Modulhandbuch

Sustainable Renewable Energy Technologies - Master-Studiengang

im Sommersemester 2020

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Mastermodule

pre011 - Fundamentals of Renewable Energy

Modulbezeichnung	Fundamentals of Renewable Energy
Modulkürzel	pre011
Kreditpunkte	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Günther, Andreas (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Jimenez Martinez, Cuauhtemoc Adrian (Prüfungsberechtigt) • Knecht, Robin (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Malz, Simone (Prüfungsberechtigt) • Ziethe, Paul (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	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
Modulinhalte	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

Literaturempfehlungen					
Links					
Unterrichtsprachen			Deutsch, Englisch		
Dauer in Semestern			1 Semester		
Angebotsrhythmus Modul					
Aufnahmekapazität Modul			unbegrenzt		
Modulart			Pflicht / Mandatory		
Modullevel			MM (Mastermodul / Master module)		
Prüfung		Prüfungszeiten		Prüfungsform	
Gesamtmodul				2 Prüfungsleistungen: Fachpraktische Übungen (Versuchsprotokolle und Übungsaufgaben, Gewicht: 75%) und entweder Hausarbeit (10-15 Seiten) oder Präsentation (15-20 min, Gewicht: 25%)	
Lehrveranstaltungsform	Kommentar		SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung oder Seminar			2	SoSe und WiSe	28
Übung			4	SoSe und WiSe	56
Präsenzzeit Modul insgesamt					84 h

pre021 - Energy Resources and Systems

Modulbezeichnung	Energy Resources and Systems
Modulkürzel	pre021
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

Modulinhalte

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

Literaturempfehlungen			
Links			
Unterrichtsprachen		Deutsch, Englisch	
Dauer in Semestern		1 Semester	
Angebotsrhythmus Modul			
Aufnahmekapazität Modul		unbegrenzt	
Modulart		Pflicht / Mandatory	
Modullevel		MM (Mastermodul / Master module)	
Prüfung	Prüfungszeiten		Prüfungsform
Gesamtmodul			1 Prüfungsleistung: Klausur (2h)
Lehrveranstaltungsform	Vorlesung		
SWS	4		
Angebotsrhythmus	SoSe und WiSe		

pre031 - Renewable Energy Technologies I

Modulbezeichnung	Renewable Energy Technologies I
Modulkürzel	pre031
Kreditpunkte	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Knecht, Robin (Prüfungsberechtigt) • Hölling, Michael (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Pehlken, Alexandra (Prüfungsberechtigt) • Steinberger-Wilckens, Robert (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	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
Modulinhalte	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, weir 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

Literaturempfehlungen	
Links	
Unterrichtsprachen	Deutsch, Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	BC (Basiscurriculum / Base curriculum)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		2 Prüfungsleistungen: Klausur (3h, Gewicht 75%) sowie Referat (15 min. Präsentation, 15 Seiten Bericht, Gewicht 25%).

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		4	SoSe und WiSe	56
Übung		4	SoSe und WiSe	56
Präsenzzeit Modul insgesamt				112 h

pre041 - Sustainability of Renewable Energy

Modulbezeichnung	Sustainability of Renewable Energy
Modulkürzel	pre041
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainability Economics and Management (Master) > Ergänzungsmodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (Prüfungsberechtigt) • Torio, Herena (Modulverantwortung) • Agert, Carsten (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

Modulinhalte

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

Literaturempfehlungen

Bruntland report: Report of the World Commission on Environment and Development: Our Common Future. UN Reports.
Link: www.un-documents.net/our-common-future.pdf

Pelenc et al. 2015. Weak sustainability vs strong sustainability. Brief for GSDR, 2015.
Link:https
://sustainabledevelopment.un.org/content/documents/6569122-Pelenc-Weak%20Sustainability%20versus%20Strong%20Sustainability.pdf

Jackson T., 2009. Prosperity without growth - Economics for a finite planet. Earthscan- London-Sterling VA, 2009

LCSDSN, 2015. Indicators and a Monitoring Framework for the Sustainable Development Goals Launching a data revolution for the SDGs. Leadership Council of the Sustainable Development Solutions Network.

Kumar et al. 2017. A review of multi criteria decision making (MCDM) towards sustainable renewable energy development. Renewable and sustainable energy

reviews, 69 (2017), pp. 596-609.

Isabel Haase & Herena Torio, 2021. "The Impact of the Climate Action Programme 2030 and Federal State Measures on the Uptake of Renewable Heating Systems in Lower Saxony's Building Stock," Energies, MDPI, Open Access Journal, vol. 14(9), pages 1-25, April.

Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	At the end of the lecture period (presentation) and end of semester (report)	1 Examination: Presentation of a Paper (presentation - 20 minutes and written report 15 pages) or Term Paper (15 pages)

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	WiSe	28
Seminar		2	SoSe und WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre051 - Renewable Energy Systems Laboratory and Modelling

Modulbezeichnung	Renewable Energy Systems Laboratory and Modelling
Modulkürzel	pre051
Kreditpunkte	6.0 KP
Workload	180 h (180 hours)
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Günther, Andreas (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Peinke, Joachim (Modulverantwortung) • Knipper, Martin (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

· communicate their results with international and interdisciplinary partners according to scientific standards

. write and evaluate scientific papers

Modulinhalte

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:

- PV System
- Wind Energy Systems
- Energy Informatics
- Meteorological Resource Assessment

- Student conference on the Performance of Renewable Energy Systems

Literaturempfehlungen	
Links	
Unterrichtsprachen	
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Sommersemester
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lecture and Laboratory

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Student conference at the end of the semester	1 Examination: Conference contribution approx. 15 min presentation and approx. 8 pages of written discussion

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe und WiSe	28
Werkstatt/Labor		2	SoSe und WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre071 - Internship

Modulbezeichnung	Internship
Modulkürzel	pre071
Kreditpunkte	9.0 KP
Workload	270 h ()
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (Prüfungsberechtigt) • Agert, Carsten (Modulverantwortung) • Torio, Herena (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

· explore career alternatives prior to graduation

· develop relevant competences for successfully completing application processes

· develop work habits and attitudes necessary for job success

· integrate theory and practice and condense lessons learned out of that process for future
professional technologies.

· assess own interests and abilities in their field of study.

· evaluate and critically reflect on their two months working experience

· appraise differences and compare several professional experiences in different working
environments (i.e. business, research, development organization…)

- present data and information both verbally and in the written form to a professional standard
(i.e. scientific report writing, presentation and quotation)

Modulinhalte

External Internship (180 h workload):

The ‘External Internship’ is a min. 180h workload stay in companies, consultancies, international development organizations or research institutes, normally outside Oldenburg University. Students perform one or several tasks related to the activities/business of the respective host organization in accordance with professional requirements. The training can be performed as full time stay during the semester breaks or spreading the workload for longer time besides regular class periods. The internship can either help to prepare for the six-month Master Thesis Project or 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 in any case. The external Internship is concluded by a short reflection portfolio on the professional experience.

The University of Oldenburg requests to fulfil a few requirements for the internship:

· A proof of the workload performed by the student. A working contract or confirmation
letter by the supervisor at the host institution are suitable documents for this aim.

· A short feedback by the local supervisor about the performance of the student during the internship is recommended, but not compulsory

Internship Seminar (90 h workload):

· Presentation (max. 20 minutes) of the host organization, the task(s) performed. Main focus of the presentation are the lessons learned and experiences during the internship from the perspective of own career development: e.g. soft-skills, team-working competences, own presentation and own role within the team and project, project and time management.

- Students are asked to hand in assignments reflecting on their internship, comprising a description of the host organization, planned and performed tasks, perspectives for a thesis project.

Literaturempfehlungen	
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	jährlich
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	At the end of the lecture period and during the semester (presentation)	1 Examination: E-Portfolio including a (presentation (incl. Discussion - 20min.) and reflection activities (short reflection summary, SWOT analysis)

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Seminar		2	SoSe und WiSe	28
Praktikum		4	SoSe und WiSe	56
Präsenzzeit Modul insgesamt				84 h

pre061 - Renewable Energy Complementary Topics

Modulbezeichnung	Renewable Energy Complementary Topics
Modulkürzel	pre061
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Lehnhoff, Sebastian (Prüfungsberechtigt) • Agert, Carsten (Prüfungsberechtigt) • Heinemann, Detlev (Prüfungsberechtigt) • Gütay, Levent (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Siebenhüner, Bernd (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt) • Aßmuth-Düster, Heidemarie (Prüfungsberechtigt) • Kobusch, Ulrich (Prüfungsberechtigt) • Tjarks, Claudia (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	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
Modulinhalte	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

Literaturempfehlungen				
Links				
Unterrichtsprachen		Deutsch, Englisch		
Dauer in Semestern		1 Semester		
Angebotsrhythmus Modul				
Aufnahmekapazität Modul		unbegrenzt		
Modulart		Wahlpflicht / Elective		
Modullevel		BC (Basiscurriculum / Base curriculum)		
Prüfung	Prüfungszeiten		Prüfungsform	
Gesamtmodul			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..	

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe und WiSe	28
Seminar und Übung		2	SoSe und WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre081 - Renewable Energy Project

Modulbezeichnung	Renewable Energy Project
Modulkürzel	pre081
Kreditpunkte	9.0 KP
Workload	270 h (270 Stunden)
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Holtorf, Hans-Gerhard (Modulverantwortung) • Wollenhaupt, Matthias (Modulverantwortung) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Wollenhaupt, Matthias (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

· distinguish between valuable / trustworthy and less valuable / less trustworthy input data,
necessary and unnecessary data

· judge and then decide on methodologies to apply in order to generate an answer to a
research question related to an energy supply system

· develop and then recommend a technical, economic and social solution for an energy
service supply system

· explain, justify and defend the developed solution

On a second level students train

· working in an international team

· managing an international team

· collaborating with an international manager

· managing their project (project management)

· conflict management

- documentation of their time spent on the project, thereby getting an insight into different
steps of a project and its expenditure on time.

Modulinhalte

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 transfer their competences to solve a real-life project. Thereby, this module trains students to apply the knowledge acquired in previous lectures to a real-life problem. The module consists of two parts, the Case Study Seminar (6CP) and the Excursion (3CP).

Case Study Seminar (180 h workload)

Students need to:

· Determine a real-life case of their interest

· 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 (90 h workload)

The excursion refers to the lectures within SuRE and complements them in terms of applying the lecture content or presenting additional, non-lectured RE technologies of interest.

Students fully self-manage the excursion whereby the lecturer consults and

supports the organisation when necessary.

For the institutions to be visited:

- Determination of a list of institutions to be visited
- Establishment of contact with those institutions
- Management of the appointments with those institutions
- Reporting on the excursion appointment and summarizing of lessons learned
- Post Excursion communication with the institutions visited

For the organisation of the excursion students:

- plan the excursion route and excursion schedule
- manage appropriate accommodation
- negotiate and commission the bus company
- establish the economical balance
- assure safety on the journey

Finally, the excursion is performed while recurring to the points above.

Literaturempfehlungen	
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Annual, in winter semester
Aufnahmekapazität Modul	unbegrenzt
Hinweise	Specifically, the Excursion will contribute to the PPRE students' bonding amongst one another and with other students at the university of Oldenburg (specifically EP, Phy, SEM). Furthermore, it enables insights in to institutions dealing with Renewable Energy on multiple levels.
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Project & Excursion
Vorkenntnisse	Contents of 1st and 2nd semester of a master programme related to renewable energy including a selection of transferrable skills (e.g. project management, leadership, language, teamwork, written and verbal communication, listening

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Throughout the semester	2 Examinations: Portfolio – Excursion – Within Group Work: - Performance on Institutions' Appointment Mgt. + - Performance in Infrastructure Management, And Personal Performance within the excursion Presentation of a Paper - Case Study – 30min presentation + 10pages report

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe und WiSe	28
Seminar		2	SoSe und WiSe	28
Exkursion		2	SoSe und WiSe	28

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Präsenzzeit Modul insgesamt				84 h

pre112 - Photovoltaics Systems & Solar Energy Meteorology

Modulbezeichnung	Photovoltaics Systems & Solar Energy Meteorology
Modulkürzel	pre112
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Heinemann, Detlev (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

Modulinhalte

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

Literaturempfehlungen					
Links					
Unterrichtsprachen			Deutsch, Englisch		
Dauer in Semestern			1 Semester		
Angebotsrhythmus Modul					
Aufnahmekapazität Modul			unbegrenzt		
Modulart			Wahlpflicht / Elective		
Modullevel			BC (Basiscurriculum / Base curriculum)		
Prüfung		Prüfungszeiten		Prüfungsform	
Gesamtmodul				1 Prüfungsleistung: Klausur (2h). Im Seminar wird Aktive Teilnahme (siehe Ergänzung zu „§ 9 Abs. (6)) gefordert und ist Voraussetzung für die Teilnahme an der Klausur.	
Lehrveranstaltungsform	Kommentar		SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung			2	SoSe und WiSe	28
Seminar			2	SoSe und WiSe	28
Präsenzzeit Modul insgesamt					56 h

pre121 - Wind Energy Converters & Fluid Dynamics

Modulbezeichnung	Wind Energy Converters & Fluid Dynamics
Modulkürzel	pre121
Kreditpunkte	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Heinemann, Detlev (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

Modulinhalte

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

Literaturempfehlungen	
Links	

Unterrichtsprachen	Deutsch, Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	BC (Basiscurriculum / Base curriculum)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		1 Prüfungsleistung: Klausur (3h) oder Präsentation (30 min.) oder mündliche Prüfung (45 min.) oder fachpraktische Übungen (max. 10) oder Hausarbeit (max. 30 Seiten)

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		4	SoSe und WiSe	56
Übung		4	SoSe und WiSe	56
Präsenzzeit Modul insgesamt				112 h

pre131 - Design and Simulation of Wind Turbines

Modulbezeichnung	Design and Simulation of Wind Turbines
Modulkürzel	pre131
Kreditpunkte	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Heinemann, Detlev (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Waldl, Hans-Peter (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	

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

Modulinhalte

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 Risø 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

Literaturempfehlungen			
Links			
Unterrichtsprachen		Deutsch, Englisch	
Dauer in Semestern		1 Semester	
Angebotsrhythmus Modul			
Aufnahmekapazität Modul		unbegrenzt	
Modulart		Wahlpflicht / Elective	
Modullevel		BC (Basiscurriculum / Base curriculum)	
Prüfung	Prüfungszeiten		Prüfungsform
Gesamtmodul			1 Prüfungsleistung: Klausur (3h) oder Präsentation (30 min.) oder mündliche Prüfung (45 min.) oder fachpraktische Übungen (max. 10) oder Hausarbeit (max. 30 Seiten)
Lehrveranstaltungsform	Vorlesung		
SWS	6		
Angebotsrhythmus	SoSe und WiSe		

pre151 - Renewable Energy in Developing Countries

Modulbezeichnung	Renewable Energy in Developing Countries
Modulkürzel	pre151
Kreditpunkte	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Günther, Andreas (Prüfungsberechtigt) • Jimenez Martinez, Cuauhtemoc Adrian (Prüfungsberechtigt) • Siebenhüner, Bernd (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	
Modulinhalte	
Literaturempfehlungen	
Links	
Unterrichtsprachen	Deutsch, Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	BC (Basiscurriculum / Base curriculum)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		1 Prüfungsleistung: Seminararbeit (40 S.) oder Referat (Präsentation - 45 Minuten, Ausarbeitung 20 Seiten) Im Seminar wird Aktive Teilnahme (siehe Ergänzung zu „§ 9 Abs. (6)) gefordert.

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		4	SoSe und WiSe	56
Seminar		4	SoSe und WiSe	56
Präsenzzeit Modul insgesamt				112 h

pre034 - Renewable Energy Technologies II

Modulbezeichnung	Renewable Energy Technologies II
Modulkürzel	pre034
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Pehlken, Alexandra (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	
Modulinhalte	
Literaturempfehlungen	
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	MM (Mastermodul / Master module)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		2 Prüfungsleistungen: - 2 Referate zu je (15 min. Präsentation, 15 Seiten Bericht, Gewicht 50%).

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Praktikum		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				112 h

pre091 - Transferrable skills

Modulbezeichnung	Transferrable skills
Modulkürzel	pre091
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Aßmuth-Düster, Heidemarie (Prüfungsberechtigt) • Kobusch, Ulrich (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	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
Modulinhalte	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
Literaturempfehlungen	
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	MM (Mastermodul / Master module)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		2 Prüfungsleistungen: Das Modul ist unbenotet, jedoch müssen 2 der möglichen Kurse mindestens

Prüfung	Prüfungszeiten	Prüfungsform
		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.

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Praktikum		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				112 h

inf511 - Smart Grid Management

Modulbezeichnung	Smart Grid Management
Modulkürzel	inf511
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Informatik (Master) > Angewandte Informatik • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule • Master Wirtschaftsinformatik (Master) > Akzentsetzungsmodule der Informatik
Zuständige Personen	• Lehnhoff, Sebastian (Modulverantwortung) • Lehrenden, Die im Modul (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Nach erfolgreichem Abschluss der Lehrveranstaltung sollen die Studierenden die bestehenden Strukturen und technischen Grundlagen von Energiesystemen zur Erzeugung, Übertragung und Verteilung elektrischer Energie und deren Zusammenspiel und Abhängigkeiten untereinander verstehen. Sie sollen ein Verständnis für die notwendigen informations- und leittechnischen Komponenten, Verfahren und Prozesse zur Führung und zum Betrieb elektrischer Energiesysteme entwickeln und An- und Herausforderungen -- insbesondere an die Informations- und Kommunikationstechnik (IKT) und für die Informatik -- abschätzen und bewerten können, die sich durch den Ausbau und die Integration unvorhersehbar fluktuierender dezentraler Erzeuger in das bestehende System ergeben. Die Studierenden sollen in die Lage versetzt werden, den Einfluss von verteilten Regelkonzepten und Algorithmen für dezentrale Erzeuger und Verbraucher in sogenannten Smart Grids auf den Betrieb elektrischer Energiesysteme einzuschätzen und hinsichtlich der Anforderungen an Betriebssicherheit, Zuverlässigkeit, Echtzeitfähigkeit und Flexibilität zur analysieren.
Kompetenzziele	**Fachkompetenzen** Die Studierenden • benennen und erkennen die bestehenden Strukturen und technischen Grundlagen von Energiesystemen zur Erzeugung, Übertragung und Verteilung elektrischer Energie und deren Zusammenspiel und Abhängigkeiten untereinander • benennen notwendigen informations- und leittechnischen Komponenten, Verfahren und Prozesse zur Führung und zum Betrieb elektrischer Energiesysteme • bewerten An- und Herausforderungen die sich durch den Ausbau und die Integration unvorhersehbar fluktuierender dezentraler Erzeuger in das bestehende System ergeben • schätzen den Einfluss von verteilten Regelkonzepten und Algorithmen für dezentrale Erzeuger und Verbraucher in sogenannten Smart Grids auf den Betrieb elektrischer Energiesysteme ein **Methodenkompetenzen** Die Studierenden • analysieren Anforderungen an Betriebssicherheit, Zuverlässigkeit, Echtzeitfähigkeit und Flexibilität in sogenannten Smart Grids auf den Betrieb elektrischen Energiesystemen • verwenden weiterführende mathematische Methoden der Netzberechnung **Sozialkompetenzen** Die Studierenden • erarbeiten in Kleingruppen Lösungen zu gegebenen Problemen • diskutiert die eigenen Lösungen mit anderen **Selbstkompetenzen** Die Studierenden • reflektieren den eigenen Umgang mit der begrenzten Ressource Energie

Modulinhalte	In dieser Veranstaltung sollen informationstechnische, energiewirtschaftliche sowie technische Grundbegriffe und Verfahren anhand konkreter Smart Grid-Ansätze herausgearbeitet und analysiert werden. Die grundlegenden Berechnungsverfahren für ein intelligentes Netzmanagement werden vorgestellt. Dieses Modul behandelt die technischen und wirtschaftlichen Rahmenbedingungen für einen zulässigen elektrischen Netzbetrieb sowie die mathematischen Modellierungsmethoden und Berechnungsverfahren zur Analyse von Betriebszuständen in elektrischen Energienetzen (im stationären Zustand). Im Einzelnen sind dies: • Organisation des europäischen Energiemarktes (Regulatorischer Rahmen, Verantwortlichkeiten im liberalisierten elektrischen Energiesystem) • Aufbau und Betrieb elektrischer Energieversorgungsnetze (Netztopologien, Versorgungsaufgabe, Netznutzungsentgelte, Versorgungsqualität/Systemdienstleistungen, Störfälle und Schutzsysteme) • Netzberechnung (Komplexe Zeigerdarstellung, Wirk-/Blindleistung, mathematische Leistungsmodelle/Netzmodelle, Abbildungen: Knotenleistungen zur Knotenspannungen / -strömen, Berechnung von Leitungsströmen, Leistungsflussrechnung, Fixpunktiterationsverfahren, Newton-Raphson-Methode, Spannungsabfall, Trafomodell) • Intelligentes Netzmanagement (Smart Grids), Aggregationsformen, Ansätze des maschinellen Lernens)
Literaturempfehlungen	• Konstantin, P.; Praxisbuch Energiewirtschaft, Springer 2006 • Schwab, A.; Elektroenergiesysteme, Springer 2009 • Kirtley, J.L.; Electric Power Principles, John Wiley & Sons, 2010 • Gremmel, H.; ABB Schaltanlagen-handbuch, Cornelsen 2007 • Lehnhoff, S.: Dezentrales vernetztes Energiemanagement, 2010 • Sutton, R.S.; Barto, A.G.: Reinforcement Learning, MIT Press 1998
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	jährlich
Aufnahmekapazität Modul	unbegrenzt
Lehr-/Lernform	1VL + 1Ü
Vorkenntnisse	keine

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Ende des Semesters, Wiederholung O-Woche des kommenden Semesters	Mündliche Prüfung oder Klausur.

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		3	SoSe	42
Übung		1	SoSe	14
Präsenzzeit Modul insgesamt				56 h

pre152 - Resilient Energy Systems

Modulbezeichnung	Resilient Energy Systems
Modulkürzel	pre152
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainability Economics and Management (Master) > Ergänzungsmodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Agert, Carsten (Modulverantwortung) • Torio, Herena (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: · analyze, and critically understand different definitions of resilience and fundamental concepts relevant in the context of energy systems analysis (e.g. complexity, homeostas equilibria, stressors,…) · understand and interlink assessment methods, principles and theories for resilience anal of energy supply systems in different scientific disciplines · critically evaluate the suitability, meaningfulness and implications of different resilience-related indicators, theories and assessment methods from several disciplines · develop a scientific discourse on suitable approaches for assessing particular aspects of resilient energy system design in the context of a particular real-life case study · identify main barriers, potentials and driving factors for improving one selected assessme approach in the context of its application to a case study · perform a literature review, apply a selected resilience and extract the main related conclusions, arguing critically on them · present scientific results and conclusions both verbally and in written form, including quotation to a professional standard
Modulinhalte	The module “Resilient energy systems” provides the theoretical background for understanding main concepts and interdisciplinary scientific methods from the context of resilience assessment as well as their role in the debate towards resilient energy systems. Resilient Energy Systems (Lecture & Seminar, 180 h workload): · Definitions and fundamental concepts in resilience analysis of energy systems (complexity, homeostasis, equilibria, feedback loops,…) · Approaches and methods for resilience assessment from different relevant disciplines: - epistemic approaches - resilience as guiding principle - aggregation methods for resilience assessment - cyber-security and informatics

- environmental modelling
- risk and vulnerability analysis
- agent-based models
- governance studies

Literaturempfehlungen

Jesse et al. 2019. Adapting the theory of resilience to energy

systems: a review and outlook. Energy, Sustainability and Society (2019) 9:27 https://doi.org/10.1186/s13705-019-0210-7

HöllingC.S., 2001. Understanding the Complexity of Economic, Ecological and SocialSystems. Ecosystems, 4, (2001), pp. 390-405.

Gössling-Reisemann, S. Resilience – Preparing Energy Systems for the Unexpected. In: Florin, Marie-Valentine / Linkov, Igor (Eds.), 2016, IRGC Resource Guide on Resilience, Lausanne EPFL International Risk Governance Center (IRGC), p. 73-80

Roegge P.E. et al. 2014. Metrics for energy resilience. Energy Policy, 72, (2014), pp. 249–256. http://dx.doi.org/10.1016/j.enpol.2014.04.012

Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Wintersemester
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lecture, Seminar

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	At the end of the semester	Presentation of a Paper (presentation - 20 minutes and written report ca. 10 pages) or Term Paper (ca. 15 pages)

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Übung			--	0
Präsenzzeit Modul insgesamt				56 h

pre153 - Mini-Grids

Modulbezeichnung	Mini-Grids
Modulkürzel	pre153
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	
Teilnahmevoraussetzungen	
Kompetenzziele	
Modulinhalte	
Literaturempfehlungen	
Links	
Unterrichtsprachen	Deutsch, Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	SPM (Schwerpunktmodul / Main emphasis)

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

phy609 - Photovoltaic Physics

Modulbezeichnung	Photovoltaic Physics
Modulkürzel	phy609
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (Modulverantwortung) • Gütay, Levent (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Solid-state-Pysics, semi-conductor Physics, Module RenewableEnergy Technologies I
Kompetenzziele	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
Modulinhalte	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
Literaturempfehlungen	S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons(2nd Edition 2011); Christiana Honsberg and Stuart Bowden, PVCDROM, http://www.pveducation.org/pvcdrom/instructions, Access date 2.10.2014; lecture notes for the respective courses
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Sommersemester
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Vorlesung: 4 SWS, Übung: 2 SWS

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		written exam between 90 and 180 minutes or presentation between 20 and 45 minutes or oral exam between 20 and 45 minutes or homework between 15 and 30 pages or internshipreport between 15 and 30 pages

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

phy616 - Computational Fluid Dynamics

Modulbezeichnung	Computational Fluid Dynamics
Modulkürzel	phy616
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > European Wind Energy Master • Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Lukassen, Laura (Modulverantwortung) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Fluid Dynamics I
Kompetenzziele	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 fluiddynamics. 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.
Modulinhalte	CFD I: The Navier-Stokes equations, introduction to numerical methods, finite-differences, finite-volume methods, linear equation systems, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy. CFD II: RANS, URANS, LES, DNS, filtering / averaging of Navier- Stokes equations, Introduction to different CFD models, Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.
Literaturempfehlungen	J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002; C. Hirsch, Numerical Computation of Internal and External Flows: Introduction to the Fundamentals of CFD, Vol 1: Fundamentals of Computational Fluid Dynamics, 2nd edition, Butterworth-Heinemann, Amsterdam; P. Sagaut, Large Eddy Simulation for Incompressible Flows, Springer, Berlin, 1998; J. Fröhlich, Large Eddy Simulationen turbulenter Strömungen, Teubner, Wiesbaden, 2006 (in German)
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	jährlich
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lecture: 2hrs/week, Excersise: 2hrs/week

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		-Max. 180 min. Klausur oder 30 min. mündliche Prüfung Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes or

Prüfung	Prüfungszeiten	Prüfungsform
		1 Term paper: Between 15 and 30 pages

Lehrveranstaltungsform	VA-Auswahl (Vorlesungen oder Praktikum oder Seminar)
SWS	4
Angebotsrhythmus	SoSe oder WiSe

phy641 - Energy Resources & Systems

Modulbezeichnung	Energy Resources & Systems
Modulkürzel	phy641
Kreditpunkte	6.0 KP
Workload	180 h (180 h (Präsenzzeit 56h, Selbststudium: 124h))
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master European Master in Renewable Energy (Master) > Mastermodule • Master Sustainability Economics and Management (Master) > Ergänzungsmodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Modulverantwortung) • Knipper, Martin (Modulverantwortung) • Knipper, Martin (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Schmidt, Thomas (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	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.
Modulinhalte	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

Literaturempfehlungen	Energy Meteorology: • IEA Word Energy Outlook (http://wordenergyoutlook.org/) • Iqbal, M. 1984: An Introduction to Solar Radiation, Academic Press, Toronto • Liou, K.-N. 2002: An Introduction to Atmospheric Radiation, Academic Press: 2nd edition, Page 2 of 39 • Peixoto, J.P. and Oort A.H. 2007: Physics of Climate Book, Surge Publishing • Rasmussen, B. 1988: Wind Energy, 2, Routledge: 1st edition • Sathyajith, M. 2006: Wind energy: fundamentals, resource analysis and economics, Springer • Stull, R.B. 1988: An Introduction to Boundary Layer Meteorology, Springer 1st edition Energy Systems: • Ramage, J.: Energy: A Guide Book (Oxford University Press, 1997) • Boyle, G. et al. (Eds.): Energy Systems and Sustainability (Oxford University Press, 2003) • Blok, K.: Introduction to Energy Analysis (Techne Press, Amsterdam, 2007) • Houghton, J.: Global Warming: The Complete Briefing, 5th Ed. (Cambridge University Press, 2015) • UNDP (Ed.): World Energy Assessment: Energy and the Challenge of Sustainability (2000/2004), http://www.undp.org/energy/weapub2000.htm • GEA: Global Energy Assessment { Toward a Sustainable Future (Cambridge University Press and International Institute for Applied System Analysis, Laxenburg, 2012), www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Chapters_Home.en.html - Goldemberg, J. et al.: Energy for a Sustainable World (Wiley Eastern, 1988) • Nakicenovic, N., A. Grübler and A. McDonald (Eds.): Global Energy Perspectives (Cambridge University Press, Cambridge, 1998) - Khartchenko, N.V.: Advanced Energy Systems (Taylor and Francis, 1998) • IEA (International Energy Agency): World Energy Statistics and Balances 2015 - BP: Statistical Review of World Energy 2016 (http://www.bp.com/en/global/corporate/ energy-economics.html) • EIA: International Energy Outlook 2016 (www.eia.doe.gov/forecasts/ieo/) • United Nations: 2013 Energy Statistics Yearbook (2016) (unstats.un.org/unsd/energy/yearbook/)
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	jährlich
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lecture, Exercises

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	At the end of the lecture period	2 Written Exams (max 90 min each)

Lehrveranstaltungsform	Vorlesung
SWS	4
Angebotsrhythmus	SoSe oder WiSe

phy647 - Future Power Supply Systems

Modulbezeichnung	Future Power Supply Systems
Modulkürzel	phy647
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Torio, Herena (Modulverantwortung) • Agert, Carsten (Modulverantwortung)
Teilnahmevoraussetzungen	Knowledge from module RE technology I, Mathematics
Kompetenzziele	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
Modulinhalte	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)
Literaturempfehlungen	Future Power Supply Systems: Buchholz, B.M., Styczynski Z. (2014). Smart Grids - Fundamentals and Technologies in Electricity Networks. Springer Ed., Khartchenko, N. et al. (2013). Advanced Energy Systems, Second Edition (Energy Technology). CRC Press Inc. Hemami, A. (2015). Electricity and Electronics for Renewable Energy Technology: An Introduction (Power Electronics and Applications) CRC Press, Schlögl, R. (2013) Ed., Chemical Energy Storage, De Gruyter
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Sommersemester
Aufnahmekapazität Modul	unbegrenzt

Modulart		Wahlpflicht / Elective	
Modullevel		MM (Mastermodul / Master module)	
Lehr-/Lernform		Lecture and Seminar: 4 hrs/week	
Prüfung	Prüfungszeiten		Prüfungsform
Gesamtmodul			Report (presentation: 50 min, Term-paper: 5 pp.) or Exercises (8 Exercises). In addition, active participation is required. The criteria to fulfil the requirement of the active participation are announced at the beginning of the term.
Lehrveranstaltungsform	Vorlesung		
SWS	4		
Angebotsrhythmus	SoSe oder WiSe		

phy648 - Wind Resources and their Applications

Modulbezeichnung	Wind Resources and their Applications
Modulkürzel	phy648
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (Modulverantwortung) • Steinfeld, Gerald (Prüfungsberechtigt) • Waldl, Hans-Peter (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Energy Meteorology
Kompetenzziele	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
Modulinhalte	

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 Risø 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
Literaturempfehlungen	
	Advanced Wind Energy Meteorology Holton, J.R. and G. J. Hakim, 2013: An Introduction to Dynamic Meteorology, 5th Edition, Academic Press, New York Stull, R.B., 1988: An Introduction to Boundary Layer Meteorology. Kluwer Academic Pub. Wind Energy Applications - from Wind Resource to Wind Farm Operations Burton, T., N. Jenkins, D. Sharpe and E. Bossanyi, 2011: Wind Energy Handbook, Second Edition, John Wiley. Gasch, R. and J. Twele, 2012: Wind Power Plants: Fundamentals, Design, Construction and Operation; Second Edition, Springer http://www.av8n.com/how/htm/airfoils.html, Last access: 4/2016 http://www.windpower.org/en/, Last access: 4/2016
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	jährlich
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Vorlesung: 4 SWS
Vorkenntnisse	Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		1 Written examination: 120 minutes or Oral examination: Between 30 and 45 minutes or Internship report: Between 15 and 20 pages in one lecture and regular active participation in the other lecture

Lehrveranstaltungsform	Vorlesung
SWS	4
Angebotsrhythmus	SoSe oder WiSe

phy649 - Design of Wind Energy Systems

Modulbezeichnung	Design of Wind Energy Systems
Modulkürzel	phy649
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 108 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (Modulverantwortung) • Kühn, Martin (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Wind Energy Utilization (Bachelor) or Wind Energy (Master)
Kompetenzziele	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
Modulinhalte	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
Literaturempfehlungen	T. Burton et. al.: Wind Energy Handbook. John Wiley, New York, 2nd ed., 2011; R. Gasch, J. Twele: Wind Power Plants. Springer, Berlin, 2nd ed., 2011.; Garrad Hassan, Bladed, Wind Turbine Design Software, Theory Manual; Selected papers from e.g. Wind Energy Journal, Wiley Interscience
Links	
Unterrichtssprache	Englisch

Dauer in Semestern		1 Semester	
Angebotsrhythmus Modul		jährlich	
Aufnahmekapazität Modul		unbegrenzt	
Modulart		Wahlpflicht / Elective	
Modullevel		MM (Mastermodul / Master module)	
Lehr-/Lernform		Lecture and seminar: 2 and 2 hrs/week	
Vorkenntnisse		Basics in Wind Energy Utilisation	
Prüfung	Prüfungszeiten		Prüfungsform
Gesamtmodul			Internship report: Between 15 and 30 pages
Lehrveranstaltungsform	Vorlesung		
SWS	4		
Angebotsrhythmus	SoSe oder WiSe		

phy987 - Control of Wind Turbines and Wind Farms

Modulbezeichnung	Control of Wind Turbines and Wind Farms
Modulkürzel	phy987
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 72 hrs, Self study: 108 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (Modulverantwortung) • Kühn, Martin (Prüfungsberechtigt) • Petrovic, Vlaho (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Wind Energy Utilization (Bachelor) or Wind Energy Physics (Master) or Basics of Wind Energy (Master SURE) and Design of Wind Energy Systems (can be attended in parllel
Kompetenzziele	After successful completion of the course, students • will have understood the structure and the main components of the control system in a wind farm • will have understood the main objectives for a wind farm control system and will be able to develop appropriate control algorithms for the said objectives • will have understood relevant physical phenomena in a wind farm • will be able to develop a control-oriented model of a wind turbine, and will have understood how to use it for the design and analysis of control algorithms • will be able to independently apply different techniques from control engineering • will have trained how to use methods from linear algebra and mathematical analysis for the design and analysis of control algorithms
Modulinhalte	The course covers the main techniques used in wind turbine and wind farm control. The course is structured in five sections: Section I: Introduction to control in wind energy • Introduction to the governing physics • Control objectives in wind energy • Overview of the control system Section II: Control oriented modelling • Modelling in time domain • Modelling in frequency domain • Time and frequency response Section III: Standard wind turbine control • Torque and pitch control • Tuning of a PI controller • Stability analysis • Control of coupled systems

	Section IV: Advanced wind turbine control • Advanced control design approaches • State space control • Estimation techniques Section V: Wind farm control • Wake control strategies • Active power control • Power maximization
Literaturempfehlungen	Burton et al: Wind Energy Handbook, John Wiley, New York, Second Edition, 2011. Ogata: Modern Control Engineering, Prentice Hall, Upper Saddle River, New Jersey, Third Edition, 1997
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	jährlich
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	EB (Ergänzungsbereich / Complementary)
Lehr-/Lernform	Lectures and exercises: 4 hours per week and home assignments
Vorkenntnisse	Basic knowledge in linear algebra and mathematical analysis is required. Furthermore, a basic understanding of wind turbines and wind farms is required (e.g. Design of Wind Energy Systems). A good grasp of the Matlab/Simulink environment is required for exercises.

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes or Internship report: Between 15 and 30 pages

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre014 - Fundamentals for Renewable Energy

Modulbezeichnung	Fundamentals for Renewable Energy
Modulkürzel	pre014
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master European Master in Renewable Energy (Master) > Mastermodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (Modulverantwortung) • Agert, Carsten (Modulverantwortung) • Torio, Herena (Prüfungsberechtigt) • Hoppmann, Jörn (Prüfungsberechtigt) • Günther, Andreas (Prüfungsberechtigt) • Ziethe, Paul (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: • develop a basic understanding and skills for programming in languages relevant for energy systems analysis and modelling (Python) • understand and apply fundamental approaches for modelling energy systems (statistical and analytical models) • 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
Modulinhalte	The module is designed to give students a solid foundation to successfully start the MSc programme. The compulsory content from the fields of Energy Systems Modelling and Programming, as well as energy economics and management intends to provide a homogeneous knowledge base in these fields. The compulsory content of the course "Python Programming and Modelling" provides a basic introduction to Python as one of the leading programming languages in the fields of energy system analysis as well as a sound introduction to fundamental modelling approaches used in energy system analysis. These two topics provide a solid basis required for understanding the content of the provided specializations during the summer term. Additional optional materials within this course include videos, scripts and exercises in the fields of electric power systems analysis, thermodynamics, fluid dynamics or solid-state physics and are provided as optional self-learning materials that can be used on demand by the students to update their knowledge on these fundamental fields. 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 • 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.

Literaturempfehlungen	Python / Modelling: T.Agami Reddy. 2011. Applied Data Analysis and Modeling for Energy Engineers and Scientists. Springer-Verlag New York. RE Management (optional): Anadon, L. D. (2012). Missions-oriented RD&D institutions in energy between 2000 and 2010: A comparative analysis of China, the United Kingdom, and the United States. *Research Policy, 41*(10), 1742-1756. Hoppmann, J., Volland, J., Schmidt, T. S., & Hoffmann, V. H. (2014). The economic viability of battery storage for residential solar photovoltaic systems–A review and a simulation model. *Renewable and Sustainable Energy Reviews, 39*, 1101-1118. Hoppmann, J., Peters, M., Schneider, M., & Hoffmann, V. H. (2013). The two faces of market support - How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry. *Research Policy, 42*(4), 989-1003. Gallagher, K. S., Grübler, A., Kuhl, L., Nemet, G., & Wilson, C. (2012). The energy technology innovation system. *Annual Review of Environment and Resources, 37*, 137-162. Jacobsson, S., & Lauber, V. (2006). The politics and policy of energy system transformation - Explaining the German diffusion of renewable energy technology. *Energy Policy, 34*(3), 256-276. Nemet, G. F. (2019). *How solar energy became cheap: A model for low-carbon innovation*. London: Routledge. Ossenbrink, J., Hoppmann, J., & Hoffmann, V. H. (2019). Hybrid ambidexterity: How the environment shapes incumbents' use of structural and contextual approaches. *Organization Science, 30*(6), 1125-1393. Simkins, B., & Simkins, R. (2013). Energy finance and economics: analysis and valuation, risk management, and the future of energy (Vol. 606): John Wiley & Sons. Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy, 35*, 2683-2691

Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lectures, Exercises

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Python / Modelling: During the semester RE Management: At the end of the lecture period	Python / Modelling: Practical Exercises (3 exercises, weight 1/3 each) RE Management: Written Exam

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung oder Seminar		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Praktikum		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				84 h

pre017 - Renewable Energy Laboratories

Modulbezeichnung	Renewable Energy Laboratories
Modulkürzel	pre017
Kreditpunkte	6.0 KP
Workload	180 h ( )
Verwendbarkeit des Moduls	• Master European Master in Renewable Energy (Master) > Mastermodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Günther, Andreas (Prüfungsberechtigt) • Agert, Carsten (Modulverantwortung) • Knipper, Martin (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should have gained general methods of scientific experimenting and scientific writing. The focus of expertise will be on renewable energy in the following fields: • Radiation and Matter (solar photovoltaic cell) • Energy Storage (battery and hydrogen storage systems) • Fluids (wind profiles and wind energy converters
Modulinhalte	This module complements and adds on to the lecture content of the modules *pre022 Solar Energy* (course Photovoltaics) as well as *pre025 Wind Energy and Storage* (courses Basics of Wind Energy and Energy Storage). **Introductory Lab** Student’s knowledge on basics of measurement are levelled out by basic measurements of voltage, resistance and current as well as general detectors transforming temperature, speed and radiation in to electric signals. **Scientific Writing** Students are introduced in to general rules and practice of scientific writing and their awareness is created towards prohibited plagiarism and proper citation. **Laboratories** The focus of the labs listed below is on the scientific principles of components and the technical description of those components. *Lab Radiation and Matter (solar photovoltaic cell)* In these experiments the relation between radiation density, its spectrum as well as PV-cell’s temperature is introduced.

Lab Energy Storage (battery systems)

Students explore the behaviour of a lead acid battery (charging and discharging, capacity, internal resistance as a function of capacity and state of charge) as well as a model electrolyser and model fuel cell whereby basic features of a hydrogen storage system and its components are distilled.

Lab Fluids (wind profiles and wind energy converters)

In a model wind tunnel students search lift and drag coefficients of objects, specifically wind profiles (lift, drag, gliding angle as a function of wind speed) and they explore the operational characteristic of a model wind energy converter (cp-? curve).

Literaturempfehlungen	
	2011, A guide to writing articles in energy science, Weiss M., Newman Alexandra PPRE Lab Reader Intro Lab (annually updated) PPRE Lab Reader Winter Lab (annually updated)
Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Winter Semester
Aufnahmekapazität Modul	40
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Laboratory, Lectures, Exercises
Vorkenntnisse	The participation in the “Introductory Laboratory 5.06.M101” as well as “Scientific Writing 5.06.M105” is compulsory for the participation in the laboratories - Radiation and Matter, - Energy Storage, - Fluids,

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Throughout the semester	Portfolio 5 lab reports + 1 exercise – in scientific writing

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	WiSe	28
Übung		2	WiSe	28
Praktikum		2	WiSe	28
Präsenzzeit Modul insgesamt				84 h

pre022 - Solar Energy

Modulbezeichnung	Solar Energy
Modulkürzel	pre022
Kreditpunkte	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainability Economics and Management (Master) > Ergänzungsmodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Modulverantwortung) • Torio, Herena (Modulverantwortung) • Torio, Herena (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Gütay, Levent (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: · understand, describe and compare major technologies for solar energy use: solar thermal and photovoltaic systems · analyse various system components and their interconnections within a solar energy system. · critically appraise and assess various technologies for solar energy use and components involved in such solar systems. · size and evaluate the performance of solar systems as a function of their operation conditions, components and system layout - critically evaluate non-technical impact and side effects when implementing renewable energy supply systems
Modulinhalte	This module gives an overview on renewable energy heat and photovoltaic technologies. Main focus hereby are the scientific principles of components and their technical description as well as first suitable system performance assessment methods. **Photovoltaics** (Lecture: 90 h workload) • Basic and most important properties of solar radiation related to photovoltaics • PV cells basics: Fundamental physical processes in photovoltaic materials • Characterization 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 **Renewable Energy Heat** (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 system components: collectors; heat exchangers; thermal storage; thermal driven compression chillers
- Solar cooling systems and components
- Characterization of solar thermal systems, their operation and performance
- F-Chart and Utilizability methods as main methods for assessing system performance

Literaturempfehlungen

Solar Energy PV

· Green, Martin A., 1981: Solar cells : operating principles, technology and system applications,
Prentice Hall.

· Green, M.A., 2007: Third Generation Photovoltaics, Advanced Solar Energy Conversion,
Springer Series in Photonics

· Markvart, Tom and Castaner, Luis, 2003: Practical Handbook of Photovoltaics, Fundamentals
and Applications, Elsevier Science

· Nelson, Jenny, 2003: The Physics of Solar Cells (Properties of Semiconductor Materials),
Imperial College Press.

· Stuart R. Wenham, Martin A. Green, Muriel E. Watt& Richard Corkish (Edit.), 2007: Applied
Photovoltaics, Earthscan Publications Ltd.;

· Twidell, John & Weir, Toni, 2005: Renewable Energy Resources Taylor & Francis.

Renewable Energy Heat

· DGS, (2010) Planning and installing solar thermal systems, a guide for installers, architects
and engineers, 2nd ed.

· Duffie JA, Beckman WA (2013) Solar engineering of thermal processes: Wiley.

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Thermal Engineering 27(10):1734-1749; DOI: 10.1016/j.applthermaleng.2006.07.021

Links	
Unterrichtsprachen	
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Wintersemester
Aufnahmekapazität Modul	unbegrenzt
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lecture, Exercises

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	At the end of the lecture period; submission of the report at the end of the semester	2 Examinations: Written Exam (1.5h, weight 50%) and Presentation of a Paper (15 min presentation, 5 pages report, weight 50%)

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Übung		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre025 - Wind Energy and Storage

Modulbezeichnung	Wind Energy and Storage
Modulkürzel	pre025
Kreditpunkte	6.0 KP
Workload	180 h (180 Hours)
Verwendbarkeit des Moduls	• Master Sustainability Economics and Management (Master) > Ergänzungsmodule • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Hölling, Michael (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Agert, Carsten (Modulverantwortung) • Knipper, Martin (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: · Critically evaluate and describe basic characteristics and functioning of wind energy converters · Understand the physical principal of wind energy conversion · Understand wind turbine aerodynamics - Critically evaluate and describe electrochemical storage systems with a focus on batteries as well as hydrogen storage systems (electrolyser, gas storage and fuel cells)
Modulinhalte	**Basics of Wind Energy:** • Wind characterization and anemometers • Aerodynamic aspects of wind energy conversion • Wind turbine performance • Design of wind turbines • Dimensional analysis and pi-theorem **Energy Storage:** • Fundamentals of electrochemistry and thermodynamics • Energy and environmental balances • Fundamental setup of most common battery types • Fundamental chemical reactions in these batteries • Operational characteristics of batteries (charging & discharging, weir processes and service lives)
Literaturempfehlungen	· E. Hau: Wind Turbines - 2nd edition, Springer, Berlin 2005

· T. Burton et al.: Wind energy Handbook, John Wiley & Sons Ltd, 2001

· J. Twele und R. Gasch: Wind Power Plants, Springer, 2011

· Gold Peak Industries. Lithium Ion technical handbook. 2003; Available from:
https://web.archive.org/web/20071007175038/http://www.gpbatteries.com/html/pdf/Li-
ion_handbook.pdf.

· Fürstenwerth, D. and L. Waldmann, Stromspeicher in der Energiewende. 2015, Agora
Energiewende: Hannover, Germany. p. 22.

· Hoppecke, Installation, commissioning and operating instructions for vented stationary lead-
acid batteries, Hoppecke, Editor. 2013, Hoppecke Batterien GmbH & Co. KG: Brilon,
Germany.

- Fischer, W., Blei Fibel - Stationary Lead-Acid Batteries, An Introductory Handbook. 1996,
Hoppecke, Germany: Hoppecke. 130p..

Links		
Unterrichtssprache		Englisch
Dauer in Semestern		1 Semester
Angebotsrhythmus Modul		Annual, Winter Semester, first semester in SuRE and EMRE
Aufnahmekapazität Modul		unbegrenzt
Modulart		Pflicht / Mandatory
Modullevel		MM (Mastermodul / Master module)
Lehr-/Lernform		Lecture, Exercises
Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	End of Module's Block	Written Exams (wind energy & energy storage)

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre042 - Water and Biomass Energy

Modulbezeichnung	Water and Biomass Energy
Modulkürzel	pre042
Kreditpunkte	6.0 KP
Workload	180 h (180 Stunden)
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule • Master Umweltmodellierung (Master) > Mastermodule
Zuständige Personen	• Holtorf, Hans-Gerhard (Modulverantwortung) • Wark, Michael (Modulverantwortung) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Pehlken, Alexandra (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	After the completion of the module students should be able to - critically evaluate and compare two Renewable Energy conversion processes which allow continuous power supply on demand (hydropower and biomass energy) - confront those systems to a Renewable Energy conversion process with intermittent output (marine power) - discuss extreme situations in Renewable Energy systems' source and transfer such situations to other Renewable Energy systems - 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 - understand the basic chemical background of bioenergy-related materials, systems and processes
Modulinhalte	Biomass Energy (Lecture - 90 h workload) – Energy mix overview; gas, heat, electricity, Pros and 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 and 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 and Marine Power (Lecture + Excursion - 90 h workload)

– Revision of hydraulic basics and their application to hydro and marine power.

– Hydropower and marine power resources and their representation

– Technological and economical state of the art.

- Description of such systems' components, their characteristics, their interaction in a system,
their main features and their challenges

Literaturempfehlungen

Biomass Energy

– IEA (2019), Renewables 2019, IEA, Paris https://www.iea.org/reports/renewables-
2019Fagerström, A., Al Seadi, T., Rasi, S., Briseid, T, (2018).

– The role of Anaerobic Digestion and Biogas in the Circular Economy. Murphy, J.D. (Ed.) IEA
Bioenergy Task 37, 2018: 8

- IEA (2020), Outlook for biogas and biomethane: Prospects for organic growth, IEA,
Paris https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth

- International Finance Corporation. 2017. Converting Biomass to Energy: A Guide for
Developers and Investors. Washington, DC © https://openknowledge.worldbank.org/handle
/10986/28305 License: CC BY-NC-ND 3.0 IGO.

- Cushion, Elizabeth, Adrian Whiteman, and Gerhard Dieterle. Bioenergy development: issues
and impacts for poverty and natural resource man-agement

- Pehlken, A., Wulf, K., Grecksch, K., Klenke, T., Tsydenova, N.; More Sustainable Bioenergy by
Making Use of Regional Alternative Biomass?, Sustainability 2020, 12(19), 7849;
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- Schlögl, Robert (2013). Chemical energy storage (Elektronische Ressource ed.). Berlin [u.a.]:
De Gruyter.

- Sackheim, G.I., Lehman, D.D.: Chemistry for the Health Sciences
(8th edition), Prentice Hall, 1998

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- Alonso, D.M., Bond, J.Q., Dumesic, J.A., Catalytic conversion of biomasses to biofuels, Green
Chem. 12, 2010, 1493-1513

Hydro and Marine Power

- Charlier R.H., (2009) Ocean Energy: Tide and Tidal Power.

- Chtrakar P (2005) Micro-hydropower design aids manual: Small Hydropower Promotion
Project, Mini Grid Support Programme. 107p.

- Croockewit J (2004) Handbook for developing micro hydro in British Columbia: BChydro. 69
p.

- Giesecke J, Heimerl S, Mosonyi E (2014) Wasserkraftanlagen: Springer Vieweg. XXVI, 940 p.

- Inversin AR (1986) Micro-hydropower sourcebook: NRECA International Foundation.

- Meder K (2011) Environment Assessment and Watershed Action Planning related to GIZ ECO
MHP Projects: Field Manual. GIZ. 24 p.

- Pelikan B (2004) Guide on how to develop a small hydropower plant. European Small
Hydropower Association ESHA. 151 p.

- Penche C (1988) Layman's handbook on how to develop a small hydro site; Commission E,
editor.
- Rodriguez L, Sánchez T (2011) Designing and building mini and micro hydropower schemes - a
practical guide; Action P, editor: Practical Action Publishing Ltd. xxii, 359 p.

Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Wintersemester
Aufnahmekapazität Modul	unbegrenzt
Hinweise	Within the lecture Hydro and Marine Power an excursion to a hydropower plant and the catchment area will be offered. The duration of this excursion will be in total 5 hours. It is recommended to know the basics of photosynthesis.
Modulart	Pflicht / Mandatory
Modullevel	MM (Mastermodul / Master module)
Vorkenntnisse	Basics of - Hydrodynamics - Mechanical Engineering - Electrical Engineering - Recommended: Basic knowledge of General Chemistry

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	End of Winter Semester	Written Exam and active participation

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre064 - Renewable Energy Complementary Topics and Transferable Skills

Modulbezeichnung	Renewable Energy Complementary Topics and Transferable Skills
Modulkürzel	pre064
Kreditpunkte	6.0 KP
Workload	180 h (180 Stunden)
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Günther, Andreas (Prüfungsberechtigt) • Günther, Andreas (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	After completing the module students will be able to: • describe basic knowledge in a wide field of disciplines which complements the topics related to renewable energy • justify their personal decision on educational fields for their career development
Modulinhalte	The module is designed to give students an outlook on fields which have not been covered so far in their previous modules with a focus on non-technical topics. This includes social and political sciences, economics, transferrable and personal development skills, and languages. It intends to allow students tailoring their personal education for their professional careers. A selection of examples of courses eligible in this module are: Ecological Economics, International Environmental Governance or any university language courses.
Literaturempfehlungen	Refer to selected courses
Links	
Unterrichtsprachen	Deutsch, Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Refer to specific lecture
Vorkenntnisse	Refer to specific lecture

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		2 exams depending on the selected courses

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Übung		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				84 h

pre113 - Photovoltaic Systems

Modulbezeichnung	Photovoltaic Systems
Modulkürzel	pre113
Kreditpunkte	6.0 KP
Workload	180 h (180 Stunden)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Knipper, Martin (Modulverantwortung) • Agert, Carsten (Modulverantwortung)
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: · categorize and feature different PV systems o PV on-grid, o PV off-grid / stand alone, o PV-pumping, o PV-hybrid by their setup and by standard quality indicators. · explain the operation principles of the listed PV systems · explain concepts behind PV system design · design a photovoltaic system by Fermi Estimate · design a photovoltaic system by a simulation software · be aware of the limitation of both design methods · discuss energy flow diagrams of PV systems · describe in depth involved balance of system components e.g. o inverter, o charge controllers o cabling o generator stand storage battery with a focus on housing (ventilation)
Modulinhalte	This specialization module covers more in-depth topics concerning photovoltaics systems. The module consists of:

Photovoltaic Systems Lecture (90h workload)

Description and operation of PV System’s balance of system components

- inverter,
- charge controllers
- cabling
- generator stand
- storage battery with a focus on housing (ventilation)

Quality indicators for PV Systems and their regional differences

- PV on-grid,
- PV off-grid / stand alone,
- PV-pumping,
- PV-hybrid

Sizing of PV systems – back of the envelope approach as well as by a simulation software

Photovoltaic Systems Seminar (90h workload)

Within the seminar groups of up to five students select a PV system related research question, work on the solution and present their findings.

In addition, external PV experts are invited to present from their work experience.

An excursion to a PV power plant concludes the lessons learned in the field.

Literaturempfehlungen

· S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011)

· C.B.Honsberg and S.G.Bowden, “Photovoltaics Education Website,” www.pveducation.org, 2019, https://www.pveducation.org/pvcdrom/welcome-to-pvcdrom/instructions, Access date 21/07/2021

· Deutsche Gesellschaft fuer Solarenergie, Planning and installing photovoltaic systems: a guide for installers, architects and engineers. Earthscan, London, Third Edition, 2013 (ISBN-13: 978-1849713436)

- Heinrich Haeberlin, Photovoltaics: System Design and Practice, John Wiley and Sons, First Edition, Chichester, 2012.(ISBN-13: 978-1119992851)

· Konrad Mertens, Photovoltaik, Lehrbuch zu Grudlagen, Technologie und Praxis, 5. Aktualisierte Auflage

· GSES, Off-Grid PV Systems – Design and Installation, first edition international, April 2020

- Lecture notes for the respective courses

Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	SPM (Schwerpunktmodul / Main emphasis)
Lehr-/Lernform	Lecture, Exercise, Seminar & Excursion Lecture: 2hrs/week Seminar: 2hrs/week
Vorkenntnisse	It is desirable to have passed the lecture Photovoltaics 5.06.M121

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Throughout the Semester	Presentation: Between 20 and 45 minutes and regular active participation

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

pre114 - Solar Energy Meteorology

Modulbezeichnung	Solar Energy Meteorology
Modulkürzel	pre114
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (Modulverantwortung) • Agert, Carsten (Modulverantwortung) • Schmidt, Thomas (Prüfungsberechtigt) • Lezaca Galeano, Jorge Enrique (Prüfungsberechtigt)
Teilnahmevoraussetzungen	Successful participation in “Energy Meteorology 5.06.M117
Kompetenzziele	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 - discuss and present state of the art of the application of modern solar energy meteorology on a wide range (from residential systems to solar power plants, from solar thermal to photovoltaic systems)
Modulinhalte	This specialization module covers more in-depth topics concerning solar energy meteorology. Based on students’ knowledge about the solar resource, solar thermal and photovoltaic technology, students deepen their knowledge on the resource for such systems. **Lecture** • 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 and relevance for solar energy systems • Satellite-based estimation of solar irradiance • Solar irradiance (and solar power) forecasting • Solar radiation measurements: Basics and setup of high quality measurement system **Seminar**

- sources of solar data and discussion of their quality
- solar resource assessment:

- basic models,
- measurements,
- satellite models
- data sets

- validation and application of solar resource data sets
- forecasting of solar radiation: sky-camera forecasts, satellite-based forecasts, numerical weather predictions, statistical methods
- forecast validation
- selected applications

- irradiance and PV power forecasting
- application of solar resource data for yield assessment

Literaturempfehlungen

- S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published Joh Wiley and Sons (2nd Edition 2011)
- MSG Cloud Physical Properties (CPP) by KNMI http://msgcpp.knmi.nl/mediawiki/index.ph /MSG_Cloud_Physical_Properties_(CPP)
- CAMS Copernicus Atmospheric monitoring service https://atmosphere.copernicus.eu /catalogue#/product/urn:xwmo:md:int.ecmwf::copernicus:cams:prod:an:surface-solar-irradiation:pid327
- https://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=SARAH_V001
- https://nsrdb.nrel.gov/
- re.jrc.ec.europa.eu/pvgis/

Links	
Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	Annual, summer semester
Aufnahmekapazität Modul	unbegrenzt
Modulart	Wahlpflicht / Elective
Modullevel	MM (Mastermodul / Master module)
Lehr-/Lernform	Lecture: 2hrs/week Seminar: 2hrs/week
Vorkenntnisse	Physical principles of Black Body Radiation Basics of Solar Radiation

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	During the semester	1 Written examination: 90 to 180 minutes and regular active participation

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenz
Vorlesung		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

Abschlussmodul

mam - Masterarbeitsmodul

Modulbezeichnung	Masterarbeitsmodul
Modulkürzel	mam
Kreditpunkte	30.0 KP
Workload	900 h
Verwendbarkeit des Moduls	• Master Sustainable Renewable Energy Technologies (Master) > Abschlussmodul
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Gütay, Levent (Prüfungsberechtigt) • Kraft, Martin (Prüfungsberechtigt) • Hammer, Annette (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Hölling, Michael (Prüfungsberechtigt) • Lehnhoff, Sebastian (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • von Bremen, Lüder (Prüfungsberechtigt) • Steinfeld, Gerald (Prüfungsberechtigt) • Siebenhüner, Bernd (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt) • Schneemann, Jörge (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Pehlken, Alexandra (Prüfungsberechtigt) • Scheele, Ulrich (Prüfungsberechtigt) • Sievers-Glotzbach, Stefanie (Prüfungsberechtigt) • Ravanbach, Babak (Prüfungsberechtigt) • Steinberger-Wilckens, Robert (Prüfungsberechtigt) • Waldl, Hans-Peter (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt)
Teilnahmevoraussetzungen	
Kompetenzziele	

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.
Modulinhalte	
	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)
Literaturempfehlungen	
Links	
Unterrichtsprachen	
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modulart	je nach Studiengang Pflicht oder Wahlpflicht

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul		G
Lehrveranstaltungsform	Seminar	
Angebotsrhythmus		