CARL VON OSSIETZKY universität OLDENBURG
FAKULTÄT V
MATHEMATIK UND NATURWISSENSCHAFTEN

European Master in Renewable Energy

Core Oldenburg

Module Handbook

Carl von Ossietzky University of Oldenburg
School of Mathematics and Science
Institut of Physics

Last Update: 31 August 2020

phy641 - Energy Ressources & Systems

Modulbezeichnung	Energy Ressources & Systems
Modulcode	phy641
Kreditpunkte	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self-study: 124 hrs)
Verwendet in Studiengängen	• Master Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master European Master in Renewable Energy (Master) > Mastermodule • Master Postgraduate Programme Renewable Energy (Master) > Mastermodule
Ansprechpartner/-in	Modulverantwortung ◦ Detlev Heinemann Prüfungsberechtigt ◦ Detlev Heinemann
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: • characterize the global energy system and analyze the structure and constraints of today's energy system, • explain the availability and connection between solar and wind energy, • identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles, • relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology.
Modulinhalte	This module will give an overview on the global energy system and the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles. Energy Meteorology (Lecture - 90 h workload) Section I: Solar Irradiance • Radiation laws, • Solar geometry, • Interaction of solar irradiance with the atmosphere, • Radiation climatology, • Solar radiation model, • Statistical properties of solar irradiance, • Measuring devices to ascertain solar radiation balance, • Satellite-supported data acquisition to assess solar irradiance, Section II: Wind Flow • Origin and potential of atmospheric energy movements, Heat balance of the atmosphere, • Physical laws of atmospheric flow, • Wind circulation in the atmosphere, local winds, • Wind flow in atmospheric layers (vertical structure, Ekman Layer), • Assessment of wind potential (European Wind Atlas: model, concept,

- Wind Measurements,

Energy Systems (Lecture - 90 h workload)

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

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

Modullevel	MM (Mastermodul / Master module)
Modulart	Wahlpflicht / Elective
Modulart	Pflicht / Mandatory
Lern-/Lehrform / Type of program	each Lecture: 2hrs/week
Lern-/Lehrform / Type of program	each Lecture: 2hrs/week
Vorkenntnisse / Previous knowledge	

Prüfung	**Prüfungszeiten**	**Prüfungsform**
Gesamtmodul		written exam

Lehrveranstaltungsform	Vorlesung
SWS	4.00
Angebotsrhythmus	SoSe oder WiSe
Workload Präsenzzeit	56 h

pre014 - Fundamentals for Renewable Energy

Modulbezeichnung	Fundamentals for Renewable Energy
Modulcode	pre014
Kreditpunkte	6.0 KP
Workload	180 h
Verwendet in Studiengängen	• Master European Master in Renewable Energy (Master) > Mastermodule • Master Postgraduate Programme Renewable Energy (Master) > Mastermodule
Ansprechpartner/-in	Modulverantwortung ◦ Herena Torio Prüfungsberechtigt ◦ Jörn Hoppmann ◦ Robin Knecht ◦ Herena Torio ◦ Paul Ziethe
Teilnahmevoraussetzungen	
Kompetenzziele	After successful completion of the module students should be able to: • identify their competence and incompetence with respect to the study of renewable energies • describe basic knowledge from a wide field of disciplines as required for renewable energies • 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
Modulinhalte	The module is designed to give students a solid foundation to successfully start the MSc programme. The content from the field of Physics, Mathematics as well as Electrical and Mechanical Engineering aims to provide a homogenous foundation for the study of renewable energies. The introduction to fundamental knowledge from the field of energy economics and management complements the homogenised 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.

Literaturempfehlungen

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

Unterrichtssprache Englisch

Dauer in Semestern 1 Semester

Angebotsrhythmus Modul	
Aufnahmekapazität Modul	unbegrenzt
Modullevel	MM (Mastermodul / Master module)
Modullevel	MM (Mastermodul / Master module)
Modulart	Pflicht / Mandatory
Modulart	Pflicht / Mandatory
Lern-/Lehrform / Type of program	
Vorkenntnisse / Previous knowledge	

Prüfung	Prüfungszeiten	Prüfungsform
Gesamtmodul	Primer: During the semester RE Management: At the end of the lecture period	Primer: Practical Exercises RE Management: Written Exam

Lehrveranstaltungsform	Kommentar	SWS	Angebotsrhythmus	Workload Präsenzzeit
Vorlesung		2.00	SoSe oder WiSe	28 h
Übung		2.00	SoSe oder WiSe	28 h
Praktikum		2.00	SoSe oder WiSe	28 h
Präsenzzeit Modul insgesamt				84 h

pre017 - Physical Principles of Renewable Energy Converters

Modulbezeichnung	Physical Principles of Renewable Energy Converters
Modulcode	pre017
Kreditpunkte	6.0 KP
Workload	180 h
Verwendet in Studiengängen	• Master European Master in Renewable Energy (Master) > Mastermodule • Master Postgraduate Programme Renewable Energy (Master) > Mastermodule
Ansprechpartner/-in	Modulverantwortung ◦ Hans-Gerhard Holtorf Prüfungsberechtigt ◦ Hans-Gerhard Holtorf ◦ Cuauhtemoc Adrian Jimenez Martinez ◦ Andreas Günther ◦ Robin Knecht
Teilnahmevoraussetzungen	
Kompetenzziele	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
Modulinhalte	Laboratories (Theoretical?practical Seminar ? 120 h workload) • Introductory Laboratory • Interaction Light and Matter • Heat Transfer • Fluid Dynamics • Storage Technologies • Scientific Writing
Literaturempfehlungen	Lecture notes for the respective courses
Links	

Unterrichtssprache	Englisch
Dauer in Semestern	1 Semester
Angebotsrhythmus Modul	
Aufnahmekapazität Modul	40
Modullevel	MM (Mastermodul / Master module)
Modullevel	MM (Mastermodul / Master module)
Modulart	Pflicht / Mandatory
Modulart	Pflicht / Mandatory
Lern-/Lehrform / Type of program	Laboratory
Lern-/Lehrform / Type of program	Laboratory
Vorkenntnisse / Previous knowledge	

Prüfung	**Prüfungszeiten**	**Prüfungsform**
Gesamtmodul	During the semester	Practical Exercises (lab reports)

Lehrveranstaltungsform	**Kommentar**	**SWS**	**Angebotsrhythmus**	**Workload Präsenzzeit**
Vorlesung		2.00	SoSe oder WiSe	28 h
Übung		2.00	SoSe oder WiSe	28 h
Praktikum		2.00	SoSe oder WiSe	28 h
Präsenzzeit Modul insgesamt				84 h

pre410 - Renewable Energy Technologies

Module label	Renewable Energy Technologies
Module code	pre410
Credit points	12.0 KP
Workload	360 h
Used in course of study	• Master's Programme European Master in Renewable Energy (EUREC) (Master) >
Contact person	Module responsibility ◦ Herena Torio Authorized examiners ◦ Michael Hölling ◦ Hans-Gerhard Holtorf ◦ Robin Knecht ◦ Herena Torio ◦ Michael Wark ◦ Alexandra Pehlken ◦ Robert Steinberger-Wilckens
Entry requirements	
Skills to be acquired in this module	After successful completion of the module students should be able to: • critically evaluate and compare three major Renewable Energy conversion processes and technologies: photovoltaics, wind energy one out of the following three: solar thermal energy, biomass energy or hydro power. • critically appraise various electrochemical storage processes and the respective storage techniques • analyse various system components and their interconnections within a complex Renewable Energy supply system. • evaluate the Renewable Energy supply systems' operational size and efficiency. • critically evaluate non-technical impact and side effects when implementing renewable energy supply systems
Module contents	This module will give an overview over a selection of the major renewable energy technologies and some possibilities of their storage. The focus lies on the scientific principles and the technical description of the components. Main aspects of the integration of components to form energy supply systems are also regarded. Photovoltaics (Lecture ? 90 h workload)

Physics of PV:

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

Component Description:

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

System Description

- Grid Connected System
- Stand Alone System

Basics of Wind Energy (Lecture ? 90 h workload)

- Wind characterization and anemometers
- Aerodynamic aspects of wind energy conversion
- Wind turbine performance
- Design of wind turbines
- Dimensional analysis and pi-theorem

Fuel Cells & Energy Storage (Lecture ? 90 h workload)

- Fundamentals of electrochemistry and thermodynamics, energy and environmental balances
- Basics of hydrogen production - starting materials, processes, efficiencies, environmental impacts
- Basics of fuel cells function, materials, construction, systems, applications
- Fundamental setup of most common battery types
- Fundamental chemical reactions in these batteries
- Operational characteristics, weir processes and service lives of these batteries.

Solar Thermal Energy (Seminar & Exercises ? 90 h workload)

- Assessment of solar thermal ambient parameters: regional global, diffuse, reflected solar radiation on horizontal and on tilted plane, ambient temperature
- Solar thermal collectors
- Solar thermal heat exchangers
- Solar thermal storages
- Solar thermal systems and their operation
- Characterization of solar thermal systems

Biomass Energy (Lecture ? 90 h workload)

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

Hydro & Marine Power (Seminar & Exercises ? 90 h workload)

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

Reader's advisory

Solar Energy PV

- Green, Martin A., 1981: Solar cells : operating principles, technology and system applications, Prentice Hall.
- Green, M.A., 2007: Third Generation Photovoltaics, Advanced Solar Energy Conversion, Springer Series in Photonics
- Markvart, Tom and Castaner, Luis, 2003: Practical Handbook of Photovoltaics, Fundamentals and Applications, Elsevier Science
- Nelson, Jenny, 2003: The Physics of Solar Cells (Properties of Semiconductor Materials), Imperial College Press.
- Stuart R. Wenham, Martin A. Green, Muriel E. Watt& Richard Corkish (Edit.), 2007: Applied Photovoltaics, Earthscan Publications Ltd.;
- Twidell, John & Weir, Toni, 2005: Renewable Energy Resources Taylor & Francis.

Basics of Wind Energy

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

Fuel Cells & Energy Storage

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

Biomass Energy

- R. Schlögl (Ed.), Chemical Energy Storage, De Gruyter, 2013, ISBN: 978-3-11-026407-4, Chapter 2, Pages 59-133.
- D.L. Klass. Biomass for renewable energy, fuels, and chemicals, Chapter 4 Virgin

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

Solar Thermal

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

Hydro Power

- Charlier R.H., (2009) Ocean Energy: Tide and Tidal Power.
- Chtrakar P (2005) Micro-hydropower design aids manual: Small Hydropower Promotion Project, Mini Grid Support Programme. 107p.
- Croockewit J (2004) Handbook for developing micro hydro in British Columbia: BChydro. 69 p.
- Giesecke J, Heimerl S, Mosonyi E (2014) Wasserkraftanlagen: Springer Vieweg. XXVI, 940 p.
- Inversin AR (1986) Micro-hydropower sourcebook: NRECA International Foundation.
- Meder K (2011) Environment Assessment and Watershed Action Planning related to GIZ ECO MHP Projects: Field Manual. GIZ. 24 p.
- Pelikan B (2004) Guide on how to develop a small hydropower plant. European Small Hydropower Association 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	Winter semester
Module capacity	unlimited
Modullevel	MM (Mastermodul / Master module)
Modullevel	MM (Mastermodul / Master module)
Modulart	Pflicht / Mandatory
Modulart	Pflicht / Mandatory

Lern-/Lehrform / Type of program	Lectures, Seminars, Exercises
Lern-/Lehrform / Type of program	Lectures, Seminars, Exercises
Vorkenntnisse / Previous knowledge	Helpful previous knowledge: Chemistry, Black Body Radiation, Semiconductor Physics, Fluid Dynamics
Vorkenntnisse / Previous knowledge	Helpful previous knowledge: Chemistry, Black Body Radiation, Semiconductor Physics, Fluid Dynamics

Examination	Time of examination	Type of examination
Final exam of module	Before the end of the lecture period	4 Exams (weight 25% each): Written exam or Paper with Presentation

Course type	Comment	SWS	Frequency	Workload attendance
Lecture		2.00	SuSe and WiSe	28 h
Exercises		4.00	SuSe and WiSe	56 h
Total time of attendance for the module				84 h