pre041 - Sustainability of Renewable Energy

Module label	Sustainability of Renewable Energy
Module code	pre041
Credit points	6.0 KP
Workload	180 h
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Torio, Herena (Authorized examiners) Agert, Carsten (Module responsibility) Torio, Herena (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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

- analyse, and critically compare and evaluate selected sustainability concepts and strategies addressing renewable energy systems

- critically appraise and analyse the principles and implications of selected scientific methods and theories for a sustainable energy supply

- critically evaluate the suitability and meaningfulness of different sustainability indicators, theories, methods and practices regarding their role and impact for developed countries, on the one hand, and developing countries, on the other

- perform an integral assessment, involving several relevant aspects related to the sustainability of a particular real-life renewable energy project as well as identify the main barriers, potentials and driving factors for improving it

- perform a literature review on selected sustainability approaches to a professional standard and extract the main related conclusions, and arguing critically on them
- present data and information both verbally and in the written form, including quotation to a professional standard

Module contents

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

Sustainability Seminar (Lecture & Seminar ? 180 h workload)

- Strategies and dimensions in sustainability research and discussion: efficiency, consistency and sufficiency, as well as related concepts (e.g. rebound)

- Growth/De-growth and decoupling of growth and emission

- Life-cycle analysis

- Thermodynamic methods: exergy, EROI and related approaches

- Social indicators and their relation to energy use

- Economic indicators and related paradigms in the context of energy consumption

- Resilience and its operationalisation for energy systems
- Methods for developing and assess socio-technical scenarios

Reader's advisory

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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module	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)

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	WiSe	28
Seminar		2	SuSe and WiSe	28
Total time of attendance for the module				56 h

pre051 - Renewable Energy Systems Laboratory and Modelling

Module label	Renewable Energy Systems Laboratory and Modelling
Module code	pre051
Credit points	6.0 KP
Workload	180 h (180 hours)
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Günther, Andreas (Authorized examiners) Holtorf, Hans-Gerhard (Authorized examiners) Jimenez Martinez, Cuauhtemoc Adrian (Authorized examiners) Torio, Herena (Authorized examiners) Knipper, Martin (Authorized examiners) Peinke, Joachim (Module responsibility) Knipper, Martin (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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

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

Module contents

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

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

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

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

- Theory, Hands-on experience and reporting on either:

  - Improved Cook Stoves
  - Wind Energy Systems
  - Solar Home Systems
  - Meteorological Resource Assessment

- Student conference on the Performance of Renewable Energy Systems

Reader's advisory	
Links	
Languages of instruction	
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	Lecture and Laboratory
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module	Student conference at the end of the semester	1 Examination: Conference contribution approx. 15 min presentation and approx. 8 pages of written discussion

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe and WiSe	28
Workshop/laboratory		2	SuSe and WiSe	28
Total time of attendance for the module				56 h

pre071 - Internship

Module label	Internship
Module code	pre071
Credit points	9.0 KP
Workload	270 h ()
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Torio, Herena (Authorized examiners) Agert, Carsten (Module responsibility) Torio, Herena (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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

- evaluate and critically reflect on his/her two months working experience

- critically appraise and compare professional working in different working environments, i.e. business, research, development organisation

- conclude whether he/she intends to work further in this particular field of Renewable Energy for his/her master thesis
- present data and information both verbally and in the written form to a professional standard (i.e. scientific report writing, presentation and quotation)

Module contents

External Internship (180 h workload)

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

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

- The university needs an acceptance letter (incl. contact details of local supervisor and topic of internship) from the host organisation prior to start the internship.

- The duration of the training should enable students to return to university at the beginning of summer term classes.

- Weekly full-time workload is required. However, it should not exceed local standards.

- Students are asked to hand in a report (approx. 20 pages) on their training, comprising a description of the host organisation, planned and performed tasks, perspectives for a thesis project, and give a presentation in the Internship Seminar in the summer term.

- If the host organisation demands a certain format of the report, the student has to comply.

- A short feedback by the local supervisor about the performance of the student during the internship is requested and recommended, but not compulsory.

Internship Seminar (90 h workload)

	Presentation (20 minutes) of the host organisation, the task(s) and experiences
Reader's advisory	
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module	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)

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Seminar		2	SuSe and WiSe	28
Practical training		4	SuSe and WiSe	56
Total time of attendance for the module				84 h

pre081 - Renewable Energy Project

Module label	Renewable Energy Project
Module code	pre081
Credit points	9.0 KP
Workload	270 h (270 Stunden)
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Holtorf, Hans-Gerhard (Authorized examiners) Knipper, Martin (Authorized examiners) Torio, Herena (Authorized examiners)
Prerequisites	
Skills to be acquired in this module	

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

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

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

Module contents

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

Case Study (Seminar ? 180 h workload)

Students need to

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

Excursion (Excursion ? 90 h workload)

The excursion refers to the case study project. Within the excursion, students collect necessary information for

	the completion of the Case Study itself. Students prepare, manage and document the excursion by - Setting up a list of institutions to be visited - Plan the excursion route and excursion schedule - Negotiate the necessary appointments - Perform the excursion - Prepare all participants for the appointments with the institutions - Conduct the appointments - Document the appointments - Draw necessary conclusions for the Case Study from the excursion
Reader's advisory	
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Annual, in winter semester
Module capacity	unlimited
Reference text	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.
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	Project & Excursion
Vorkenntnisse / Previous knowledge	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

Examination	Time of examination	Type of examination
Final exam of module	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

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe and WiSe	28
Seminar		2	SuSe and WiSe	28
Study trip		2	SuSe and WiSe	28
Total time of attendance for the module				84 h

inf511 - Smart Grid Management

Module label	Smart Grid Management
Module code	inf511
Credit points	6.0 KP
Workload	180 h
Applicability of the module	• Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik • Master's Programme Computing Science (Master) > Angewandte Informatik • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Lehnhoff, Sebastian (Authorized examiners) Lehrenden, Die im Modul (Authorized examiners)
Prerequisites	
Skills to be acquired in this module	After successful completion of the course the students should be able to understand the existing structures and technical basis of energy systems to produce, transfer and distribute electricity and their interaction and dependency on each other. They should have developed an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. The students are able to estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseable fluctuations of decentralised plants. The students will be able to estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems. Regarding the requirements the students will be able to analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems. **Professional competence** The students: • understand the existing structures and the technical basis of energy systems producing, transferring and distributing electricity and their interaction and dependency on each other. • develop an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. • estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants. • estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems. **Methodological competence** The students: • analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems • use advanced mathemtical methods to calculate networks **Social competence** The students: • create solutions in small teams • discuss their solutions **Self-competence** The students: • reflect their own use of electricity as a limited resource
Module contents	Content of the Module: In this course information technology, economical energy industry and technical basic knowledge and methods are analysed by using concrete Smart Grid approaches. The basic calculation methods for an intelligent grid management are introduced. This module deals with the technical and economical framework for a permissable electrical network as well as mathematical modelling and calculation methods to analyse conditions of electrical energy networks (in stationary conditions). These are:

- The organisation of the EU energy market (regulatory framework, responsibility in liberalisation of electrical energy systems)
- Establishment and operation of electrical energy supply networks (network topology, statutory duties of supply, supply quality/system services, malfunctions and protection systems)
- Network calculation (complex vector representation, effective/idle power, mathematical performance models/net model, transformation: node performance to node voltage and electricity, calculation of conductive current, current flow, fix-point-iteration, Newton-Raphson-Method, voltage drop, transformer model)

- Intelligent network management (Smart Grids), aggregation forms, machine learning approaches)

Reader's advisory	**Suggested reading:**

- Crastan V.: "Elektrische Energieversorgung II", Springer 2004
- Heuck K., Dettman K. D., Schulz D.: "Elektische Energieversorgung I", 7. Aufl., Vieweg 2007
- Konstantin, P.: "Praxisbuch Energiewirtschaft", Springer 2006
- Schwab, A.: "Elektroenergiesysteme, Springer 2009

Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited
Modullevel / **module level**	AS (Akzentsetzung / Accentuation)
Modulart / **typ of module**	je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / **Teaching/Learning method**	V+Ü
Vorkenntnisse / **Previous knowledge**	

Examination	Time of examination	Type of examination
Final exam of module	At the end of the semester	Oral exam

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		3	SuSe	42
Exercises		1	SuSe	14
Total time of attendance for the module				56 h

pre152 - Resilient Energy Systems

Module label	Resilient Energy Systems
Module code	pre152
Credit points	6.0 KP
Workload	180 h
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Agert, Carsten (Authorized examiners) Jimenez Martinez, Cuauhtemoc Adrian (Authorized examiners) Torio, Herena (Authorized examiners) Agert, Carsten (Module responsibility) Torio, Herena (Module responsibility)
Prerequisites	
Skills to be acquired in this module	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, homeostasis, equilibria, stressors,…) · understand and interlink assessment methods, principles and theories for resilience analysis 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 a 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 assessment 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
Module contents	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

Reader's advisory	

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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module	At the end of the semester	G

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Seminar		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

phy609 - Photovoltaic Physics

Module label	Photovoltaic Physics
Module code	phy609
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Kühn, Martin (Module responsibility) Gütay, Levent (Authorized examiners)
Prerequisites	Solid-state-Pysics, semi-conductor Physics, Module Renewable Energy Technologies I
Skills to be acquired in this module	describe schematically the events around the pn-junction under bias in the dark and under illumination, calculate the width of the space charge region, use solar cell data sheets in their professional career, discuss the concepts of solar cell materials, design and optimization, choose a PV technology for a given project
Module contents	This specialization module covers the physics of photovoltaics. The behaviour of solar cells is discussed from a fundamental physical point of view to explain the differences in performance and limits of various photovoltaic materials. Students learn how solar cells function, are designed and optimized, Optical and electronical properties of semiconductors, light absorption, Charge carrier generation/recombination/life time, Charge carrier transport across the pn-junction in equilibrium and under light and voltage bias, Transport equations, Current-voltage characteristics, efficiency, Quantum efficiency, Design concepts to optimize the efficiency, Overview of the most important PV technologies
Reader's advisory	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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Wahlpflicht / Elective
Lehr-/Lernform / Teaching/Learning method	Lecture: 4 hrs/week
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module		1 Exam

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

phy616 - Computational Fluid Dynamics 1 / 2

Module label	Computational Fluid Dynamics 1 / 2
Module code	phy616
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Applicability of the module	• Master's Programme Engineering Physics (Master) > European Wind Energy Master • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Lukassen, Laura (Authorized examiners) Stoevesandt, Bernhard (Authorized examiners) Lukassen, Laura (Module responsibility)
Prerequisites	
Skills to be acquired in this module	Deeper understanding of the fundamental equations of fluid dynamics. Overview of numerical methods for the solution of the fundamental equations of fluid dynamics. Confrontation with complex problems in 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.
Module contents	CFD I: The Navier-Stokes equations, filtering / averaging of Navier- Stokes equations, introduction to numerical methods, finite- differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy. CFD II: Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.
Reader's advisory	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	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	Lecture: 2hrs/week, Excersise: 2hrs/week
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module		• 1 Klausur oder • 1 Referat oder • 1 mündliche Prüfung oder • 1 fachpraktische Übung

Course type	Course selection (Vorlesungen oder Praktikum oder Seminar)
SWS	4
Frequency	SuSe or WiSe
Workload attendance	56 h

phy641 - Energy Ressources & Systems

Module label	Energy Ressources & Systems
Module code	phy641
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self-study: 124 hrs)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Knipper, Martin (Authorized examiners) Torio, Herena (Authorized examiners) Knipper, Martin (Module responsibility) Agert, Carsten (Module responsibility)
Prerequisites	
Skills to be acquired in this module	After successful completion of the module students should be able to: • characterize the global energy system and analyze the structure and constraints of today's energy system, • explain the availability and connection between solar and wind energy, • identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles, • relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology.
Module contents	This module will give an overview on the global energy system and the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles. Energy Meteorology (Lecture - 90 h workload) Section I: Solar Irradiance • Radiation laws, • Solar geometry, • Interaction of solar irradiance with the atmosphere, • Radiation climatology, • Solar radiation model, • Statistical properties of solar irradiance, • Measuring devices to ascertain solar radiation balance, • Satellite-supported data acquisition to assess solar irradiance, Section II: Wind Flow • Origin and potential of atmospheric energy movements, Heat balance of the atmosphere, • Physical laws of atmospheric flow, • Wind circulation in the atmosphere, local winds, • Wind flow in atmospheric layers (vertical structure, Ekman Layer), • Assessment of wind potential (European Wind Atlas: model, concept, • Wind Measurements, Energy Systems (Lecture - 90 h workload) • Definitions, separation electrical - thermal energy use, • Resources and reserves, • Energy system analysis: Efficiencies at various levels of the energy chain; Exergy analysis, • Energy scenarios, • Climate change, • Advanced (power plant) technologies for conventional fuels, • Electric power systems with large shares of renewables
Reader's advisory	Energy Meteorology: • IEA Word Energy Outlook (http://wordenergyoutlook.org/) • 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		
Language of instruction	English	
Duration (semesters)	1 Semester	
Module frequency	Winter semester	
Module capacity	unlimited	
Modullevel / module level	MM (Mastermodul / Master module)	
Modulart / typ of module	Pflicht / Mandatory	
Lehr-/Lernform / Teaching/Learning method		
Vorkenntnisse / Previous knowledge		
Examination	Time of examination	Type of examination
Final exam of module	At the end of the lecture period	written exam
Course type	Lecture	
SWS	4	
Frequency	SuSe or WiSe	
Workload attendance	56 h	

phy647 - Future Power Supply Systems

Module label	Future Power Supply Systems
Module code	phy647
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Agert, Carsten (Authorized examiners)
Prerequisites	Knowledge from module RE technology I, Mathematics
Skills to be acquired in this module	After successful completion of the module students should be able to • explain the management, power balancing and the provision of ancillary services within future electricity grid configurations with high shares of fluctuating and distributed generation • perform power system simulation with related software tools • describe different grid-designs, including mini- and microgrids • compare different markets for electricity (Futures' Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and assess the suitability of these concepts for promoting the implementation of higher shares of fluctuating distributed power generation within the electricity grid. • explain the technical principles and resulting limiting factors of concepts and components required for power control within \Smart City", \Smart Grid", and \Smart Home" concepts
Module contents	Future Power Supply Systems: • Technology and characteristics of conventional power plants based e. g. on coal, gas, and nuclear, • Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.), • Fluctuating distributed generation: Characteristics and solutions on the transmission and distribution grid levels, incl. storage, vehicle-to-grid-concepts, smart inverters, heat pumps / CHP, etc, • Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world, - \Smart City", \Smart Grid", \Smart Home", - Mini- and Micro-Grids, • Energy scenarios and modelling, • Chemical energy carriers in the energy system: power-togas (e.g. methane) and power-to-liquids (e.g.methanol)
Reader's advisory	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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Wahlpflicht / Elective
Lehr-/Lernform / Teaching/Learning method	Lecture and Seminar: 4 hrs/week
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module		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

Examination	Time of examination	Type of examination
		announced at the beginning of the term.

Course type	Lecture
SWS	4
Frequency	SuSe or WiSe
Workload attendance	56 h

phy648 - Wind Resources and its Applications

Module label	Wind Resources and its Applications
Module code	phy648
Credit points	6.0 KP
Workload	180 h (Attendance: 72 hrs, Self study: 108 hrs)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Heinemann, Detlev (Authorized examiners) Waldl, Hans-Peter (Authorized examiners) Kühn, Martin (Module responsibility)
Prerequisites	Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab
Skills to be acquired in this module	assess different aspects of wind energy farms by modelling, comparison, explanation of wind energy potential, wind energy farm's output, power curves, wind energy project development, assess in detail in uences of meteorological/ climatological aspects on the performance of wind power systems, summarize physical processes governing atmospheric wind flows, value atmospheric boundary layer flow relevant for wind power conversion, argue methods for wind resource assessment and forecasting
Module contents	Advanced Wind Energy Meteorology (Lecture -90 h workload) Atmospheric Boundary Layer (turbulence, vertical structure, special BL effects) Atmospheric Flow Modelling: Linear models, RANS and LES models Wind farm modelling Offshore-Specific Conditions Resource Assessment and Wind Power Forecasting Wind Measurements and Statistics Wind Energy Applications - from Wind Resource to Wind Farm Operations (Lecture - 90 h workload) Evaluation of Wind Resources Weibull Distribution Wind velocity measurements to determine energy yield Basics of Wind Atlas Analysis and Application Program (WAsP) Method, Partial models using WAsP Measure-Correlate-Predict (MCP) Method of long term corrections of wind measurement data in correlation to long term reference data Conditions for stable, neutral and instable atmospheric conditions Wind yield from wind distribution and the power curve Basics in appraising the yearly wind yield from a wind turbine. Wake Effect and Wind Farm Recovery of original wind fields in the downstream of wind turbines Basics of Riso Models Spacing and effciency in wind farms Positive and Negative Effects of Wind Farms Wind Farm Business Income from the energy yield from wind farms Profit optimization by increase of energy production Wind farm project development Wind farm operation and Surveillance of power production vs. wind climate, power curves, and turbine availability
Reader's advisory	Advanced Wind Energy Meteorology 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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited

Modullevel / module level	MM (Mastermodul / Master module)	
Modulart / typ of module	Wahlpflicht / Elective	
Lehr-/Lernform / Teaching/Learning method	Lecture: 4 hrs/week	
Vorkenntnisse / Previous knowledge		
Examination	Time of examination	Type of examination
Final exam of module		1 Exam
Course type	Lecture	
SWS	4	
Frequency	SuSe or WiSe	
Workload attendance	56 h	

phy649 - Design of Wind Energy Systems

Module label	Design of Wind Energy Systems
Module code	phy649
Credit points	6.0 KP
Workload	180 h (Attendance: 72 hrs, Self study: 108 hrs)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Kühn, Martin (Authorized examiners)
Prerequisites	Basics in Wind Energy Utilisation
Skills to be acquired in this module	Design of Wind Energy Systems: The students attending the course will have the possibility to expand and sharpen of their knowledge about wind turbine design from the basic courses. The lectures include topics covering the whole spectrum from early design phase to the operation of a wind turbine. Students will learn in exercises how to calculate and evaluate design aspects of wind energy converters. At the end of the lecture, they should be able to: estimate the site specific energy yield, calculate the aerodynamics of wind turbines using the blade element momentum theory, model wind fields to obtain specfic design situations for wind turbines, estimate the influence of dynamics of a wind turbine, especially in the context of fatigue loads, transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads, calculate the economic aspects of wind turbine Aeroelastic Simulation of Wind turbines: student who has met the objectives of the course will be able to: understand the basic concept of an aero-servo-elastic computer code to determine the unsteady aerodynamic loads, derive and validate the required parameters to model the aero-hydro-elastic response of a wind turbine, identify and interpret the required empirical parameters to correct the blade element momentum (BEM) method with respect to dynamic in flow, unsteady airfoil aerodynamics (dynamic stall), yawed flow, dynamic wake modeling, explain the effects of the different models on the resulting time series and validate the code, interpret design standards for on- and offshore wind turbines, select the required load cases according to sitespecific environmental data, identify the dimensioning load cases and calculate design loads for different main components of a wind turbine.
Module contents	Design of Wind Energy Systems Introduction to industrial wind turbine design, rotor aerodynamics and Blade Element Momentum (BEM) theory, dynamic loading and system dynamics, wind field modelling for fatigue and extreme event loading, design loads and design aspects of onshore wind turbines, simulation and measurements of dynamic loads, design of offshore wind turbines, power quality and grid integration on wind turbines. Aeroelastic Simulation of Wind turbines: The course focuses on the practical implications and handson experience of the aero-hydro-servo-elastic modelling and simulation of wind turbines. The subjects are similar but the treatment is complementary to the parallel course `Design of Wind Energy Systems', which deals with the underlying theoretical background: advanced wind field modelling for fatigue and extreme event loading, modelling of wind farm flow and wake effects, rotor aerodynamics (e.g. stationary or dynamic effects, comparison of Blade Element Momentum theory and more advanced methods like free vortex methods or CFD), structural dynamics and dynamic modelling of wind turbine structures (modelling by ordinary or partial differential equations, stochastics, multi body system modelling), advanced control of wind turbines, design standards, design loads and design aspects of off-shore and onshore wind turbines. The students analyse in pairs a model of an entire wind turbine with the aid of a typical wind turbine design tool like GH Bladed, Flex5 or Aerodyn/FAST.
Reader's advisory	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	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Wintersemester
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Wahlpflicht / Elective
Lehr-/Lernform / Teaching/Learning	Lecture and seminar: 2 and 2 hrs/week

method		
Vorkenntnisse / Previous knowledge		
Examination	Time of examination	Type of examination
Final exam of module		Exam or presentation or oral exam or homework or practical report
Course type	Lecture	
SWS	4	
Frequency	SuSe or WiSe	
Workload attendance	56 h	

phy987 - Control of Wind Turbines and Wind Farms

Module label	Control of Wind Turbines and Wind Farms
Module code	phy987
Credit points	6.0 KP
Workload	180 h
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Kühn, Martin (Authorized examiners) Petrovic, Vlaho (Authorized examiners)
Prerequisites	
Skills to be acquired in this module	
Module contents	
Reader's advisory	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Modullevel / module level	EB (Ergänzungsbereich / Complementary)
Modulart / typ of module	Wahlpflicht / Elective
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module		KL

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

pre014 - Fundamentals for Renewable Energy

Module label	Fundamentals for Renewable Energy
Module code	pre014
Credit points	6.0 KP
Workload	180 h
Applicability of the module	• Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Hoppmann, Jörn (Authorized examiners) Knecht, Robin (Authorized examiners) Torio, Herena (Authorized examiners) Ziethe, Paul (Authorized examiners)
Prerequisites	
Skills to be acquired in this module	

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

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

Module contents

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

The following Primers are offered:

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

The course "Renewable Energy Management" offers an introduction to the most important areas relevant to the management of renewable energy companies. To this end, the course first provides a general introduction to economic fundamentals and principles. Students then gain insights into the following topics:

- Energy markets
- Renewable energy policy and climate policy
- Energy and society
- Foundation and strategies of renewable energy companies

- Investment and financing in the renewable energy sector
- Innovation management in the renewable energy sector

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

Reader's advisory	Primers: lecture notes for the respective courses RE Management (opitonal): 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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

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

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Course or seminar		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Practical training		2	SuSe or WiSe	28
Total time of attendance for the module				84 h

pre017 - Physical Principles of Renewable Energy Converters

Module label	Physical Principles of Renewable Energy Converters
Module code	pre017
Credit points	6.0 KP
Workload	180 h (180 Stunden)
Applicability of the module	• Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Torio, Herena (Authorized examiners) Holtorf, Hans-Gerhard (Authorized examiners) Jimenez Martinez, Cuauhtemoc Adrian (Authorized examiners) Knipper, Martin (Authorized examiners) Günther, Andreas (Authorized examiners) Agert, Carsten (Module responsibility) Knipper, Martin (Module responsibility)
Prerequisites	
Skills to be acquired in this module	After successful completion of the module students should be able to: • perform laboratory measurements in a university environment according to scientific standards • present a sound analysis of the results and related conclusions in a scientific report • analyse and interpret measurement results using relevant and widely used software tools • work and communicate their results with international and interdisciplinary partners
Module contents	Laboratories (Theoretical?practical Seminar ? 120 h workload) • Introductory Laboratory • Interaction Light and Matter • Heat Transfer • Fluid Dynamics • Storage Technologies • Scientific Writing
Reader's advisory	Lecture notes for the respective courses

Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Winter Semester
Module capacity	40
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	Laboratory
Vorkenntnisse / Previous knowledge	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, - Heat Transfer

Examination	Time of examination	Type of examination
Final exam of module	During the semester	Practical Exercises (lab reports)

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Practical training		2	SuSe or WiSe	28
Total time of attendance for the module				84 h

pre022 - Solar Energy

Module label	Solar Energy
Module code	pre022
Credit points	6.0 KP
Workload	180 h
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Torio, Herena (Authorized examiners) Knipper, Martin (Authorized examiners) Torio, Herena (Module responsibility) Agert, Carsten (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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

Module contents

This module gives an overview on solar thermal 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)

Physics of PV:

· 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

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 system components: collectors; heat exchangers; thermal storage; thermally 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

Reader's advisory

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.

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.
- Henning H-M. 2007. Solar assisted air conditioning of buildings - an overview. Applied Thermal Engineering 27(10):1734-1749; DOI: 10.1016/j.applthermaleng.2006.07.021

Links	
Languages of instruction	
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module	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%)

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

pre025 - Wind Energy and Storage

Module label	Wind Energy and Storage
Module code	pre025
Credit points	6.0 KP
Workload	180 h (180 Hours)
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Hölling, Michael (Authorized examiners) Holtorf, Hans-Gerhard (Authorized examiners) Agert, Carsten (Module responsibility) Holtorf, Hans-Gerhard (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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)

Module contents

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

· Basics of hydrogen production (materials, processes, efficiencies, environmental impacts)

· Basics of fuel cells (function, materials, construction, systems applications)

· Basics of hydrogen storage systems (their setup, control, safety aspects)

· Fundamental setup of most common battery types

· Fundamental chemical reactions in these batteries

- Operational characteristics of batteries (charging & discharging, weir processes and service lives).

Reader's advisory

· 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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Annual, Winter Semester, first semester in SuRE and EMRE
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Pflicht / Mandatory
Lehr-/Lernform / Teaching/Learning method	
Vorkenntnisse / Previous knowledge	

Examination	Time of examination	Type of examination
Final exam of module	End of Module's Block	Written Exam (wind energy) & Active Participation (energy storage)

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

pre042 - Water and Biomass Energy

Module label	Water and Biomass Energy
Module code	pre042
Credit points	6.0 KP
Workload	180 h (180 Stunden)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Wark, Michael (Authorized examiners) Holtorf, Hans-Gerhard (Authorized examiners) Pehlken, Alexandra (Authorized examiners) Wark, Michael (Module responsibility) Holtorf, Hans-Gerhard (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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

Module contents

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

Reader's advisory

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; https://doi.org/10.3390/su12197849

- 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 (8^{th} edition), Prentice Hall, 1998

- Chemistry – General, Organic and Biological, Pearson International Edition (2^{nd} edition), 2007

- 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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Wintersemester
Module capacity	unlimited
Reference text	
	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.
Modullevel / **module level**	MM (Mastermodul / Master module)
Modulart / **typ of module**	Pflicht / Mandatory
Lehr-/Lernform / **Teaching/Learning method**	
Vorkenntnisse / **Previous knowledge**	Basics of - Hydrodynamics - Mechanical Engineering - Electrical Engineering - Recommended: Basic knowledge of General Chemistry

Examination	Time of examination	Type of examination
Final exam of module	End of Winter Semester	Written Exam and active participation

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Seminar		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

pre064 - Renewable Energy Complementary Topics and Transferable Skills

Module label		Renewable Energy Complementary Topics and Transferable Skills
Module code		pre064
Credit points		6.0 KP
Workload	180 h (180 Stunden)	
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule	
Responsible persons	Holtorf, Hans-Gerhard (Authorized examiners) Agert, Carsten (Module responsibility) Holtorf, Hans-Gerhard (Module responsibility)	
Prerequisites		
Skills to be acquired in this module	After completing the module students will be able to: · describe basic knowledge in two of a wide field of disciplines (technical, scientific, social, political, transferrable, language) as required for the implementation of renewable energy · critically discuss basic principles of the implementation of renewable energy - justify their personal decision on educational fields for their career development	
Module contents	The module is designed to give students an outlook on fields which have not been covered so far in their previous lectures and specialization modules. The content from different disciplines allows deepening knowledge and skills in the fields of technology, natural and social sciences, policy-making, 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: All SuRE specialization lectures (beyond the own specialisation lectures), Ecological Economics, International Environmental Governance or any university language courses.	
Reader's advisory	Refer to selected lectures within pre064	
Links		
Languages of instruction	German, English	
Duration (semesters)	1 Semester	
Module frequency		
Module capacity	unlimited	
Modullevel / **module level**	MM (Mastermodul / Master module)	
Modulart / **typ of module**	Wahlpflicht / Elective	
Lehr-/Lernform / **Teaching/Learning method**	Refer to specific lecture	
Vorkenntnisse / **Previous knowledge**	Refer to specific lecture	
Examination	Time of examination	Type of examination
Final exam of module		

Examination	Time of examination	Type of examination

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Seminar		2	SuSe or WiSe	28
Exercises		2	SuSe or WiSe	28
Total time of attendance for the module				84 h

pre113 - Photovoltaic Systems

Module label	Photovoltaic Systems
Module code	pre113
Credit points	6.0 KP
Workload	180 h (180 Stunden)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Holtorf, Hans-Gerhard (Authorized examiners) Knipper, Martin (Authorized examiners) Torio, Herena (Module responsibility) Holtorf, Hans-Gerhard (Module responsibility)
Prerequisites	
Skills to be acquired in this module	

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)

Module contents

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.

Reader's advisory

· 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	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Modullevel / module level	SPM (Schwerpunktmodul / Main emphasis)
Modulart / typ of module	Wahlpflicht / Elective
Lehr-/Lernform / Teaching/Learning method	Lecture, Exercise, Seminar & Excursion
Vorkenntnisse / Previous knowledge	It is desirable to have passed the lecture Photovoltaics 5.06.M121

Examination	Time of examination	Type of examination
Final exam of module	Throughout the Semester	
		Active Participation and Seminar Presentation
		Lecture, Exercise, Seminar & Excursion

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Seminar		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

pre114 - Solar Energy Meteorology

Module label	Solar Energy Meteorology
Module code	pre114
Credit points	6.0 KP
Workload	180 h (180 Stunden)
Applicability of the module	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Postgraduate Programme Renewable Energy (Master) > Mastermodule
Responsible persons	Torio, Herena (Module responsibility) Holtorf, Hans-Gerhard (Module responsibility) Schmidt, Thomas (Authorized examiners)
Prerequisites	Successful participation in “Energy Meteorology 5.06.M117
Skills to be acquired in this module	

After successful completion of the module students should be able to

- explain the concepts of physical processes governing the surface solar irradiance available for solar energy applications
- model the solar radiation and show their expertise in application, adaptation and development of models
- discuss state-of-the-art-methods in satellite-based irradiance estimation and solar power forecasting
- 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)

Module contents

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.

I. Adv. 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 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

II. Solar Energy Meteorology Applications (Lecture and Seminar – 90h workload)

- sources of solar data and discussion of their quality
- solar resource assessment:
  - o basic models,
  - o measurements,
  - o satellite models
  - o 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

Reader's advisory

- S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011)
- MSG Cloud Physical Properties (CPP) by KNMI http://msgcpp.knmi.nl/mediawiki/index.php /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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Annual, summer semester
Module capacity	unlimited
Modullevel / module level	MM (Mastermodul / Master module)
Modulart / typ of module	Wahlpflicht / Elective
Lehr-/Lernform / Teaching/Learning method	Presence (when possible
Vorkenntnisse / Previous knowledge	Physical principles of Black Body Radiation Basics of Solar Radiation

Examination	Time of examination	Type of examination
Final exam of module	During the semester	1 x active participation 1 x written exam

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SuSe or WiSe	28
Seminar		2	SuSe or WiSe	28
Total time of attendance for the module				56 h

Abschlussmodul

mam - Master´s Thesis Module

Module label	Master´s Thesis Module
Module code	mam
Credit points	30.0 KP
Workload	900 h
Applicability of the module	• Master's Programme Postgraduate Programme Renewable Energy (Master) > Abschlussmodul
Responsible persons	Agert, Carsten (Authorized examiners) Günther, Andreas (Authorized examiners) Gütay, Levent (Authorized examiners) Heinemann, Detlev (Authorized examiners) Knecht, Robin (Authorized examiners) Jimenez Martinez, Cuauhtemoc Adrian (Authorized examiners) Hammer, Annette (Authorized examiners) Hölling, Michael (Authorized examiners) Holtorf, Hans-Gerhard (Authorized examiners) Kraft, Martin (Authorized examiners) Kühn, Martin (Authorized examiners) von Bremen, Lüder (Authorized examiners) Lukassen, Laura (Authorized examiners) Siebenhüner, Bernd (Authorized examiners) Schmidt, Andreas Hermann (Authorized examiners) Schneemann, Jörge (Authorized examiners) Steinfeld, Gerald (Authorized examiners) Stoevesandt, Bernhard (Authorized examiners) Torio, Herena (Authorized examiners) Wark, Michael (Authorized examiners) Pehlken, Alexandra (Authorized examiners) Lehnhoff, Sebastian (Authorized examiners) Scheele, Ulrich (Authorized examiners) Sievers-Glotzbach, Stefanie (Authorized examiners) Ravanbach, Babak (Authorized examiners) Malz, Simone (Authorized examiners) Steinberger-Wilckens, Robert (Authorized examiners) Waldl, Hans-Peter (Authorized examiners)
Prerequisites	
Skills to be acquired in this module	The master thesis module finalizes and concludes the master programme. The student presents the achieved results as a written thesis and defends the results / conclusions to a board of examiners.

	As a general objective for the Master Thesis, the student shall demonstrate the ability to constructively, critically and independently formulate, discuss and communicate issues at stake, integrating theory and methodology related to Renewable Energy. As specific competency objectives within the Master Thesis, after completion the student shall be able to: - demonstrate knowledge of relevant and latest publications concerning the selected topic - elaborate the Master Thesis on the basis of clearly formulated, general objectives and specific characteristics of the topic - identify and put to use in an operational manner empirical or other scientific material and methods that are appropriate in relation to the subject - develop a balanced discussion of material, methods, results and possible consequences of these in relation to the field of Renewable Energy - present the Master Thesis orally and defend the results and conclusions in a critical discussion The module is designed to apply and deepen the methodologies acquainted throughout the PPRE programme to a specific scientific problem given by the supervisor. In order to achieve a result the student needs to apply scientific as well as key-competencies described in the next section. Students have understood the scientific problem, they have learned the ropes of the problem, they have selected, acquainted or deepened a set of scientific and methodologies and key-competencies necessary to solve the problem and they have applied those methods. The publication of thesis results is appreciated.
Module contents	
	The Master Thesis finalises the course of studies within PPRE. Master Thesis Colloquium (Colloquium 180 h workload) - Skills for thesis elaboration - negotiation of conditions & rules with the supervisors - setting the scene - scientific writing, - literature research & management (database), - time management, - communication with involved stakeholders, - networking with helpful partners, - development of research question - Presentation and discussion of thesis project proposal (own and other students' project proposals) Finalizing discussion with network (PPRE colleagues, friends and supervisors)
Reader's advisory	
Links	
Languages of instruction	
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Modullevel / module level	---
Modulart / typ of module	je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method	

Vorkenntnisse / Previous knowledge		
Examination	Time of examination	Type of examination
Final exam of module		G
Course type	Seminar	
SWS		
Frequency		
Workload attendance	0 h	