FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Module handbook

for a consecutive master study programme in

Renewable Energy

M.Eng.

Fb 2: Department of Computer Science and Engineering

Inhalt

1. Programme learning outcomes

The English-language Master programme “Renewable Energy” (M.Eng.) qualifies students for employment in applied research and development, project lead and project management in the field of renewable energies and related disciplines, in companies involved in energy production, distribution and application of renewable energies, research institutions and organisations working on energy system transformation issues at regional, national and international level.

Students have demonstrated knowledge and understanding that builds on the Bachelor's level of an electrical engineering degree course and deepens this considerably in a sub-area of electrical power engineering. The students of the four-semester study programme acquire the very energy-related competences in the first semester that are required for the students of the three-semester study programme.

Graduates demonstrate knowledge and understanding of advanced methods such as the analysis of sustainable systems, the application of simulation-based development methods of electrical power as well as the integration of renewable energies into intelligent power grids and the energy storage for volatile renewable energies.
By following through on experiments and project work in the laboratories “Electrical Machines and Power Electronics”, “Dataprocessing” and “Simulation of power systems” students apply engineering methods and strategies to solve energy-related problems. They evaluate the technical, economic and ethical aspects of the sustainable technologies “Energy-efficient drives”, “Industrial usability of biomass”, “Electro-mobility” and practise environmental assessments. In doing so they reflect their professional self-concept with regards to the renewable energy industry.

By working on term papers, project reports, written exams and the Master thesis graduates demonstrate systemic knowledge of theoretical, energy-related contexts and apply knowledge and methods in a research-oriented manner. They have acquired key competences such as social interaction, presentation and communication skills. Students of the four-semester programme reflect cultural aspects and ethical standards and familiarize themselves with the German university and industry culture.

The Master degree qualifies for a Doctorate.

2a. Recommended course time-table (programme length 3 semesters)

Renewable Energy (3 semesters) (M.Eng.)						
						Credit Points ECTS
3rd Sem.	11					
	Master-Thesis and Colloquium					
	30 CP					30
	Study Field "Renewable Power Engineering"		**Study Field "Sustainable Engineering"**			
2nd Sem.	6	7	8	9	10	
	Renewable Energy Integration and Smart Grids 5 CP	**Flexible Power Generation and Storage** 5 CP	**Environmental Assessments** 5 CP	**Electro-Mobility** 5 CP	**Renewable Energy Project 2** 10 CP	
						30
1st Sem.	1	2	3	4	5	
	Simulation of Power Systems 5 CP	**Power Control of Renewable Energy Systems** 5 CP	**Energy-Efficient Drives** 5 CP	**Biomass for Industrial Energy and Renewable Compounds** 5 CP	**Renewable Energy Project 1 and Project Management** 10 CP	
						30

2b. Recommended course time-table (programme length 4 semesters)

							Credit Points ECTS
4th Sem.	11 **Master -Thesis and Colloquium** 30 CP						30
	Study field "Renewable Power Engineering"		**Study field "Sustainable Engineering"**				
3rd Sem.	6 **Renewable Energy Integration and Smart Grids** 5 CP	7 **Flexible Power Generation and Storage** 5 CP	8 **Environmental Assessments** 5 CP	9 **Electro-Mobility** 5 CP	10 **Renewable Energy Project 2** 10 CP		30
2nd Sem.	1 **Simulation of Power Systems** 5 CP	2 **Power Control of Renewable Energy Systems** 5 CP	3 **Energy-Efficient Drives** 5 CP	4 **Biomass for Industrial Energy and Renewable Compounds** 5 CP	5 **Renewable Energy Project 1 and Project Management** 10 CP		30
1st Sem.	A **Power Electronics and Control Theory**	B **Electric Power Systems** 5 CP	C **Electrical Machines** 5 CP	D **Renewable Energy** 5 CP	E **Cultural Diversity and Business Ethics**	F **Energy Economics** 5 CP	30

3a. Module and examination overview (programme length 3 semesters)

(Module – CP – Duration – Examination Type – Language - Weight)

Nr.	Module title	ECTS [CP]	Duration [Sem.]	Examination Type	Language	Weight
1st semester						
1	Simulation of Power Systems	5	1	Project assignment software development (submission period 8 weeks) and presentation (at least 15, at most 20 minutes)	English	5/90
2	Power Control of Renewable Energy Systems	5	1	Oral examination (at least 15, at most 20 minutes) PL*: Advanced laboratory exercises (processing time 8 h)	English	5/90
3	Energy-Efficient Drives	5	1	Written examination (90 minutes) PL: Laboratory exercises (processing time 15 h)	English	5/90
4	Biomass for Industrial Energy and Renewable Compounds	5	1	Written homework assignment (submission period 8 weeks) with presentation (at least 15, at most 25 minutes)	English	5/90
5	Renewable Energy Project 1 and Project Management	10	1	Written assignment (submission period 10 weeks) with presentation (at least 15 minutes, at most 25 minutes)	English	10/90
2nd semester						
6	Renewable Energy Integration and Smart Grids	5	1	Project assignment (submission period 8 weeks) with presentation (at least 15, at most 20 minutes)	English	5/90
7	Flexible Power Generation and Storage	5	1	Written homework assignment (submission period 8 weeks) VL: Laboratory experiment with written assignment (processing time 30 hours)	English	5/90

Nr.	Module title	ECTS [CP]	Duration [Sem.]	Examination Type	Language	Weight
8	Environmental Assessments	5	1	Written examination (90 minutes)	English	5/90
9	Electro-Mobility	5	1	Written examination (90 minutes)	English	5/90
10	Renewable Energy Project 2	10	1	Project work (submission period 15 weeks)	English	10/90
3rd semester						
11	Master-Thesis	30	1	Master-Thesis (processing time 22 weeks) weight 80% with colloquium (at least 30, at most 45 minutes), weight 20%	English	30/90

*PL= preliminary examination

3b. Module and examination overview (programme length 4 semesters)

(Module – CP – Duration – Examination Type – Language - Weight)

Nr.	Module title	ECTS [CP]	Duration [Sem.]	Examination Type	Language	Weight
1st semester						
A	Power Electronics and Control Theory	5	1	Written examination (90 minutes)	English	5/120
B	Electric Power Systems	5	1	Written examination (90 minutes) PL*: Laboratory exercises with written assignment (processing time:40 hours)	English	5/120
C	Electrical Machines	5	1	Written examination (90 minutes) PL: Laboratory exercises (processing time 15 h)	English	5/120
D	Renewable Energy	5	1	Written examination (90 minutes)	English	5/120
E	Cultural Diversity and Business Ethics	5	1	Written paper (submission period 4 weeks) with presentation (at least 15, at most 30 minutes)	English	5/120
F	Energy Economics	5	1	Written examination (90 minutes)	English	5/120
2nd semester						
1	Simulation of Power Systems	5	1	Project assignment software development (submission period 8 weeks) and presentation (at least 15, at most 20 minutes)	English	5/120
2	Power Control of Renewable Energy Systems	5	1	Oral examination (at least 15, at most 20 minutes) VL: Advanced laboratory exercises (processing time 8 h)	English	5/120
3	Energy-Efficient Drives	5	1	Written examination (90 minutes) PL: Laboratory exercises (processing time 15 h)	English	5/120
4	Biomass for Industrial Energy and Renewable Compounds	5	1	Written homework assignment (submission period 8 weeks) and presentation (at least 15, at most 25 minutes)	English	5/120

Nr.	Module title	ECTS [CP]	Duration [Sem.]	Examination Type	Language	Weight
5	Renewable Energy Project 1 and Project Management	10	1	Written assignment (submission period 10 weeks) with presentation (at least 15 minutes, at most 25 minutes)	English	10/120
3rd semester						
6	Renewable Energy Integration and Smart Grids	5	1	Project assignment (submission period 8 weeks) and presentation (at least 15, at most 20 minutes)	English	5/120
7	Flexible Power Generation and Storage	5	1	Written homework assignment (submission period 8 weeks) PL: Laboratory experiment with written assignment (processing time 30 hours)	English	5/120
8	Environmental Assessments	5	1	Written examination (90 minutes)	English	5/120
9	Electro-Mobility	5	1	Written examination (90 minutes)	English	5/120
10	Renewable Energy Project 2	10	1	Project work (submission period 15 weeks)	English	10/120
4th semester						
11	Master-Thesis	30	1	Master-Thesis (processing time 22 weeks) weight 80% with colloquium (at least 30, at most 45 minutes), weight 20%	English	30/120

* PL= preliminary examination

4. Module descriptions

Module A: Power Electronics and Control Theory

Module title	Power Electronics and Control Theory
Module number	A
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	Mechatronik und Automobiltechnik (M.Sc.)
Module duration	One semester
Recommended semester	1st semester for students with a programme length of 4 semesters
Module type	Compulsory module for students with a programme length of 4 semesters
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	None
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • describe and explain the operation of PWM controlled forced commutated converters (non-isolated DC/DC converters and DC/AC inverters) • specify the switching behavior of individual topologies and their application range with regard to circuits used in renewable energy systems • describe control systems mathematically • explain and apply methods to characterize transient and steady-state behavior • apply methods for the examination of control loop stability and of controller design
Module contents	Power Electronics - Lecture Control Theory - Lecture
Module teaching methods	Lectures combined with exercises
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr. Hartmut Hinz
Comments	None

Unit A.1.: Power Electronics - Lecture

Unit title	Power Electronics - Lecture
Code	
Module title	Power Electronics and Control Theory
Unit contents	• Electronic Switches • Pulse-Width Modulation • Buck and Boost Converts • Bidirectional DC-DC converters • Full bridge DC-DC converters • Single and Three-Phase Voltage Source Inverters • Phase-controlled converters
Unit teaching methods	Lectures and exercices
Semester periods (hours) per week	2 SWS
Unit workload (h)	75
Class hours (h)	30
Total time of examination incl. preparation (h)	5
Total time of individual study (h)	40
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Hartmut Hinz
Recommended reading	• Issa Batarseh, Ahmad Harb: Power Electronics: Circuit Analysis and Design, Springer International Publishing AG 2nd edition 2018 • Ned Mohan, Tore M. Undeland, William P. Robbins: Power Electronics: Converters, Applications, and Design, Wiley,3rd Edition 2002 • Katsuhiko Ogata: Modern Control Engineering, Pearson Education, Inc., 5th edition 2010 • Farid Golnaraghi, Benjamin C. Kuo: Automatic Control Systems, McGraw-Hill Education, 10th edition 2017
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit A.2.: Control Theory - Lecture

Unit title	Control Theory - Lecture
Code	
Module title	Power Electronics and Control Theory
Unit contents	• Mathematical description of control engineering systems • Transient and Steady-State Response Analyses • PID Controllers • Stability analysis of control systems • Controller design
Unit teaching methods	Lectures and exercices
Semester periods (hours) per week	2 SWS
Unit workload (h)	75
Class hours (h)	30
Total time of examination incl. preparation (h)	5
Total time of individual study (h)	40
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Hartmut Hinz
Recommended reading	• Issa Batarseh, Ahmad Harb: Power Electronics: Circuit Analysis and Design, Springer International Publishing AG 2nd edition 2018 • Ned Mohan, Tore M. Undeland, William P. Robbins: Power Electronics: Converters, Applications, and Design, Wiley,3rd Edition 2002 • Katsuhiko Ogata: Modern Control Engineering, Pearson Education, Inc., 5th edition 2010 • Farid Golnaraghi, Benjamin C. Kuo: Automatic Control Systems, McGraw-Hill Education, 10th edition 2017
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module B: Electric Power Systems

Module title	Electric Power Systems
Module number	B
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	1st semester for students with a programme length of 4 semesters
Module type	Compulsory module for students with a programme length of 4 semesters
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Students participating in the module should be able to: • apply network theorems to the analysis of sinusoidal electric circuits • analyze three-phase networks under balanced conditions • outline and assess the behavior and models of transformers, synchronous and asynchronous machines • describe and explain the basis of magnetic and electrical fields Main previous topics are: Alternating Current (AC) circuit analysis, complex power, three-phase circuits, fundamentals of energy conversion (transformers and electrical machines) and fundamentals of renewable energy.
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. Laboratory exercises with written assignment (processing time 40 hours) b. Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: - illustrate major components of electric power grids: power generating plants, substations, AC lines, DC lines, cables and loads - explain the steady state operation of interconnected electric power systems and apply the concept practically - identify advantages and challenges of the integration of renewable energy resources into different levels of the grid - specify the requirements to perform different steady-state power systems studies - formulate the nonlinear power flow problem. - explain and apply numerical methods for solving non-linear equations and can use the Newton Raphson one. - model power grids appropriately and apply methods to analyze symmetrical and non-symmetrical faults. - simulate steady state operation of transmission systems to evaluate transmission line designs - capability and thermal constraints of components, impacts of short circuits analysis contingency analysis and perform economic analyses.
Module contents	Power Systems - Lecture Basics on Simulation of Power Systems
Module teaching methods	Lecture, laboratory exercises
Module language	(PO) English
Module availability	(PO) Each winter semester
Module coordination	Prof. Dr.-Ing. Carolina Tranchita
Comments	None

Unit B.1.: Power Systems – Lecture

Unit title	Power Systems - Lecture
Code	
Module title	Electric Power Systems
Unit contents	The structure of electric power systems and their components: • Overview of power systems structure and operation, specificities of the European power systems, trends, smart grids, integration of renewable resources. • Review of basic concepts in balanced three-phase circuits, per unit normalization, changing the base, one line diagram, impedance and reactance diagrams. • Transmission lines: design considerations, parameters, parallel circuit three-phase lines, long, medium and short line approximations, reactive compensation techniques. • Transformers: equivalent circuit of a single-phase transformer, per-unit impedances in single-phase transformer circuits, three-phase transformers, the autotransformer, per-unit impedances of three-winding transformers, tap-changing and regulating transformers. • Numerical methods for solving non-linear equations, Gauss Seidel and Newton-Raphson methods. • Power flow calculations: power flow in a line, line losses, non-linear power flow equations, power-flow solution by newton–Raphson, fast decoupled method, ‘‘DC’’ power flow. • Symmetrical components: definition, sequence networks, power in sequences networks, description of positive-, negative, and zero-sequence networks of an unbalanced system. • Symmetrical faults: fault analysis and fault types, balanced three-phase faults at no load, fault interruption, balanced three-phase faults at full load, circuit breaker and fuse selection. • Unsymmetrical faults: single line-to-ground fault, line-to-line fault, double line-to-ground fault.
Unit teaching methods	Lecture and Exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	100 h
Class hours (h)	45 h
Total time of examination incl. preparation (h)	25 h
Total time of individual study (h)	30 h
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Carolina Tranchita
Recommended reading	• J.J. Grainger, W.D. Stevenson, Power Systems Analysis. McGraw-Hill, 1994. • J.D. Glover, M. S. Sarma, and T.J. Overbye, Power System Analysis and Design, Fifth Edition, CENGAGE Learning, 2012. • A.R. Bergen and V. Vittal, Power System Analysis, Second Edition. Prentice-Hall, 1999.
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit B.2: Basics on simulation of power systems

Unit title	Basics on simulation of power systems
Code	
Module title	Electric Power Systems
Unit contents	Steady State simulation of electric power grids by using appropriate technical software: Matlab and Power Factory. A portfolio of laboratory and reports words and software-based simulation will be used as coursework. Topics included are: • Transmission line simulation using, e.g. Matlab • Newton Raphson numerical methods using, e.g. Matlab • Power flow studies and power plant scheduling using, e.g., Power Factory • Symmetrical fault analysis using, e.g., Power Factory
Unit teaching methods	Laboratory exercises
Semester periods (hours) per week	1 SWS
Unit workload (h)	50 h
Class hours (h)	15 h
Total time of examination incl. preparation (h)	10 h
Total time of individual study (h)	25 h
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Carolina Tranchita
Recommended reading	• J.D. Glover, M. S. Sarma, and T.J. Overbye, Power System Analysis and Design, Fifth Edition, CENGAGE Learning, 2012. • DIgSILENT PowerFactory, User's Manual (including other Technical References)
Assessment type and form of the unit	Laboratory exercises with written assignment (processing time 40 hours)
Assessment grading of the unit	Pass/fail
Unit comments	None

Module C: Electrical Machines

Module title	Electrical Machines
Module number	C
Module code	EED
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	1st Semester for students with a programme length of 4 semesters
Module type	Compulsory module for students with a programme length of 4 semesters
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Complex AC-Calculation, Modelling, Basics of DC and AC Machines, Mechanics
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	Laboratory exercises (processing time 15 h) Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module the students will be able to: • reproduce and explain the characteristics of different electrical machines • describe and calculate the operating range and the differences of basic speed and field weakening area • apply different methods for measuring electrical and mechanical quantities • calculate steady state operating points in basic and field weakening range • chose and use measurement instruments according to the requirements of the test procedure • evaluate the behavior of electrical machines in renewable energy systems • cooperate in a laboratory context and achieve results within a given time-frame
Module contents	• Electrical Machines – Lecture • Electrical Machines – Laboratory Experiments
Module teaching methods	Lectures combined with exercises Laboratory experiments
Module language	(PO) English
Module availability	(PO) Each winter semester
Module coordination	Prof. Dr.-Ing. Erich Flach
Comments	None

Unit C.1.: Electrical Machines - Lecture

Unit title	Electrical Machines - Lecture
Code	EED
Module title	Electrical Machines
Unit contents	• Characteristics and limitations of DC and AC Machines • Armature control and field weakening for DC machines • Three phase stator winding principles • Circle diagram of AC induction machines • Operation of synchronous machines • Measurement techniques for the characterization of electrical machines
Unit teaching methods	Lectures combined with exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	90
Class hours (h)	45
Total time of examination incl. preparation (h)	20
Total time of individual study (h)	25
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Erich Flach
Recommended reading	• Salam: Fundamentals of electrical machines, Oxford Alpha Science, 2005 • Dieter Gerling: Electrical machines, Springer, 2015 • Jan A. Melkebeek: Electrical Machines and Drives: Fundamentals and Advanced Modelling, Springer 2018
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit C.2.: Electrical Machines – Laboratory Experiments

Unit title	Electrical Machines – Laboratory Experiments
Code	EED
Module title	Electrical Machines
Unit contents	• DC machine experiment • AC machines experiment • Three phase voltage and current measurements • Analysis of electrical machines using a power meter • Speed measurement in steady state • Torque measurement in steady state
Unit teaching methods	Laboratory experiments
Semester periods (hours) per week	1 SWS
Unit workload (h)	60
Class hours (h)	15
Total time of examination incl. preparation (h)	20
Total time of individual study (h)	25
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Erich Flach
Recommended reading	• Salam: Fundamentals of electrical machines, Oxford Alpha Science, 2005 • Dieter Gerling: Electrical machines, Springer, 2015 • Jan A. Melkebeek: Electrical Machines and Drives: Fundamentals and Advanced Modelling, Springer 2018
Assessment type and form of the unit	Laboratory exercises (processing time 15 h)
Assessment grading of the unit	Pass/fail
Unit comments	None

Module D: Renewable Energy

Module title	Renewable Energy
Module number	D
Module code	REN
Study programme	Master Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	1st semester for students with a programme length of 4 semesters
Module type	Compulsory module for students with a programme length of 4 semesters
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Fundamentals of electrical engineering and physics
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module the students will be able to: • explain the supply with renewable energy, i.e. the function and setup of components and systems for the power generation by photovoltaics, solar thermal power, wind power, hydroelectric power and geothermal power • estimate the current relevance and the future potential of the different power generation technologies • apply methods and techniques for the design, dimensioning and calculation of renewable energy power generation systems • assess the potential and limits of renewable energy sources • evaluate the reduction of greenhouse gas emissions • reflect and apply professional standards to renewable energy contexts
Module contents	Renewable Energy - Lecture
Module teaching methods	Lectures combined with exercises
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr. Torsten Kolb
Comments	None

Unit D.1: Renewable Energy - Lecture

Unit title	Renewable Energy
Code	REN
Module title	Renewable Energy
Unit contents	• Fundamentals of the supply with renewable energy • Photovoltaics • Utilization of thermal solar energy • Power generation with wind power • Hydroelectric power generation • Energetic utilization of biomass • Geothermal energy
Unit teaching methods	Lectures combined with exercises
Semester periods (hours) per week	4 SWS
Unit workload (h)	150
Class hours (h)	60
Total time of examination incl. preparation (h)	30
Total time of individual study (h)	60
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Torsten Kolb
Recommended reading	• Häberlin, Heinrich: Photovoltaics : System Design and Practice. Chichester : Wiley, 2012. • Hau, Erich: Wind Turbines : Fundamentals, Technologies, Application, Economics. 3rd Ed., Berlin : Springer, 2013. • Kaltschmitt, Martin (Ed.): Renewable Energy : Technology, Economics and Environment. Berlin : Springer, 2007.
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module E: Cultural Diversity and Business Ethics

Module title	Cultural Diversity and Business Ethics
Module number	E
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	1st semester for students with a programme length of 4 semesters
Module type	Compulsory module for students with a programme length of 4 semesters
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	None
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Written paper (submission period 4 weeks) with presentation (at least 15, at most 30 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • define and describe the concepts "culture", "cultural diversity" and "cultural diversity management" (e.g. the concepts of Schein & Adler, Hofstede, Trompenaars) • apply core-concepts of the relevant theory to cross-cultural situations • explore and use different standards of verbal and nonverbal communication styles (e.g. styles for greetings and partings, initiating and concluding business discussions, body language, personal space, listening) • analyze and reflect on his / her own communication style • reflect on his / her own attitudes and biases • specify the requirements of managers working in intercultural environment • perceive and understand German characteristics (e.g. history, democracy, values, dignity, clichés) • distinguish between ethics and morale • describe and apply ethical theories and principles • describe and assess Business Ethics Management strategies and instruments They will be able to apply these insights so they can • show sensitivity regarding cultural and ethical issues • comprehend the complexity of cultural and ethical problems • take decisions regarding cultural and ethical dilemmas and reflect them
Module contents	Cultural Diversity Business Ethics
Module teaching methods	Lecture
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr. Barbara Lämmlein
Comments	None

Unit E.1: Cultural Diversity

Unit title	Cultural Diversity
Code	
Module title	Cultural Diversity and Business Ethics
Unit contents	• Cultural diversity and cultural diversity management (definition, advantages, risks) • Culture and culture dimensions (e.g. definitions of Schein & Adler, Hofstede, Trompenaars) • Communicating effectively across cultures • Intrapersonal and interpersonal awareness • Intercultural management • Introduction to German characteristics
Unit teaching methods	Seminar type class with exercises
Semester periods (hours) per week	2 SWS
Unit workload (h)	75 h
Class hours (h)	30 h
Total time of examination incl. preparation (h)	11 h
Total time of individual study (h)	34 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	t.b.a.
Recommended reading	• Hampden-Turner, C., & Trompenaars, F. (2012). Riding the Waves of Culture: Understanding cultural diversity in business. New York: McGraw-Hill. • Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). Cultures and Organizations - Software of the Mind: Intercultural cooperation and its importance for survival (3 ed.). New York: McGraw-Hill. • Solomon, C., & Schell, M. S. (2009). Managing Across Cultures: The Seven Keys to Doing Business with a Global Mindset. New York: McGraw-Hill. • UNESCO World Report: Investing in Cultural Diversity and Intercultural Dialogue.
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit E.2.: Business Ethics

Unit title	Business Ethics
Code	
Module title	Cultural Diversity and Business Ethics
Unit contents	• Differentiation between ethics and morale • Ethical theories and principles • Diverging interests of stakeholders and ethical dilemmas • Situational and non-situational factors of ethical behavior • Implications on leadership • Instruments of business ethics management (e.g. CSR, corruption prevention, whistleblowing) • Case studies (current topics)
Unit teaching methods	Seminar type class with exercises
Semester periods (hours) per week	2 SWS
Unit workload (h)	75 h
Class hours (h)	30 h
Total time of examination incl. preparation (h)	11 h
Total time of individual study (h)	34 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	t.b.a.
Recommended reading	• Holmes, R. (2018). *Introduction to Applied Ethics.* London: Bloomsbury. • O'Sullivan, P., Smith, M., & Esposito, M. (Eds.). (2012). *Business Ethics. A Critical Approach: integrating ethics across the business world* London, New York: Routledge. • Schwartz, M. S. (2017). *Business Ethics. An Ethical Decision-Making Approach.* West Sussex: Wiley. • *Business Ethics: A European Review*. Wiley. • The Journal of Business Ethics. Springer.
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module F: Energy Economics

Module title	Energy Economics
Module number	F
Module code	ECO
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	1st semester for students with a programme length of 4 semesters
Module type	Compulsory module for students with a programme length of 4 semesters
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	None
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • outline and assess the German energy market in technical and commercial terms particularly in the following areas: stakeholders, processes and products in the energy market, purchase and delivery, price design including taxes and fees, plus the legal basis and any relevant interdisciplinary and operational aspects • illustrate, analyze and assess the complex commercial interrelations in the energy market • do calculations of energy prices and fees • explain the relevant processes of the market • show and reflect the basic mechanism of the supply chain
Module contents	Energy Economics - Exercises
Module teaching methods	Seminaristic Lecture
Module language	English
Module availability	(Each winter semester
Module coordination	Dipl.- Psych. Sabine Schröder
Comments	None

Unit F.1.: Energy Economics - Exercises

Unit title	Energy Economics - Exercises
Code	ECO
Module title	Energy Economics
Unit contents	• Logistics and commercial interrelations within the energy market (focus on electricity): • Responsibilities and processes of stakeholders, delivery of products, sourcing, price design • Promotion of renewable energy
Unit teaching methods	Seminaristic Lecture
Semester periods (hours) per week	4 SWS
Unit workload (h)	150 h
Class hours (h)	60 h
Total time of examination incl. preparation (h)	45 h
Total time of individual study (h)	45 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Dipl.- Psych. Sabine Schröder
Recommended reading	• Consumers and deregulation of the electricity market in Germany, Lucia A. Reisch, Hans-W. Micklitz, Journal of Consumer Policy volume 29, pages399–415(2006) • Classification of electricity market models worldwide, LA Barroso, TH Cavalcanti, P Giesbertz, K. Purchala, Date of Conference: 5-7 Oct. 2005, Date Added to IEEE Xplore: 21 November 2005, Print ISBN: 0-7803-9191-8, INSPEC Accession Number: 9285842, DOI: 10.1109/CIGRE.2005.1532720, Publisher: IEEE, Conference Location: New Orleans, LA, USA • The merit-order effect, F. Sensfuß, M. Ragwitz, M. Genoese, • A detailed analysis of the price effect of renewable electricity generation on spot market prices in Germany, Energy Policy; Volume 36, Issue 8, August 2008, Pages 3086-3094
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 1: Simulation of Power Systems

Module title	Simulation of Power Systems
Module number	M1
Module code	
Study programme	Renewable Energy (M. Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters : 2nd semester Programme length 3 semesters : 1st semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Programme length 4 semesters: Module B (Electric Power Systems) Students participating in the module should be able to: • describe the steady state operation of interconnected electric power systems • list the specifications required to perform different steady-state power systems studies • understand the power flow problem and its nonlinear formulation • model power grids appropriately and apply methods to analyze symmetrical and non-symmetrical faults • simulate short circuits in real power systems by using appropriate computational tools
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Project assignment software development (submission period 8 weeks) with presentation (at least 15, at most 20 minutes).
Learning outcomes and skills	The operation of electric power systems is dynamic because of the continuously change of the behavior of electrical consumption and generators. The objective of this course is to study the dynamical properties of the electric power grids based on simulation. Students are able to: - identify and interpret issues, explain basic models and apply methods which are used in the analysis of dynamics, stability and control electric power systems - outline and explain the operation and control of modern power systems - explain physical phenomena of power system dynamics and analyze the behavior of a generator, coupled with the basic physical laws of electrical engineering - simulate various power system instabilities and dynamics in power systems and classify these power system dynamics. - select and specify the requirements to perform different dynamic simulation problems of power systems - model and simulate dynamics following a disturbance in power systems - cooperate and communicate in a project context - present results to a specialist audience and discuss results
Module contents	Power System Dynamics, Control and Operation - Lecture Simulation of Power Systems - Project
Module teaching methods	Lessons combined with practical exercises based on simulation of dynamics, control and operation of Power Systems. Project based on simulation
Module language	English
Module availability	Each summer semester
Module coordination	Prof. Dr.-Ing. Carolina Tranchita
Comments	The module is part of the study field “Renewable Power Engineering”

Unit 1.1.: Power System Dynamics, Control and Operation- Lecture

Unit title	Power System Dynamics, Control and Operation - Lecture
Code	
Module title	Simulation of Power Systems
Unit contents	The aim of this module is to introduce and simulate topics which are crucial for planning, operation, and control of power systems and its future development. Main topics include: - Optimal System Operation - Frequency and Voltage Control - Power System Stability: transient stability, equal area criterion, model for small disturbances - State Estimation of Power Systems
Unit teaching methods	Lecture/ Exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	60 h
Class hours (h)	45 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	15 h
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Carolina Tranchita
Recommended reading	• P. Kundur, Power System Stability and Control, Tata McGraw Hill, Publications, 1994 • Vittal V., McCalley J., Anderson P., Fouad A. A., Power System Control and Stability, 3rd Edition, ISBN: 978-1-119-43371-2, 2019. • Wood Allen. J., Wallenberg B.F., Power Generation, Operation and Control, John Wiley & Sons, Inc., 2003. • Machowski J., Lubosny Z., Bialek J., Bumby J., Power System Dynamics: Stability and Control, 3rd Edition, ISBN: 978-1-119-52634-6, 2020.
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit 1.2.: Simulation of power systems – Project

Unit title	Simulation of power systems - Project
Code	
Module title	Simulation of Power Systems
Unit contents	Dynamic simulation of electric power grids by using appropriate technical software, eg. Matlab RTLab and Power Factory.
Unit teaching methods	Simulation Project
Semester periods (hours) per week	2 SWS
Unit workload (h)	90 h
Class hours (h)	30 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination.
Total time of individual study (h)	60 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Prof. Dr.-Ing. Carolina Tranchita
Recommended reading	• Machowski J., Lubosny Z., Bialek J., Bumby J., Power System Dynamics: Stability and Control, 3rd Edition, ISBN: 978-1-119-52634-6, 2020. • DIgSILENT PowerFactory, User's Manual (including other Technical References)
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 2: Power Control of Renewable Energy Systems

Module title	Power Control of Renewable Energy Systems
Module number	2
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters : 2nd semester Programme length 3 semesters : 1st semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Programme length 4 semesters: Module A, B, C and D Programme length 3 semesters: None
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. Laboratory exercises (processing time 8 h) b. Oral examination (at least 15, at most 20 minutes)
Learning outcomes and skills	Students are able to: • describe and explain advanced control techniques and their application in the power conversion of renewable energy systems. • assess power electronic topologies and their description as control elements in conversion processes • employ suitable tools, required for the modelling of dynamic energy conversion processes in photovoltaic and wind power systems • solve and demonstrate the related control engineering problems • cooperate and communicate efficiently in a laboratory setting
Module contents	Power Control of Renewable Energy Systems - Lectures Power Control of Renewable Energy Systems – Laboratory exercises
Module teaching methods	Lectures combined with exercises, Simulation laboratory
Module language	English
Module availability	Each summer semester
Module coordination	Prof. Dr. Hartmut Hinz
Comments	The module is part of the study field “Renewable Power Engineering”

Unit 2.1: Power Control of Renewable Energy Systems - Lectures

Unit title	Power Control of Renewable Energy Systems – Lectures
Code	
Module title	Power Control of Renewable Energy Systems
Unit contents	• Controller design for photovoltaic conversion systems • Maximum Power Point Tracking (MPPT) of PV arrays, DC-voltage control • AC-current control in single and three-phase systems • Controller design for wind energy conversion systems • Speed control of synchronous and asynchronous AC machines • Active and reactive power control
Unit teaching methods	Lectures and exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	105
Class hours (h)	45
Total time of examination incl. preparation (h)	15
Total time of individual study (h)	45
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Hartmut Hinz
Recommended reading	• Qing-Chang Zhong ; Tomas Hornik: Control of Power Inverters in Renewable Energy and Smart Grid Integration, Wiley-IEEE Press, 2012 • Remus Teodorescu, Marco Liserre, Pedro Rodríguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, Ltd, 2012 • Slobodan N. Vukosavic: Grid-Side Converters Control and Design, Springer International Publishing AG, 2018
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit 2.2: Power Control of Renewable Energy Systems – Laboratory exercises

Unit title	Power Control of Renewable Energy Systems – Laboratory exercises
Code	
Module title	Power Control of Renewable Energy Systems
Unit contents	Simulation task 1: Power control grid-connected Photovoltaic System Simulation task 2: Power control wind power system
Unit teaching methods	Simulation laboratory
Semester periods (hours) per week	1 SWS
Unit workload (h)	45
Class hours (h)	15
Total time of examination incl. preparation (h)	10
Total time of individual study (h)	20
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Hartmut Hinz
Recommended reading	• Qing-Chang Zhong ; Tomas Hornik: Control of Power Inverters in Renewable Energy and Smart Grid Integration, Wiley-IEEE Press, 2012 • Remus Teodorescu, Marco Liserre, Pedro Rodríguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, Ltd, 2012 • Slobodan N. Vukosavic: Grid-Side Converters Control and Design, Springer International Publishing AG, 2018
Assessment type and form of the unit	Laboratory exercises (processing time 8 h)
Assessment grading of the unit	Pass/fail
Unit comments	None

Module 3: Energy-Efficient Drives

Module title	Energy-Efficient Drives
Module number	3
Module code	EED
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters : 2nd semester Programme length 3 semesters : 1st semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Complex AC-Calculation, Modelling, Electrical Machines
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	Laboratory exercises (processing time 15 h) Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • explain and implement the dynamic modeling of electrical machines which is needed for power converters • establish two axis simulation models for machines • distinguish between flux and torque building current and calculate the influence of both at a given operating point • name and assess the limitations for the use of electrical drives in mechanical systems • select the appropriate electrical machine and drive system in matters of the requirements of a system • calculate specific operating points of selected machines • estimate and evaluate losses of the electrical system • verify the performance and estimated losses on a test stand • coordinate laboratory measurements • cooperate and communicate in a laboratory environment
Module contents	Energy-Efficient Drives - Lecture Energy- Efficient Drives - Laboratory experiments
Module teaching methods	Lectures combined with exercises Laboratory experiments
Module language	English
Module availability	Each summer semester
Module coordination	Prof. Dr.-Ing. Erich Flach
Comments	The module is part of the study field “Sustainable Engineering”

Unit 3.1: Energy-Efficient Drives - Lecture

Unit title	Energy-Efficient Drives - Lecture
Code	EED
Module title	Energy-Efficient Drives
Unit contents	• Dynamic modelling of a DC machine • Dynamic modelling of three phase AC machines with d/q-axis • Energy Efficiency according to international Regulation and Energy-Using Products Directive • Typical applications with constant and variable speed
Unit teaching methods	Lectures combined with exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	90
Class hours (h)	45
Total time of examination incl. preparation (h)	20
Total time of individual study (h)	25
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Erich Flach
Recommended reading	• Salam: Fundamentals of electrical machines, Oxford Alpha Science, 2005 • Dieter Gerling: Electrical machines, Springer, 2015 • Masmoudi: Control Oriented Modelling of AC Electric Machines, Springer 2018 • Jan A. Melkebeek: Electrical Machines and Drives: Fundamentals and Advanced Modelling, Springer 2018
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit 3.2: Energy-Efficient Drives - Laboratory experiments

Unit title	Energy-Efficient Drives Laboratory experiments
Code	EED
Module title	Energy-Efficient Drives
Unit contents	• Measurement of the electrical machines in different operating points • Verification of the theory presented in the lecture
Unit teaching methods	Laboratory experiments
Semester periods (hours) per week	1 SWS
Unit workload (h)	60
Class hours (h)	15
Total time of examination incl. preparation (h)	20
Total time of individual study (h)	25
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Erich Flach
Recommended reading	• Salam: Fundamentals of electrical machines, Oxford Alpha Science, 2005 • Dieter Gerling: Electrical machines, Springer, 2015 • Masmoudi: Control Oriented Modelling of AC Electric Machines, Springer 2018 • Jan A. Melkebeek: Electrical Machines and Drives: Fundamentals and Advanced Modelling, Springer 2018
Assessment type and form of the unit	Laboratory exercises (processing time 15 h)
Assessment grading of the unit	Pass/fail
Unit comments	None

Module 4: Biomass for Industrial Energy and Renewable Compounds

Module title	Biomass for Industrial Energy and Renewable Compounds
Module number	4
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	Bio- und Umwelttechnik (M.Sc.)
Module duration	One semester
Recommended semester	Programme length 4 semesters : 2nd semester Programme length 3 semesters : 1st semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	None
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	None Written homework assignment (submission period 8 weeks) with presentation (at least 15, at most 25 Minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • explain and reflect the necessity to substitute fossil energy sources by renewable ones • discuss the advantages and disadvantages of biomass use in comparison to other renewable energy sources • describe and assess the aspects of their material use to obtain platform and special chemicals as well as biopolymers • outline and explain the most important processes for energetic and material use of renewable raw materials • critically evaluate these processes and assess the possibilities of their effective use • demonstrate conclusions as well as the underlying assumptions and reasoning • present results and discuss conclusions
Module contents	Biomass for Industrial Energy and Renewable Compounds - Seminar
Module teaching methods	Seminaristic lecture
Module language	English
Module availability	Each summer semester
Module coordination	Prof. Dr. Axel Blokesch
Comments	The module is part of the study field “Sustainable Engineering”

Unit 4.1: Biomass for Industrial Energy and Renewable Compounds – Seminar

Unit title	Biomass for Industrial Energy and Renewable Compounds – Seminar
Code	
Module title	Biomass for Industrial Energy and Renewable Compounds
Unit contents	• Reasons for the necessity to substitute fossil energy sources by renewable ones • Present share and future impact of biomass use in comparison to other renewable energy sources (e.g. solar energy, wind power, hydroelectric energy) and their possible combination (e.g. Power to Gas) • Availability of renewable energy sources from biomass (wood, sugar cane and sugar beet, cereals, oil seeds and oil trees, micro algae): Presentation of fundamental processes of extraction and possible chemical modification (e.g. Biodiesel-FAME), fermentation (biogas,bioethanol, bio butanol – including downstream processing) and pyrolysis (e.g. BTL – biomass to liquid, hydrogen technologies) • Perspectives for second generation biomass use (cellulose extraction, pyrolysis processes, jatropha oi) • Material use of biomass to obtain platform chemicals (“bricks” for chemical synthesis in the range of 2 to 6 carbon atoms), specialty chemicals and biopolymers • Problem of land use competition (food and feed production, material and energetic use of biomass, preservation of natural habitats)
Unit teaching methods	Seminaristic Lecture, Group work on scientific papers and case studies, discussion and short presentation to all participants
Semester periods (hours) per week	4 SWS
Unit workload (h)	150
Class hours (h)	60
Total time of examination incl. preparation (h)	20
Total time of individual study (h)	70
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Axel Blokesch
Recommended reading	• Boyle, G: Renewable energy, 2nd edition, Oxford Univ. Press, Oxford, 2004 • Wengenmayr, R. and Bührke, T. (eds) Renewable Energy – Sustainable Energy Concepts for the Future, 1st ed., Wiley – VCH, Weinheim, 2008 • Glick, B.R., Pasternak, J.J. and Patten, C.L.: Molecular Biotechnology, 4th ed., ASM Press, Birmingham (AL) 2010
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 5: Renewable Energy Project 1 and Project Management

Module title	Renewable Energy Project 1 and Project Management
Module number	5
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters : 2nd semester Programme length 3 semesters : 1st semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	10 CP / 300 hours
Recommended previous knowledge	None
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None
	b. Written assignment (submission period 10 weeks) with presentation (at least 15 minutes, at most 25 minutes)
Learning outcomes and skills	The objective of this course to learn and apply fundamental principles, tools and techniques of project management. Students explore project management with a practical, hands-on approach through the development of a project on Renewable Energy. Upon completion of the module students will be able to: - determine the viability of a project - understand project management design, development, and implementation - plan and control projects - implement business concepts, best practices, and tools to facilitate project success - identify and plan the risks of a project - manage scope, time, costs, and quality of a project that satisfies the needs for which the project was undertaken - apply project management principles by developing a project focused on Renewable Energy - cooperate and communicate in a project team context - reflect on their professional role and responsibility as project managers - present project results to a specialist audience and discuss conclusions
Module contents	Project Management - Lecture Renewable Energy – Project 1
Module teaching methods	Lecture and Project Work
Module language	English
Module availability	Each summer semester
Module coordination	Prof. Dr.-Ing. Carolina Tranchita
Comments	The project work and presentation contribute each 50 % and 50 % to the final mark (total 100 %).

Unit 5.1. Project Management – Lecture

Unit title	Project Management - Lecture
Code	
Module title	Renewable Energy Project 1 and Project Management
Unit contents	This course develops the competencies and skills for planning and controlling projects. Focusing on the development of new products and services within the framework of Renewable Energy, students will learn about project management life cycle, project parameters, effective project management tools and techniques, and the role of a project manager. Main topics are project management tools and behavioural skills necessary to successfully launch, realize and close projects.
Unit teaching methods	Lecture
Semester periods (hours) per week	2 SWS
Unit workload (h)	30 h
Class hours (h)	30 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	0 h
Total time of practical training (h)	0
Unit language	English
Lecturer	t.b.a.
Recommended reading	• Project Management Institute, Inc., A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Fifth Edition ISBN: 978-1-935589-67-9 • Kerzner, H. Project Management: A Systems Approach to Planning, Scheduling, and Controlling 11th Edition, 2013, ISBN-13: 978-1118022276 • Warburton R, Kanabar V., The Art & Science of Project Management, RW - Press, ISBN: 978-0-9831788-4- • Verzuh E., The Portable MBA: The Fast Forward MBA in Project Management, 4th edition, ISBN: 978-1-118-07377-3
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit 5.2.: Renewable Energy Project 1

Unit title	Renewable Energy Project 1
Code	
Module title	Renewable Energy Project 1 and Project Management
Unit contents	• Project management organized in Learning-by-doing/Project-based learning manner. • Students plan, carry out and finish a Renewable Energy Project • Application of project management methods learnt in Unit M5.1. • Content depending on the selected project subject
Unit teaching methods	Project development
Semester periods (hours) per week	6 SWS
Unit workload (h)	270
Class hours (h)	90 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination.
Total time of individual study (h)	180 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Kolb, Hinz, Schröder, Flach, Tranchita
Recommended reading	Depending on the individual project topic
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 6: Renewable Energy Integration and Smart Grids

Module title	Renewable Energy Integration and Smart Grids
Module number	M6
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters: 3rd semester Programme length 3 semesters: 2nd semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Programme length 4 semesters: Module B (Electric power systems) and Module 1 (Simulation of power systems) Programme length 3 semesters: Module 1 (Simulation of power systems) Students participating in the module should be able to: • describe the steady state and dynamic operation of interconnected electric power systems. • outline and assess the behavior and performance of Renewable Energy Resources • model renewable generation technology • identify and evaluate the behavior and performance of power electronics for renewable energy
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Project assignment (submission period 8 weeks) with presentation (at least 15, at most 20 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: - outline and assess the challenges for the power systems operation due to the integration of Distributed Energy Resources (DERs) and especially due to renewables generation (e.g. photovoltaics and wind generation) - explain how DERs influence the design of distribution power systems - evaluate the need of modernization of power systems and new technology to facilitate the development of smart grids with a high integration of DERs. - illustrate what the Smart Grid concept means - simulate and highlight various technical constraints, which appear due to the insertion of DERs in power systems - simulate and assess a Smart Grid - perform dynamic analyses of electrical system with DERs as stability analysis, frequency and voltage regulation, among others. - communicate and cooperate in a project context - organize themselves as a team and achieve project results within a given time-frame - present project results and discuss their findings
Module contents	Renewable Energy Integration and Smart Grids - Lecture Renewable Energy Integration and Smart Grids – Simulation Project
Module teaching methods	Lessons combined with practical exercises Project based on Simulation
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr.-Ing. Carolina Tranchita
Comments	The module is part of the study field “Renewable Power Engineering”

Unit 6.1.: Renewable Energy Integration and Smart Grids – Lecture

Unit title	Renewable Energy Integration and Smart Grids - Lecture
Code	
Module title	Renewable Energy Integration and Smart Grids
Unit contents	The impact of large scale integration of renewable energy resources, such as wind and solar power, on the operation of power systems and security of supply are explained and simulated. This course provides an overview of the smart grid concept and offers a review of technologies and applications, which are transforming the traditional power grid into an intelligent and environmental-friendly one. In this course, Students will learn how to model and simulate a Smart Grid. Main topics are: - Network interconnection of DERs - Impacts of Distribution Generation on fault currents and voltage - Smart Grid – Generation: DERs, Energy Storage Technologies, Virtual Power Plants (VPP) - Smart Grid – Customers: Demand Side Management (DSM), Advanced Metering Infrastructure (AMI) - Smart Grid – Distribution: Distribution network reconfiguration, Microgrids - Smart Grid – Transmission: Flexible AC Transmission Systems (FACTS) and High Voltage DC (HVDC)
Unit teaching methods	Lecture and Exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	60 h
Class hours (h)	45 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	15 h
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr.-Ing. Carolina Tranchita
Recommended reading	• Smart Grid: Fundamentals of Design and Analysis, ISBN-10: 047088939X, Wiley-IEEE Press; 1 edition, 2012. • Keyhani A., Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-1-118-00581-1, Wiley-IEEE Press, 1 edition, 2011. • Key references are recent papers of IEEE Transactions on Smart Grid
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit 6.2.: Renewable Energy Integration and Smart Grids – Simulation Project

Unit title	Renewable Energy Integration and Smart Grids – Simulation Project
Code	
Module title	Renewable Energy Integration and Smart Grids
Unit contents	• Static and Dynamic simulation of electric power grids with a high integration of renewable energy resources. • Modelling and Simulation of new concepts on Smart Grids by using appropriate technical software, eg. Matlab, RTLab and Power Factory.
Unit teaching methods	Simulation Project
Semester periods (hours) per week	2 SWS
Unit workload (h)	90 h
Class hours (h)	30 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination.
Total time of individual study (h)	60 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Prof. Dr.-Ing. Carolina Tranchita
Recommended reading	• Smart Grid: Fundamentals of Design and Analysis, ISBN-10: 047088939X, Wiley-IEEE Press; 1 edition, 2012. • Keyhani A., Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-1-118-00581-1, Wiley-IEEE Press, 1 edition, 2011. • Key references are recent papers of IEEE Transactions on Smart Grid • DIgSILENT PowerFactory, User's Manual (including other Technical References)
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 7: Flexible Power Generation and Storage

Module title	Flexible Power Generation and Storage
Module number	7
Module code	STO
Study programme	Master Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters: 3rd semester Programme length 3 semesters: 2nd semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Power generation based on renewable energy sources, fundamentals of thermodynamics
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. Laboratory experiment with written assignment (processing time 30 hours) b. Written homework assignment (submission period 8 weeks)
Learning outcomes and skills	Upon completion of the module the students will be able to: • explain and assess the quantitative and dynamic demand of flexible power generation in a power system based on volatile renewable energy sources • recall and reflect various technical relevant energy storage technologies, especially concerning the physical working principle and formal modelling, the energy storage density, power density and economic boundary conditions • estimate the benefits and limitations of the different energy storage technologies and apply formal models for energy storage systems • determine an appropriate energy storage technology for a specific application considering both the physical-technical and the economic boundary conditions • define specifications for energy storage systems for the stationary, grid-connected use and also for applications in the mobility sector • calculate the fundamental parameters for the components of an energy storage system • estimate the benefits and limitations for the dynamic power generation with flexible power plants driven by conventional fuels • communicate and cooperate in a laboratory context • review technical literature
Module contents	• Flexible Power Generation and Storage – Lecture • Flexible Power Generation and Storage – Laboratory experiments
Module teaching methods	Lectures combined with exercises Laboratory experiments including software simulation
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr. Torsten Kolb
Comments	The module is part of the study field “Renewable Power Engineering”

Unit 7.1: Flexible Power Generation and Storage - Lecture

Unit title	Flexible Power Generation and Storage - Lecture
Code	STO
Module title	Flexible Power Generation and Storage
Unit contents	Demand of flexible power generation and energy storage in a power system based on renewable energy sources. Technologies and systems for energy storage: • Electrical energy storage • Electrochemical energy storage, batteries and battery systems • Chemical energy storage, electrolysis, hydrogen, Power-to-Gas, Power-to-Liquid • Mechanical energy storage • Thermal energy storage, Power-to-Heat Integration of storage systems into the power system Sector coupling and load management Flexible power generation with conventional and renewable fuels: • Thermodynamics of conventional power plants • Combined heat and power generation • Gas engine and gas turbine power plants • Combined cycle power plants
Unit teaching methods	Lectures combined with exercises
Semester periods (hours) per week	3 SWS
Unit workload (h)	120
Class hours (h)	45
Total time of examination incl. preparation (h)	30
Total time of individual study (h)	45
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Torsten Kolb
Recommended reading	• Sterner, Michael ; Stadler, Ingo : Handbook of Energy Storage : Demand, Technologies, Integration. Berlin : Springer, 2019. • Braun, Artur : Electrochemical Energy Systems : Foundations, Energy Storage and Conversion. Berlin : De Gruyter, 2019. • Moseley, Patrick T. ; Garche, Jürgen ; Adelmann, Peter : Electrochemical Energy Storage for Renewable Sources and Grid Balancing. Amsterdam : Elsevier, 2015. • Díaz-González, Francisco ; Sumper, Andreas ; Gomis-Bellmunt, Oriol ; Energy storage in power systems. Chichester : Wiley, 2016.
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Unit 7.2: Flexible Power Generation and Storage – Laboratory experiments

Unit title	Flexible Power Generation and Storage – Laboratory experiments
Code	STO
Module title	Flexible Power Generation and Storage
Unit contents	Laboratory experiments including software simulation in the field of energy storage systems
Unit teaching methods	Laboratory experiments
Semester periods (hours) per week	1 SWS
Unit workload (h)	30
Class hours (h)	15
Total time of examination incl. preparation (h)	Included in total time of individual study
Total time of individual study (h)	15
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Torsten Kolb
Recommended reading	• Sterner, Michael ; Stadler, Ingo : Handbook of Energy Storage : Demand, Technologies, Integration. Berlin : Springer, 2019. • Braun, Artur : Electrochemical Energy Systems : Foundations, Energy Storage and Conversion. Berlin : De Gruyter, 2019. • Moseley, Patrick T. ; Garche, Jürgen ; Adelmann, Peter : Electrochemical Energy Storage for Renewable Sources and Grid Balancing. Amsterdam : Elsevier, 2015. • Díaz-González, Francisco ; Sumper, Andreas ; Gomis-Bellmunt, Oriol ; Energy storage in power systems. Chichester : Wiley, 2016.
Assessment type and form of the unit	Laboratory experiment with written assignment (processing time 30 hours)
Assessment grading of the unit	Pass / fail
Unit comments	None

Module 8: Environmental Assessments

Module title	Environmental Assessments
Module number	8
Module code	EVI
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters: 3rd semester Programme length 3 semesters: 2nd semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Programme length 4 semesters: Module F (Energy Economics)
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • describe, explain and generate state-of-the art assessments in the ecological area • analyze the results with regard to their environmental impact. • recognize the stakeholders in the voluntary market and reflect their motivation and drives • analyze the outcome and assess the environmental responsibility of the stakeholders • proceed the relevant steps in sustainable domains and draw their own conclusions • calculate environmental balance sheets • explain the relevant processes of the market and show the basic mechanism of the supply chain • reflect the ethical dimensions of environmental assessments and their professional self-concept
Module contents	Environmental Assessments - Exercises
Module teaching methods	Seminaristic Lecture
Module language	(PO) English
Module availability	(PO) Each winter semester
Module coordination	Dipl.-Psych. Sabine Schröder
Comments	The module is part of the study field “Sustainable Engineering”

Unit 8.1. Environmental Assessments – Exercises

Unit title	Environmental Assessments - Exercises
Code	EVI
Module title	Environmental Assessments
Unit contents	• Analysis and practice of state-of-the art assessments in the ecological area. • Interaction between conclusions, environmental responsibility and sustainable proceedings. • Focus on voluntary activities in conjunction with regulative policies.
Unit teaching methods	Seminaristic Lecture, Exercises
Semester periods (hours) per week	4 SWS
Unit workload (h)	150 h
Class hours (h)	60 h
Total time of examination incl. preparation (h)	45 h
Total time of individual study (h)	45 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Dipl.-Psych. Sabine Schröder
Recommended reading	• IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara, Kiyoto Tanabe, Editors. 2006, Intergovernmental Panel on Climate Change • EnvCan, National Inventory Report: Greenhouse Gas Sources and Sinks in Canada (1990–2005), in: The Canadian Government's Submission to the UN Framework Convention on Climate Change. 2007, Environment Canada • Hoekstra, Arjen Y., Chapagain, Ashok K, Aldaya, Maite M., Mekonnen, Mesfin M.: The Water Footprint Assessment Manual, Earthscan, London 2011 • Water Footprint Network (WFN): Water Footprint Assessment Manual – Setting the Global Standard, online verfügbar unter: http://waterfootprint.org/en/standard/global-water-footprint-standard/Abruf am 8.8.2016 • Ridoutt, Bradley G.; Pfister, Stefan: A revised approach to water footprinting to make transparent the impacts of consumption and production on global freshwater scarcity. In: Global Environmental Change, Vol. 20, Issue 1, S. 113–120, Zürich 2010. • Allan, James Anthony: Virtual Water – the Water, Food, and Trade Nexus, Useful Concept or Misleading Metaphor?; in: Water International, 2003, Vol. 28, 1, S. 106–113
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 9: Electro-Mobility

Module title	Electro-Mobility
Module number	9
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	Mechatronik und Automobiltechnik (M.Sc.)
Module duration	One semester
Recommended semester	Programme length 4 semesters: 3rd semester Programme length 3 semesters: 2nd semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	5 CP / 150 hours
Recommended previous knowledge	Programme length 4 semesters: Modules A, B, C and D
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None b. Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module students will be able to: • evaluate the capabilities and limitations of electrified powertrains • classify different degrees of electrification and identify fuel saving potentials • understand and apply torque control systems of electric drives • discuss an overall assessment of the life cycle analysis of vehicles with regard to greenhouse gas emissions • present the challenges of a necessary infrastructure for electric vehicles • reflect the ethical and societal dimensions of electro-mobility
Module contents	Electro-Mobility - Lectures
Module teaching methods	Lectures combined with exercises
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr. Hartmut Hinz
Comments	The module is part of the study field “Sustainable Engineering”

Unit 9.1: Electro-Mobility - Lectures

Unit title	Electro-Mobility - Lectures
Code	
Module title	Electro-Mobility
Unit contents	• Well-to-wheel efficiency • Electrified powertrain concepts • Torque control of synchronous and asynchronous AC machines • Hybrid vehicle • Battery electric vehicle • Fuel cell electric vehicle • Infrastructure
Unit teaching methods	Lectures and exercises
Semester periods (hours) per week	4 SWS
Unit workload (h)	150
Class hours (h)	60
Total time of examination incl. preparation (h)	10
Total time of individual study (h)	80
Total time of practical training (h)	0
Unit language	English
Lecturer	Prof. Dr. Hartmut Hinz
Recommended reading	• John G. Hayes, G. Abas Goodarzi: Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, Wiley, 1st Edition 2018 • Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi: Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: International Student Edition, Taylor & Francis Ltd; 3rd edition, 2018 • Hui Zhang, Dongpu Cao, Haiping Du: Modeling, Dynamics and Control of Electrified Vehicles, Elsevier Inc. 2018
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 10: Renewable Energy Project 2

Module title	Renewable Energy Project 2
Module number	10
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters: 3rd semester Programme length 3 semesters: 2nd semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	10 CP / 300 hours
Recommended previous knowledge	Modules 1, 2, 3, 4 and 5
Prerequisites for participation in the module and the module examination	None
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None
	b. Project work (submission period 15 weeks)
Learning outcomes and skills	Upon completion of the module students will be able to: • independently solve a scientific problem on the basis of the course content taught • work on the relevant literature in a problem-related manner • professionally analyze and evaluate engineering problems • demonstrate that they have communication and time management skills which are necessary for the successful completion of complex tasks
Module contents	Renewable Energy Project 2
Module teaching methods	Project
Module language	English
Module availability	Each winter semester
Module coordination	Prof. Dr. Hartmut Hinz
Comments	None

Unit 10.1: Renewable Energy Project 2

Unit title	Renewable Energy Project 2
Code	
Module title	Renewable Energy Project 2
Unit contents	Depending on the selected project subject
Unit teaching methods	Project
Semester periods (hours) per week	8 SWS
Unit workload (h)	300
Class hours (h)	120
Total time of examination incl. preparation (h)	15
Total time of individual study (h)	165
Total time of practical training (h)	0
Unit language	English
Lecturer	Respective supervisor
Recommended reading	Depends on the individual project topic, literature is specified by the respective supervisor
Assessment type and form of the unit	None
Assessment grading of the unit	None
Unit comments	None

Module 11: Master-Thesis and Colloquium

Module title	Master-Thesis and Colloquium
Module number	11
Module code	
Study programme	Renewable Energy (M.Eng.)
Module usability	
Module duration	One semester
Recommended semester	Programme length 4 semesters: 4th semester Programme length 3 semesters: 3rd semester
Module type	Compulsory module
ECTS-Points (CP) / Workload (h)	30 CP / 900 hours
Recommended previous knowledge	None
Prerequisites for participation in the module and the module examination	Programme length 4 semesters: Successful completion of modules A to F and 1 to 10 Programme length 3 semesters: successful completion of modules 1 – 10
Prerequisites for the acquisition of credit points: a. preliminary examination b. Module examination	a. None
	b. Master-Thesis (processing time 22 weeks) with colloquium (at least 30, at most 45 minutes)
Learning outcomes and skills	The student is able to • plan, organize, develop, operate and present renewable energy systems that meet practical requirements • develop research questions • review technical literature • explain research results and interpret them critically • integrate existing and new knowledge • apply professional standards • assess economic and ethical consequences • present findings to a specialist audience and defend them
Module contents	Master-Thesis Colloquium
Module teaching methods	Master-Thesis Colloquium
Module language	English
Module availability	Each semester
Module coordination	Prof. Dr. Hartmut Hinz
Comments	None

Unit 11.1: Master Thesis

Unit title	Master Thesis
Code	
Module title	Master Thesis and Colloquium
Unit contents	Depending on master thesis subject
Unit teaching methods	Master Thesis
Semester periods (hours) per week	0
Unit workload (h)	880
Class hours (h)	0
Total time of examination incl. preparation (h)	0
Total time of individual study (h)	880
Total time of practical training (h)	0
Unit language	English
Lecturer	Respective supervisor
Recommended reading	
Assessment type and form of the unit	
Assessment grading of the unit	
Unit comments	None