

Module: Energy Resources and Systems [PRE021]

Duration:	1 semester	Teaching form:	Lectures
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	1 st semester	Required attendance:	52 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Dr. Detlev Heinemann, Dr. Herena Torío		
Alternative person(s) responsible for this module: -	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

Content of the module:

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

Suggested reading:

Energy Meteorology:

- IEA World 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
- Peixoto, J.P. & 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 (Techné 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 & 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. Grubler and A. McDonald (Eds.): Global Energy Perspectives (Cambridge University Press, Cambridge, 1998).
- Khartchenko, N.V.: Advanced Energy Systems (Taylor & 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/)

Comments: -	Helpful previous knowledge: n/a
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Weblink: n/a	Associated with the module(s): n/a
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Prerequisites for admission: n/a	
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Maximum number of students / selection criteria
50 (PPRE & EUREC students have priority)

Requirements for awarding the credit points
Written Exam 120 min

Examination periods:
Before the end of the lecture period

Additional Recommendations:
n/a

Registration procedure:
Stud.IP

Last update:
20.07.2017

Abbreviations:
V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar

Module: Renewable Energy Technologies I [PRE031]

Duration:	1 semester	Teaching form:	Lectures, Seminars, Exercises
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	12 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	1 st semester	Required attendance:	112 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Hans-Gerhard Holtorf PhD		
Alternative person(s) responsible for this module: Prof. Dr. Michael Wark, Dr. Michael Hölling, Dr. Robin Knecht, Dr. Alexandra Pehlken, Prof. Dr. Robert Steinberger-Wilckens, Dr. Herena Torio	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

Content of the module:

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

Suggested reading:

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.

Basics of Wind Energy

- T. Burton et. al.: Wind Energy Handbook. John Wiley, New York, 2nd ed., 2011
- R. Gasch, J. Twele: Wind Power Plants. Springer, 2nd ed., 2011

Fuel Cells & Energy Storage

- Larminie/Dicks: Fuel Cells Systems Explained, 2000, (Wiley, 2000, ISBN 0-471-49026-1)
- EG&G Services, Parsons Inc.: Fuel Cell Handbook, (DE-AM26-99FT40575, 7th Edition, 2005; www.fuelcells.org/fchandbook.pdf)
- G. Hoogers (Ed.): Fuel Cell Technology Handbook, (CRC Press, Boca Raton/London, 2003, ISBN 0-8493-0877-1)
- C.-J. Winter/J. Nitsch: Hydrogen as an Energy Carrier (Springer-Verlag, Heidelberg/N.Y., 1985, ISBN 0-387-18896-7/3-540-18896-7)
- O'Hayre/Cha/Colella/Prinz: Fuel Cell Fundamentals, (Wiley, 2009, 2nd ed., ISBN 978-0-470-25843-9)
- C.H. Hamann, A. Hammett, W. Vielstich, Electrochemistry, 2nd Ed. Wiley, Weinheim 2007
- D. Pletcher, A First Course in Electrode Processes. The Electrochemical Consultancy, 1991.
- A.J. Bard, L.R. Faulkner, Electrochemical Methods, Fundamentals and Applications. 2. Ed., Wiley, 2001.
- M. Winter, R.J. Brodd; What are Batteries, Fuel Cells and Supercapacitors? in Chem. Rev. 2004, Vol. 104, pp. 4245-4269
- A.J. Bard, G. Inzelt, F. Scholz (Eds.) Electrochemical Dictionary. 2. Aufl. Springer, Berlin 2012 (Available as an eBook, very good explanation in English)
- Fischer, W. (1996). Stationary lead-acid batteries - an introductory handbook. Brilon, Germany: Hoppecke.

Biomass Energy

- R. Schlögl (Ed.), Chemical Energy Storage, De Gruyter, 2013, ISBN: 978-3-11-026407-4, Chapter 2, Pages 59-133.
- D.L. Klass. Biomass for renewable energy, fuels, and chemicals, Chapter 4 Virgin Biomass Production, p. 91ff
- Food and Agriculture Organization of the UN (FAO) <http://www.fao.org>
- IEA Energy Technology Essentials - Biomass for Power Generation and CHP. <http://www.iea.org/techno/essentials3.pdf>
- R.A. Houghton, Forest Hall, and Scott J. Goetz. Importance of biomass in the global carbon cycle J. Geophys. Res., 114, 2009
- Schlögl, Robert (2013). Chemical energy storage (Elektronische Ressource] ed.). Berlin [u.a.]: De Gruyter.
- Twidell & Weir. Renewable Energy Resources, Chapter 10, http://www.4shared.com/document/HpYwRDPy/Renewable_Energy_Resources_2nd.html
- Wheildon's 2013, <http://www.wheildons.co.uk/wp-content/uploads/2013/07/carbon-neutral.jpg>
- Waste-to-Energy Research and Technology Council (WtERT), 2009, <http://www.wtert.eu/default.asp?Menue=13&ShowDok=12#Hydrolysis>

Solar Thermal

- 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.
- Kasper, B., & Antony, F. (2004). Solarthermische Anlagen.

Hydro 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

<p>ESHA. 151 p.</p> <ul style="list-style-type: none"> - 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. 	
<p>Comments: Selection of one of the units in part 4 (Solar Thermal Energy, Biomass Energy and Hydro Power) excludes the selection of this unit in Renewable Energy Technologies II.</p>	<p>Helpful previous knowledge: Chemistry, Black Body Radiation, Semiconductor Physics, Fluid Dynamics</p>
<p>Weblink: n/a</p>	<p>Associated with the module(s): Renewable Energy Technologies II</p>
<p>Prerequisites for admission: Enrolment in PPRE, EUREC, EP, Physics, SEM or WCM master programmes</p>	
<p>Maximum number of students / selection criteria 50 (PPRE & EUREC students have priority)</p>	
<p>Requirements for awarding the credit points Written Exam 180min (75% weight, Solar PV+Wind Energy+Energy Storage) Presentation / 15min of a Paper / 15 pages (25% weight, Solar Thermal or Biomass or Hydro Power, PPRE internal conference - refer to module Renewable Energy Technology II)</p>	
<p>Examination periods: Before the end of the lecture period</p>	
<p>Additional Recommendations: Compulsory attendance during the sessions of group work and tutorials</p>	
<p>Registration procedure: Stud.IP</p>	
<p>Last update: 20.07.2017</p>	
<p>Abbreviations: V: lecture , Ú: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar</p>	

Module: Fundamentals for Renewable Energy [PRE011]

Duration:	1 semester	Teaching form:	Lectures, Practical training
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	12 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	1st semester	Required attendance:	80 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Dr. Robin Knecht		
Alternative person(s) responsible for this module: Dr. Herena Torio, Hans Holtorf PhD, Michael Golba, Simone Malz	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

Content of the module:

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

Suggested reading: lecture notes for the respective courses	
Comments: Forms of learning: Lectures. The primers are predominantly communicated via reading material and an online forum. On-campus meetings for discussion of difficult issues are provided. (Flipped Classroom). Exercises are provided to each lecture session. The laboratory experiments are performed on campus on dedicated experimental setups. Reading material on the laboratory setups and tasks is given.	Helpful previous knowledge: n/a
Weblink: n/a	Associated with the module(s) n/a
Prerequisites for admission: none	
Maximum number of students / selection criteria 25 (only registered PPRE students)	
Requirements for awarding the credit points Completing all experiments of the introductory lab during the campus phase. Submission of four lab reports from different categories (50%). Submission of exercises from primers (25%). Country report either in the presentation or written report format (25%).	
Examination periods: At the end of the lecture period.	
Additional Recommendations: n/a	
Registration procedure: Stud.IP	
Last update: 20.07.2017	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar	

Module: Sustainability of Renewable Energy [PRE041]

Duration:	1 semester	Teaching form:	Lectures, Seminar
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	2 nd semester	Required attendance:	56 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Dr. Herena Torío		
Alternative person(s) responsible for this module: Dr. Herena Torío	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

Content of the module:

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

Suggested reading:

An additional list of relevant up to date scientific papers and literature will be given in the seminar. Some basic reading hints are:

- Klöpffer, Walter (Ed.), Background and Future Prospects in Life Cycle Assessment, Springer Dordrecht 2014
- United Nations, Our Common Future, Report of the World Commission on Environment and Development, 1987
- Daly, Herman / Farley, Joshua, Ecological Economics - Principles and Applications, Island Press Washington 2004
- Kallis, Giorgos / Kerschner, Christian / Martinez, Joan, The Economics of Degrowth; in: Ecological Economics XXX 2012, p. 1-9
- Krysiak, Frank C., Entropy, Limits to Growth, and the prospects for weak sustainability; Ecological Economics 58, 2006, p. 182-191

Comments:

n/a

Helpful previous knowledge:

n/a

Weblink: n/a	Associated with the module(s): n/a
Prerequisites for admission: n/a	
Maximum number of students / selection criteria PPRE students have priority	
Requirements for awarding the credit points Report (20 pages) or presentation (45 minutes) and report (10 pages)	
Examination periods: Before the end of the lecture period	
Additional Recommendations: n/a	
Registration procedure: Stud.IP	
<i>Last update:</i> 20.07.2019	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar	

Module: Renewable Energy Systems Laboratory and Modelling [PRE051]

Duration:	1 semester	Teaching form:	Lectures, Practical training
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	2nd semester	Required attendance:	60 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert		Persons responsible for this module: Prof. Dr. Joachim Peinke, Dr. Robin Knecht	
Alternative person(s) responsible for this module: Dr. Herena Torio		Examiner(s): the previously named persons	

Objective of the module /learning outcomes:

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

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

Content of the module:

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

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

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

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

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

Suggested reading:

lecture notes/ lab manuals for the respective courses, tutorials on programming in MATLAB / GNU Octave

Comments:

Forms of learning:

Lecture, Literature research, planning and performing an experiment (hands-on), Programming a simulation program, Application of several software tools, presentation of results on conference

Helpful previous knowledge:

Programming in MATLAB / GNU Octave

Weblink:

n/a

Associated with the module(s)

n/a

Prerequisites for admission: none	
Maximum number of students / selection criteria 25 (only registered PPRE students)	
Requirements for awarding the credit points Paper / poster / talk at a conference on the results of the outdoor lab in comparison with a simulation of the chosen setup.	
Examination periods: At the end of the lecture period.	
Additional Recommendations: n/a	
Registration procedure: Stud.IP	
<i>Last update:</i> 20.07.2019	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar	

Specialisation “Energy System Integration”

Module I: Future Power Supply [PRE142]

Duration:	1 semester	Teaching form:	Lectures, Exercises, Seminar
Cycle:	once a year	Language:	English
Type of module:	elective	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	2 nd semester	Required attendance:	56 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Dr. Herena Torío		
Alternative person(s) responsible for this module: Babak Ravanbach	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

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

Content of the module:

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

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

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

Suggested reading:

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

Comments:

Helpful previous knowledge:

- Basic knowledge on chemical processes (Chemistry-Primer: 1CP) and energy storage (course "Energy storage") are also advantageous.
- Knowledge in Semiconductor Physics is desired (Semiconductor Physics Primer: 1CP)

Weblink:

n/a

Associated with the module(s):

Prerequisites for admission:

n/a

Maximum number of students / selection criteria

PPRE students have priority

Requirements for awarding the credit points

1 Examination

Examination: Presentation of a paper (consisting of presentation: 50 min; related paper: 5 to 10 pages)

Examination periods:

Before the end of the lecture period

Additional Recommendations:

n/a

Registration procedure:

Stud.IP

Last update:

06.03.2019

Abbreviations:

V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar

Specialisation “Energy System Integration” Module II: Smart Grid Management [INF511]

Duration:	1 semester	Teaching form:	Lectures, Seminar, Exercises
Cycle:	once a year	Language:	English
Type of module:	elective	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	2 nd semester	Required attendance:	112 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Sebastian Lehnhoff, lecturers within the module		
Alternative person(s) responsible for this module: Sebastian Lehnhoff, lecturers within the module	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

After successful completion of the course the students should be able to understand the existing structures and technical basis of energy systems to produce, transfer and distribute electricity and their interaction and dependency on each other. They should have developed an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. The students are able to estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants.

The students will be able to estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so-called Smart Grid energy systems. Regarding the requirements the students will be able to analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems.

Content of the module:

Professional competence

The students:

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

Methodological competence

The students:

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

Social competence

The students:

- create solutions in small teams
- discuss their solutions

Self-competence

The students:

- reflect their own use of electricity as a limited resource

Suggested reading:

-

Comments: -	Helpful previous knowledge: - Basic knowledge in Python Programming advisable.
Weblink: n/a	Associated with the module(s):
Prerequisites for admission: n/a	
Maximum number of students / selection criteria	
Requirements for awarding the credit points	
Examination periods: Before the end of the lecture period	
Additional Recommendations: n/a	
Registration procedure: Stud.IP	
<i>Last update:</i> 20.02.2020	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar	

Specialisation “Photovoltaics”

Module: Photovoltaic Physics [PRE111]

Duration:	1 semester	Teaching form:	Lectures, Exercise
Cycle:	once a year	Language:	English
Type of module:	elective	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	2 nd semester	Required attendance:	50 hours
Person responsible for the study programme: Prof. Dr. C. Agert		Persons responsible for this module: Prof. Dr. C. Agert, Dr. Robin Knecht	
Alternative person(s) responsible for this module: Dr. Michael Richter		Examiner(s): the previously named persons	
<p>Objective of the module / learning outcomes:</p> <p>After successful completion of the module students should be able to:</p> <ul style="list-style-type: none"> - 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 			
<p>Content of the module:</p> <p>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.</p> <p>Physical Basics of Photovoltaics (Lecture & Exercises - 180 h workload)</p> <ul style="list-style-type: none"> - 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 			
<p>Suggested reading:</p> <ul style="list-style-type: none"> - 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 			
<p>Comments:</p> <p><u>Forms of learning:</u> Lecture, Exercises</p>		<p>Helpful previous knowledge:</p> <p>n/a</p>	
<p>Weblink:</p> <p>n/a</p>		<p>Associated with the module(s):</p> <p>Photovoltaic Systems and Meteorology (PPRE) Angewandte Physik (Engineering Physics) Physikalische Grundlagen der Photovoltaik (MSc. Physics)</p>	
<p>Prerequisites for admission:</p> <p>Background in Semiconductor Physics (e.g. Primer Solid State Physics), RE Technologies I</p>			
<p>Maximum number of students / selection criteria</p> <p>25 (only registered PPRE students, this applies only to this specific module not the courses)</p>			

<p>Requirements for awarding the credit points Successful participation during the exercises. The specific conditions (required percentages) will be communicated in the beginning of the semester.</p>
<p>Examination periods: During the semester accompanying the lecture and exercise sessions.</p>
<p>Additional Recommendations: n/a</p>
<p>Registration procedure: Stud.IP</p>
<p><i>Last update:</i> 20.07.2017</p>
<p>Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar</p>

Specialisation "Photovoltaics"

Module: Photovoltaic Systems and Meteorology [PRE112]

Duration:	1 semester	Teaching form:	Lectures
Cycle:	once a year	Language:	English
Type of module:	elective	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	2 nd semester	Required attendance:	50 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Hans Holtorf PhD		
Alternative person(s) responsible for this module: Dr. Detlev Heinemann	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

Content of the module:

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

Suggested reading:

- 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
- 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 & Sons, First Edition, Chichester, 2012. (ISBN-13: 978-1119992851)
- lecture notes for the respective courses

Comments:

Forms of learning:
Lectures, Active participation

Helpful previous knowledge:

n/a

<p>Weblink: n/a</p>	<p>Associated with the module(s)</p> <ul style="list-style-type: none"> - Photovoltaic Physics - Energiesysteme - Renewable Energies in Developing Countries - System Integration of Renewable Energy - Renewable Energy Complementary Topics
<p>Prerequisites for admission: RE Technologies I</p>	
<p>Maximum number of students / selection criteria 25 (only registered PPRE students, this applies only to this specific module not the courses)</p>	
<p>Requirements for awarding the credit points Passing of the written exam in Solar Energy Meteorology (120 min). Active participation in Photovoltaic Systems. The specific conditions of the active participation will be communicated in the beginning of the semester.</p>	
<p>Examination periods: At the end of the lecture period.</p>	
<p>Additional Recommendations: n/a</p>	
<p>Registration procedure: Stud.IP</p>	
<p><i>Last update:</i> 20.12.2019</p>	
<p>Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar</p>	

Specialisation “Wind Turbine Design”

Module: Design & Simulation of Wind Turbines [PRE131]

Duration:	1 semester	Teaching form:	Lectures, Seminar, Tutorials
Cycle:	once a year	Language:	English
Type of module:	elective	Attainable credit points:	12 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	2 nd semester	Required attendance:	112 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Martin Kühn, Hans-Gerhard Holtorf PhD		
Alternative person(s) responsible for this module: Dr. Detlev Heinemann, Dr. Hans-Peter Waldl	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

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

Suggested reading:

Design of Wind Energy Systems

- Burton, T., N. Jenkins, D. Sharpe & E. Bossanyi, 2011: Wind Energy Handbook, Second Edition, John Wiley.
- Gasch, R. & J. Twele, 2012: Wind Power Plants: Fundamentals, Design, Construction and Operation; Second Edition, Springer
- Selected papers (e.g. Wind Energy Science, Wind Energy, ...)

Advanced Wind Energy Meteorology

- Holton, J.R. & 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 & E. Bossanyi, 2011: Wind Energy Handbook, Second Edition, John Wiley.
- Gasch, R. & 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

Comments: -	Helpful previous knowledge: - Fluid Dynamics Primer
Weblink: n/a	Associated with the module(s): - Energy Resources and Systems - RE Basics - RE Technologies I
Prerequisites for admission: Unit Basics of Wind Energy Unit Energy Meteorology Unit Modelling and Simulation Good "Matlab" Proficiency	
Maximum number of students / selection criteria Design of Wind Energy Systems 30, Others 50	
Requirements for awarding the credit points The students' performance is evaluated in this module by written exam (180 min) or presentation (30 min) or oral exam (45 min) or exercises (max. 10) or practical report (max. 30 pages).	
Examination periods: Before the end of the lecture period	
Additional Recommendations: Participation in any kind of group work or exercise is compulsory	
Registration procedure: Stud.IP	
<i>Last update:</i> 20.07.2017	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar	

Specialisation “Wind Energy Physics”

Module: Wind Energy Converters & Fluid Dynamics [PRE121]

Duration:	1 semester	Teaching form:	Lectures, Seminar, Tutorials
Cycle:	once a year	Language:	English
Type of module:	elective	Attainable credit points:	12 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	2 nd semester	Required attendance:	112 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Joachim Peinke, Hans-Gerhard Holtorf PhD		
Alternative person(s) responsible for this module: Prof. Dr. Martin Kühn, Dr. Bernhard Stoevesandt, Andreas H. Schmidt	Examiner(s): the previously named persons		
<p>Objective of the module / learning outcomes:</p> <p>After successful completion of the module students should be able to:</p> <ul style="list-style-type: none"> - 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 			

Content of the module:

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

Suggested reading:

Wind Physics Measurement Project (Project)

- Gasch, R. & J. Tvele, 2012: Wind Power Plants: Fundamentals, Design, Construction and Operation; Second Edition, Springer
- Evaluation of site-specific wind conditions; MEASNET-Guideline; Version 2; April 2016; free available in the internet: http://www.measnet.com/wp-content/uploads/2016/05/Measnet_SiteAssessment_V2.0.pdf
- Emeis, S., 2013: Wind Energy Meteorology: Atmospheric Physics for Wind Power Generation, Springer

Computational Fluid Dynamics (CFD) I + Computational Fluid Dynamics II

- Ferziger J.H., M. Peric, 2002: Computational Methods for Fluid Dynamics, 3rd Edition, Springer
- Hirsch, C., 2007: 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,
- Sagaut, P., 2006: Large Eddy Simulation for Incompressible Flows, 3rd Edition, Springer, Berlin
- Fröhlich, J., 2006: Large Eddy Simulationen turbulenter Strömungen, Teubner, Wiesbaden, (in German) ...

Fluid Dynamics II

- Frisch, U., 2001: Turbulence: The legacy of A.N. Kolmogorov. Cambridge University Press, Cambridge
- Mathieu, J. & J. Scott, 2000: An introduction to turbulent flow. Cambridge University Press, Cambridge
- Davidson, P.A., 2004: Turbulence, Oxford

Comments:

-

Helpful previous knowledge:

- Fluid Dynamics Primer

Weblink:

n/a

Associated with the module(s):

- Energy Resources and Systems
- RE Basics
- RE Technologies I

Prerequisites for admission:

Units Wind Energy I, Energy Meteorology, Modelling & Simulation, Unit Fluid Dynamics: Fluid Dynamics I and Navier-Stokes equations and properties; Basic Physics, Electrodynamics, Knowledge of divergence and rotation operators
Computational Fluid Dynamics I: Fluid Dynamics I; mathematical background, CFD II: Fluid Dynamics I, CFD I
Good "Matlab" Proficiency

Maximum number of students / selection criteria

Wind Physics Measurement Project 24, others 50

Requirements for awarding the credit points

The students' performance is evaluated in this module by written exam (180 min) or presentation (30 min) or oral exam (45 min) or exercises (max. 10) or practical report (max. 30 pages).

Examination periods:

Before the end of the lecture period

Additional Recommendations:

Participation in any kind of group work or exercise is compulsory

Registration procedure:

Stud.IP

Last update:

20.07.2017

Abbreviations:

V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar

Module: Renewable Energy Complementary Topics [PRE061]

Duration:	1 semester	Teaching form:	Lectures, Practical training
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	2 nd semester	Required attendance:	56 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert		Persons responsible for this module: Prof. Dr. Carsten Agert, Hans-Gerhard Holtorf, PhD	
Alternative person(s) responsible for this module: Refer to the lecturing persons given in the section "Content of the Module".		Examiner(s): the previously named persons	

Objective of the module/learning outcomes:

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

Content of the module:

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

Suggested reading:

lecture notes for the respective courses will be given in the first lecture

Comments: Refer to first lecture for further details.	Helpful previous knowledge: n/a
Weblink: n/a	Associated with the module(s) n/a
Prerequisites for admission: none	

Maximum number of students / selection criteria
25 (PPRE students have priority)

Requirements for awarding the credit points Passing of the individual units' assessments. Refer to the first lecture of the units for details.
Examination periods: At the end of the lecture period
Additional Recommendations: n/a
Registration procedure: Stud.IP
<i>Last update:</i> 20.07.2017
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical-practical seminar

Module: Renewable Energy Project [PRE081]

Duration:	1 semester	Teaching form:	Lectures
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	9 ECTS
Level:	MM (master module)	Workload:	270 hours
This module should be taken in:	3 rd semester	Required attendance:	132 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Dr. Detlev Heinemann, Hans-Gerhard Holtorf PhD		
Alternative person(s) responsible for this module: -	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

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

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

Content of the module:

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

Case Study (Seminar - 180 h workload)

Students need to

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

Excursion (Excursion - 90 h workload)

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

Students prepare, manage and document the excursion by

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

Suggested reading:

Case Study

- Case Study project related literature which was proposed within the lectures given before
- Technical documentation of the system under investigation (as available)
- Scientific journal papers related to the topic of the Case Study.

Excursion

- Homepages of the hosting institutions
- Newspaper articles on the hosting institutions
- General journey related information sites: travel guides, maps, timetables

Comments:

External experts in different subjects related to the Case Study unit will coach the students.

Helpful previous knowledge:

The contents of the up to date lectures within PPRE.

Weblink:

n/a

Associated with the module(s):

All modules presented in the 1st, 2nd and 3rd semester

Prerequisites for admission:

Participation in minimum 7 lectures of PPRE's first semester and *Sustainability Seminar* (2nd PPRE semester).

Maximum number of students / selection criteria

35 (PPRE students have priority)

Requirements for awarding the credit points

Group Presentation (≈ 15min per group) & Report (≈ 15 pages per group). 50% weight for each of the items.

Examination periods:

Before the end of the lecture period

Additional Recommendations:

Generally participation in 12 out of 14 Case Study meetings and in the unit Excursion is compulsory for participating students.

Registration procedure:

Stud.IP

Last update:

20.07.2017

Abbreviations:

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Module: Internship Module [PRE071]

Duration:	1 semester	Teaching form:	Seminar
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	9 ECTS
Level:	MM (master module)	Workload:	270 hours
This module should be taken in:	3 rd semester	Required attendance:	84 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Michael Golba		
Alternative person(s) responsible for this module: Dr, Herena Torío	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

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

Content of the module:

External Internship (180 h workload)

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

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

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

Internship Seminar (90 h workload)

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

Suggested reading: Internship Guideline

Comments: n/a	Helpful previous knowledge: Working experience, report writing
Weblink: n/a	Associated with the module(s): n/a
Prerequisites for admission: Enrolment in PPRE	

Maximum number of students / selection criteria
PPRE students only

Requirements for awarding the credit points

Oral presentation of 20 minutes and written report of approximately 20 pages

Examination periods:

During the internship seminar (presentation) and by the end of the summer term (written report) respectively

Additional Recommendations:

Compulsory attendance during the external internship and internship seminar

Registration procedure:

Stud.IP

Last update:

20.07.2017

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Module: Transferable Skills [PRE091]

Duration:	1 semester	Teaching form:	Seminar, Practical training
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	3rd semester	Required attendance:	60 hours
Person responsible for the study programme: Prof. Dr. C. Agert	Persons responsible for this module: Dr. Robin Knecht		
Alternative person(s) responsible for this module: tba	Examiner(s): the previously named persons		
<p>Objective of the module / learning outcomes:</p> <p>After successful completion of the module students should be able to:</p> <ul style="list-style-type: none"> - 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 			
<p>Content of the module:</p> <p>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:</p> <ul style="list-style-type: none"> - 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 			
<p>Suggested reading:</p> <p>To be announced at the beginning of the lecture period</p>			
Comments: Forms of learning: Project, Supervising, Workshops, Seminar	Helpful previous knowledge:		
Weblink: n/a	Associated with the module(s) n/a		
Prerequisites for admission: none			
<p>Maximum number of students / selection criteria 25 (only registered PPRE students)</p>			
<p>Requirements for awarding the credit points Successful participation in the courses with a workload equivalent of 6 ECTS. The conditions for successful participation of each course will be communicated at the beginning of the course. The module is not marked.</p>			
<p>Examination periods: At the end of the course.</p>			
<p>Additional Recommendations: n/a</p>			
<p>Registration procedure: Stud.IP</p>			

Last update

20.07.2017

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Module: Renewable Energy Technologies II [PRE033]

Duration:	1 semester	Teaching form:	Lectures, Seminars, Exercises
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	3 rd semester	Required attendance:	56 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Dr. Herena Torío		
Alternative person(s) responsible for this module: Prof. Dr. Michael Wark, Hans-Gerhard Holtorf PhD, Dr. Alexandra Pehlken	Examiner(s): the previously named persons		

Objective of the module / learning outcomes:

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

- critically evaluate and compare a selection of major Renewable Energy conversion processes and technologies out of solar thermal energy, biomass energy and hydro power
- 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

Content of the module:

Students select two out of the proposed three units for completion of their 6CP module Renewable Energy Technology II:

1. Solar Thermal Energy
2. Biomass Energy
3. Hydro Power

Thereby the unit, which was selected in the module Renewable Energy Technology I in the first semester, is excluded.

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 storage
- 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 Biomass
- Chemical composition of biomass: sugar, starch, fats. Oils, proteins, lignin
- Natural photosynthesis: chemical storage of solar energy; efficiency of plants
- Degradation processes of biomass: microorganisms, classification and metabolism (main degradation pathways)
- Chemistry & Biology of Biogas Technology
- 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

Suggested reading:

Biomass

- BP Statistical Review of World Energy 2012, <http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>
- Donald L. Klass. Biomass for renewable energy, fuels, and chemicals, Chapter 4 Virgin Biomass Production, p. 91ff
- Food and Agriculture Organization of the UN (FAO) <http://www.fao.org>
- IEA Energy Technology Essentials - Biomass for Power Generation and CHP. <http://www.iea.org/techno/essentials3.pdf>
- IEA World Energy Outlook 2012. http://www.worldenergyoutlook.org/media/weowebiste/2012/WEO2012_Renewables.pdf
- R.A. Houghton, F. Hall, and S.J. Goetz. Importance of biomass in the global carbon cycle J. Geophys. Res., 114, 2009
- Schlögl, Robert (2013). Chemical energy storage (Elektronische Ressource] ed.). Berlin [u.a.]: De Gruyter.
- Twidell & Weir. Renewable Energy Resources, Chapter 10, http://www.4shared.com/document/HpYwRDPy/Renewable_Energy_Resources_2nd.html
- Wheildon's 2013, <http://www.wheildons.co.uk/wp-content/uploads/2013/07/carbon-neutral.jpg>
- Waste-to-Energy Research and Technology Council (WtERT), 2009, <http://www.wtert.eu/default.asp?Menu=13&ShowDok=12#Hydrolysis>

Solar Thermal

- DGS, (2010) Planning and installing solar thermal systems, a guide for installers, architects and engineers, 2nd edition.
- Duffie JA, Beckman WA (2013) Solar engineering of thermal processes: Wiley.
- Kasper, B., & Antony, F. (2004). Solarthermische Anlagen.

Hydro 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.

Comments:

Selection of two units in order to complement Renewable Energy Technologies I (RET). The selection in RET II excludes the selection of one of the units selected in RET I.

Helpful previous knowledge:

Chemistry, Biology, Black Body Radiation, Fluid Dynamics, Heat Transfer

Weblink:

n/a

Associated with the module(s):

Renewable Energy Technologies I

Prerequisites for admission:

Enrolment in PPRE, EUREC, EP, Physics, SEM or WCM master programmes.

Maximum number of students / selection criteria

50 (PPRE students have priority)

Requirements for awarding the credit points

2 Presentations - 15min each of a Paper - 15 pages each (50% weight each, within PPRE internal conference - refer to module Renewable Energy Technology I)

Examination periods:

Before the end of the lecture period

Additional Recommendations:

Compulsory attendance during the sessions of group work and tutorials.

Registration procedure:

Stud.IP

Last update:

10.08.2017

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Module: Thesis Module [MAM]

Duration:	1 semester	Teaching form:	Individual work
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	30 ECTS
Level:	MM (master module)	Workload:	900 hours
This module should be taken in:	4 th semester	Required attendance:	To be negotiated between student and supervisor
Person responsible for the study programme: Prof. Dr. Carsten Agert		Persons responsible for this module: Prof. Dr. Carsten Agert, Hans-Gerhard Holtorf, PhD	
Alternative person(s) responsible for this module: All supervisors involved in the supervision of the candidate		Examiner(s): Authorised teaching staff (see Exam Regulations)	

Objective of the module / learning outcomes:

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.

Content of the module:

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)

Master Thesis (Thesis - 720 h workload)

Apart from the application of specific scientific methodologies which need to be discussed with the student and finally approved by the supervisor the following key-competences are required:

- Specification of the Research Question
- Project management
- Communication with all stakeholders involved in the project and on all hierarchical levels
- Setting and achieving of milestones
- Goal oriented work
- Self-organization and self-management
- Documentation of work done
- Presentation of work done in writing, sketching and oral presentation
- Literature research, literature management and adequate referencing of sources
- Personal discipline
- Personal credibility (persönliche Verbindlichkeit)
- Disputation of the thesis results

Suggested reading:

- Blum, K. (2012). Advice Thesis Writing (pp. 25). Oldenburg (Germany): Postgraduate Programme Renewable Energy.
- Hyland, K., & Tse, P. (2004). "I would like to thank my supervisor". Acknowledgements in graduate dissertations. *International Journal of Applied Linguistics*, 14(2), 259-275. doi:10.1111/j.1473-4192.2004.00062.x
- Merten, M., Trivett, N., Woodward-Kron, R., Skillen, J., Percy, A., & Cincotta, A. (1999). *Studying for Examinations*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2000a). *Academic Writing* (pp. 44). Wollongong: University of Wollongong.
- University of Wollongong. (2000b). *Referencing* (pp. 7). Wollongong: University of Wollongong.
- University of Wollongong. (2000c). *Report Writing* (pp. 21). Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2000d). *Time Management* (pp. 2). Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2001a). *Critical Thinking* (pp. 18). Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2001b). *Research and Thesis Writing* (pp. 63). Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015a). *Thesis 0 - Body Chapters*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015b). *Thesis 1 - Abstract*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015c). *Thesis 2 - Introduction*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015d). *Thesis 3 - Literature Review*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015e). *Thesis 4 - Methods and Materials Section* Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015f). *Thesis 5 - Results*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015g). *Thesis 6 - Discussion*. Wollongong, Australia: University of Wollongong.
- University of Wollongong. (2015h). *Thesis 7 - Conclusion*. Wollongong, Australia: University of Wollongong.

Comments:

The master thesis may take place in research groups at the University of Oldenburg or it may take place in an external institution. A board of supervisors coaches the student. This board of supervisors consists of a project responsible (University of Oldenburg or external project), a PPRE responsible and a professor at the University of Oldenburg. The board of examiners consists of a minimum of two persons out of which one is professor of the University of Oldenburg and the second person is a member of the University of Oldenburg who is authorised to examine within the field of research.

Helpful previous knowledge:

The knowledge acquired in the preceding Postgraduate Programme Renewable Energy.

Weblink:

n/a

Associated with the module(s):

n/a

Prerequisites for admission:

Optional - needs negotiation with thesis supervisor

Maximum number of students / selection criteria

PPRE students only

Requirements for awarding the credit points

Participation in and contribution to the Master Thesis Colloquium, Examination of the Master Thesis (80%), Defence of the Master Thesis (20%)

Examination periods:

Six months after the submission of the project proposal - see Exam Regulations

Additional Recommendations:

n/a

Registration procedure:

Stud.IP

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20.07.2017

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