Hermann Schmidt
- Bernhard Stoevesandt

Entry requirements

Skills to be acquired in this module

After successful completion of the module students should be able to:

- Resolve fluid dynamic problems occurring in the field of wind energy converters
- Measure characteristics of wind energy converters
- Evaluate wind energy related measurements
- Interpret such measurements gained in the field of wind energy applications
- Critically evaluate measured data

Module contents

This module allows students to access wind energy from the hydrodynamic view angle of the wind resource.

Computational Fluid Dynamics (CFD) I (Lecture ? 90 h workload)

- Navier-Stokes equations
- Filtering / averaging of Navier-Stokes equations
- Introduction to numerical methods
- Finite-differences
- Finite-volume methods
- Linear equation systems
- Incompressible flows
- Compressible flows
- C++

Computational Fluid Dynamics (CFD) II (Lecture ? 90 h workload)

- Introduction to different CFD and Large Eddy Simulation (LES) models, such as OpenFOAM, PALM
- Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer
- Navier-Stokes solvers: RANS, URANS, LES, DNS
- Turbulent flows
- efficiency and accuracy

Fluid Dynamics II (Lecture ? 90 h workload)

The unit is oriented towards research based topics:

- Modeling turbulence ? CFD methods: Reynolds Equation, Eddy viscosity, Boundary layers flows, Large Eddy Simulation
  - Models of idealised turbulence and statistical methods: Hierarchies of moment equations, turbulence hypothesis, fine structure of turbulence, multi-fractal models, other.
  - Models of turbulence: cascade models and stochastic models and other hypothesis

Wind Physics Measurement Project (Project ? 90 h workload)

Case study like problems based on real world data will be solved on at least four important aspects in wind physics. The course will comprise lectures and assignments as well as self-contained work in groups of 3 persons.

The content consists of the following four main topics, following the chronological order of the work process:

- Data handling:
  - measurement technology
  - handling of wind data
  - assessment of measurement artefacts in wind data
  - preparation of wind data for further processing

- Energy Meteorology:
  - geographical distribution of winds
  - wind regimes on different time and length scales
  - vertical wind profile
  - distribution of wind speed
  - differences between onshore and offshore conditions.

- Measure ? Correlate ? Predict (MCP):
  - averaging of wind data
  - long term correlation and long term correction of wind data
  - sources of long term wind data.

- LIDAR (Light Detection and Ranging):
  - analyses and conversion of data from LIDAR measurements

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Reader's advisory

Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
unlimited
### Modullevel

BC (Basiscurriculum / Base curriculum)

### Modullevel

---

### Modulart

Wahlpflicht / Elective

### Modulart

je nach Studiengang Pflicht oder Wahlpflicht

### Lern-/Lehrform / Type of program

### Vorkenntnisse / Previous knowledge

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### Course type

<table>
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<td>Lecture</td>
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<td>4.00</td>
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<td>4.00</td>
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### Total time of attendance for the module

112 h
Module label: Design and Simulation of Wind Turbines

Module code: pre131

Credit points: 12.0 KP

Workload: 360 h

Used in course of study: Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
- Detlev Heinemann
- Hans-Gerhard Holtorf
- Martin Kühn
- Hans-Peter Waldl

Entry requirements:

Skills to be acquired in this module:

After successful completion of the module students should be able to:

- critically contribute to the discourse on wind energy design and simulation
- explain and evaluate technical details of a wind energy converter
- decide and to defend a design of a wind energy converter
- recommend on technical details of a wind energy converter
- transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads
- assess different aspects of wind energy farms by modelling, comparison, explanation of wind energy potential, wind energy farm’s output, power curves, wind energy project development
- assess in detail influences of meteorological/climatological aspects on the performance of wind power systems
- summarize physical processes governing atmospheric wind flows
- value atmospheric boundary layer flow relevant for wind power conversion
- argue methods for wind resource assessment and forecasting

Module contents:

Content of the module:
The module accesses wind energy from a rather technical approach.

Design of Wind Energy Systems (Lecture & Project ? 180 h workload)

- Calculation of the aerodynamics of wind turbines using the blade element momentum theory,
- Specific design situations for wind turbines,
- Estimation of the influence of dynamics of a wind turbine, especially in the context of fatigue loads,
- Aeroelastic simulation of wind turbines
- Annual Energy Production (AEP)
- Design of a commercial (equivalent) wind turbine

Advanced Wind Energy Meteorology (Lecture ? 90 h workload)

- Atmospheric Boundary Layer (turbulence, vertical structure, special BL effects)
- Atmospheric Flow Modelling: Linear models, RANS & LES models
- Wind farm modelling
- Offshore-Specific Conditions
- Resource Assessment & Wind Power Forecasting
- Wind Measurements & Statistics

Wind Energy Applications - from Wind Resource to Wind Farm Operations (Lecture ? 90 h workload)

- Evaluation of Wind Resources
  - Weibull Distribution
  - Wind velocity measurements to determine energy yield
  - Basics of Wind Atlas Analysis and Application Program (WAsP) Method, Partial models using WAsP
  - Measure-Correlate-Predict (MCP) Method of long term corrections of wind measurement data in correlation to long term reference data
  - Conditions for stable, neutral and instable atmospheric conditions
  - Wind yield from wind distribution and the power curve
  - Basics in appraising the yearly wind yield from a wind turbine.

- Wake Effect and Wind Farm
  - Recovery of original wind fields in the downstream of wind turbines
  - Basics of Riso Models
  - Spacing and efficiency in wind farms
  - Positive and Negative Effects of Wind Farms

- Wind Farm Business
  - Income from the energy yield from wind farms
  - Profit optimization by increase of energy production
  - Wind farm project development
  - Wind farm operation and
  - Surveillance of power production vs. wind climate, power curves, and turbine availability

Reader's advisory
Links
Languages of instruction  German, English
Duration (semesters)  1 Semester
Module frequency
Module capacity  unlimited
Modullevel  BC (Basiscurriculum / Base curriculum)
Modullevel
Modulart  Wahlpflicht / Elective
Modulart
Lern-/Lehrform / Type of program
Vorkenntnisse / Previous knowledge
Examination  Time of examination  Type of examination
Final exam of module  1 Prüfungsleistung: Klausur (3h) oder Präsentation (30 min.) oder mündliche Prüfung (45 min.) oder fachpraktische Übungen (max. 10) oder Hausarbeit (max. 30 Seiten)
Course type  Lecture
SWS  6.00
Frequency  SuSe and WiSe
Workload attendance  84 h
**pre141 - System Integration of Renewable Energy**

<table>
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**Used in course of study**
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**
- Module responsibility
  - Sebastian Lehnhoff

**Entry requirements**

**Skills to be acquired in this module**
- After successful completion of the module students should be able to:
  - explain the management, modelling and power balancing within future electricity grid configurations with high shares of fluctuating and distributed generation and the requirements for successful application to real power balancing regarding capacity utilization, robustness, and flexibility.
  - appraise the main components (incl. chemical storage options) involved in future AC-grid concepts, to soundly assess the reciprocal constrains between them to propose solutions for improving its performance.
  - explain necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems.
  - estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants.
  - explain necessary conversion procedures and to judge the ecologic and economic balance
  - categorise different grid-designs, including mini- and micro-grids
  - compare different electricity markets existing currently (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) based on the motivation, role, advantages and limiting factors and to critically judge and assess the suitability of these concepts for promoting the implementation of higher shares of fluctuating distributed power generation within the electricity grid.
  - explain the technical principles and resulting limiting factors for different components required for power control within “Smart City”, “Smart Grid”, “Smart Home” concepts, estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems and analyse their safety, reliability, real time capability and flexibility

**Module contents**

The module is designed to give specialized insight on the management, modelling and power balancing within future grid configurations. It gives the students a thorough overview on the challenges and solutions in electricity grids that shall accommodate a high share of fluctuating distributed generation. It deals with the technical and economic framework for a permissible electrical network as well as mathematical modelling and calculation methods to analyse conditions of electrical energy networks (in stationary conditions). Technology, economical energy industry and technical basic knowledge and methods are analysed by using concrete Smart Grid approaches. The basic calculation methods for an intelligent net management are introduced.

**Future Power Supply Systems (Lecture & Seminar – 180 h workload):**

- Technology and characteristics of conventional power plants based e. g. on coal, gas, and nuclear
- Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.)
- Fluctuating distributed generation: Characteristics and solutions on the transmission and distribution grid levels, incl. storage, vehicle-to-grid-concepts, smart inverters, heat pumps / CHP, etc.
- Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world
  - “Smart City”, “Smart Grid”, “Smart Home”
  - Mini- and Micro-Grids
  - Energy scenarios and modelling
  - Chemical energy carriers in the energy system: power-to-gas (e.g. methane) and power-to-liquids (e.g.methanol)

**Smart grid management (Lecture and Exercises – 180 h workload):**

- Organisation of the EU energy market (regulatory framework, responsibility in liberalisation of electrical energy systems)
- Establishment and operation of electrical energy supply networks (network topology, statutory duties of supply, supply quality/system services, malfunctions and protection systems)
- Network calculation (complex pointer, effective/idle power, mathematical performance models/net
model, transformation: node performance to node voltage and electricity, calculation of conductive current, power-flow calculation, fix-point-iteration, Newton-Raphson-Method, voltage drop, transformer model)
- Intelligent network management (Smart Grids), Aggregation forms, machine learning approaches
- Detailed description of involved balance of system components (e.g. inverter, charge controllers)
- System Operation
- Detailed System Design – from meteorological input across component rating to energy service output

Reader's advisory
Future Power Supply Systems:


Smart grid management:

- Konstantin, P.: „Praxisbuch Energiewirtschaft“, Springer 2006
- Lehnhoff, S.: „Dezentrales vernetztes Energiemanagement“, 2010

Links
Language of instruction English
Duration (semesters) 1 Semester
Module frequency once a year
Module capacity unlimited
Reference text Helpful previous knowledge:

- For the course “Smart grid management” is basic knowledge in Python Programming advisable.
- Basic knowledge on chemical processes (Chemistry-Primer: 1CP) and energy storage (course “Energy storage”) are also advantageous.
- Knowledge in Semiconductor Physics is desired (Semiconductor Physics Primer: 1CP)

Modullevel MM (Mastermodul / Master module)
Modulart Wahlpflicht / Elective
Lern-/Lehrform / Type of program Lectures, Exercises, Seminar
Vorkenntnisse / Previous knowledge

Examination Time of examination Type of examination
Final exam of module 2 Examinations
- Report (presentation: 50 min, paper: 5 pages) or Exercises (8 exercises): Future Power Supply, 50% weight.
- Oral Exam (ca. 30 minutes) or Exercises (8 exercises): Smart Grid Management, 50% weight

Course type Comment SWS Frequency Workload attendance
Lecture 4.00 SuSe and WiSe 56 h
Seminar 4.00 SuSe and WiSe 56 h

Total time of attendance for the module 112 h
pre142 - Future Power Supply Systems

Module label: Future Power Supply Systems
Module code: pre142
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
Authorized examiners:
- Carsten Agert
- Babak Ravanbach

Entry requirements

Skills to be acquired in this module

After successful completion of the module students should be able to:

- explain the management, modelling and power balancing within future electricity grid configurations with high shares of fluctuating and distributed generation and the requirements for successful application to real power balancing regarding capacity utilization, robustness, and flexibility.
- appraise the main components (incl. chemical storage options) involved in future AC-grid concepts, to soundly assess the reciprocal constrains between them to propose solutions for improving its performance.
- explain necessary conversion procedures and to judge the ecologic and economic balance
- categorise different grid-designs, including mini- and micro-grids
- compare different electricity markets existing currently (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) based on the motivation, role, advantages and limiting factors and to critically judge and assess the suitability of these concepts for promoting the implementation of higher shares of fluctuating distributed power generation within the electricity grid.
- explain the technical principles and resulting limiting factors for different components required for power control within “Smart City”, “Smart Grid”, “Smart Home” concepts, estimate the influence of distributed control concepts

Module contents

The module is designed to give specialized insight on the management, modelling and power balancing within future grid configurations. It gives the students a thorough overview on the challenges and solutions in electricity grids that shall accommodate a high share of fluctuating distributed generation. It deals with the technical and economic framework for a permissible electrical network as well as mathematical modelling and calculation methods to analyse conditions of electrical energy networks (in stationary conditions). Technology, economical energy industry and technical basic knowledge and methods are analysed by using concrete Smart Grid approaches. The basic calculation methods for an intelligent net management are introduced.

Future Power Supply Systems (Lecture & Seminar – 180 h workload):

- Technology and characteristics of conventional power plants based e. g. on coal, gas, and nuclear
- Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.)
- Fluctuating distributed generation: Characteristics and solutions on the transmission and distribution grid levels, incl. storage, vehicle-to-grid-concepts, smart inverters, heat pumps / CHP, etc.
- Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world
- “Smart City”, “Smart Grid”, “Smart Home”
- Mini- and Micro-Grids
- Energy scenarios and modelling
- Chemical energy carriers in the energy system: power-to-gas (e.g. methane) and power-to-liquids
(e.g. methanol)

**Reader's advisory**

**Links**

**Languages of instruction**  German, English

**Duration (semesters)**  1 Semester

**Module frequency**

**Module capacity**  unlimited

**Modullevel**  SPM (Schwerpunktmodul / Main emphasis)

**Modulart**  Wahlpflicht / Elective

**Modulart**  je nach Studiengang Pflicht oder Wahlpflicht

**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

**Examination**  Time of examination  Type of examination

**Final exam of module**  KL

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**Total time of attendance for the module**  56 h
### pre151 - Renewable Energy in Developing Countries

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<tr>
<td></td>
<td>Carsten Agert</td>
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<td></td>
<td>Andreas Günther</td>
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<td>Cuauhtemoc Adrian Jimenez Martinez</td>
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<td>Bernd Siebenhüner</td>
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<td>Herena Torio</td>
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**pre034 - Renewable Energy Technologies II**

**Module label**
Renewable Energy Technologies II

**Module code**
pre034

**Credit points**
6.0 KP

**Workload**
180 h

**Used in course of study**
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**
Authorized examiners
- Carsten Agert
- Hans-Gerhard Holtorf
- Herena Torio
- Michael Wark
- Alexandra Pehiken

**Entry requirements**

**Skills to be acquired in this module**

**Module contents**

**Reader's advisory**

**Language of instruction**
English

**Duration (semesters)**
1 Semester

**Module frequency**

**Module capacity**
unlimited

**Modulelevel**
MM (Mastermodul / Master module)

**Modulart**
Wahlpflicht / Elective

**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

**Examination**

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<td>Exercises</td>
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**Total time of attendance for the module**
112 h
pre091 - Transferrable skills

Module label  | Transferrable skills
---|---
Module code  | pre091
Credit points  | 6.0 KP
Workload  | 180 h

Used in course of study
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person
Authorized examiners
- Evelyn Brudler
- Hans-Gerhard Holtorf
- Heidemarie Aßmuth-Düster
- Ulrich Kobusch

Entry requirements

Skills to be acquired in this module

After successful completion of the module students should be able to:

- Identify and reflect their own interests and competences
- Discuss the topics of their interest/choice more profoundly
- Apply and transfer the acquired communication skills in various situations outside the classroom

Module contents

Within this module multiple courses with a highlight on communication are offered. From the offered courses students can select multiple courses with a combined workload of 180 hours to deepen their competence in these fields of interest. The following courses are currently eligible:

- Teaching in Renewable Energies
- Deutsch,
- Kreatives Schreiben (level B1+),
- Deutsch für Naturwissenschaftler (level B1+),
- Wissenschaftliches Arbeiten - Schwerpunkt Lesen und Schreiben (level B2+),
- Wissenschaftliches Arbeiten - Schwerpunkt Sprechen und Referieren (level B2+)
- Developing and Presenting a Conference Poster
- Academic Writing
- Module 1: Writing and Publishing a Research Paper
- Basics of Project Management

Reader's advisory

Links

Language of instruction  | English
Duration (semesters)  | 1 Semester

Module frequency

Module capacity  | unlimited
Modullevel  | MM (Mastermodul / Master module)
Modulart  | ---

Lern-/Lehrform / Type of program

je nach Studiengang Pflicht oder Wahlpflicht
Vorkenntnisse / Previous knowledge

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inf511 - Smart Grid Management

Module label  Smart Grid Management
Module code    inf511
Credit points  6.0 KP
Workload       180 h

Used in course of study
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
- Master's Programme Environmental Modelling (Master) > Mastermodule
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person
Module responsibility
- Sebastian Lehnhoff
- Die im Modul Lehrende

Authorized examiners
- Sebastian Lehnhoff
- Die im Modul Lehrende

Entry requirements
Skills to be acquired in this module
After successful completion of the course the students should be able to understand the existing structures and technical basis of energy systems to produce, transfer and distribute electricity and their interaction and dependency on each other. They should have developed an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. The students are able to estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants. The students will be able to estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems. Regarding the requirements the students will be able to analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems.

Professional competence
The students:

- understand the existing structures and the technical basis of energy systems producing, transferring and distributing electricity and their interaction and dependency on each other.
- develop an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems.
- estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants.
- estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems.

Methodological competence
The students:

- analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems
- use advanced mathematical methods to calculate networks

Social competence
The students:

- create solutions in small teams
- discuss their solutions

Self-competence
The students:

- reflect their own use of electricity as a limited resource

Module contents
Content of the Module: In this course information technology, economical energy industry and technical basic knowledge and methods are analysed by using concrete Smart Grid approaches. The basic calculation methods for an intelligent grid management are introduced.

This module deals with the technical and economical framework for a permissable electrical network as well as
mathematical modelling and calculation methods to analyse conditions of electrical energy networks (in stationary conditions).

These are:

- The organisation of the EU energy market (regulatory framework, responsibility in liberalisation of electrical energy systems)
- Establishment and operation of electrical energy supply networks (network topology, statutory duties of supply, supply quality/system services, malfunctions and protection systems)
- Intelligent network management (Smart Grids), aggregation forms, machine learning approaches

Reader's advisory

Suggested reading:

- Crastan V.: "Elektrische Energieversorgung II", Springer 2004

Links

Language of instruction: English

Duration (semesters): 1 Semester

Module frequency: jährlich

Module capacity: unlimited

Modullevel: AS (Akzentsetzung / Accentuation)

Modulart: je nach Studiengang Pflicht oder Wahlpflicht

Lern-/Lehrform / Type of program: V+Ü

Vorkenntnisse / Previous knowledge

Examination

Time of examination: At the end of the semester

Type of examination: Oral exam

Final exam of module

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Total time of attendance for the module: 56 h
## pre152 - Resilient Energy Systems

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<tr>
<td></td>
<td>Cuauhtemoc Adrian Jimenez Martinez</td>
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**pre153 - Mini-Grids**

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**Contact person**

**Entry requirements**

**Skills to be acquired in this module**

**Module contents**

**Reader's advisory**

**Links**

**Languages of instruction** | German, English

**Duration (semesters)** | 1 Semester

**Module frequency**

**Module capacity** | unlimited

**Modullevel** | SPM (Schwerpunktmodul / Main emphasis)

**Modulart** | Wahlpflicht / Elective

**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

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**Total time of attendance for the module** | 56 h

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**SWS**

**Frequency**

**Workload attendance**
### phy609 - Photovoltaic Physics

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<td>Workload</td>
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<td>Module responsibility &lt;br&gt; - Martin Kühn &lt;br&gt; Authorized examiners &lt;br&gt; - Levent Gütay</td>
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<td>Solid-state-Physics, semi-conductor Physics, Module Renewable Energy Technologies I</td>
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<td>describe schematically the events around the pn-junction under bias in the dark and under illumination, calculate the width of the space charge region, use solar cell data sheets in their professional career, discuss the concepts of solar cell materials, design and optimization, choose a PV technology for a given project</td>
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<tr>
<td>Module contents</td>
<td>This specialization module covers the physics of photovoltaics. The behaviour of solar cells is discussed from a fundamental physical point of view to explain the differences in performance and limits of various photovoltaic materials. Students learn how solar cells function, are designed and optimized, Optical and electronical properties of semiconductors, light absorption, Charge carrier generation/recombination/life time, Charge carrier transport across the pn-junction in equilibrium and under light and voltage bias, Transport equations, Current-voltage characteristics, efficiency, Quantum efficiency, Design concepts to optimize the efficiency, Overview of the most important PV technologies</td>
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### phy616 - Computational Fluid Dynamics 1 / 2

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#### Used in course of study
- Master's Programme Engineering Physics (Master) > European Wind Energy Master
- Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

#### Contact person
- Module responsibility
  - Martin Kühn
- Authorized examiners
  - Laura Lukassen
  - Bernhard Stoevesandt

#### Entry requirements

#### Skills to be acquired in this module
Deeper understanding of the fundamental equations of fluid dynamics. Overview of numerical methods for the solution of the fundamental equations of fluid dynamics. Confrontation with complex problems in fluid dynamics. To become acquainted with different, widely used CFD models that are used to study complex problems in fluid dynamics. Ability to apply these CFD models to certain defined problems and to critically evaluate the results of numerical models.

#### Module contents
- **CFD I:**
  - The Navier-Stokes equations, filtering / averaging of Navier-Stokes equations, introduction to numerical methods, finite-differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy.
- **CFD II:**
  - Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.

#### Reader's advisory

#### Links

#### Languages of instruction
German, English

#### Duration (semesters)
1 Semester

#### Module frequency
Sommersemester

#### Module capacity
unlimited

#### Modullevel
MM (Mastermodul / Master module)

#### Modulart
Pflicht / Mandatory

#### Lern-/Lehrform / Type of program
Lecture: 2hrs/week, Excercise: 2hrs/week

#### Vorkenntnisse / Previous knowledge

#### Examination

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<td>1 Referat oder</td>
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<td>1 mündliche Prüfung oder</td>
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<td>1 fachpraktische Übung</td>
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#### Course type
VA-Auswahl (Vorlesungen oder Praktikum oder Seminar)

#### SWS
4.00

#### Frequency
SuSe or WiSe

#### Workload attendance
56 h
phy641 - Energy Resources & Systems

Module label: Energy Resources & Systems

Module code: phy641

Credit points: 6.0 KP

Workload: 180 h
(Attendance: 56 hrs, Self-study: 124 hrs)

Used in course of study:
- Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
- Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
- Module responsibility: Detlev Heinemann

Authorized examiners:
- Detlev Heinemann

Entry requirements

Skills to be acquired in this module:
After successful completion of the module students should be able to:
- characterize the global energy system and analyze the structure and constraints of today's energy system,
- explain the availability and connection between solar and wind energy,
- identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles,
- relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology.

Module contents:
This module will give an overview on the global energy system and the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles.

Energy Meteorology (Lecture - 90 h workload)

Section I: Solar Irradiance
- Radiation laws,
- Solar geometry,
- Interaction of solar irradiance with the atmosphere,
- Radiation climatology,
- Solar radiation model,
- Statistical properties of solar irradiance,
- Measuring devices to ascertain solar radiation balance,
- Satellite-supported data acquisition to assess solar irradiance,

Section II: Wind Flow
- Origin and potential of atmospheric energy movements, Heat balance of the atmosphere,
- Physical laws of atmospheric flow,
- Wind circulation in the atmosphere, local winds,
- Wind flow in atmospheric layers (vertical structure, Ekman Layer),
- Assessment of wind potential (European Wind Atlas: model, concept,
- Wind Measurements,

Energy Systems (Lecture - 90 h workload)

- Definitions, separation electrical - thermal energy use,
- Resources and reserves,
- Energy system analysis: Efficiencies at various levels of the energy chain; Exergy analysis,
- Energy scenarios,
- Climate change,
- Advanced (power plant) technologies for conventional fuels,
- Electric power systems with large shares of renewables

Reader's advisory:

Energy Meteorology:
- IEA Word Energy Outlook (http://wordenergyoutlook.org/)
• Sathyajith, M. 2006: Wind energy: fundamentals, resource analysis and economics, Springer

Energy Systems:
• Boyle, G. et al. (Eds.): Energy Systems and Sustainability (Oxford University Press, 2003)
• Blok, K.: Introduction to Energy Analysis (Techno Press, Amsterdam, 2007)
• EIA: International Energy Outlook 2016 (www.eia.doe.gov/forecasts/ieo/)

Links
Language of instruction
English
Duration (semesters)
1 Semester
Module frequency
Winter semester
Module capacity
unlimited
Module level
MM (Mastermodul / Master module)
Module level
MM (Mastermodul / Master module)
Modulart
Wahlpflicht / Elective
Modulart
Pflicht / Mandatory
Lern-/Lehrform / Type of program
each Lecture: 2hrs/week
Lern-/Lehrform / Type of program
each Lecture: 2hrs/week
Vorkenntnisse / Previous knowledge
Final exam of module
written exam
Examination
Time of examination
Type of examination
Course type
Lecture
SWS
4.00
Frequency
SuSe or WiSe
Workload attendance
56 h
phy647 - Future Power Supply Systems

Module label: Future Power Supply Systems
Module code: phy647
Credit points: 6.0 KP
Workload: 180 h (Attendance: 56 hrs, Self study: 124 hrs)

Used in course of study:
- Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
Module responsibility:
- Carsten Agert

Authorized examiners:
- Carsten Agert

Entry requirements:
Knowledge from module RE technology I, Mathematics

Skills to be acquired in this module:
After successful completion of the module students should be able to:

- explain the management, power balancing and the provision of ancillary services within future electricity grid configurations with high shares of fluctuating and distributed generation
- perform power system simulation with related software tools
- describe different grid-designs, including mini- and microgrids
- compare different markets for electricity (Futures' Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and assess the suitability of these concepts for promoting the implementation of higher shares of fluctuating distributed power generation within the electricity grid.
- explain the technical principles and resulting limiting factors of concepts and components required for power control within 'Smart City', 'Smart Grid', and 'Smart Home' concepts

Module contents:
Future Power Supply Systems:

- Technology and characteristics of conventional power plants based e. g. on coal, gas, and nuclear,
- Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.),
- Fluctuating distributed generation: Characteristics and solutions on the transmission and distribution grid levels, incl. storage, vehicle-to-grid-concepts, smart inverters, heat pumps / CHP, etc,
- Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world, - 'Smart City', 'Smart Grid', 'Smart Home', - Mini- and Micro-Grids,
- Energy scenarios and modelling,
- Chemical energy carriers in the energy system: power-togas (e.g. methane) and power-to-liquids (e.g.methanol)

Reader's advisory:

Links:

Language of instruction: English
Duration (semesters): 1 Semester
Module frequency: Sommersemester
Module capacity: unlimited
Modulelevel: MM (Mastermodul / Master module)
Modulart: Wahlpflicht / Elective
Lern-Lehrform / Type of program: Lecture and Seminar: 4 hrs/week
Vorkenntnisse / Previous knowledge:

Examination:
Time of examination:
Type of examination:
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<th>Type of examination</th>
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<td>Report (presentation: 50 min, Term-paper: 5 pp.) or Exercises (8 Exercises). In addition, active participation is required. The criteria to fulfill the requirement of the active participation are announced at the beginning of the term.</td>
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<td>Workload attendance</td>
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phy648 - Wind Resources and its Applications

Module label: Wind Resources and its Applications

Module code: phy648

Credit points: 6.0 KP

Workload: 180 h
- Attendance: 72 hrs
- Self study: 108 hrs

Used in course of study:
- Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person
- Module responsibility
- Martin Kühn
- Authorized examiners
- Detlev Heinemann
- Hans-Peter Waldl

Entry requirements: Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab

Skills to be acquired in this module:
- Assess different aspects of wind energy farms by modelling, comparison, explanation of wind energy potential, wind energy farm's output, power curves, wind energy project development, assess in detail uncertainties of meteorological/ climatological aspects on the performance of wind power systems, summarize physical processes governing atmospheric wind flows, value atmospheric boundary layer flow relevant for wind power conversion, argue methods for wind resource assessment and forecasting

Module contents:
- Advanced Wind Energy Meteorology (Lecture - 90 h workload)
- Atmospheric Boundary Layer (turbulence, vertical structure, special BL effects)
- Atmospheric Flow Modelling: Linear models, RANS and LES models
- Wind farm modelling
- Offshore-Specific Conditions
- Resource Assessment and Wind Power Forecasting
- Wind Measurements and Statistics
- Wind Energy Applications - from Wind Resource to Wind Farm Operations (Lecture - 90 h workload)
- Evaluation of Wind Resources
- Weibull Distribution
- Wind velocity measurements to determine energy yield
- Basics of Wind Atlas Analysis and Application Program (WAsP) Method, Partial models using WAsP
- Measure-Correlate-Predict (MCP) Method of long term corrections of wind measurement data in correlation to long term reference data
- Conditions for stable, neutral and instable atmospheric conditions
- Wind yield from wind distribution and the power curve Basics in appraising the yearly wind yield from a wind turbine.
- Wake Effect and Wind Farm
- Recovery of original wind fields in the downstream of wind turbines
- Basics of Riso Models
- Spacing and efficiency in wind farms
- Positive and Negative Effects of Wind Farms
- Wind Farm Business
- Income from the energy yield from wind farms
- Profit optimization by increase of energy production
- Wind farm project development
- Wind farm operation and Surveillance of power production vs. wind climate, power curves, and turbine availability

Reader's advisory:
- Advanced Wind Energy Meteorology

Links:
- Language of instruction: English
- Duration (semesters): 1 Semester
- Module frequency: Sommersemester
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phy649 - Design of Wind Energy Systems

Module label: Design of Wind Energy Systems
Module code: phy649
Credit points: 6.0 KP
Workload: 180 h
   - Attendance: 72 hrs, Self study: 108 hrs

Used in course of study:
- Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person:
Module responsibility
- Martin Kühn
Authorized examiners
- Martin Kühn

Entry requirements:
Basics in Wind Energy Utilisation

Skills to be acquired in this module:
Design of Wind Energy Systems:
The students attending the course will have the possibility to expand and sharpen of their knowledge about wind turbine design from the basic courses. The lectures include topics covering the whole spectrum from early design phase to the operation of a wind turbine. Students will learn in exercises how to calculate and evaluate design aspects of wind energy converters.
At the end of the lecture, they should be able to:
estimate the site specific energy yield,
calculate the aerodynamics of wind turbines using the blade element momentum theory,
model wind fields to obtain specific design situations for wind turbines,
estimate the influence of dynamics of a wind turbine, especially in the context of fatigue loads,
transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads,
calculate the economic aspects of wind turbine
Aeroelastic Simulation of Wind turbines:
student who has met the objectives of the course will be able to:
understand the basic concept of an aero-servo-elastic computer code to determine the unsteady aerodynamic loads, derive and validate the required parameters to model the aero-hydro-elastic response of a wind turbine, identify and interpret the required empirical parameters to correct the blade element momentum (BEM) method with respect to dynamic in flow, unsteady airfoil aerodynamics (dynamic stall), yawed flow, dynamic wake modeling, explain the effects of the different models on the resulting time series and validate the code, interpret design standards for on- and offshore wind turbines, select the required load cases according to sitespecific environmental data, identify the dimensioning load cases and calculate design loads for different main components of a wind turbine.

Module contents:
Design of Wind Energy Systems:
Introduction to industrial wind turbine design, rotor aerodynamics and Blade Element Momentum (BEM) theory, dynamic loading and system dynamics, wind field modelling for fatigue and extreme event loading, design loads and design aspects of onshore wind turbines, simulation and measurements of dynamic loads, design of offshore wind turbines, power quality and grid integration on wind turbines.
Aeroelastic Simulation of Wind turbines:
The course focuses on the practical implications and hands-on experience of the aero-hydro-servo-elastic modelling and simulation of wind turbines. The subjects are similar but the treatment is complementary to the parallel course 'Design of Wind Energy Systems', which deals with the underlying theoretical background: advanced wind field modelling for fatigue and extreme event loading, modelling of wind farm flow and wake effects, rotor aerodynamics (e.g. stationary or dynamic effects, comparison of Blade Element Momentum theory and more advanced methods like free vortex methods or CFD), structural dynamics and dynamic modelling of wind turbine structures (modelling by ordinary or partial differential equations, stochastics, multi body system modelling), advanced control of wind turbines, design standards, design loads and design aspects of off-shore and onshore wind turbines. The students analyse in pairs a model of an entire wind turbine with the aid of a typical wind turbine design tool like GH Bladed, Flex5 or Aerodyn/FAST.

Reader's advisory:
Garrad Hassan, Bladed, Wind Turbine Design Software, Theory Manual; Selected papers from e.g. Wind Energy Journal, Wiley Interscience

Links:
Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: Wintersemester
Module capacity: unlimited
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# phy987 - Control of Wind Turbines and Wind Farms

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<td>Authorized examiners</td>
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<tr>
<td></td>
<td>- Martin Kühn</td>
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<tr>
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<td>- Vlaho Petrovic</td>
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## Entry requirements

## Skills to be acquired in this module

## Reader's advisory

## Module contents

## Languages of instruction
- German, English

## Duration (semesters)
- 1 Semester

## Module frequency

## Module capacity
- unlimited

## Modullevel
- EB (Ergänzungsbereich / Complementary)

## Modulart
- Wahlpflicht / Elective

## Lern-/Lehrform / Type of program

## Vorkenntnisse / Previous knowledge

## Examination

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## Total time of attendance for the module
- 56 h
# pre014 - Fundamentals for Renewable Energy

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<td>Workload</td>
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**Used in course of study**
- Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**

Module responsibility
- Herena Torio

Authorized examiners
- Jörn Hoppmann
- Robin Knecht
- Herena Torio
- Paul Ziethe

**Entry requirements**

**Skills to be acquired in this module**

After successful completion of the module students should be able to:
- identify their competence and incompetence with respect to the study of renewable energies
- describe basic knowledge from a wide field of disciplines as required for renewable energies
- understand the most important economic principles
- have a basic understanding of the functioning of energy markets
- have an overview of the types and effectiveness of policies to promote renewable energy technologies
- understand the interaction between society and renewable energy technologies
- know which aspects play an important role when founding renewable energy start-ups and developing corporate strategies in the renewable energy sector
- be able to assess alternative investment and financing possibilities in the context of renewable energy
- understand how renewable energy innovation projects can be structured and implemented

**Module contents**

The module is designed to give students a solid foundation to successfully start the MSc programme. The content from the field of Physics, Mathematics as well as Electrical and Mechanical Engineering aims to provide a homogenous foundation for the study of renewable energies. The introduction to fundamental knowledge from the field of energy economics and management complements the homogenized technical knowledge.

The following Primers are offered:
- Mathematics
- Programming
- Modelling
- Electronic Power Systems
- Semiconductor Physics
- Material Characterization
- Thermodynamics
- Fluid Dynamics

The course "Renewable Energy Management" offers an introduction to the most important areas relevant to the management of renewable energy companies. To this end, the course first provides a general introduction to economic fundamentals and principles. Students then gain insights into the following topics:
- Energy markets
- Renewable energy policy and climate policy
Energy and society
Foundation and strategies of renewable energy companies
Investment and financing in the renewable energy sector
Innovation management in the renewable energy sector

Each of these topics will be explored in depth through practical exercises, including guest lectures, simulations, stakeholder discussions, case studies and investment calculations.

Reader's advisory

Primer: lecture notes for the respective courses

RE Management (optional):


Links

Language of instruction  English
Duration (semesters)  1 Semester
Module frequency
Module capacity unlimited
Modullevel MM (Mastermodul / Master module)
Modullevel MM (Mastermodul / Master module)
Modulart Pflicht / Mandatory

Lern-/Lehrform / Type of program

Vorkenntnisse / Previous knowledge

Examination Time of examination Type of examination
Final exam of module Primer: During the semester Primer: Practical Exercises
RE Management: At the end of the lecture period RE Management: Written Exam

Course type Comment SWS Frequency Workload attendance
Lecture 2.00 SuSe or WiSe 28 h
Exercises 2.00 SuSe or WiSe 28 h
Practical 2.00 SuSe or WiSe 28 h
Total time of attendance for the module 84 h
pre017 - Physical Principles of Renewable Energy Converters

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<tr>
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<td>6.0 KP</td>
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| Used in course of study      | • Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule  
                                 • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule |
| Contact person               |                                                      |
| Module responsibility        |                                                      |
|                              | • Hans-Gerhard Holtorf                               |
| Authorized examiners         |                                                      |
|                              | • Hans-Gerhard Holtorf                               |
|                              | • Cuauhtemoc Adrian Jimenez Martinez                 |
|                              | • Andreas Günther                                    |
|                              | • Robin Knecht                                      |
| Entry requirements           |                                                      |
| Skills to be acquired in this module |                                                      |
| After successful completion of the module students should be able to: |                                                      |
|                              | • perform laboratory measurements in a university environment according to scientific standards 
                              | • present a sound analysis of the results and related conclusions in a scientific report 
                              | • analyse and interpret measurement results using relevant and widely used software tools 
                              | • work and communicate their results with international and interdisciplinary partners |
| Module contents              |                                                      |
| Laboratories (Theoretical?practical Seminar ? 120 h workload) |                                                      |
|                              | • Introductory Laboratory                             |
|                              | • Interaction Light and Matter                        |
|                              | • Heat Transfer                                       |
|                              | • Fluid Dynamics                                      |
|                              | • Storage Technologies                                |
|                              | • Scientific Writing                                  |
| Reader's advisory            | Lecture notes for the respective courses             |
| Links                        |                                                      |
| Language of instruction      | English                                              |
| Duration (semesters)         | 1 Semester                                           |
| Module frequency             |                                                      |
| Module capacity              | 40                                                   |
| Modulelevel                  | MM (Mastermodul / Master module)                     |
| Modulelevel                  | MM (Mastermodul / Master module)                     |
| Modulart                     | Pflicht / Mandatory                                  |
| Modulart                     | Pflicht / Mandatory                                  |
| Lern-/Lehrform / Type of program | Laboratory                                           |
### Lern- / Lehrform / Type of program

Laboratory

### Vorkenntnisse / Previous knowledge

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### Course type

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<td>SuSe or WiSe</td>
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<td>Practical</td>
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**Total time of attendance for the module**

84 h
**pre022 - Solar Energy**

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Module label: Water and Biomass Energy
Module code: pre042
Credit points: 6.0 KP
Workload: 180 h

**Used in course of study**
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**

**Entry requirements**

**Skills to be acquired in this module**

**Module contents**

**Reader's advisory**

**Links**

**Languages of instruction**
- German, English

**Duration (semesters)**
- 1 Semester

**Module frequency**

**Module capacity**
- unlimited

**Modullevel**
- MM (Mastermodul / Master module)

**Modular**
- Pflicht / Mandatory

**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

**Examination**

**Time of examination**

**Type of examination**

**Final exam of module**

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**Total time of attendance for the module**
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### pre064 - Renewable Energy Complementary Topics and Transferable Skills

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#### Languages of instruction
- German, English

#### Duration (semesters)
- 1 Semester

#### Module frequency
- unlimited

#### Modulart
- Wahlpflicht / Elective

### Type of program
- Lern-/Lehrform: Wahlpflicht / Elective

### Vorkenntnisse / Previous knowledge

### Examination

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<td>2 Prüfungsleistungen gemäß Ergänzung zu §11 Arten der Modulprüfungen: Das Modul ist unbenotet, jedoch müssen 2 der möglichen Prüfungsleistungen mindestens als „bestanden“ gewertet werden um das Modul zu bestehen.</td>
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#### Course type

<table>
<thead>
<tr>
<th>Course type</th>
<th>Comment</th>
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<td>Seminar</td>
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#### Total time of attendance for the module
- 84 h
pre13 - Photovoltaic Systems

Module label: Photovoltaic Systems
Module code: pre13
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master’s Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

Contact person

Entry requirements

Skills to be acquired in this module

Module contents

Reader’s advisory

Links
Languages of instruction: German, English

Duration (semesters): 1 Semester

Module frequency

Module capacity: unlimited

Modullevel: SPM (Schwerpunktmmodul / Main emphasis)

Modulart: Wahlpflicht / Elective

Lern-/Lehrform / Type of program

Vorkenntnisse / Previous knowledge

Examination
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Final exam of module

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Total time of attendance for the module: 56 h
pre114 - Solar Energy Meteorology

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**Used in course of study**
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule

**Contact person**

**Entry requirements**

**Skills to be acquired in this module**

**Module contents**

**Reader's advisory**

**Links**

**Languages of instruction**
- German, English

**Duration (semesters)**
- 1 Semester

**Module frequency**

**Module capacity**
- unlimited

**Modullevel**
- SPM (Schwerpunktmodul / Main emphasis)

**Modulart**
- Wahlpflicht / Elective

**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

**Examination**

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**Course type**

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**Total time of attendance for the module**
- 56 h
Abschlussmodul

mam - Master`s Thesis Module

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Used in course of study
- Master's Programme Postgraduate Programme Renewable Energy (Master) > Abschlussmodul

Contact person

Authorized examiners
- Carsten Agert
- Andreas Günther
- Levent Gülay
- Annette Hammer
- Detlev Heinemann
- Michael Hölling
- Hans-Gerhard Hettorf
- Cuauhtemoc Adrian Jimenez Martinez
- Robin Knecht
- Martin Kraft
- Martin Kühn
- Lüder von Bremen
- Laura Lukassen
- Bernd Siebenhüner
- Andreas Hermann Schmidt
- Jörg Schneemann
- Gerald Steinfeld
- Bernhard Stoevesandt
- Herena Torio
- Michael Wark
- Alexandra Pehken
- Sebastian Lehnhoff
- Ulrich Scheele
- Stefanie Sievers-Glotzbach
- Babak Ravanbach
- Simone Malz
- Robert Steinberger-Wickens
- Hans-Peter Waldl

Entry requirements

Skills to be acquired in this module

The master thesis module finalizes and concludes the master programme. The student presents the achieved results as a written thesis and defends the results / conclusions to a board of examiners.

As a general objective for the Master Thesis, the student shall demonstrate the ability to constructively, critically and independently formulate, discuss and communicate issues at stake, integrating theory and methodology related to Renewable Energy.

As specific competency objectives within the Master Thesis, after completion the student shall be able to:

- demonstrate knowledge of relevant and latest publications concerning the selected topic
- elaborate the Master Thesis on the basis of clearly formulated, general objectives and specific characteristics of the topic
- identify and put to use in an operational manner empirical or other scientific material and methods that are appropriate in relation to the subject
- develop a balanced discussion of material, methods, results and possible consequences of these in relation to the field of Renewable Energy
- present the Master Thesis orally and defend the results and conclusions in a critical discussion

The module is designed to apply and deepen the methodologies acquainted throughout the PPRE programme to a specific scientific problem given by the supervisor. In order to achieve a result the student needs to apply scientific as well as key-competencies described in the next section.
Students have understood the scientific problem, they have learned the ropes of the problem, they have selected, acquainted or deepened a set of scientific and methodologies and key-competencies necessary to solve the problem and they have applied those methods.

The publication of thesis results is appreciated.

**Module contents**

The Master Thesis finalises the course of studies within PPRE.

Master Thesis Colloquium (Colloquium 180 h workload)

- Skills for thesis elaboration
- negotiation of conditions & rules with the supervisors
- setting the scene
- scientific writing,
- literature research & management (database),
- time management,
- communication with involved stakeholders,
- networking with helpful partners,
- development of research question
- Presentation and discussion of thesis project proposal (own and other students' project proposals)

Finalizing discussion with network (PPRE colleagues, friends and supervisors)

**Reader's advisory**

**Links**

**Languages of instruction**

**Duration (semesters)** 1 Semester

**Module frequency**

**Module capacity** unlimited

**Modullevel** ---

**Modulart** ---

**Modulart** je nach Studiengang Pflicht oder Wahlpflicht

**Modulart** je nach Studiengang Pflicht oder Wahlpflicht

**Lern-/Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

**Examination**

**Time of examination**

**Type of examination**

**Final exam of module** G

**Course type** Seminar

**SWS**

**Frequency**

**Workload attendance** 0 h