Renewable Energy Online

Module Handbook

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Module PRE600
Renewable Energy Basics

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

This module consists of several self-studying courses called primers. The primers cover fundamental knowledge to succeed in the courses of the technology orientation from the fields of Mathematics, Thermodynamics, Fluids, Mechanics, Programming and Electrical Power Systems. Their aim is to provide the heterogeneous audience a common knowledge base especially in those fields which were not covered in the previous studies of the students.

For each of the primers, reading material is provided with the study content. This material is accompanied by a respective course on the learning platform where students can evaluate their progress using self-evaluation features, pose questions, discuss with class mates and mentors on a forum and submit mandatory assignments.

Duration:	1 semester	Teaching form:	Self-learning (E-books)
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s)	n/a

Lecturer(s): Robin Knecht, Paul Ziethe	Mentor(s): Mónica Gutiérrez, Adnan Shihab
Designer(s) of the module: Robin Knecht, Paul Ziethe	Examiner(s): Robin Knecht, Paul Ziethe

Objective of the module / learning outcomes:

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

- identify fields where they are lacking competences
- self-organize their time and study methods for better results
- describe basic knowledge from a wide field of disciplines as required for renewable energies
- effectively use the features of the learning environment

Forms of learning:

The learning process will be based on self-learning, i.e. reading material and online exercises in the form of self-tests as well as exercises which have to be submitted. During the self-learning process, the students will be supported by lecturers and mentors using forums, messages and video conferences on the online platform C3LLO to address questions and any type of difficulties.

Helpful previous knowledge:

n/a

Content of the module: - Mathematics (Logic, Functions, Calculus, Coordinate Systems, Differential Equations, Stochastics) - Thermodynamics (Laws of thermodynamics, Heat Transfer Processes, Radiation, Planck-Spectrum, Sun-Earth Equilibrium, Heat Engines) - Fluids (Density, Pressure, Bernoulli Equation, Rayleigh-number, Principle of Connected Pipes, Measurement Principles, Pumps and Turbines) - Mechanics (Forces, Momentum, Linear & Rotational Movement, Oscillations, Material Properties) - Programming (Introduction to GNU Octave / MATLAB, Basic Programming, Modelling Fundamentals, Special Features) - Electrical Power Systems (AC & DC Circuit Concepts and components, Balanced 3 phase AC circuits, Magnetic Circuits, Transformers, DC/Induction/Synchronous Machines)
Useful literature: Reading material for the respective courses
Requirements for awarding the credit points Practical exercises: Obtaining at least 50% of the points awarded for the assigned exercises on the learning environment.
Examination periods: During the lecture period.
Comments: none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE605
Renewable Energy Laboratories and Excursion

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

The module is designed to give students a solid foundation to successfully start the Renewable Energy Online (REO) programme. It aims at introducing the online learning platform C3LLO as well as some important basics and principles of scientific working. Furthermore, in an on-campus period at the University of Oldenburg, the students will gain some first hands-on experiences in an introductory laboratory. Subsequently, they will get a deeper look into the underlying principles of selected Renewable Energy technologies in a second laboratory. Also excursions and workshops will be part of the on-campus period, in which the students will get to know various companies and institutes in the field of Renewable Energy as well as train strategies for working in international, virtual teams.

Duration:	1 semester	Teaching form:	Theoretical-practical seminar: e-learning. Laboratory: on-campus.
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s)	n/a

Lecturer(s): Robin Knecht, Andreas Günther, Angelika Basch	Mentor(s): Mónica Gutiérrez, Adnan Shihab
Designer(s) of the module: Robin Knecht, Christiane Stroth	Examiner(s): Robin Knecht, Andreas Günther, Angelika Basch

Objective of the module / learning outcomes:

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

- efficiently apply features of the online learning platform
- perform a basic analysis of the situation of the (Renewable) Energy sector in a certain country
- describe and apply the principles of scientific working
- explain and experimentally investigate underlying principles of selected Renewable Energy technologies
- perform laboratory measurements on Renewable Energy technologies in a university environment according to scientific standards
- analyse and interpret measurement results on Renewable Energy technologies according to scientific standards using relevant and widely used software tools
- work and communicate results with international and interdisciplinary partners
- describe and apply strategies to solve conflicts in working teams

Forms of learning:

The learning process will be based on reading material (self-learning), online exercises (alone and in groups) as well as performing experiments and writing lab reports (group work). The students will be supported by lecturers, mentors and other students using forums, messages and video conferences on the online platform C3LLO as well as in special sessions during the on-campus period. The laboratory experiments are performed on-campus on dedicated experimental setups. Reading material on the laboratory setups and tasks is given, support is provided by supervisors. The students are expected to actively participate in the laboratories as well as excursions and workshops.

Helpful previous knowledge:

n/a

Content of the module:

- Introduction:
  - The REO programme
  - The online learning platform C3LLO
  - Country presentations
- Scientific Working:
  - Good Scientific Practice
  - Scientific Writing
- Laboratories (on-campus period)
  - Introductory Laboratory
  - Interaction Light and Matter
  - Heat Transfer
  - Fluid Dynamics
  - Storage Technologies
- Excursions and workshops (on-campus period)
  - Companies and institutes in the field of Renewable Energy, working in teams

Useful literature:

To be announced at the beginning of the semester.

Requirements for awarding the credit points

Portfolio:

Online exercises (25% of the module grade). Completing lab experiments during the on-campus period and submission of two lab reports from different categories (25% of the module grade for each lab report). Brief presentation of a paper about the energy situation in a certain country (25% of the module grade).

Active participation in the excursions and workshops. The criteria to fulfil the requirement of the active participation will be announced at the beginning of the semester.

Examination periods:

The online exercises have to be submitted during the semester, the presentations will be given during the on-campus period, and the reports have to be submitted at the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE610
Introduction to Energy Resources and Systems

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

This module introduces the concepts of solar and wind energy meteorology. This includes solar radiation basics and modelling and the atmospheric flow as well as the fundamentals of solar and wind resource assessment. The module also provides an overview on the global energy system, explaining the basic terms and definitions. The principles of energy scenarios will be explained as well as the main conventional power plant technologies. Finally, the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles will be discussed.

Duration:	1 semester	Teaching form:	Theoretical-practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s)	n/a

Lecturer(s): Gerald Lohmann, Indradip Mitra	Mentor(s): Mónica Gutiérrez, Adnan Shihab
Designer(s) of the module: Detlev Heinemann, Tanja Behrendt, Adnan Shihab	Examiner(s): Gerald Lohmann, Indradip Mitra

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

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical online exercises. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

n/a

Content of the module:

Part I: Solar Energy Meteorology

- Radiation Laws
- Solar Geometry
- Atmospheric Interaction
- Solar Radiation Modelling
- Statistical Properties of Solar Irradiance
- Surface Solar Irradiance

Part II: Wind Energy Meteorology

- Atmospheric Flow
- Atmospheric Boundary Layer
- Wind Resource Assessment

Part III: Energy Systems

- Basic Definitions and Terminology
- Resources and Reserves
- Energy scenarios
- Climate Change
- Power Plant Technologies
- Electric Power Systems

Useful literature:

- 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
- 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
- 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),
- GEA: Global Energy Assessment (Cambridge University Press, Laxenburg, 2012)

Requirements for awarding the credit points

Portfolio: Online exercises on wind and solar energy meteorology (60% of the module grade), brief oral test on energy systems (40% of the module grade).

Examination periods:

Submission of online exercises during the lecture period, oral test in a video conference at the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE620
Simulation and Laboratory

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

In this module, the students obtain the competence on modelling and critically analysing simulations. Students apply those in a topic on renewable energies of their choice. Students 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 as the results from differently implemented simulations from which they deduce the limits and validity of the respective models.

In a practical simulation course, the students will identify a renewable energy system of their interest and collaboratively develop relevant research questions. The students will construct a model to answer their research question with respect to a real experimental setup. At the end, they will present their results at a students' conference where they detail their model and their results and apply the previously learned critical measures to it.

In a practical laboratory course during an on-campus period the students will continue to work in groups and perform hands-on investigations on a setup. Students will setup measurement equipment, program data loggers for long-term measurements and plan measurement campaigns.

Finally, they will present their measurement results in a research paper and compare their measurement data to those obtained from the simulations. A peer-review process will increase their competence to evaluate, discuss and communicate results according to scientific standards.

In an additional workshop during the on-campus period, the students will focus on moderation and communication techniques and strategies.

Duration:	1 semester	Teaching form:	Lectures, Laboratories
Cycle:	Summer Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s)	n/a
Lecturer(s): Robin Knecht		Mentor(s): NN	
Designer(s) of the module: Robin Knecht		Examiner(s): Robin Knecht	

Objective of the module / learning outcomes:

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

- apply renewable energy technologies in systems including different components
- implement as well as critically analyse and discuss models of Renewable Energy systems and their limitations using various methods
- develop research questions and approaches to answer them, based on a sound literature research
- plan and perform laboratory measurements or simulations on Renewable Energy systems in a university environment according to scientific standards
- analyse and interpret their results on Renewable Energy systems using relevant and widely used software tools according to scientific standards
- work and communicate their results with international and interdisciplinary partners according to scientific standards
- communicate in the form of a conference talk, poster and research paper
- describe and apply strategies for communication as well as for moderation in meetings and discussions

Forms of learning:

The learning process will be based on reading material (self-learning), working on a simulation project (group work) as well as performing experiments (group work). The students will be supported by lecturers, mentors and other students using forums, messages and video conferences on the online platform C3LLO. The laboratory experiments are performed on-campus. Reading material on the laboratory setups and tasks is given, support is provided by supervisors. The students are expected to actively participate in the laboratories as well as further workshops.

Helpful previous knowledge:

Programming, Performing Laboratory Experiments

Content of the module:

- Simulation Theory (Introduction to Modelling, Stationary versus Dynamic Modelling, Continuous versus Discrete Modelling, Statistical Modelling)
- Data-Loggers (Signals, Sensors, Operation)
- Laboratory experiment on Solar Home System, Wind Energy System, Meteorological Measurements
- Workshop on soft skills

Useful literature:

- To be announced at the beginning of the semester.

Requirements for awarding the credit points

Portfolio:

Online exercises on simulation (20% of the module grade), brief presentation of a paper on the simulation results (in the form of a poster and talk at a students' conference; 30% of the module grade), report on the results from laboratory experiments performed during the on campus period as well as the previous simulation results (in the form of a research paper; 40% of the module grade), review of a colleagues' report as part of the peer-review process (10% of the module grade).

Active participation in workshops. The criteria to fulfil the requirement of the active participation will be announced at the beginning of the semester.

Examination periods:

Submission of online exercises during the semester, conference presentation during the on-campus period, submission of the final report and the review at the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE700
Wind Energy Fundamentals and Wind Farm Design

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

In this module, the students will learn the fundamentals of wind power generation and utilization. The course starts with the explanation of the physics behind the generation of the wind, its occurrence and how wind measurements are carried out. Concepts about the energy and power available in the wind, as well as the types of wind energy converters will be described. The aeromechanical energy conversion is explained thoroughly, including the basic blade aerodynamic design. The main components of the wind turbine are also characterized, along with the main drive train, generator concepts and power control strategies. Insights on the mechanical design of the wind turbine components will be given, based on the generation and occurrence of loads. Environmental effects, political and social aspects of wind energy utilisation will be discussed as well.

In the practical part of the module, calculation exercises will be given to complement the theoretical knowledge. Additionally, students will get insights on how wind farm planning is done in the industry. They will perform tasks related with the assessment of the wind resource, energy yield, wind farm efficiency, shadow casting and noise emission of a wind farm. In a self-contained work they will select types of wind turbines and establish a wind farm layout for a given site. They will also optimize the wind farm design, in regard of energy yield and environmental impacts. Tasks to learn about basic economic calculations will be also provided.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Summer Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Andreas H. Schmidt	Mentor(s): Mónica Gutiérrez, Adnan Shihab
Designer(s) of the module: Martin Kühn, Andreas H. Schmidt, Mónica Gutiérrez	Examiner(s): Andreas H. Schmidt

Objective of the module / learning outcomes:

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

- describe a wind resource by means of physical and statistical parameters
- explain the aeromechanical concepts of wind power generation
- characterise the main components of a wind turbine
- perform basic aerodynamic blade design calculations
- perform a basic design of a wind farm layout, based on energy yield, turbine characteristics and environmental impacts applying widely used software tools
- discuss limitations and critical factors of design processes and calculations
- describe the environmental effects, political and social aspects of wind energy utilisation

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical exercises, which are designed to complement the content of each chapter of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

- Basic knowledge of mechanics (statics and dynamics)
- Mathematics for physics and engineering

Content of the module:

- The wind: generation, occurrence and measurements.
- Aerodynamic concepts of wind turbines.
- Aero-mechanical wind turbine design.
- Wind turbine components.
- Wind turbine characteristics and control.
- Grid connection and integration.
- Wind farm aerodynamics and planning.
- Economics of wind energy utilization.

Useful literature:

- T. Burton, D. Sharpe, N. Jenkins, and E. Bossanyi. Wind energy handbook. Ed. by John Wiley & sons Ltd. Chichester, 2001. ISBN: 0-471-48997-2.
- R. Gash and J. Twele, eds. Wind power plants - Fundamentals, design, construction and operation. Second. Berlin: Springer, 2012. ISBN: 978-3-642-22937-4. DOI: 10.1007/978-3-642-22938-1.
- J. Manwell, J. McGowan, and A. Rogers. Wind Energy Explained - Theory, Design and Application. Ed. by John Wiley & Sons Ltd. Second Edi. Chichester, 2009. ISBN: 978-0-470-01500-1.
- S. Mathew. Wind energy - fundamentals. resource analysis and economics. Netherlands: Springer-Verlag Berlin Heidelberg, 2016. ISBN: 9783540309055.
- E. Hau.Wind turbines - Fundamentals, technologies, application, economics. Third. Springer-Verlag Berlin Heidelberg, 2013.

Requirements for awarding the credit points

Practical exercises: Submission of the solutions of the calculation exercises and tasks in due time. Each set of tasks will be graded. The average of the grades obtained during its duration will be calculated, giving the final grade.

Examination periods:

Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in 2 weeks' time frame. Deadlines to deliver the tasks will be at the end of each month.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE701
Design and Simulation of Wind Turbines

This module is associated to the following degrees

Master > Renewable Energy Online > Elective Module

Abstract:

This module consists of topics covering the whole development process of a wind turbine from early design phase over simulation to the operation of a wind turbine. Students will learn in exercises how to calculate and evaluate design aspects of wind energy converters, focusing on an industrial wind turbine design. They learn to estimate the site specific energy yield followed by calculations of the aerodynamics of wind turbines using the blade element momentum theory. The rotor aerodynamics of a wind turbine will be calculated and the influence of stationary or dynamic effects will be demonstrated. The students gain insight into design standards, design aspects and advanced control of offshore and onshore wind turbines.

In the form of a students' research project, students learn collaboratively about the practical implications of the aero-hydro-servo-elastic modelling and simulation of wind turbines. In this phase, transfer of the gained knowledge to more complex topics such as simulation and measurements of dynamic loads is requested. Students learn to model wind fields to obtain specific design situations for wind turbines in order to gain data for fatigue and extreme event loading. An estimation of the influence of the structure dynamics of a wind turbine, especially in the context of fatigue loads, will be done. Finally, the modelling of wind farm flow and wake effects will be handled.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Elective	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Wind Energy Fundamentals and Wind Farm Design
Weblink:	n/a	Associated with the module(s):	n/a
Lecturer(s): NN		Mentor(s): NN	
Designer(s) of the module: Martin Kühn, Luis Vera-Tudela		Examiner(s): NN	

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 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
- perform literature research and formulate research questions
- present own results in form of a research paper
- work in international groups on a students' research project, applying the rules for good scientific practice

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical exercises and the form of a student's research project (group work). These tasks are designed to complement the content of each chapter of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

- Basic scientific programming
- Wind energy fundamentals

Content of the module:

- 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

Useful literature:

- 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, …)

Requirements for awarding the credit points

Practical exercises: Submitting practical exercises. The submitted results will be graded according to precision and understanding of the tasks. Writing a research paper on the last bigger project in the end of the course.

Examination periods:

Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in a time frame of two weeks. Deadlines to deliver the tasks will be at the end of each month during the lecture period, deadline for the project is the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	26.04.2018

Module PRE702
Fluid Dynamics

This module is associated to the following degrees

Master > Renewable Energy Online > Elective Module

Abstract:

The motion of fluids, particularly of air, plays a fundamental role in the context of renewable energies. Global weather systems as well as the flow around a single blade element of a wind turbine follow the natural laws of fluid dynamics. This module offers additional insight into the origin of fluid motion and the underlying equations. It will therefore complement the fluid dynamical concepts used in other modules such as wind energy fundamentals or energy resources and conversion. After introducing the basic concepts, the fundamental equations of motion will be thoroughly deduced. These equations will then act as a starting point to explore different topics such as turbulence, aerodynamics and atmospheric dynamics. The theoretical input in this module will be complemented by practical exercises as well as a final students' research project, which will be conducted as group work.

The module covers a lot of topics and can therefore not provide all important details of e.g. aerodynamics. It rather aims for enabling the students to study more complex and aerodynamical and meteorological topics by themselves. Furthermore, it is a strongly recommended prerequisite for the module Computational Fluid Dynamics.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Elective	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Wind Energy Fundamentals and Wind Farm Design
Weblink:	n/a	Associated with the module(s):	n/a
Lecturer(s): David Bastine		Mentor(s): NN	
Designer(s) of the module: David Bastine		Examiner(s): David Bastine	

Objective of the module / learning outcomes:

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

- describe the fundamental physical principles and equations concerning the dynamics of fluids
- perform basic analytical calculations, approximations and derivations in the context of fluid dynamical problems
- explain the role of important fluid dynamic quantities such as viscosity, vorticity, circulation and shear stresses
- relate fluid dynamical equations to problems of aerodynamics and meteorology
- explain and apply the basic principles of turbulent motion, its statistical interpretation and modelling approaches
- illustrate basic ideas how the fundamental fluid dynamic equations can be solved numerically
- transfer the obtained knowledge to more complex aerodynamical or meteorological topics
- perform literature research and formulate research questions
- present own results in form of a research paper
- work in international groups on a students' research project, applying the rules for good scientific practice

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical exercises and in the form of a students' research project (group work). These tasks are designed to complement the content of each chapter of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

- Basic knowledge of ordinary and partial differential equations, vector analysis and statistics
- Basic scientific programming
- Wind energy fundamentals

Content of the module:

- Introduction and Basic Concepts
- Equations of Motion
- Solving, Analysing and Approximating the Navier-Stokes Equation
- Vorticity Dynamics and Irrotational Flow
- Boundary Layers
- Aerodynamics, Turbulence
- Fluid Dynamics in the Atmosphere
- Computational Fluid Dynamics

Useful literature:

- P.K. Kundu and I.M. Cohen. Fluid Mechanics. Ed. by Academic Press San Diego, 2008.
- J.D. Anderson Jr. Fundamentals of Aerodynamics. Tata McGraw-Hill Education, 2010.

Requirements for awarding the credit points

Practical exercises: Passing the weekly exercises. The submitted results will be graded according to precision and understanding of the tasks. Writing a research paper on the last bigger project in the end of the course.

Examination periods:

Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in a time frame of two weeks. Deadlines to deliver the tasks will be at the end of each month during the semester, deadline for the project is the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE703
Computational Fluid Dynamics

This module is associated to the following degrees

Master > Renewable Energy Online > Elective Module

Abstract:

In this course, the students will learn the fundamentals of computational fluid dynamics. It concerns the numerical solution of the governing equations describing a fluids motion. These equations are systems of partial differential equations for which analytical solutions exist only for a few special cases. Therefore, CFD methods have to be applied to allow a prediction of the specific flow problem. Different methods will be discussed to understand the strengths and weaknesses of the numerical approximations. The most important iteration schemes and their foundations are discussed in this context.

In a practical part, exercises for the use of the open source software tool OpenFOAM will be given to complement the theoretical knowledge. The students will get a first overview on how to perform fluid dynamic simulations and which details have to be regarded. They will conduct steady-state simulations for incompressible flows. Various cases such as airfoil simulations at different angles of attack will be performed. A comparison towards experimental data will be conducted to understand strengths and weaknesses of numerical simulations in OpenFOAM. At the end of the module, students will work in groups on a bigger OpenFOAM project in the form of a students' research project.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Elective	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Wind Energy Fundamentals and Wind Farm Design
Weblink:	n/a	Associated with the module(s):	n/a
Lecturer(s): NN		Mentor(s): NN	
Designer(s) of the module: Leo Höning		Examiner(s): NN	

Objective of the module / learning outcomes:

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

- explain the fundamental equations of fluid dynamics
- describe numerical methods for the solution of the fundamental equations of fluid dynamics
- confront complex physical problems in fluid dynamics
- perform simulations with different widely used CFD models that are used to study complex problems in fluid dynamics
- apply these CFD models to certain defined problems and critically evaluate the results of numerical models
- use OpenFOAM to simulate basic problems
- discuss strengths and weaknesses of OpenFOAM towards other tools and experiments
- perform literature research and formulate research questions
- present own results in form of a research paper
- work in international groups on a students' research project, applying good scientific practice

Forms of learning:

The learning process will be based on reading material (self-learning) as well as on applying new knowledge in practical exercises on simulation. At the end of the module, a last bigger task will be performed as a group work project. All tasks are designed to complement the content of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

- Basic knowledge on the use of linux terminals and basic linux text editors like vim, gedit etc
- Mathematics for physics and engineering

Content of the module:

- Introduction to computational fluid dynamics
- Mathematical discretization methods
- Finite difference method
- Finite volume method
- Linear algebraic equation systems
- Non-linear algebraic equation systems
- Ordinary differential equations: Initial value problems
- Simulation setup in OpenFOAM

Useful literature:

- J. H. Ferziger and M. Peric. Computational Methods for Fluid Dynamics. Third. Berlin: Springer, 2002. ISBN: 978-3-540-42074-3. DOI: 10.1007/978-3-642-56026-2
- H. Lomax, T.H. Pulliam and D. W. Zingg. Fundamentals of Computational Fluid Dynamics. First. Berlin: Springer, 2001. ISBN: 978-3-540-41607-4. DOI: 10.1007/978-3-662-04654-8
- C. Hirsch. Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics. Second. Butterworth-Heinemann, 2007. ISBN: 9780750665940

Requirements for awarding the credit points

Practical exercises: Passing the weekly exercises on OpenFOAM. The submitted results will be graded according to precision and understanding of the tasks. Writing a research paper on the last bigger project in the end of the course.

Examination periods:

An OpenFOAM project will be given to the students alongside the numerical background in the chapters. The tasks are designed to be solved every week. Deadlines to deliver the tasks will be at the end of each month during the lecture period, deadline for the students' research paper is the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	19.04.2018

Module PRE710
Basics of Photovoltaics

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

This course covers the physics of photovoltaic devices where we discuss the solar cell from a microscopic point of view to explain the macroscopic behaviour of solar cells. We discuss design and optimization strategies as well as the limits of solar cells, various technologies and materials which are on the market. .

In the practical part of the module, calculation exercises will be given to complement the new theoretical knowledge. Additionally, the students will simulate solar cells and their behaviour under varying conditions using a research based simulation software.

Duration:	1 semester	Teaching form:	Lectures, Seminar
Cycle:	Summer Semester	Language:	English
Type of module:	Compulsory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Robin Knecht, Angelika Basch	Mentor(s): Mónica Gutiérrez, Adnan Shihab
Designer(s) of the module: Robin Knecht	Examiner(s): Robin Knecht, Angelika Basch

Objective of the module / learning outcomes:

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

- describe schematically the events around the pn-junction under bias in the dark and under illumination
- compute and discuss the mismatch factor from IV data
- perform a basic simulation of a solar cell and its behaviour under varying conditions
- apply solar cell data sheets in their professional career
- discuss the concepts of solar cell materials, design and optimization
- discuss the limitations of solar cells and reflect on needed resources and linked environmental effects

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical exercises and simulation tasks, which are designed to complement the content of each chapter of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge: - Mathematics for physics and engineering
Content of the module: - Macroscopic Solar cell behaviour - Physics of semiconductor materials - Pn-Junctions in the dark or under illumination with or without voltage bias - Characterization of Solar Cells - Simulation of solar cells - Design, Optimization, Limits - Photovoltaic materials (Silicon, III-V, a-Si, CdTe, CIGS, Organic PV, dye-sensitized PV, Perovskite, …) - Applications of solar cells: Overview and Outlook
Useful literature: - S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, (2nd Edition, 2011) John Wiley and Sons - Ch. Honsberg, S. Bowden, PVCDROM, http://www.pveducation.org/pvcdrom/instructions, Access date 2.10.2014 - J. Nelson, Physics of Solar Cells, (1st Edition, 2003), Imperial College Press - lecture notes for the respective courses
Requirements for awarding the credit points Practical exercises: Submission of the solutions of the calculation exercises and simulation tasks in due time. Each set of tasks will be graded. The average of the grades obtained during its duration will be calculated, giving the final grade.
Examination periods: Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in two weeks' time frame. Deadlines to deliver the tasks will be at the end of each month.
Comments: none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE711
Solar Resources and Systems

This module is associated to the following degrees

Master > Renewable Energy Online > Elective Module

Abstract:

In this module, the solar resource is described and modelled in detail. Students learn the theoretical meteorological models and concepts to predict the solar radiation as well as optimize systems with the goal to improve energy security and grid performance.

Additionally, practical exercises will be given to the students to complement the theoretical input of the module. The students will work with real data (e.g. from a satellite) and get to know various measurement techniques as well as relevant modelling software and programming tools used in solar energy meteorology. In the form of a students' research project, they will work collaboratively on the analysis or modelling of real life data and finally communicate their results in the form of a scientific paper.

Duration:	1 semester	Teaching form:	Lectures, Seminar, Practical Training
Cycle:	Winter Semester	Language:	English
Type of module:	Elective	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Basics of Photovoltaics
Weblink:	n/a	Associated with the module(s):	n/a
Lecturer(s): NN		Mentor(s): NN	
Designer(s) of the module: Robin Knecht		Examiner(s): NN	

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
- apply, adapt and develop solar radiation models
- discuss state-of-the-art-methods in satellite-based irradiance estimation and solar power forecasting
- perform literature research and formulate research questions
- analyse and discuss data from solar energy measurements as well as forecasting
- present own results in form of a research paper
- work in international groups on a students' research project, applying the rules for good scientific practice

Forms of learning: The learning process will be based on reading material (self-learning), live and recorded online sessions as well as on applying new knowledge in practical exercises and a real data analysis/modelling project (group work), These tasks are designed to complement the content of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.
Helpful previous knowledge: - Basics of Photovoltaics - Solar Energy Meteorology
Content of the module: - Solar resource - Basic models, measurement methods and validation - Data sources and PV Forecasting - Applications - System Components (Photovoltaic Modules, Batteries, Inverters/Battery Charge Regulators) - System Integration types (Standalone, Mini-Grid and Grid-connected Systems) - System Sizing Methods and Tools, Economic and Regulatory Frameworks
Useful literature: - 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
Requirements for awarding the credit points Practical exercises: Submitting practical exercises. The submitted results will be graded according to precision and understanding of the tasks. Writing a research paper on the last bigger project in the end of the course.
Examination periods: Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in a time frame of two weeks. Deadlines to deliver the tasks will be at the end of each month during the lecture period, deadline for the students' research paper is the end of the lecture period.
Comments: none

Registration procedure:	C3LLO	Last update:	26.04.2018

Module PRE720
Energy Storage

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

In this module, students will learn about the concepts of several technologies for central electrical energy storage to compensate fluctuations in the grid due to Renewable Energy sources. A review of fundamentals of the chemistry of secondary batteries is explained and helps to understand different charging and discharging behaviours. A comparison of different technologies will be given, before the most relevant battery principles are explained and the advantages or shortcomings are discussed. For every type of secondary battery the typical applications are explained by examples. Typical charging strategies are described and typical battery characterisation methods are shown.

In the practical part of the module, the students will focus on a certain battery technology and model its behaviour under varying conditions using relevant programming software. Additionally, calculation exercises have to be done, which complement the theoretical part of the module.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Summer Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Angelika Basch, Hans Holtorf	Mentor(s): Mónica Gutiérrez, Adnan Shihab
Designer(s) of the module: DLR Institute of Networked Energy Systems	Examiner(s): Angelika Basch, Hans Holtorf

Objective of the module / learning outcomes:

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

- classify storage systems by their characteristics to different tasks in the power grid
- explain the basic methods of charging batteries
- explain basic battery characterisation methods and laboratory techniques of measuring
- perform a basic modelling of a battery technology
- discuss the specific advantages and shortcomings of different battery technologies in various applications
- discuss environmental aspects and recycling possibilities for different battery technologies

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical exercises and modelling tasks, which are designed to complement the content of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge: - Mathematics for physics and engineering.
Content of the module: - Energy storage - Storage technologies - Fundamental batteries - Secondary batteries - Charging management - Laboratory methods - Battery modelling
Useful literature: To be announced at the beginning of the semester.
Requirements for awarding the credit points Practical Exercises: Submission of the solutions of the calculation exercises and modelling tasks in due time. Each set of tasks will be graded. At the end of the module, the average of the grades obtained during its duration will be calculated, giving the final grade.
Examination periods: Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in 2 weeks' time frame. Deadlines to deliver the tasks will be at the end of each month.
Comments: none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE730
Selected Technologies of Renewable Energy

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

This module will give an overview over a selection of renewable energy technologies, namely Biomass Energy, Hydro Power and Solar Thermal Energy. The focus is on the scientific principles and the technical description of the components. The Biomass part introduces the fundamental chemical processes and main bioenergy technologies. In the Hydro Power part, the physical principles and the main components will be explained. The Solar Thermal Energy part contains a description of solar thermal collectors, heat exchangers and storage. In all parts, students perform calculations and/or develop a basic system design.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Axel Brehm, Hans-Gerhard Holtorf, Herena Torío	Mentor(s): NN
Designer(s) of the module: Axel Brehm, Hans-Gerhard Holtorf, Herena Torío	Examiner(s): Axel Brehm, Hans-Gerhard Holtorf, Herena Torío

Objective of the module / learning outcomes:

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

- critically evaluate and compare selected Renewable Energy conversion processes and technologies, namely Biomass Energy, Hydro Power and Solar Thermal Energy
- analyse various system components and their interconnections within a supply system based on Biomass, Hydro or Solar Thermal Energy
- evaluate the supply systems' operational size and efficiency
- discuss limitations and non-technical impacts of Biomass Energy, Hydro Power and Solar Thermal Energy

Forms of learning:

The learning process will be predominantly based on reading material and teaching videos (self-learning) and applying new knowledge in exercises and tasks, which are designed to complement the content of each part of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

n/a

Content of the module:

Biomass Energy:

- 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:

- 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

Solar Thermal Energy:

- 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

Useful literature:

- 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
- 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.
- 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.

Requirements for awarding the credit points

Portfolio: Online exercises (on Biomass Energy, 1/3 of the module grade). Brief oral test (online, on Hydro Power, 1/3 of the module grade). Brief presentation of a paper (on Solar Thermal Energy, 1/3 of the module grade).

Examination periods:

The online exercises have to be submitted during the semester, the brief presentation of a paper as well as the oral test will be done at the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE770
Grid-Connected and Off-Grid RE Systems

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

After successful completion of the course, students will understand the existing structures and technical fundamentals for the generation, transmission and distribution of electrical. They should develop an understanding of the necessary technical components and processes for the management and operation of an electrical energy systems, and can assess and evaluate problems and challenges, in particular through the expansion and integration of unpredictably fluctuating decentralized generators into the existing system. Decentralized and centralized power generation will be discussed, as well as off-grid systems such as mini and micro grids. Balancing requirements in systems with high penetration levels of Renewable Energy, grid codes, voltage control mechanisms as well as reactive power management will be covered. Furthermore, basics of wind and solar power forecasting will be introduced and the application of forecasting in grid operations is discussed. Finally, basic concepts of smart grids and virtual power plants will be studied.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Indradip Mitra	Mentor(s): NN
Designer(s) of the module: Indradip Mitra	Examiner(s): Indradip Mitra

Objective of the module / learning outcomes:

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

- explain the elements of the power system and how they are modelled in a simple way
- describe the key parameters to monitor power system stability and how they can be affected
- discuss the main issue concerning the connection of power electronics into the grid
- discuss the structure of the energy market and its regulation
- explain the mechanisms used to help integrate RE into the grid and reflect on issues
- name main electrical studies to assess the behaviour of the power system in different conditions

Forms of learning:

The learning process will be predominantly based on reading material (self-learning) and applying new knowledge in practical exercises, which are designed to complement the content of each chapter of the module. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

- Basic knowledge about solar and wind energy, storage and renewable energy systems

Content of the module:

- Composition of the electrical grid
- Centralised and Decentralised Power Generation
- Mini and Micro Grids
- Ancillary Services, Balancing and Scheduling
- Grid Codes and Technical Standards
- Forecasting of RE Generation
- Grid and System Integration Studies
- Power System Stability and Security of Supply
- Flexibility Options
- Smart Grids, Smart Cities and Smart Homes
- Virtual Power Plants

Useful literature:

- Buchholz, B.M., Styczynski Z. (2014). Smart Grids - Fundamentals and Technologies in Electricity Networks. Springer Ed.
- El-Khattam, W., & Salama, M. M. A. (2004). Distributed generation technologies, definitions and benefits. Electric Power Systems Research, 71(2), 119-128. doi:http://dx.doi.org/10.1016/j.epsr.2004.01.006
- Hemami, A. (2015). Electricity and Electronics for Renewable Energy Technology: An Introduction (Power Electronics and Applications) CRC Press.
- Khartchenko, N. et al. (2013). Advanced Energy Systems, Second Edition (Energy Technology). CRC Press Inc.
- Kirtley, J.L.; Electric Power Principles, John Wiley & Sons, 2010

Requirements for awarding the credit points

Practical Exercises: Submission of the solutions of the calculation exercises and tasks in due time. Each set of tasks will be graded. The average of the grades obtained during its duration will be calculated, giving the final grade.

Examination periods:

Tasks corresponding to each chapter will be given to the students. The tasks are designed to be solved in a time frame of two weeks. Deadlines to deliver the tasks will be at the end of each month.

Comments:

none

Registration procedure:	C3LLO	Last update:	26.04.2018

Module PRE771
Grid Integration Project

This module is associated to the following degrees

Master > Renewable Energy Online > Elective Module

Abstract:

The module will give insight into the complex and interdisciplinary planning and scientific background of a real-life project on renewable energy grid integration. Depending on the real-life project's energy supply system, students will learn about the corresponding technical knowledge and methods, including resource assessment. Additionally, economic, environmental and social methods and theories required for a comprehensive analysis of the project will be presented. Throughout the course, the students will work on different dimensions of a real-life project. By this, they will get a full and close insight into project work and a broad understanding of underlying theoretical and methodological concepts.

The first part of the module is a lecture about 'Project Management and Financing'. The students will be introduced to basic aspects of development and financing of large renewable energy grid integration projects. This includes private and public financing instruments and typical business models. Relevant concepts for cost and investment calculation will be explained.

In the second part of the module, a real-life project will be introduced. The students will get in contact with the partners on-site and establish a full picture of the project. Subsequently, the approach of 'Problem-Based Learning', which is the underlying didactical concept of this module, will be presented. Following this approach, the students will work in groups to collaboratively investigate aspects and issues of the real-life project: In international and interdisciplinary teams, the students will analyse technical, social, financial or ecological aspects, relevant for the project's implementation, development and sustainability. They will identify issues and appropriate methods for an analysis. Finally, they will select a specific topic or problem important for the further development of the project according to their personal preference individually or in small groups in order to analyse the problem. At the end of the module, the findings will be presented via a video conference to the whole group including the project partners. Furthermore, a project report has to be submitted.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Summer Semester	Language:	English
Type of module:	Elective	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Grid-Connected and Off-Grid RE Systems
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Indradip Mitra	Mentor(s): NN
Designer(s) of the module: Christiane Stroth, Andreas Günther, Indradip Mitra	Examiner(s): Indradip Mitra

Objective of the module / learning outcomes:

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

- critically evaluate the impact of the integration of renewable energy into the electricity grid regarding its technical, economic, environmental and social dimension
- perform an in-depth analysis, focussing on either a technical, economic, environmental or social dimension for the implementation of a renewable energy grid integration project
- perform a literature review on a selected topic to a professional standard
- present data, information and evaluation to a professional standard verbally and in the form of a written project report
- moderate discussions on the presented results
- work in groups to identify and discuss relevant aspects of a project
- reflect on the learning as well as working process within the group including diversity aspects

Forms of learning:

The learning process will be predominantly based on project work (group work) and reading material (self-learning). The students are expected to actively participate in the process of problem-based learning and to prepare a presentation for an online meeting as well as write a report. The students will be supported by lecturers, mentors and experts from the project using forums, messages and video conferences on the online platform C3LLO.

Helpful previous knowledge:

- Basic knowledge about solar and wind energy and energy storage
- Grid integration of Renewable Energy

Content of the module:

- Project Management
  - Project Planning and Risk Assessment
  - Financing
  - Investment Calculation
- Introduction to a real-life project
- Introduction to the seminar concept, structure and approach (Problem-based learning)
- Definition of and work on problem(s) in a specific area related to the project:
  - Engineering: identify technology/engineering relevant aspects of the project
  - Economics & Business Administration: project financing, regulatory framework
  - Social Aspects: gender, migration
  - Environmental Aspects: environmental assessment (e.g. life cycle assessment)
- Comprehensive report writing and presentation regarding a specific dimension of the project

Useful literature:

To be announced at the beginning of the semester.

Requirements for awarding the credit points

Presentation of a paper: Report and presentation on the results of the project work. Active participation is required. The criteria to fulfil the requirement of the active participation will be announced at the beginning of the semester.

Examination periods:

The presentations will be given in online meetings at the end of the lecture period, the reports have to be submitted until the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE772
Off-Grid Electrification Project

This module is associated to the following degrees

Master > Renewable Energy Online > Elective Module

Abstract:

The module will give insight into the complex and interdisciplinary planning and scientific background of a real-life project with a Renewable Energy off-grid electricity supply system in a developing country. Depending on the real-life project's energy supply system, it will provide the corresponding technical knowledge and methods, including the resource assessment. Additionally, economic, environmental and social methods and theories required for a comprehensive analysis of the project will be presented. Throughout the course, the students will work on different dimensions of a real-life project in a developing or emerging country. By this, they will get a full and close insight into the project and a broad understanding of underlying theoretical and methodological concepts.

The first part of the module is a lecture about 'Project Management and Financing'. The students will be introduced to basic aspects of development and financing of renewable energy projects with a special focus on developing and emerging countries. This includes private and public financing instruments and typical business models for off-grid electrification projects. Relevant concepts for cost and investment calculation will be explained.

In the second part of the module, a real-life project will be introduced. The students will get in contact with the partners on-site and establish a full picture of the project. Subsequently, the approach of 'Problem-Based Learning', which is the underlying didactical concept of this module, will be presented. Following this approach, the students will work in groups to collaboratively investigate aspects and issues of the real-life project: In international and interdisciplinary teams, the students will analyse technical, social, financial or ecological aspects, relevant for the project's implementation, development and sustainability. They will identify issues and appropriate methods for an analysis. Finally, they will select a specific topic or problem important for the further development of the project according to their personal preference individually or in small groups in order to analyse the problem. At the end of the module, the findings will be presented via a video conference to the whole group including the project partners. Furthermore, a project report has to be submitted.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Summer Semester	Language:	English
Type of module:	Elective	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Grid-Connected and Off-Grid RE Systems
Weblink:	n/a	Associated with the module(s):	n/a
Lecturer(s): Simone Malz, NN		Mentor(s): NN	
Designer(s) of the module: Christiane Stroth, Andreas Günther		Examiner(s): NN	

Objective of the module / learning outcomes:

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

- critically evaluate the impact of an energy supply system for a developing region regarding its technical, economic, environmental and social dimension
- perform an in-depth analysis, focussing on either a technical, economic, environmental or social dimension for the implementation of a renewable energy supply system in a developing region
- perform a literature review on a selected topic to a professional standard
- present data, information and evaluation to a professional standard verbally and in the form of a written project report
- moderate discussions on the presented results
- work in groups to identify and discuss relevant aspects of a project
- reflect on the learning as well as working process within the group including diversity aspects

Forms of learning:

The learning process will be predominantly based on project work (group work) and reading material (self-learning). The students are expected to actively participate in the process of problem-based learning and to prepare a presentation for an online meeting as well as write a report. The students will be supported by lecturers, mentors and experts from the project using forums, messages and video conferences on the online platform C3LLO.

Helpful previous knowledge:

- Basic knowledge about solar and wind energy and energy storage
- Fundamentals of off-grid renewable energy systems

Content of the module:

- Project Management
  - Project Planning and Risk Assessment
  - Financing
  - Investment Calculation
- Introduction to a real-life project
- Introduction to the seminar concept, structure and approach (Problem-based learning)
- Definition of and work on problem(s) in a specific area related to the project:
  - Engineering: identify technology/engineering relevant aspects of the project
  - Economics & Business Administration: project financing, regulatory framework
  - Social Aspects: gender, migration
  - Environmental Aspects: environmental assessment (e.g. life cycle assessment)
- Comprehensive report writing and presentation regarding a specific dimension of the project

Useful literature:

To be announced at the beginning of the semester.

Requirements for awarding the credit points

Presentation of a paper: Report and presentation on the results of the project work. Active participation is required. The criteria to fulfil the requirement of the active participation will be announced at the beginning of the semester.

Examination periods:

The presentations will be given in online meetings at the end of the lecture period, the reports have to be submitted until the end of the lecture period.

Comments:

none

Registration procedure:	C3LLO	Last update:	26.04.2018

Module PRE780
Energy and Society

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

This module comprises two introductory parts: One to sociology and the second one to energy economics. It will address student's with a natural science and engineering background to apply and critical assess economics and social science research

Sociology - Theory and Methods; students will learn the fundamentals of sociological theory and method. The course provides an overview of some major strands of contemporary influential sociological theories and the historic development of the discipline, including its relation to societal development. The founding fathers of the discipline namely Comte, Marx, Durkheim and Weber will be introduced, as well as proponents from the structural functionalism strands, like Parsons and Luhmann, contemporary Marxian and new approaches. These contrastive 'sociological views' and methods will be related to selective major development theories.

With the problem based learning approach students will learn to distinguish between different theories and methods through analysing, i.e. attributing policy measures to sociological and development theories.

Energy Economics – Mainstream and Heterodox Approaches; the course starts with an introduction to mainstream economics, with an energy focus. Markets, demand and supply will be addressed. This will be followed by analysing selected contemporary influential heterodox economics approaches: Post-Keynesian, environmental and New Marxian. Analogous to the sociology unit, with a problem based learning approach students will analyse contemporary energy policy measures.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Summer Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	none
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): Michael Golba, Ulrich Schachtschneider, Simone Malz	Mentor(s): NN
Designer(s) of the module: Michael Golba, Ulrich Schachtschneider, Simone Malz	Examiner(s): Michael Golba, Ulrich Schachtschneider, Simone Malz

Objective of the module / learning outcomes:

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

- understand and critically distinguish between contemporary influential sociological and economic theories and methods
- understand and critically analyse the historic development of sociology and economics
- critically analyse and evaluate exemplary policy measures in terms of their relation to different sociological and economic approaches
- understand and critically assess the relation between energy and economics and the social whole
- critically assess the application of different sociological methods
- conduct basic research by using social science methods
- communicate results verbally and in the written form to a professional standard
- work in international groups and reflect on the learning as well as working process within the group

Forms of learning:

The learning process will be predominantly based on reading material (self-learning), discussions in forums and video conferences as well as group work in the framework of problem-based learning. The students are expected to actively participate in discussions and the process of problem-based learning. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

n/a

Content of the module:

- Introduction to selected contemporary strands of sociological theory and methods
- Introduction to major strands of development theory
- Introduction to mainstream energy economics and selected heterodox economic approaches
- Analysis of exemplary policy measures

Useful literature:

- Cowen, M.P. / Shenton, R.W., Doctrines of Development, Routledge London and New York 1996
- Daly, Herman E. / Farley, Joshua, Ecological Economics. Principles and Applications, Island Press Washington 2004
- Hill, Rod / Myatt, Tony, The Economics Anti Texbook, Fernwood Publishing Black Point / Novia Scotia 2010
- Lavoie, Marc, Post-Keynesian Economics: New Foundations, Edgar Elgar Publishing Cheltenham 2014Preston, P. W., Development Theory – An Introduction, Blackwell Publishers Oxford 2002 (1996)
- Ritzer, George, Sociological Theory, McGraw-Hill Boston 2000
- Todaro, Michael / Smith, Stephen C., Economic Development, Pearson Education Boston 2003
- Varian, Hal R., Intermediate Microeconomics: A Modern Approach, New York 2014

Requirements for awarding the credit points

Portfolio:

Brief presentation of a paper on the results of the problem-based learning process in one of the two parts of the module (50% of the module grade). Learning diary on the problem-based learning process and its results in the other part of the module (50% of the module grade).

Active participation is required. The criteria to fulfil the requirement of the active participation will be announced at the beginning of the semester.

Examination periods:

The presentations will be given in online meetings at the end of the respective part of the module, i.e either after the first half or at the end of the lecture period. Also the written paper as well as the learning diaries have to be submitted at the end of the respective part.

Comments:

none

Registration procedure:	C3LLO	Last update:	03.08.2018

Module PRE781
Renewable Energy and Sustainability

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

The module “Renewable Energy and Sustainability” takes a look at the interaction of the development of humankind and the condition of the natural environment. The aim of the module is to illuminate the areas of sustainable development where technological and formal changes are at their limits and depend on social processes to prevent irreversible destruction of the world as we have known it until today. It is shown that a paradigm of growth has entered modern life that is widely left unquestioned. Ideas and new ways of thinking and living are addressed that could handle the growth paradigm and sketch a different system in which sustainable development is possible.

In this module, students will not only read about concepts, but discuss and get to know the concepts’ strengths and weaknesses, deal and argue with and about them. Therefore, besides the theoretical input, the study material also contains sections with guidance for discussions. These discussions will be done in webinars or group forums and will be moderated by the lecturers/mentors as well as by the students themselves.

Additionally, the students will do a collaborative project work, focusing on topics, which interlink sustainability, renewable energy and society (e.g. sustainable mobility concepts). Within this work, a situation analysis is done, future scenarios with implementation concepts are developed and a consultancy report is written as well as presented in an online video conference.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Energy and Society
Weblink:	n/a	Associated with the module(s):	n/a
Lecturer(s): Herena Torío, Michael Golba, Alexandra Pehlken		Mentor(s): NN	
Designer(s) of the module: Herena Torío, Michael Golba, Christiane Stroth		Examiner(s): Herena Torío, Michael Golba, Alexandra Pehlken	

Objective of the module / learning outcomes:

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

- analyse, 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 hand
- 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 form of a consultancy report to a professional standard
- negotiate their own position as well as moderate discussions in a group with diverse interests or opinions
- work in international and interdisciplinary groups on a consultancy project

Forms of learning:

The learning process will be predominantly based on reading material (self-learning), preparing for as well as participating in discussions as well as project work (group work). The students are expected to actively participate in discussions and project work. The students will be supported by lecturers and mentors using forums, messages and video conferences for active discussions and constant contact to address questions and any type of difficulties.

Helpful previous knowledge:

- Basic knowledge of social science, economics and renewable energy technologies

Content of the module:

- Strategies and dimensions in sustainability research and discussion: efficiency, consistency and sufficiency, as well as related concepts (e.g. rebound effect)
- Growth/Degrowth and decoupling of growth and emission
- Planetary boundaries
- 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
- Selected heterodox economics

Useful literature:

- 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.

Requirements for awarding the credit points

Presentation of a paper: Report and presentation on the results of the project work. Active participation is required. The criteria to fulfil the requirement of the active participation will be announced at the beginning of the semester.

Examination periods:

The presentations will be given in online meetings at the end of the lecture period, the reports have to be submitted until the end of the lecture period.

Comments: none			
Registration procedure:	C3LLO	Last update:	03.08.2018

Module MAM
Master Thesis

This module is associated to the following degrees

Master > Renewable Energy Online > Mandatory Module

Abstract:

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.

The module is designed to apply and deepen the methodologies acquainted throughout the REO 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 learning outcomes.

Duration:	1 semester	Teaching form:	Theoretical – practical seminar: e-learning.
Cycle:	Winter Semester	Language:	English
Type of module:	Mandatory	Credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
Max. No. of students:	30	Pre-requisites:	Energy and Society
Weblink:	n/a	Associated with the module(s):	n/a

Lecturer(s): NN	Mentor(s): NN
Designer(s) of the module: Christiane Stroth	Examiner(s): NN

Objective of the module / learning outcomes:

After successful completion of the module students should 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

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.

Forms of learning:

n/a

Helpful previous knowledge:

n/a

Content of the module:

Master Thesis Colloquium

- 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 (REO colleagues, friends and supervisors)

Master Thesis

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
- Disputation of the thesis results

Useful literature:

- 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.

Requirements for awarding the credit points

Submission of the Master Thesis, Defence of the Master Thesis in a Master Thesis colloquium.

Examination periods:

The defence presentations will be given in online meetings in the final phase of the module.

Comments:

none

Registration procedure:	C3LLO	Last update:	05.02.2018