Technische Hochschule Ingolstadt

Module Handbook

WS 2026/27

Renewable Energy Systems

Master

Faculty of Mechanical Engineering

Study and examination regulation: WS 2024/25

as of: 2026-07-14

Content

1 Overview

Name of course	Renewable Energy Systems
Type of study & degree	Master of Science full-time
First start date	October 1st, 2017 with an annual start in the winter semester
Normal period	3 semesters (90 ECTS, 46,5 SWS)
Duration of study	3 semesters
Place of study	THI Ingolstadt
Language of instruction	English
cooperation	no

Course director:

Name: Matthias Huber
Email: Matthias.Huber@thi.de
Tel.: +49 841 9348-2402

2 Introduction

The text describes the status of the courses on offer in the Renewable Energy Systems master's program according to the study and examination regulations of July 18, 2016 in the version of the amended articles of association dated April 29, 2024.

A complete overview of the modules, their content and examination **types** can be found in **Part 4 - Module descriptions** for the degree program.

In particular, the curriculum specifies the study goals and content of the individual compulsory modules, the subject-specific elective modules and the practical courses as well as the time layout of the weekly hours per module and study semester.

It also contains the more detailed provisions on course-related performance and participation certificates.

In the event of ambiguity, the subordinate study and examination regulations take precedence.

2.1 Objective

The master's program in Renewable Energy Systems is essentially based on the undergraduate bachelor's program in Energy Systems and Renewable Energies at the Technical University of Ingolstadt and aims to provide students with a deeper and detailed understanding of energy systems and their development. On this basis, the graduates can develop and apply their own ideas for design, planning, development, control and management of future energy systems in practice. The graduates proficient in the fields of renewable and conventional energy technology as well as in system analysis and design. They are able to expand their knowledge independently in this complex and dynamic subject area. This is achieved through the application of practical, proven methods, the deepening of theoretical principles, and the scientific research methods. The program also prepares students for the possibility of pursuing a doctoral degree or a research position. Additionally, they can effectively communicate their knowledge to non-experts and engage in scientific discussions with professionals in the production sector.

The knowledge acquired in the Renewable Energy System master's program enables graduates to take on qualified specialist and managerial tasks in all areas of energy technology and enables them to manage complex projects. The graduates have intercultural and communicative competencies that is an activity that is required in an international context. The master's course also gives students the opportunity to pursue a doctoral degree or work in research.

The program is offered completely in English.

2.2 Admission Requirements

The general legal admission requirements apply. The binding regulations for the curriculum can be found in:

- Study and examination regulations for the Renewable Energy Systems master's program in the version of July 18, 2016 (SPO RES) in the version of the amended articles of association dated 29 April 2024
- General examination regulations (APO) of the Technical University of Ingolstadt
- Enrollment statutes of the Technical University of Ingolstadt.

In addition to the general admission requirements, there is also an aptitude assessment procedure, which is described in the study and examination regulations for the Renewable Energy Systems master's program in the version of the amended articles of association dated 29 April 2024 (SPO RES) and on the documents submitted on the applicant's energy experience is based.

2.3 Target group

The target group of the Renewable Energy Systems master's program is made up of two different groups. On the one hand, the graduates of the ESYS course or similar German bachelor courses, on the other hand international graduates of technical courses that are equivalent to a bachelor's degree at THI and the experience in the field of energy technology through specialization within their studies or their bachelor thesis or through professional activity in the field of power engineering.

2.4 Course structure

The students expand their knowledge of regenerative technologies, whereby the focus is not on a single technology, but on the mutual interrelationships with one another and with the structure of requirements.

In order to familiarize all students with the basics of technology and to establish a uniform knowledge level, the essential technological aspects of a certain renewable technologies are taught at the beginning of the so-called system courses. Main part of the courses, however, is about the efficient the use of these technologies in an energy system. Thereby different methods of engineering from simulation and laboratory tests to project development are employed. The basic structure of the course is shown in Figure 1. For the EEE graduates of the THI, the short induction phase represents a repetition of the knowledge from the bachelor's degree, which is then deepened in the system-oriented tasks. For the international students, the introduction phase means a phase of intensive examination of partly new technologies, which can then be applied in practice.

The regular study time is 3 semesters, the first two being covered by courses and the third being reserved for the preparation of the master's thesis.

1. Semester				
Introductory Laboratory Course	System Analysis and Control	Hydrogen in Energy Technology and Energy Markets	Elective course (p.e. Energy Management and Energy Efficiency)	Urban Area Energy Systems
2. Semester				
Energy Markets and Energy Policies	Numerical Methods and Computational Simulation	Off Grid Energy Systems	Industrial Energy Systems Theory	Industrial Energy Systems Project
3. Semester				
Master's Thesis				

Three of the four available energy system modules are selected and taught by the course management for each year. In these energy system modules, students have to design and dimension an energy system. Using a project-oriented approach, you will develop solutions for a task and will be advised by a team of specialists who will provide you with the necessary detailed knowledge of technologies. The students compare different technologies for the required issue and choose the most suitable. In doing so, they learn about the important boundary conditions and requirements for the planning, installation, financing and operation of these technologies. The idea on which the energy system modules are based is that there is no single technology in the foreground, but the integral approach of meeting a specific demand with the best possible regenerative technology.

2.5 Advancement Requirements

The topic for the master's thesis is assigned no earlier than the beginning of the second semester. To be eligible for the thesis topic assignment, students must have successfully completed a minimum of 30 ECTS credits.

2.6 Concept and advisory board

The course was developed in close collaboration with industry representatives, whose specific requirements were carefully considered. Its focus on sector coupling, interdisciplinarity, and systematic thinking reflects the importance of these areas to the economy, resulting in a well-rounded curriculum. The program aims to equip our master's graduates with the skills needed to assume managerial positions in companies and institutions or to pursue further academic qualifications, such as a doctorate. The advisory board, which includes students, alumni, professors from other universities, and industry representatives, provides valuable insights and guidance.

3 Qualification profil

3.1 Mission Statement

Creating a climate-friendly, sustainable, and secure energy supply is one of the great challenges of our time. Renewable energy sources are central to this effort, representing a rapidly growing industry with significant potential for regional, national, and international development. The program is founded on the understanding that modern sector-coupling energy systems increasingly integrate different renewable energy and storage technologies. However, many optimization opportunities remain untapped because experts in individual disciplines often miss the chance to leverage synergies. Therefore, individual technologies and various scientific methods are taught, but these are conveyed in the context of an energy system consideration:

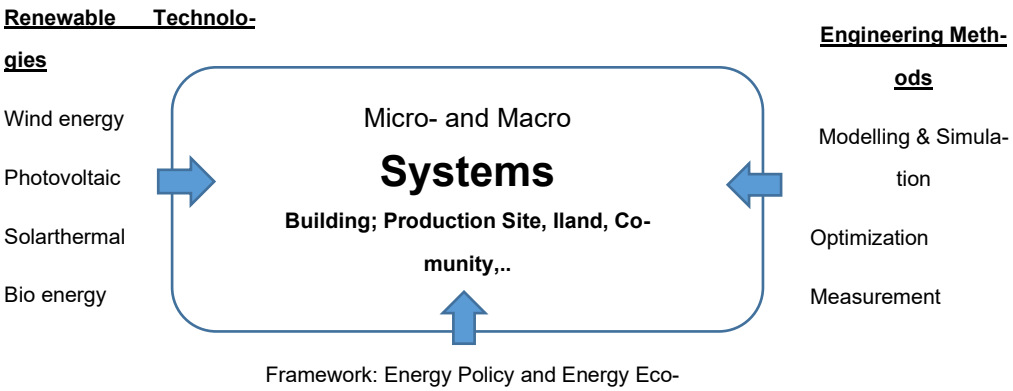

Fig.1: Conceptual representation of the RES master's course at THI

The master's program in Renewable Energy Systems enables students to take on specialist and managerial tasks in an interdisciplinary and international environment, in which in-depth specialist knowledge and its application are conveyed.

3.2 Study objectives

3.2.1 Subject-specific competencies of the degree program

Upon completion of the program, the participants have

- knowledge of the various energy supply technologies and their suitability in different applications
- knowledge of power distribution and load management
- the ability to recognize and assess systematic dependencies in energy systems
- the ability to select, dimension and plan complex energy systems including their dependencies
- the ability to simulate complex systems and interpret simulation results
- the ability to evaluate energy systems economically and ecologically
- the ability to assess political and economic boundary conditions for energy production

3.2.2 Interdisciplinary competencies of the degree program

The following interdisciplinary skills are of particular importance for the course.

- Scientific work
- Working together on larger assignments in teams
- Targeted and sensitive work in an intercultural context
- Fluent English including technical terms
- Conflict management
- Time management
- Project organization
- self-organisation
- Self-presentation

3.2.3 Examination concept of the course

The examinations are based on the desired learning outcomes of a module, the successful delivery of which is to be checked.

Courses and exams are held in English. Selected modules, including examinations, can be held in German as specified in the module handbook.

All modules are either compulsory or elective modules:

1. Compulsory modules are the modules of the course that are binding for all students. The energy system modules are compulsory, as the three taught out of the four possible modules are selected by the course director.

2. Compulsory elective modules are the modules of the course that are offered individually or alternatively in groups. Each student has to choose one of them. The selected module is treated as a compulsory module.

In the energy system modules, the focus is on imparting current specialist knowledge and its application in practice, as well as improving general skills. Therefore, these are checked by the examination form study or seminar paper including the presentation.

3.2.4 Application relevance of the degree program

In the drafting of the course curriculum, the aspect of application relevance was given high priority. A large number of discussions with company representatives have shown that there is a great need, especially in the interface areas between individual technologies. Interdisciplinary planning and working as well as coordination play an increasingly important role. The range of subjects in the degree program meets these requirements. The three large system modules deal with the use of different technologies in an energy system. Various methods of engineering work are to be used, from simulation and laboratory tests to project development. In the group work there, the students not only acquire specialist knowledge for practical use but also practice the soft skills that are indispensable for today's working world, working together in teams and planning and managing projects.

The master's theses are usually written in companies. In addition to the practical relevance of the topics, the transfer of knowledge is of outstanding importance.

3.2.5 Contribution of individual modules to the course objectives

In the Energy System modules, the course imparts specialist skills and subject-specific applications. These teaching objectives are flanked by a business assessment of the solutions found. In the smaller modules, in- depth theoretical knowledge in selected areas of energy technology is imparted.

In addition to the specialist skills, the imparting of methodological, social and personal skills rounds off the course. The implementation of the qualification objectives of the course through the modules is described in detail in the module descriptions under learning objectives and content. The objectives-module matrix, which is shown on the following page, provides an overall overview of the competencies imparted per module.

	Modules **Aims Of Course**	Urban Area Energy Systems	Off Grid Energy Systems	Industrial Energy Systems	Hydrogen in Energy Technology and Energy Markets	Elective, ie Energy Management and Energy Efficiency	System Analysis and Control	Introductory Laboratory course	Energy Policies and Economics	Numerical Methods and Computational simulation	Master thesis
Professional skills	Knowledge of the various energy supply technologies and their suitability in different applications	++	++	++	+	+	+	++		+	
	Knowledge of power distribution & load management	+	+	+	+	++	++	+	+	+	
	Recognizing and assessing systematic dependencies in energy systems	++	++	++	+						
	Selection, dimensioning and planning of complex energy systems including the dependencies	++	++	++	+		+				
Methodological skills	Simulation of complex systems and interpretation of simulation results	+	+	+	+	+	+	+	+	++	
	Economic and ecological assessment of energy systems	+	+	+	+	++			++		

	Modules **Aims Of Course**	Urban Area Energy Systems	Off Grid Energy Systems	Industrial Energy Systems	Hydrogen in Energy Technology and Energy Markets	Elective, ie Energy Management and Energy Efficiency	System Analysis and Control	Introductory Laboratory course	Energy Policies and Economics	Numerical Methods and Computational simulation	Master thesis
	Assessment of political and economic boundary conditions for energy production	+	+	+	++				++		
	Scientific work	+	+	+					+	+	++
Social skills	Working together on larger assignments in teams	+	+	+			+	++			
	Targeted and sensitive work in an intercultural context	+	+	+		+	+	+	+	+	
	Fluent English including technical terms	+	+	+	+	+	+	+	+	+	++
	conflict management	+	+	+			+	+	+		
Personal skills	Time management	+	+	+	+			+	+		+
	Project organization	+	+	+	+			+	+		+
	self-organisation	+	+	+	+		+	+	+	+	++
	Self-presentation	+	+	+	+			+	+		+

3.3 Possible occupational fields

The students should acquire a broad knowledge of regenerative energy systems, so that the graduates of the course are primarily prepared for specialist and managerial tasks in the following areas:

- Planning
- Government / Administration
- Utilities / municipal utilities
- Project development
- Science
- Production

The following sectors are the focus of the graduates' future fields of activity:

- Power engineering
- Building technology
- Environmental technology

However, the master’s degree should also qualify and be accredited for academic work, so that a doctorate can also be followed.

4 Dual Studies

In this course of study, a dual degree is not possible. For dual study beginners in the winter semester 2023/24 & summer semester 2024, as well as for those who register late (§8b (1) Nr. 17 registration regulations), the dual requirements will be continuingly implemented until their completion. The following applies to these students:

In cooperation with selected industry partners, the study program Renewable Energy Systems can also be completed in a dual studies model. The dual study model is offered as a study program with in-depth practice, in which the regular study program is supplemented by intensive practical phases in a company.

In the dual study model, university and practical phases (especially during semester breaks and for the final thesis) regularly alternate during the course of study. The lecture times in the dual study model correspond to the standard study and lecture times at the THI.

By systematically linking the learning locations of university and company, students gain professional practical experience with selected practice partners as an integral part of their studies.

The curriculum of the dual study program model differs from the regular degree program concept in the following points:

- **Final thesis in the cooperation company**
  In the dual study model, the final thesis is written at a cooperating company, usually on a practice-relevant topic related to the focus of study.

Organizationally, the dual study program model is characterized by the following components:

- **Introduction track**
  A seperate event for dual students is offered as part of the welcome day(s) at the beginning of the program.
- **Mentoring**
  The central contact persons for dual students in the faculty are the respective program head of studies. They organize an annual mentoring meeting with the dual students of the respective study program.
- **Quality management**
  In the evaluation and surveys at the THI on the quality assurance of the dual study separate question blocks are included.
- **„Forum dual“**
  Organized by the Career Service and Student Counseling (CSS), the “Forum Dual” takes place once a year. The “Forum Dual“ promotes the professional-organizational exchange between the dual cooperation partners and the faculty and serves to ensure the quality of the dual study program. All cooperation partners in the dual study program as well as representatives and dual students of the faculty are invited to the meeting.

Formal-legal regulation for dual studies for all degree programs of the THI is regulated in the APO (see §§ 17, 29 und 30) and the enrollment statutes (see §§ 8b und 18).

5 Description of Modules

5.1 Compulsory Modules

Introductory Laboratory Course

Module abbreviation:	IntroLabC_M-RES	**SPO-No.:**	1
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	1
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Schrag, Tobias	
Lecturers:	Reum, Tobias; Rufino, Carlos; Schrag, Tobias	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Introductory Laboratory Course (IntroLabC_M-RES)	
Lecture types:	Pr - laboratory	
Examinations:	PP - Portfolio-Exam (all exams before the examination period) (IntroLabC_M-RES)	
Special features of the examination performance:	Portfolio exam consisting of: • moodle quizzes 20% • presentations 40% • report 40%	

Recommended prerequisites:

None

Objectives:

The course follows to objectives

1. To create a common level of knowledge in the fields of thermodynamics, fluid dynamics, mechanics, electrical engineering, bio energy and solar energy
2. To enable the students to prepare, carry out, calculate and present complex experiments in the energy laboratories

The students

- can calculate the error of a value determined in an experiment dependent on the errors of the measurement quantities.
- are able to create reports on experiments according to a scientific standard.
- are able to carry out complex physical measurements.
- are familiar with hard and software of different teststandards.
- can evaluate different measurement methods as they know the advantages/disadvantages of different methods.
- have reached a common knowledge basis in the fields of thermodynamics, physics, electrical engineering, fluid dynamics, bio energy and solar radiation.
- are able to present and discuss measurement results with respect to theory.

Content:

The course consists of ca. 10 experiments.

The experiments and excursions described below can change slightly due to resources available.

The first experiments are carried out in very small groups (ca. 2 Persons) and then follow 2*4 experiments that are carried out in small groups (ca 6 Persons).

In the first sessions several experiments are carried out. The aim is to establish a common level in problem perception, problem solution, calculation, presenting and reporting. The first four experiments aim to establish a common basis in thermodynamics, electronics, solar energy and fluid dynamics.

The second circle of experiments aims to establish and advanced level in the same fields.

The examplary laboratory course given below reflects the structure, also some experiments may change due to resources:

Initial Experiments in very small groups 2 sessions:

Pressure/Volume

Spring stiffness/energy storage

Gravitational energy/air pressure

PV-driven motors/ efficiency

(mechanical and electrical engineering)

experiments in small groups

PV-System: MPP-Tracking (electrical eng.)

DEC-Plant: HVAC-principles and sorption

Heatexchanger: Dependence of hat transfer coefficient through flow rate (thermodynamics)

CHP-Plant (thermodynamics)

Wind channel (fluiddynamics)

Test of solarthermal collector (solar thermal)

Battery measurement (elektrical eng.)

Steam power station (thermodynamics)

Literature:

Compulsory:

None

Recommended:

- BROWNE, Michael E., 2010. *Physics for engineering and science: [788 fully solved problems]*. New York [u.a.]: McGraw-Hill. ISBN 978-0-07-161399-6, 0-07-161399-4
- SPLINTER, Robert, 2017. *Illustrated encyclopedia of applied and engineering physics*. Boca Raton; London; New York: CRC Press. ISBN 978-1-4398-6086-1

Additional remarks:

None

System Analysis and Control

Module abbreviation:	SysAnaCon_M-RES	**SPO-No.:**	2
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	1
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Navarro Gevers, Daniel	
Lecturers:	Navarro Gevers, Daniel	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	System Analysis and Control (SysAnaCon_M-RES)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	schrP90 - written exam, 90 minutes (SysAnaCon_M-RES)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

The students

- can model a physical system.
- can characterize a control loop understanding what the controller is, the actuator, the measurement device and the system.
- can take a decision on the dynamic needs of a system response.
- understands different methods of tuning the controllers to fulfill the dynamic demands.
- know the different controller types and can decide which controller is needed for each case.
- are able to apply different controller tuning methods and are able to predict the dynamic behavior of a system.
- are able to evaluate and discuss simulation results with respect to theory and experiments.
- can take the decision of existing hardware to design a given.

Content:

- System description
- Definition of a control loop
- Stability in a control loop
- Transfer function
- Frequency response
- Main control variables
- Root locus method

- Alternative Design Methods
- Design variables in a control system (calculation frequency, sample frequency, variables to be measured etc.)
- Response of first order and second order Systems
- Speed Control of a Wind turbine
- Frequency control in an electrical grid
- Application to practical problems (computer lab Matlab)

Literature:

Compulsory:

- OGATA, Katsuhiko, 2010. *Modern control engineering*. Boston [u.a.]: Pearson. ISBN 978-0-13-713337-6, 0-13-713337-5

Recommended:

None

Additional remarks:

None

Energy Policies and Economies

Module abbreviation:	EnPolEc_M-RES	**SPO-No.:**	3
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	2
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Huber, Matthias	
Lecturers:	Huber, Matthias; Kotak, Yash	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Energy Policies and Economies (EnPolEc_M-RES)	
Lecture types:	S - seminar	
Examinations:	SA - Seminar paper with oral examination (15 min), written elaboration (8-15 pages) and presentation (15-20 pages) (EnPolEc_M-RES)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

The students

- understand climate protection policies worldwide and their relation to energy issues.
- are able to critically reflect on and discuss issues of climate change and energy.
- understand different shaping of energy legislation in selected countries.
- are able to critically reflect on and discuss issues of energy legislation.
- understand renewable energies as an economic factor.
- understand the energy economy in selected countries.
- are able to critically reflect on and discuss issues of the energy economy.

Content:

Energy and climate change

- Climate protection policies worldwide, in Germany and other selected countries
- Energy legislation in Germany and other selected countries
- Renewable energies as economic factor
- Energy economy / industry in Germany and other selected countries

Literature:

Compulsory:

None

Recommended:

- QUASCHNING, Volker, EPPEL, Herbert, 2020. *Renewable energy and climate change* [online]. Chichester, West Sussex, UK: Wiley. PDF e-Book. ISBN 978-1-119-51490-9. Available via: https://doi.org/10.1002/9781119514909.
- BHATTACHARYYA, Subhes C., 2019. *Energy economics: concepts, issues, markets and governance* [online]. London: Springer. PDF e-Book. ISBN 978-1-4471-7468-4. Available via: https://doi.org/10.1007/978-1-4471-7468-4.
- TAGHIZADEH-HESARY, Farhad, ZHANG, Dayong , 2023. *The handbook of energy policy* [online]. [s.l.]: Springer. PDF e-Book.

Additional remarks:

None

Numerical Methods and Computational Simulation

Module abbreviation:	NumMetCS_M-RES	**SPO-No.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	2
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Bschorer, Sabine
Lecturers:	Bschorer, Sabine; Horak, Jiri
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours 47 h Self-study 78 h Total 125 h
Subjects of the module:	Numerical Methods and Computational Simulation (NumMetCS_M-RES)
Lecture types:	SU/Ü - lecture with integrated exercises
Examinations:	schrP90 - written exam, 90 minutes (NumMetCS_M-RES)
Special features of the examination performance:	None

Recommended prerequisites:

None

Objectives:

The students

- can estimate the error of a numerical approximation of derivatives and use a suitable order of approximation for the given application.
- understand the influence of the round-off error and conditioning on the numerical solution of linear algebraic equations and can assess which direct or iterative methods are suitable for the given purpose.
- recognize the above methods in the finite difference discretization of the heat equation, can explain consistency, stability and convergence, are able to evaluate the merits of the explicit and implicit approaches.
- are familiar with simple implementations of the discussed numerical methods in some widely used computer algebra system (e.g. MATLAB) or programming language.
- are familiar with the mathematical background of the Finite-Volume method.
- are able to apply different computational methods like Computational Fluid Dynamics and 1D simulation of thermal and hydraulic processes to problems in renewable energy systems.
- are able to evaluate and discuss simulation results with respect to theory and experiments.

Content:

- Numerical approximation of derivatives
- Numerical solution of large systems of linear algebraic equations, round-off error,
- Numerical solution of the linear heat equation
- Introduction into numerical flow simulation theory (computational fluid dynamics, CFD)

- Finite-volume method and its mathematical background
- Application to 3D fluid simulation with commercial software
- Theory of computational simulation of thermal and hydraulic processes
- Thermal and hydraulic simulation in building services engineering
- Computational simulation of thermodynamic processes
- Application to practical problems (computer lab)

Literature:

Compulsory:

None

Recommended:

- FERZIGER, Joel H., PERIĆ, Milovan, STREET, Robert L., 2020. *Computational methods for fluid dynamics* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-99693-6. Available via: https://doi.org/10.1007/978-3-319-99693-6.
- FERZIGER, Joel H., PERIĆ, Milovan, STREET, Robert L., 2020. *Computational methods for fluid dynamics* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-99693-6. Available via: https://doi.org/10.1007/978-3-319-99693-6.
- KAJISHIMA, Takeo, TAIRA, Kunihiko, 2017. *Computational fluid dynamics: incompressible turbulent flows* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-45304-0. Available via: https://doi.org/10.1007/978-3-319-45304-0.
- KAJISHIMA, Takeo, TAIRA, Kunihiko, 2017. *Computational fluid dynamics: incompressible turbulent flows* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-45304-0. Available via: https://doi.org/10.1007/978-3-319-45304-0.
- ANDERSON, Dale A. and others, 2021. *Computational fluid mechanics and heat transfer*. Boca Raton; London; New York: CRC Press, an imprint of Taylor & Francis Group. ISBN 978-0-8153-5712-4, 978-0-3675-6903-7
- MOUKALLED, F., MANGANI, L., DARWISH, M., 2016. *The finite volume method in computational fluid dynamics: an advanced introduction with OpenFOAM and Matlab* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-16874-6, 978-3-319-16873-9. Available via: https://doi.org/10.1007/978-3-319-16874-6.
- REDDY, Junuthula Narasimha and David K. GARTLING, 2010. *The finite element method in heat transfer and fluid dynamics*. Boca Raton, Fla. [u.a.]: CRC Press, Taylor & Francis. ISBN 978-1-4398-8257-3
- TURYN, Larry, 2014. *Advanced engineering mathematics*. Boca Raton [u.a.]: CRC Press. ISBN 978-1-4398-3447-3
- STRANG, Gilbert, 2007. *Computational science and engineering*. Wellesley, Ma.: Wellesley-Cambridge Press. ISBN 978-0-9614088-1-7, 0-9614088-1-2
- STRANG, Gilbert. *Mathematical methods for engineers II* [online]. [s.l.]: Massachusetts Institute of Technology. [Accessed on:]. Available via: https://ocw.mit.edu/courses/18-086-mathematical-methods-for-engineers-ii-spring-2006/

Additional remarks:

None

Industrial Energy System Theory

Module abbreviation:	IndEnSysT	**SPO-No.:**	5
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	2
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Goldbrunner, Markus	
Lecturers:	Baldauf, Tobias; Goldbrunner, Markus	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Industrial Energy System Theory (IndEnSysT)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	schrP90 - written exam, 90 minutes (IndEnSysT)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

The students

- have an overview of the most important consumers of electricity, heat and gas in a typical industrial operation.
- can establish and evaluate the different energy consumption and efficiency improvement strategies in an industrial operation.
- are familiar with the biogas process, the construction of biogas plants, the most important components and process parameters and can dimension a biogas plant.
- are familiar with the most important procedural basics and concepts of the combustion of solid biomass and the corresponding plant technology for heat and power generation and can design a corresponding power plant.
- know the most important procedural basics and concepts of the thermal gasification of solid biomass and the corresponding plant technology for heat and power generation.
- are able to project the energy supply of an industrial company with the acquired knowledge.

Content:

- Energy efficiency
- Rating of energy systems
- Example project meat processing

  Definition of boundaries

  Applied thermodynamics for energy efficiency

  Presentation and Reporting

- Cross cutting technologies
    - Drives and pumps
    - Mechanical power
    - Lighting
    - Thermal Energy
    - Renewable Electricity Integration
- Bio energy
- Biogas
- Anaerobic fermentation
- Construction of biogas plants
- operating parameters and environmental conditions
- substrates and manure
- process and plant engineering
- process variants
- biogas production and storage
- Solid biomass
- basics of combustion
- special features and design of the furnace
- combustion concepts
- cyclic processes
- plants for electricity and heat generation and their components
- basics and concepts of gasification
- Project
- Building an energy-efficient and environmentally friendly energy supply for an industrial company

Literature:

Compulsory:

None

Recommended:

- WELLINGER, Arthur, 2013. *The biogas handbook: science,production and application*. Oxford [u.a.]: Woodhead Publ.. ISBN 978-0-85709-498-8
- SPLIETHOFF, Hartmut, 2010. *Power generation from solid fuels*. Berlin [u.a.]: Springer. ISBN 978-3-642-02855-7

Additional remarks:

None

Industrial Energy System Project

Module abbreviation:	IndEnSysProj	**SPO-No.:**	6
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	2
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Goldbrunner, Markus	
Lecturers:	Herrmann, Felix	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Industrial Energy System Project (IndEnSysProj)	
Lecture types:	S - seminar	
Examinations:	Proj - Project work (5-25 pages) with oral presentation (15 minutes) (IndEnSysProj)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

For a specific industrial plant the students are able to

- make a concept for a sustainable co2-free energy supply.
- work in a team, make time plans and divide up the various work packages.
- establish and evaluate energy consumption, efficiency improvement and new renewable energy production strategies.
- design a biogas plant for the specific residues of the industrial plant.
- design a combustion biomass plant for the solid residues.
- summarize and present the results.

Content:

Concepts for a specific industrial plant for a sustainable co2-free energy supply:

- project management
- energy consumption
- energy efficiency
- energy concept
- design of a biogas plants for specific residues
- design of a solid biomass plant for the solid residues
- presentation techniques
- writing techniques

Literature:
Compulsory: None Recommended: • WELLINGER, Arthur, 2013. *The biogas handbook: science,production and application*. Oxford [u.a.]: Woodhead Publ.. ISBN 978-0-85709-498-8 • SPLIETHOFF, Hartmut, 2010. *Power generation from solid fuels*. Berlin [u.a.]: Springer. ISBN 978-3-642-02855-7 • GRAHAM, Nick and Stanley E. PORTNY, 2015. *Project management for dummies*. Chichester: Wiley. ISBN 978-1-119-02573-3
Additional remarks:
None

Hydrogen in Energy Technology and Energy Markets			
Module abbreviation:	HydETEM_M-RES	**SPO-No.:**	9
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	1
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Huber, Matthias	
Lecturers:	Huber, Matthias; Kotak, Yash	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Hydrogen in Energy Technology and Energy Markets (HydETEM_M-RES)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	schrP90 - written exam, 90 minutes (HydETEM_M-RES)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

The students

- can compare different hydrogen production/storage/logistic technologies.
- gain knowledge regarding hydrogen policies, standards and regulatio
- know about the electricity generation with fossil and renewable energy sources as competing and complementing technologies.
- can differentiate current and future colors of hydrogen.
- can understand multifarious energy storage systems
- understand the possibilities and limits that hydrogen can play in future energy systems.
- know the substitution potential of hydrogen.
- understand fundamental mechanism of energy markets.
- understand market mechanism of gas trading as well as technical boundaries.
- understand market mechanism of electricity trading as well as technical boundaries.

Content:

- Fundamentals of energy economics and markets (incl. price formation)
- Different hydrogen production/storage/logistic technologies and their cost structures
- Hydrogen relevant standards and regulations
- Hydrogen generation with renewable energies and competing technologies based on fossile fuels

- Different types of energy storage system and colors of hydrogen
- Possibilities and limits that hydrogen can play in future energy systems
- Substitution potential of hydrogen in other sectors.
- Market mechanism of gas trading as well as technical boundaries.
- Market mechanism of electricity trading as well as technical boundaries.

Literature:

Compulsory:

- STOFT, Steven, 2002. *Power system economics: designing markets for electricity* [online]. Piscataway, New Jersey: IEEE Press. PDF e-Book. ISBN 978-0-470-54558-4. Available via: https://ieeexplore.ieee.org/xpl/bkabstractplus.jsp?bkn=5264048.
- SEDDON, Duncan, *The Hydrogen Economy Fundamentals, Technology, Economics.* ISBN https://doi.org/10.1142/12593
- BHATTACHARYYA, Subhes C., 2019. *Energy economics: concepts, issues, markets and governance*. London: Springer. ISBN 978-1-4471-7467-7, 978-1-4471-7470-7
- QUASCHNING, Volker and Herbert EPPEL, 2020. *Renewable energy and climate change*. Chichester, West Sussex, UK: Wiley. ISBN 978-1-119-51486-2, 1-119-51486-X
- DUNLAP, Richard A., 2025. *Renewable Energy: Requirements and Sources* [online]. Cham: Springer Nature Switzerland. PDF e-Book. ISBN 978-3-031-77185-9. Available via: https://doi.org/10.1007/978-3-031-77185-9.
- DARMAWAN, Arif, DEWI, Eniya Listiani, HARIANA, Hariana, AZIZ, Muhammad, 2025. *Decarbonizing Power Generation Sectors Using Biomass and Hydrogen-Based Fuels: A Roadmap to Sustainable Energy Transformation* [online]. Singapore: Springer Nature Singapore. PDF e-Book. ISBN 978-981-9793-60-0. Available via: https://doi.org/10.1007/978-981-97-9360-0.

Recommended:

None

Additional remarks:

None

Master's Thesis

Module abbreviation:	MA_RES	**SPO-No.:**	10
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Compulsory Subject	3
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	winter and summer term

Responsible for module:	Huber, Matthias	
Lecturers:	All lecturers	
Credit points / SWS:	30 ECTS / 0 SWS	
Workload:	Contact hours	0 h
	Self-study	750 h
	Total	750 h
Subjects of the module:	Master Thesis (MA_RES)	
Lecture types:		
Examinations:	MA - Master's Thesis (MA_RES)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

The students

- can work independently on complex problems from the field of technical development at a high scientific level within a specified period of time using the specialist knowledge acquired as well as scientific methods and findings.
- are also able to classify the results in technical and interdisciplinary contexts and to present them in the form of a scientific paper.
- are able to work independently on a defined topic and discuss it competently.

Content:

- Analysis of the problem and definition of the topic
- Literature/patent research
- Formulation of the research approach/procedure
- Definition of a solution concept/approach
- Planning and elaboration of the solution, analysis of the results
- Classification of the subject-related and non-subject-related references
- Application of scientific working methods, i.e. proceeding systematically, analytically and methodically correct, arguing logically and concisely as well as working goal-oriented and time-critical and presenting the results formally correctly.

For dual students, the thesis must be prepared in cooperation with the respective dual company. The content details and the scientific standard are ensured in cooperation between the company's supervisor and the first examiner at the Technical University.
Literature:
Compulsory: None Recommended: • RECKER, Jan, 2021. *Scientific Research in Information Systems: A Beginner's Guide* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-030-85436-2. Available via: https://doi.org/10.1007/978-3-030-85436-2. • LÖVEI, Gábor L., 2021. *Writing and publishing scientific papers: a primer for the non-English speaker* [online]. Cambridge, UK: Open Book Publishers. PDF e-Book. ISBN 978-1-80064-091-7, 978-1-80064-092-4. Available via: https://doi.org/10.11647/OBP.0235.
Additional remarks:
None

5.2 Core Electives

Building Energy System

Module abbreviation:	BuildEnerSys_M-RES	**SPO-No.:**	7.1
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Core Elective	1
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Schrag, Tobias
Lecturers:	NN
Credit points / SWS:	10 ECTS / 8 SWS
Workload:	Contact hours 93 h Self-study 157 h Total 250 h
Subjects of the module:	Building Energy System (BuildEnerSys_M-RES)
Lecture types:	S - seminar
Examinations:	PP - Portfolio-Exam (all exams before the examination period) (BuildEnerSys_M-RES)
Special features of the examination performance:	Portfolio Exam: • Moodle quizz • Simulation exercise • Library course • Presentation Report

Recommended prerequisites:

None

Objectives:

The students

- are familiar with building energy systems for heat and cold supply as solar thermal, geothermal, CHP, fossil fuel and heat pump-based technologies.
- understand the economic and technical principles of planning, design and operation of different HVAC systems.
- can strategically combine different energy sources to identify technically, environmentally and economically optimal solutions.
- can model heating solutions with different energy sources and multiple users in a building.
- have an insight into the specific boundaries and challenges of energy engineering in modelling and simulation.
- are able to formulate and solve complex problems of real-world energy engineering.
- are able to condense the experience and results of a multifaceted energy engineering project in compact reports and presentations.

Content:

- Energy Consumption in buildings
- HVAC-Systems
- Climate adptive building design
- Solar thermal systems
- Geothermal systems
- Heat-pump based technologies
- Building simulation
- PVSystems
- Economic Analysis
- Detailed analysis of selected real-world case of district heating with multiple sources and consumers

Literature:

Compulsory:

None

Recommended:

- DUFFIE, John A., BECKMAN, William A., BLAIR, Nathan, 2020. *Solar engineering of thermal processes, photovoltaics and wind* [online]. Hoboken, New Jersey: Wiley. PDF e-Book. ISBN 978-1-119-54031-1, 978-1-119-54030-4. Available via: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119540328.
- KLEE, Harold and Randall ALLEN, 2018. *Simulation of dynamic systems with MATLAB and Simulink*. Boca Raton: CRC Press. ISBN 978-1-4987-8777-2
- YANG, Jinhuan, YUAN, Xiao, JI, Liang, 2020. *Solar photovoltaic power generation* [online]. Berlin; Boston: De Gruyter. PDF e-Book. ISBN 978-3-11-052483-3. Available via: https://doi.org/10.1515/9783110524833.
- GRASSI, Walter, 2018. *Heat pumps: fundamentals and applications* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-62199-9. Available via: https://doi.org/10.1007/978-3-319-62199-9.

Additional remarks:

None

Off-Grid Energy System			
Module abbreviation:	Off-GridEnSy_M-RES	**SPO-No.:**	7.2
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Core Elective	2
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Navarro Gevers, Daniel	
Lecturers:	Ausin Calvo, Juan Carlos; Jain, Rushabh Bansilal; Navarro Gevers, Daniel; Ngetuny, Joshua	
Credit points / SWS:	10 ECTS / 8 SWS	
Workload:	Contact hours	93 h
	Self-study	157 h
	Total	250 h
Subjects of the module:	Off-Grid Energy System (Off-GridEnSy_M-RES)	
Lecture types:	S - seminar	
Examinations:	PP - Portfolio-Exam (all exams before the examination period) (Off-GridEnSy_M-RES)	
Special features of the examination performance:	The portfolio examination consists of the following parts: • written exam 35% • working in group 25% • presentations 20% • reports 20%.	

Recommended prerequisites:

None

Objectives:

The students

- can model an off-grid electrical system Know the main components in an off-grid System like Generators, Loads, safety devices.
- know the principles of the grid frequency control.
- know the principles of the grid voltage control.
- are able to determine the stability of an off-grid system.
- know how to do a power flow analysis.
- can take the decision of the needed requirements (Hardware and control) to design an off-grid system.
- can write the project specification for the given system.

Content:

- Voltage Control
- Frequency Control
- Generators (Synchornous, Asynchronous)

- Converters description
- Load flow calculation
- Load behavior
- Energy Storage
- Energy conversion and transport
- Wind Power description

Literature:

Compulsory:

None

Recommended:

- LOUIE, HENRY, *Off-Grid electrical systems in developing countries*. ISBN 978-3-319-91890-7
- MOHANTY, PARIMITA; MUNEER, TARIQ; KOLHE, MOHAN, *Solar Photovoltaic System Applications: A Guidebook for Off-Grid Electrification.* ISBN 978-3-319-14663-8; 978-3-319-14662-1

Additional remarks:

None

Urban Area Energy System

Module abbreviation:	UrbanAreaEner-Sys_M-RES	**SPO-No.:**	7.3
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Core Elective	1
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Schrag, Tobias
Lecturers:	Müller, Lucas; Schrag, Tobias; Weitz, Klaus Peter
Credit points / SWS:	10 ECTS / 8 SWS
Workload:	Contact hours 93 h Self-study 157 h Total 250 h
Subjects of the module:	Urban Area Energy System (UrbanAreaEnerSys_M-RES)
Lecture types:	S - seminar
Examinations:	PP - Portfolio-Exam (all exams before the examination period) (UrbanAreaEnerSys_M-RES)
Special features of the examination performance:	Portofolioprüfung: • Initial Simulation Task • Moodle tests • Library Course • Presentation • Report

Recommended prerequisites:

None

Objectives:

The students

- can analyse different energy systems for heat and cold supply such as solar thermal, geothermal, CHP, fossil fuel and heat pump-based technologies.
- can compare and evaluate the economic and technical principles of planning, design and operation of different energy supply systems.
- can strategically combine different energy sources to identify technically, environmentally and economically optimal solutions.
- know how to conceptually describe and how to model heating solutions with different energy sources and multiple users in an urban environment.
- can analyse specific boundaries and challenges of energy engineering in modelling and simulation.
- are able to formulate and solve complex problems of real-world energy engineering.
- are able to condense the experience and results of a multifaceted energy engineering project in compact reports and presentations.

Content:

- networks with focus on renewable sources and efficient fossil energy use (CHP), incl. heat storage
- buildings with heating and cooling need
- Geothermal systems
- Heat-pump based technologies
- Fundamental of heating and cooling network modelling
- Training in heating and cooling network model applications
- Detailed analysis of selected real-world case of district heating with multiple sources and consumers

Literature:

Compulsory:

None

Recommended:

- HASTINGS, S. Robert, 1994. *Passive solar commercial and institutional buildings: a sourcebook of examples and design insights*. Chichester u.a.: Wiley. ISBN 0-471-93943-9
- SUMATHI, S., L. ASHOK KUMAR and P. SUREKHA, 2015. *Solar PV and wind energy conversion systems: an introduction to theory, modeling with MATLAB/SIMULINK, and the role of soft computing techniques*. Cham [u.a.]: Springer. ISBN 978-3-319-14940-0
- NAGPAL, Neetika Kaushal, ALHELOU, Hassan Haes, SIANO, Pierluigi, SANJEEVIKUMAR, Padmanaban, LAKSHMI, D., 2023. *Applications of big data and artificial intelligence in smart energy systems: Volume 2 Energy planning, operations, control and market perspectives* [online]. Gistrup, Denmark: River Publishers. PDF e-Book. ISBN 9788770228268, 8770228264. Available via: https://ieeexplore.ieee.org/book/10173467.

Additional remarks:

None

5.3 Individual Elective

Adaptive Systeme

Module abbreviation:	Adapt_M-TE	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Müller, Dieter	
Lecturers:	Müller, Dieter	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Adaptive Systeme (Adapt_M-TE)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - schriftliche Prüfung, 90 Minuten (Adapt_M-TE)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- kennen den Aufbau und die Funktionsweise von Fuzzy-Reglern.
- können mit einem Simulationsprogramm Eigenschaften von Fuzzy-Reglern testen.
- kennen den Aufbau und die Funktion von künstlichen neuronalen Netzen.
- können künstliche neuronale Netze simulieren.
- kennen Techniken zur Identifikation dynamischer Systeme.
- können die Parameter dynamischer Systeme mit Hilfe von Identifikationsalgorithmen bestimmen.

Content:

- Fuzzy Regler
- Künstliche neuronale Netze
- Beobachter und erweiterter Beobachter
- Adaptive Reglerkonzepte

Literature:

Verpflichtend:

Keine

Empfohlen:

- LUTZ, Holger und Wolfgang WENDT, 2021. *Taschenbuch der Regelungstechnik: mit MATLAB und Simulink*. 12. Auflage. Haan-Gruiten: Verlag Europa-Lehrmittel. ISBN 978-3-8085-5870-6
- UNBEHAUEN, Heinz, Band 1, [21992. *Regelungstechnik*. [7. Auflage. Braunschweig [u.a.]: Vieweg. ISBN 3-528-06469-2
- STRIETZEL, Roland, 1996. *Fuzzy-Regelung: mit 36 Tabellen*. München [u.a.]: Oldenbourg. ISBN 3-486-23359-9

Additional remarks:

Keine Anmerkungen

Aerodynamische Methoden

Module abbreviation:	AerodynM_M-LT	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Stadlberger, Korbinian	
Lecturers:	Stadlberger, Korbinian	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Aerodynamische Methoden (AerodynM_M-LT)	
Lecture types:	SU/Pr - Seminaristischer Unterricht/Praktikum	
Examinations:	LN - schriftliche Prüfung, 90 Minuten (AerodynM_M-LT)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Nach dem Besuch des Moduls sind die Studierenden in der Lage,

- Theorien und Grundprinzipien numerischer und experimenteller aerodynamischer Methoden für Profil-, Flügel- und Flugzeugumströmungen zu analysieren und anwendungsbezogen einzuordnen.
- geeignete Modellierungsansätze einschließlich Potentialmethoden, RANS und semiempirischer Verfahren für industrierelevante Strömungsprobleme auszuwählen und fachlich zu begründen.
- Stärken, Schwächen, Modellgrenzen und Unsicherheiten aerodynamischer Methoden zu bewerten und daraus belastbare Schlussfolgerungen für technische Fragestellungen abzuleiten.
- aerodynamische Datensätze aus numerischen, semiempirischen oder experimentellen Quellen zu erstellen, zu validieren und kritisch zu interpretieren.
- Methodenentscheidungen hinsichtlich Genauigkeit, Rechenaufwand, Versuchsaufwand sowie ressourcen- und energieeffizienter Entwicklungsprozesse zu beurteilen.

Content:

- Grundbegriffe der Aerodynamik einschließlich Profil-, Flügel- und Flugzeugumströmung
- Numerische Modellierungsmethoden auf Grundlage der Potentialtheorie
- Semiempirische Methoden und aerodynamische Abschätzverfahren
- Experimentelle Aerodynamik im Windkanal und Datenerfassung
- RANS-basierte Modellierungsmethoden und Abgrenzung zu vereinfachten Verfahren
- Erstellung, Plausibilisierung und Bewertung aerodynamischer Datensätze
- Methodenwahl unter Berücksichtigung von Genauigkeit, Aufwand und ressourceneffizienter Entwicklung

Literature:

Verpflichtend:

- FERZIGER, Joel H., Milovan PERIĆ und Robert L. STREET, 2020. *Numerische Strömungsmechanik*. Berlin: Springer Vieweg. ISBN 978-3-662-46543-1, 978-3-662-46544-8
- ANDERSON, John David, 2017. *Fundamentals of aerodynamics*. New York, NY: McGraw Hill Education. ISBN 978-1-259-12991-9, 978-1-259-25134-4

Empfohlen:

- KÜCHEMANN, Dietrich, 2012. *The aerodynamic design of aircraft: a detailed introduction to the current aerodynamic knowledge and practical guide to the solution of aircraft design problems*. Reston, VA: American Institute of Aeronautics and Astronautics. ISBN 978-1-62198-370-5
- ANDERSON, John David, 2001. *A history of aerodynamics and its impact on flying machines*. Cambridge [u.a.]: Cambridge Univ. Press. ISBN 0-521-66955-3, 0-521-45435-2
- OSWATITSCH, Klaus, 1976. *Grundlagen der Gasdynamik*. Wien [u.a.]: Springer. ISBN 3-211-81318-7, 0-387-81318-7
- ZIEREP, Jürgen, 1991. *Ähnlichkeitsgesetze und Modellregeln der Strömungslehre* [online]. Karlsruhe: Braun-Verlag. PDF e-Book. ISBN 978-3-662-21597-5, 978-3-7650-2041-4. Verfügbar unter: https://doi.org/10.1007/978-3-662-21597-5.
- OERTEL, Herbert und P. ERHARD, 2010. *Prandtl-essentials of fluid mechanics*. New York, NY [u.a.]: Springer. ISBN 978-1-4419-1563-4, 978-1-4419-1564-1
- WHITFORD, Ray, 1987. *Design for air combat*. London: Jane's. ISBN 0-7106-0426-2
- THOMAS, Fred, 1984. *Grundlagen für den Entwurf von Segelflugzeugen*. Stuttgart: Motorbuch-Verl.. ISBN 3-87943-682-7
- GERSTEN, Klaus, 1991. *Einführung in die Strömungsmechanik: mit 10 Tabellen und 52 durchgerechneten Beispielen*. Braunschweig: Vieweg. ISBN 3-528-43344-2
- SCHLICHTING, Hermann, GERSTEN, Klaus, KRAUSE, Egon, OERTEL, Herbert, MAYES, Katherine, 2017. *Boundary-layer theory* [online]. Berlin; Heidelberg: Springer. PDF e-Book. ISBN 978-3-662-52919-5. Verfügbar unter: https://doi.org/10.1007/978-3-662-52919-5.
- SCHLICHTING, Hermann und Erich TRUCKENBRODT, 2001. *Aerodynamik des Flugzeuges*. Berlin: Springer.
- ROSSOW, Cord-Christian, 2014. *Handbuch der Luftfahrzeugtechnik: mit 1130 Bildern und 34 Tabellen* [online]. München: Hanser. PDF e-Book. ISBN 978-3-446-42341-1, 3-446-42341-9. Verfügbar unter: https://doi.org/10.3139/9783446436046.

Additional remarks:

Sichere Grundkenntnisse aus dem Bachelor Luftfahrttechnik (v.a. Aerodynamik) werden erwartet.

Programmierkenntnisse (z.B. Matlab) sind hilfreich. PC-Übungen erfordern Eigeninitiative für den autodidaktischen Lernerfolg.

Akustik

Module abbreviation:	WModul-Akust_M-RES	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Bienert, Jörg	
Lecturers:	Bienert, Jörg	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Akustik (WModul-Akust_M-RES)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - mündliche Prüfung, 15 Minuten (WModul-Akust_M-RES)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Maschinendynamik, Ingenieurmathematik

Objectives:

Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage,

- die physikalischen Grundlagen akustischer Feldgrößen zu analysieren, deren Zusammenhänge mathematisch zu formulieren und auf komplexe akustische Fragestellungen anzuwenden.
- Pegel unterschiedlicher Signalarten unter Berücksichtigung zeitlicher und spektraler Eigenschaften sowie normgerechter Bewertungsfilter sicher zu berechnen und zu interpretieren.
- die Ausbreitung von Schallwellen auf Grundlage der Wellengleichung und weiterer partieller Differentialgleichungen – einschließlich dreidimensionaler Problemstellungen – mathematisch zu beschreiben, geeignete Lösungsansätze auszuwählen und Weg-Zeit-Beziehungen herzuleiten.
- akustische Messverfahren einschließlich digitaler Messdatenerfassung, Signalverarbeitung und Frequenzanalyse hinsichtlich ihrer Eignung für unterschiedliche Aufgabenstellungen auszuwählen, zu konfigurieren, durchzuführen und die Ergebnisse kritisch zu bewerten.
- Anforderungen des technischen und gesetzlichen Lärmschutzes in geeignete akustische Kenngrößen und Messgrößen zu überführen sowie Messergebnisse normgerecht zu interpretieren.
- psychoakustische Wirkmechanismen des Hörens zu analysieren und für unterschiedliche Anwendungsfälle geeignete psychoakustische Kenngrößen und Bewertungsverfahren auszuwählen.
- Schallentstehung, Schallausbreitung und Schallübertragung in Kraftfahrzeugen systematisch zu analysieren sowie geeignete Maßnahmen zur Schallminderung hinsichtlich ihrer Wirksamkeit zu bewerten.

- die physikalischen Wirkprinzipien von Schalldämmung und Schallabsorption quantitativ zu beschreiben, mathematisch zu modellieren und deren Einfluss auf akustische Systeme zu berechnen.
- die Beiträge einzelner Fahrzeugkomponenten zur Gesamtfahrzeugakustik zu analysieren, Wechselwirkungen zwischen den Komponenten zu bewerten und daraus Maßnahmen zur Optimierung des akustischen Gesamtsystems abzuleiten.

Content:

- Grundlagen des Schallfelds (Luft- und Körperschall)
- Wellenausbreitung
- mathematische Beschreibung mit partiellen Differenzialgleichungen (1D und 3D)
- Elementarstrahler
- Spektrale Darstellungen
- Schallabsorption
- Fahrzeugakustik Grundlagen
- Schallwahrnehmung
- Messtechnik-Körperschall
- Vibroakustische Simulationen
- Fahrgeräusche
- Akustische Komponenten im Fahrzeug
- Motorgeräusche
- Ladungswechselgeräusch
- Rollgeräusche
- Windgeräusche
- Nebenaggregate
- Störgeräusche
- Zusammenhang mit Schwingungsphänomenen
- weiterführende Mess- und Berechnungsverfahren
- Raumakustik / akustische Prüfräume

Literature:

Verpflichtend:

- SINAMBARI, Gholam Reza, SENTPALI, Stefan, 2020. *Ingenieurakustik: physikalische Grundlagen, Anwendungsbeispiele und Übungen* [online]. Wiesbaden: Springer Vieweg. PDF e-Book. ISBN 978-3-658-27289-0. Verfügbar unter: https://doi.org/10.1007/978-3-658-27289-0.
- MÖSER, Michael, 2015. *Technische Akustik* [online]. Berlin, Heidelberg: Springer Berlin Heidelberg. PDF e-Book. ISBN 978-3-662-47704-5, 978-3-662-47703-8. Verfügbar unter: https://doi.org/10.1007/978-3-662-47704-5.
- GENUIT, Klaus, 2010. *Sound-Engineering im Automobilbereich: Methoden zur Messung und Auswertung von Geräuschen und Schwingungen* [online]. Berlin; Heidelberg: Springer. PDF e-Book. ISBN 978-3-642-01414-7, 978-3-642-01415-4. Verfügbar unter: https://doi.org/10.1007/978-3-642-01415-4.
- ZELLER, Peter, 2018. *Handbuch Fahrzeugakustik: Grundlagen, Auslegung, Berechnung, Versuch* [online]. Wiesbaden: Springer Fachmedien Wiesbaden. PDF e-Book. ISBN 978-3-658-18520-6. Verfügbar unter: https://doi.org/10.1007/978-3-658-18520-6.

Empfohlen:

- FAHY, Frank, 2005, 2001. *Foundations of engineering acoustics*. San Diego, Calif.: Elsevier Academic Press. ISBN 978-0-08-050683-8, 0-08-050683-6
- ZOLLNER, Manfred, ZWICKER, Eberhard, 1993. *Elektroakustik* [online]. Berlin, Heidelberg: Springer Berlin Heidelberg. PDF e-Book. ISBN 978-3-642-58003-1, 978-3-540-56600-7. Verfügbar unter: https://doi.org/10.1007/978-3-642-58003-1.
- MÖSER, Michael und andere, 2010. *Körperschall: physikalische Grundlagen und technische Anwendungen*. Heidelberg [u.a.]: Springer. ISBN 978-3-540-40336-4, 3-540-40336-1

Additional remarks:
Keine Anmerkungen

Colloborative Project Management for Sustainability			
Module abbreviation:	SMT_CollPMSust	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Lüdecke, Gesa	
Lecturers:	Lüdecke, Gesa	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Colloborative Project Management for Sustainability (SMT_CollPMSust)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	LN - project work (SMT_CollPMSust)	
Special features of the examination performance:	The assignment is a group project in which several students work on a shared task as a team and present the results both orally and in writing. Each student is required to make an individual contribution to the shared task and deliver an oral presentation of 15 minutes. The assessment consists of a written project documentation, and a final presentation at the end of the lecture period. Exact dates will be communicated at the beginning of the semester via Moodle.	

Recommended prerequisites:

None

Objectives:

After completing this module, students will be able to

- describe and distinguish classical and agile project management approaches.
- explain core methods of goal clarification, planning and project control.
- develop goals and work packages for a project.
- plan and carry out team roles and coordination processes.
- apply facilitation techniques to structure group processes.
- apply digital collaboration tools for project management.
- account for the specific demands of sustainability projects.

Content:

- Project management: Relevance and fields of application
- Classical and agile project management
- Characteristics of sustainability projects

• Goal clarification and stakeholder analysis • Milestones, progress monitoring and risk management • Roles and responsibilities in project teams • Coordination processes and meeting formats • Facilitation and collaborative communication • Digital Tools for project management • Impact measurement and assessment
Literature:
Will be specified at the beginning
Additional remarks:
Up to 5 bonus points can be gained for semester-accompanying partial presentations and active participation in classroom discussions.

DOE / Datenanalyse

Module abbreviation:	DOEDat_M-FT	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Horak, Jiri	
Lecturers:	Horak, Jiri	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	DOE / Datenanalyse (DOEDat_M-FT)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - mündliche Prüfung, 15-30 Minuten (DOEDat_M-FT)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Die Studierenden sind in der Lage,

- ingenieurwissenschaftliche Fragestellungen in statistisch auswertbare Untersuchungsfragen zu überführen und geeignete Datenanalyse- oder DOE-Methoden auszuwählen.
- Daten mit Methoden der deskriptiven Statistik aufzubereiten, graphisch darzustellen und hinsichtlich Qualität, Streuung, Ausreißern und Aussagekraft zu bewerten.
- wahrscheinlichkeitstheoretische Modelle auf zufällige Prozesse anzuwenden, Verteilungsannahmen zu prüfen, Parameter zu schätzen und Hypothesen zu testen.
- vollfaktorielle und Screening-Versuchspläne zu planen, auszuwerten und die Ergebnisse hinsichtlich Effekten, Wechselwirkungen, Modellgüte und Ressourceneinsatz zu beurteilen.
- industrienahe Softwarewerkzeuge für Datenanalyse und statistische Versuchsplanung anzuwenden und Ergebnisse nachvollziehbar zu dokumentieren, zu interpretieren und zu verteidigen.

Content:

- Grundbegriffe der deskriptiven Statistik, Verteilungsfunktion und Verteilungsparameter
- Wahrscheinlichkeit, Zufallsvariable, Verteilungen
- Schätzen und Testen
- Grundbegriffe der statistischen Versuchsplanung wie Faktor, Stufe, Effekt, Wechselwirkung
- Versuchspläne: vollfaktoriell, Screening-Versuchspläne, Auflösungsstufen, Yates-Standard
- Lineares Beschreibungsmodell, Ermittlung der Modellkonstanten, Kontrollverfahren

Literature:
Verpflichtend: • ARENS, Tilo, HETTLICH, Frank, KARPFINGER, Christian, KOCKELKORN, Ulrich, LICHTENEGGER, Klaus, STACHEL, Hellmuth, 2022. *Mathematik* [online]. Berlin, Heidelberg: Springer Spektrum. PDF e-Book. ISBN 978-3-662-64389-1. Verfügbar unter: https://doi.org/10.1007/978-3-662-64389-1. • SIEBERTZ, Karl, BEBBER, David van, HOCHKIRCHEN, Thomas, 2017. *Statistische Versuchsplanung: Design of Experiments (DoE)* [online]. Berlin, Heidelberg: Springer Berlin Heidelberg. PDF e-Book. ISBN 978-3-662-55743-3. Verfügbar unter: https://doi.org/10.1007/978-3-662-55743-3. • MOHR, Richard, 2014. *Statistik für Ingenieure und Naturwissenschaftler: Grundlagen und Anwendung statistischer Verfahren*. Renningen: expert-Verl.. ISBN 9783816981541 Empfohlen: Keine
Additional remarks:
Keine Anmerkungen

Electrolysis and Fuel Cell Technology

Module abbreviation:	EleFuCeTe_M-HTA	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Akgün, Ertan	
Lecturers:	Akgün, Ertan; Mainka, Julia	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Electrolysis and Fuel Cell Technology (EleFuCeTe_M-HTA)	
Lecture types:	SU/Ü/Pr - seminar based teaching/Exercise course/laboratory	
Examinations:	LN - written exam, 90 minutes (EleFuCeTe_M-HTA)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

Students will be able to

- analyze the electrochemical fundamentals and operating principles of electrolysis and fuel cell systems and apply them to advanced engineering problems.
- compare electrolyzer and fuel cell types, system architectures, key components and subsystems, and assess their application-specific suitability.
- evaluate control strategies, dynamic behavior, efficiency, degradation mechanisms and lifetime aspects and derive mitigation and lifetime-extension measures.
- assess the integration of electrolysis and fuel cell systems into practical applications and energy systems with respect to performance, cost, safety, and resource efficiency.
- identify implementation barriers, critically evaluate technical and economic solution options, and justify system concepts in broader energy and industrial contexts.

Content:

Content:

- Fundamentals of electrochemistry
- Water electrolysis and types of electrolyzers
- Fuel cell types and application examples
- Operating principles, system architecture, components, and subsystems
- Specific features, dynamics, control strategies, lifetime and degradation
- Gas conditioning and purification
- Economic aspects and efficiency discussion

- Industrialization: manufacturers, production capacities, and current development programs
- Challenges and current issues

Literature:

Verpflichtend:

- GODULA-JOPEK, Agata und Detlef STOLTEN, 2015. *Hydrogen Production: By Electrolysis*. Berlin: John Wiley & Sons, Incorporated. ISBN 978-3-527-67652-1, 978-3-527-33342-4
- ZOHURI, Bahman, 2019. *Hydrogen energy: challenges and solutions for a cleaner future*. Cham: Springer. ISBN 978-3-319-93460-0

Empfohlen:

- 2002. *Fuel cell handbook: DOE/NETL-2002/1179; [prepared by Energy and Environmental solutions under contract DE-AM26-99FT40575 ... low-cost CD format]*.
- SASAKI, Kazunari und andere, 2016. *Hydrogen energy engineering: a Japanese perspective*. Tokyo: Springer. ISBN 978-4-431-56040-1

Additional remarks:

- Guest lectures may take place as part of the course.
- Bonus system: During the course, each student may work on and present a selected topic. Depending on the quality of the written preparation and oral presentation, bonus points may be awarded and added to the examination grade. A maximum of 10% bonus points, relative to the total number of points achievable in the examination, can be obtained. There is no entitlement to the implementation of this bonus system.

Energy Management and Energy Efficiency

Module abbreviation:	WMod_EnManaE-nEff_M-RES	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Weitz, Klaus Peter	
Lecturers:	Patel, Dharmik; Weitz, Klaus Peter	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Energy Management and Energy Efficiency (WMod_EnManaEnEff_M-RES)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	LN - written exam, 90 minutes (WMod_EnManaEnEff_M-RES)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

The students

- understand the design rules of a photovoltaic system and will be able to layout specific systems.
- are familiar with supply versus demand simulations of photovoltaic system in industrial environments and understand methods to increase self-consumption of produced energy.
- understand the different contributions of the electricity bill and know methods to reduce costs.
- can analyze and understand electric load profiles and extract exposed loads.
- understand energy management systems and know how to manage exposed loads.
- are familiar with the cross-sectional technologies in industrial companies, can identify potential of savings and take measures to reduce energy consumption.

Content:

- Photovoltaic: design rules for solid photovoltaic system layout (connection module to inverter). Overall planning of photovoltaic systems. Simulation of provided energy.
- Electric load profile: analyzing electric load profiles and identification of exposed loads.
- Supply versus demand simulation of photovoltaic systems in industrial environments. Methods of supply and demand displacements.
- Contributions to energy costs of industrial companies and methods to reduce the cost level.
- Energy management systems in industrial companies (DIN EN ISO 50001 and DIN EN 16247).

- Methods to identify, measure and manage energy consumption of exposed loads.
- Methods to analyze general cross-sectional technologies (compressed air, ventilation, cooling, process heating, lighting, heat recovery).
- Methods to identify and reduce the energy consumption of cross-sectional technologies (electricity and other energy sources).

Literature:

Verpflichtend:

- BILGE, Ali Nezihi, 2015. *Energy systems and management* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-319-16024-5, 978-3-319-16023-8. Verfügbar unter: https://doi.org/10.1007/978-3-319-16024-5.
- THORPE, David, 2014. *Energy management in industry: the Earthscan Expert Guide*. London: Routledge, Taylor & Francis Group. ISBN 978-1-134-64941-9, 1-134-64941-X

Empfohlen:

Keine

Additional remarks:

Course selection varies depending on availability and demand. The actual selection for each semester can be found in the timetable. Courses may be canceled at the beginning of the semester. Participation is limited in some cases.

Fahrzeugstrukturauslegung

Module abbreviation:	Fzstraus_M-FT	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Kessler, Jörg	
Lecturers:	Kessler, Jörg	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Fahrzeugstrukturauslegung (Fzstraus_M-FT)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - mündliche Prüfung, 15-30 Minuten (Fzstraus_M-FT)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Die Studierenden:

- erwerben vertiefte Kenntnisse in ausgewählten Kapiteln der höheren Technischen Mechanik mit praxisorientierten Beispielen aus der Karosserietechnik.
- erwerben vertieftes Verständnis für anwendungsorientierte Leichtbauformeln durch Herleitung und Beurteilung der Berechnungsmethodik mit speziellem Focus auf die Auslegung vom Kontinuum zum Leichtbauträger.
- erwerben vertieftes Wissen in Bereich der Tensoralgebra und der angewandten Kontinuumsmechanik für den Bereich der Strukturmechanik.
- können modellbeherrschende Gleichungen von Leichtbauträgern wissenschaftlich anwenden.
- können die Grundlagen der Plattentheorie auf aktuelle Karosseriebauweisen anwenden.
- können Fahrzeugstrukturen bewerten und auslegen sowie die Tragwerkstheorie anwenden.

Content:

Die Inhalte:

- Tragwerksberechnung und Auslegung, Strukturoptimierung, lastoptimierte Gestaltung und Dimensionierung von Leichtbauträgern in Fahrzeugbau
- Behandlung ebener und gekrümmter Flächentragwerke, Herleitung und Anwendung partieller Differentialgleichungen mit Fokus auf Platte, Scheibe, schwach gekrümmte Schalen folgend der höheren technischen Mechanik
- Bewertung und Auslegung von Leichtbaustrukturen hinsichtlich des Stabilitätsversagens von Balkensystemen, Knicken, Kippen, Stabilitätsversagen von dünnwandigen Flächentragwerken, Zylinderschale unter Axialdruck und Radialdruck

- Ausgewählte Auslegestrategien für Leichtbaukonstruktionen mit besonderem Schwerpunkt auf Fahrzeugtechnik insbesondere Schwingungen von flächigen Tragwerken, Stabilität von Crash Trägern, Mehrachsiger Spannungszustand im Kontinuum
- Anwendung der Tensoralgebra auf das Anisotrope Kontinuum im Schalenraum
- Berechnung von Invarianten in Bezug auf Versagenskriterien im Karosseriebau

Literature:

Verpflichtend:

- BAŞAR, Yavuz, KRÄTZIG, Wilfried B., 1985. *Mechanik der Flächentragwerke: Theorie, Berechnungsmethoden, Anwendungsbeispiele* [online]. Wiesbaden: Vieweg+Teubner. PDF e-Book. ISBN 978-3-322-93983-8, 978-3-322-93984-5. Verfügbar unter: https://doi.org/10.1007/978-3-322-93983-8.
- PFLÜGER, Alf, 1981. *Elementare Schalenstatik* [online]. Berlin, Heidelberg: Springer Berlin Heidelberg. PDF e-Book. ISBN 978-3-642-52216-1, 978-3-642-52217-8. Verfügbar unter: https://doi.org/10.1007/978-3-642-52216-1.

Empfohlen:

Keine

Additional remarks:

Keine Anmerkungen

Funktionswerkstoffe und ressourceneffizientes Engineering

Module abbreviation:	FWStuRE_M-WR	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Kerschenlohr, Annegret
Lecturers:	Kerschenlohr, Annegret; Lohr, Christoph; Oberhauser, Simon; Tetzlaff, Ulrich
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours 47 h Self-study 78 h Total 125 h
Subjects of the module:	Funktionswerkstoffe und ressourceneffizientes Engineering (FWStuRE_M-WR)
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung
Examinations:	schrP90 - schriftliche Prüfung, 90 Minuten (FWStuRE_M-WR)
Special features of the examination performance:	Keine

Recommended prerequisites:

Keine

Objectives:

Nach dem Besuch des Moduls sind die Studierenden in der Lage,

- Funktionswerkstoffe und Funktionsschichten anhand von Eigenschaftsprofilen, Wirkprinzipien, Einsatzgrenzen und ressourceneffizienzbezogenen Anforderungen zu analysieren und für technische Anwendungen auszuwählen.
- metallurgische, polymere und halbleitertechnische Prozessrouten hinsichtlich Material- und Energieeinsatz, Ausbeute, Ausschuss, Skalierbarkeit und Bauteillebensdauer zu bewerten.
- funktionsrelevante Werkstoffgruppen wie Elektrobleche, Leiterwerkstoffe, Hartlotwerkstoffe, Batterie- und Elektrolysewerkstoffe sowie Polymere anforderungsbezogen zu beurteilen und Substitutionsmöglichkeiten abzuleiten.
- tribologische und grenzflächenbezogene Wirkmechanismen in Funktionswerkstoffen und Beschichtungen zu erklären, auf neue Anwendungen zu übertragen und daraus Maßnahmen zur Reibungs-, Verschleiß- und Ressourcenreduktion abzuleiten.
- Lebenszyklus-, Kreislauf- und Nachhaltigkeitsaspekte mithilfe von Life Cycle Assessment und Fallstudien in werkstofftechnische Entscheidungen einzubeziehen und ressourceneffiziente Engineering-Konzepte kritisch zu überprüfen.

Content:

- Metallurgische Prozessrouten und ressourceneffiziente Stahlherstellung durch Wasserstoffreduktion
- Funktionsschichten und Schichttechnologien für Halbleitertechnik

- Polymere als Funktionswerkstoffe
- additive Fertigung von Polymeren
- Tribologie, Reibung, Verschleiß und tribologische Systembetrachtung
- Elektrobleche
- Werkstoffe der Batterietechnik, Elektrolyse und energietechnischer Anwendungen
- Hartlote mit Blick auf Prozesssicherheit, Materialeinsatz und Lebensdauer
- elektrische Leiterwerkstoffe, elektrische Steckkontakte und Einsatz von Schichten
- Life Cycle Assessment, Recycling und Fallstudien zum ressourceneffizienten Einsatz der besprochenen Materialien

Literature:

Verpflichtend:

- AUERSWALD, Janko und Pius PORTMANN, 2022. *Grundlagen der Funktionswerkstoffe für Studium und Praxis*. Weinheim: Wiley-VCH. ISBN 978-3-527-34963-0
- KAISER, Wolfgang, 2024. *Kunststoffchemie für Ingenieure: von der Synthese bis zur Anwendung* [online]. München: Hanser. PDF e-Book. ISBN 978-3-446-47807-7. Verfügbar unter: https://doi.org/10.3139/9783446478077?locatt=mode:legacy.

Empfohlen:

- CZICHOS, Horst, HABIG, Karl-Heinz, 2020. *Tribologie-Handbuch: Tribometrie, Tribomaterialien, Tribotechnik* [online]. Wiesbaden: Springer Vieweg. PDF e-Book. ISBN 978-3-658-29484-7. Verfügbar unter: https://doi.org/10.1007/978-3-658-29484-7.
- CALLISTER, William D., David G. RETHWISCH und Michael SCHEFFLER, 2013. *Materialwissenschaften und Werkstofftechnik: eine Einführung*. Weinheim: Wiley-VCH. ISBN 978-3-527-33007-2, 3-527-33007-0

Additional remarks:

Keine Anmerkungen

Getriebe

Module abbreviation:	Getriebe_M-TE	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Perponcher, Christian von	
Lecturers:	Perponcher, Christian von; Suchandt, Thomas	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Getriebe (Getriebe_M-TE)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - schriftliche Prüfung, 90 Minuten (Getriebe_M-TE)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- analysieren Getriebe für unterschiedliche stationäre und mobile Anwendungen zielgerichtet und ordnen deren Einsatzbereiche ein.
- analysieren und synthetisieren auch komplexe Getriebestrukturen systematisch und anwendungsorientiert.
- beurteilen und bewerten Verzahnungen hinsichtlich Auslegung und Tragfähigkeit auf Grundlage rechnerischer Nachweise.
- evaluieren und bewerten die Qualität von Verzahnungen anhand technischer Kriterien und Qualitätsmerkmale.
- analysieren Schadensbilder an Getrieben, beurteilen deren Ursachen und bewerten geeignete Maßnahmen zur Vermeidung.

Content:

Getriebekonzepte

- Bauarten von Industrie-, Anlagen- und Fahrzeuggetrieben
- Auslegung von Getrieben
- Verzahnungsberechnung
- Verzahnungstoleranzen
- Herstellung von Verzahnungen
- Schadensbilder an Getrieben

Praktikum

Literature:
Verpflichtend: • NAUNHEIMER, Harald, BERTSCHE, Bernd, RYBORZ, Joachim, NOVAK, Wolfgang, FIETKAU, Peter, 2019. *Fahrzeuggetriebe: Grundlagen, Auswahl, Auslegung und Konstruktion* [online]. Berlin; Heidelberg: Springer Vieweg. PDF e-Book. ISBN 978-3-662-58883-3. Verfügbar unter: https://doi.org/10.1007/978-3-662-58883-3. Empfohlen: • NIEMANN, G. und H. WINTER, 1989. *Maschinenelemente Bd. 2*. Berlin, Heidelberg, New York, Tokyo: Springer. ISBN 978-3540111498 • DECKER, Karl-Heinz, Frank RIEG und Karlheinz KABUS, 2024. *Decker Maschinenelemente - Aufgaben*. 17. Auflage. München: Hanser. ISBN 978-3-446-47332-4
Additional remarks:
Im Rahmen der Vorlesung sind Gastvorträge vorgesehen.

Hydrogen Economy			
Module abbreviation:	HydEco_M-HTA	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Akgün, Ertan	
Lecturers:	Akgün, Ertan	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Hydrogen Economy (HydEco_M-HTA)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	LN - Portfolio-Exam (all exams before the examination period) (HydEco_M-HTA)	
Special features of the examination performance:	**Exam Information:** After 6–8 weeks of the semester, a written exam (60 minutes) will take place. This exam accounts for 50% of the final grade. During the last 2–4 weeks of the semester, presentations on group projects will be held. Each team will present for 15–20 minutes, followed by a 10-minute discussion session. This presentation accounts for 50% of the final grade. **Retake Examination (Summer Semester):** The retake examination in the summer semester consists of two written exams. After 4–6 weeks of the semester, the first written exam (60 minutes) will take place. This exam accounts for 50% of the final grade. During the last 2–4 weeks of the semester, the second written exam (60 minutes) will take place. Only students who participated in the first written exam are eligible to take this exam. This exam accounts for 50% of the final grade.	

Recommended prerequisites:

None

Objectives:

Students will be able to

- analyze the main applications of hydrogen, their implementation forms and their relevance for energy, industry, products, transport and storage, and mobility.

- evaluate the relationship between the physicochemical properties of hydrogen and the resulting opportunities, constraints and risks in practical applications.
- compare hydrogen applications and system configurations across sectors and assess their operating principles, components and design options.
- assess hydrogen-based concepts using ecological, sustainability, resource-efficiency and economic indicators and interpret their feasibility in specific contexts.
- critically evaluate technical, ecological and economic aspects of hydrogen use in comparison with alternative energy carriers and derive justified implementation recommendations.

Content:

- Physical and chemical properties of hydrogen
- Fundamentals of the hydrogen economy
- Fundamentals of hydrogen utilization
- Applications in industry and mobility
- Ecological assessment / sustainability
- Economic assessment

Literature:

Verpflichtend:

- VOORDE, Marcel H. van de, 2021. *Utilization of hydrogen for sustainable energy and fuels*. Berlin; Boston: De Gruyter. ISBN 978-3-11-059624-3
- BALL, Michael, 2009. *The hydrogen economy: opportunities and challenges*. Cambridge [u.a.]: Cambridge Univ. Press. ISBN 978-0-521-88216-3

Empfohlen:

- SASAKI, Kazunari und andere, 2016. *Hydrogen energy engineering: a Japanese perspective*. Tokyo: Springer. ISBN 978-4-431-56040-1
- ZOHURI, Bahman, 2019. *Hydrogen energy: challenges and solutions for a cleaner future*. Cham: Springer. ISBN 978-3-319-93460-0

Additional remarks:

Guest lectures may take place as part of the course.

Hydrogen Safety and Standardization

Module abbreviation:	HydSafStan_M-HTA	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Diel, Sergej	
Lecturers:	NN	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Hydrogen Safety and Standardization (HydSafStan_M-HTA)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	LN - written exam, 90 minutes (HydSafStan_M-HTA)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

After completing the course, students will be able to:

- identify the chemical and physical properties of hydrogen and derive the associated hazards and explain the main hazard areas in hydrogen applications and classify their impact on technological development across different sectors.
- convey foundational knowledge for understanding the concept of “safety” and assess basic safety-related situations in hydrogen contexts.
- develop a basic framework for safety engineering analysis and evaluation and distinguish between different approaches.
- describe methods of safety analysis, explain their significance, and differentiate their application depending on the use case.
- outline the fundamentals of product safety and operational safety and differentiate between them and understand the applicable regulations and abstract their underlying significance.
- assess basic safety aspects of hydrogen applications in comparison with similar applications of other energy storage and transport technologies and, based on this, develop the basic structure of a safety concept.

Content:

- Common hazard areas in hydrogen applications
- Distinct chemical and physical properties of hydrogen and hydrogen mixtures
- Prerequisites for safe engineering in hydrogen applications
- Hazard transfer - specific considerations and responsibilities
- Hydrogen in occupational health and safety

- Legal considerations
- Regulations, Codes, and Standards (RCS)
- Field trip(s) to companies in the stationary plant engineering sector as well as in automotive manufacturing

Literature:

Verpflichtend:

- KOTCHOURKO, Alexei und Thomas JORDAN, 2022. *Hydrogen safety for energy applications: engineering design, risk assessment, and codes and standards*. Oxford; Cambridge: Butterworth-Heinemann. ISBN 978-0-12-820492-4

Empfohlen:

- RIGAS, Fotis und Paul AMYOTTE, 2013. *Hydrogen safety*. Boca Raton, Fla. [u.a.]: CRC Press. ISBN 978-1-4398-6231-5, 1-4398-6231-1

Additional remarks:

Bonus program: Preparation and presentation of a safety concept for novel hydrogen storage systems, with the goal of integrating it into future course content. Bonus points will be credited toward the exam grade. Based on the total points achievable on the exam, a maximum of 10 percent in bonus points can be earned. Participation in the bonus program is voluntary. There is no entitlement to the bonus program being offered in any given semester.

Hydrogen Storage and Transportation

Module abbreviation:	HydStoTra_M-HTA	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Akgün, Ertan	
Lecturers:	Akgün, Ertan; Moll, Klaus-Uwe; Oberhauser, Simon	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Hydrogen Storage and Transportation (HydStoTra_M-HTA)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	LN - written exam, 90 minutes (HydStoTra_M-HTA)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

Students will be able to

- evaluate the thermodynamic behaviour of hydrogen.
- describe and evaluate the current state of the art in physical and materials-based methods for the storage and transport of hydrogen.
- understand and apply the fundamentals of chemical process engineering and assess relevant chemical hydrogen carriers.
- analyze and evaluate the underlying technologies and assess them from technical, economic, and environmental perspectives.
- identify and assess associated challenges and risks and develop and propose suitable mitigation strategies and solutions.
- analyze and evaluate emerging technologies that are still in the research stage and assess their potential for future application.
- assess and design hydrogen storage and transport concepts based on given technical requirements and constraints.
- analyze hydrogen uptake mechanisms, evaluate the influence of hydrogen absorption on material properties, and assess potential hazards associated with the use of materials in hydrogen environments.

Content:

Content:

- Thermodynamic fundamentals
- Physical hydrogen storage forms

- Material-based hydrogen storage forms
- Emerging and novel technologies
- Technological, economic, and environmental assessment of storage and transport options
- Sources and mechanisms of hydrogen uptake in materials
- Permeation of hydrogen in metallic and polymeric materials
- Influence of hydrogen on material properties and associated damage mechanisms (degradation potential)

Literature:

Verpflichtend:

Keine

Empfohlen:

- STOLTEN, Detlef und Bernd EMONTS, 2016. *Hydrogen science and engineering: materials, processes, systems and technology*. Weinheim: Wiley-VCH Verlag GmbH & Co. KGaA. ISBN 3-527-33238-3, 978-3-527-33238-0
- GODULA-JOPEK, Agata, Walter JEHLE und Jörg WELLNITZ, c2012. *Hydrogen storage technologies: new materials, transport, and infrastructure*. Weinheim: Wiley-VCH. ISBN 3-527-32683-9, 978-1-283-54229-6
- ZOHURI, Bahman, 2019. *Hydrogen energy: challenges and solutions for a cleaner future*. Cham: Springer. ISBN 978-3-319-93460-0

Additional remarks:

- Guest lectures may take place as part of the course.
- Bonus system: During the course, each student may work on and present a selected topic. Depending on the quality of the written preparation and oral presentation, bonus points may be awarded and added to the examination grade. A maximum of 10% bonus points, relative to the total number of points achievable in the examination, can be obtained. There is no entitlement to the implementation of this bonus system.

Inner Capacities for Personal Strength and Regenerative Change			
Module abbreviation:	SMT_InnCapaPers-Strength_FW	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Risi, Annette	
Lecturers:	Risi, Annette	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Inner Capacities for Personal Strength and Regenerative Change (SMT_InnCapaPersStrength_FW)	
Lecture types:	SU/Ü - lecture with integrated exercises	
Examinations:	LN - seminar paper and presentation (SMT_InnCapaPersStrength_FW)	
Special features of the examination performance:	None	

Recommended prerequisites:

None

Objectives:

After completing this module, students will be able to

- understand how personal well-being and societal transformation are deeply intertwined, e. g., differentiating between downloading and happiness vs. presencing and well-being.
- reflect on their own thought patterns, purpose, habits, and narratives to expand empathy and conscious choice.
- cultivate self-care, self-compassion, personal energy, vitality, strength-based action and flow.
- design and implement interventions that strengthen mental, emotional, and social well-being in times of volatility.
- facilitate co-creation and regenerative societal transformation processes in living labs that bring together diverse perspectives.
- develop pathways to activate sustainable well-being across individual, organizational, and community levels.
- strengthen human capacities that become increasingly important in AI-supported work.
- build and maintain healthy relationships, also for teamwork and project leadership

Content:

- Connections between national health status of social groups and climate change drivers

- Principles of neuroscience, holistic health, mental clarity and focus in an age of information overload and AI-supported work
- Principles of cognitive, positive, emotional and biological psychology
- Practices of deep listening, perspective-taking, mindfulness and embodied awareness inspired by MBSR, PERMA, Theory U, and SPT
- Identification of personal and systemic unsustainable patterns, with hands-on methods to transform them
- Cultivation of grit, vulnerability, openness, optimism, and curiosity as capacities for everyday life and sustainable change
- Frameworks for evaluating regenerative initiatives in organizational and societal systems, connecting knowledge with real-world application
- Intervention design and practice to foster social connectedness, purpose, and long-term flourishing, contributing to individual growth and societal progress
- Case studies and cross-cultural dialogue on sustainable well-being

Literature:

Verpflichtend:

Keine

Empfohlen:

- HARARI, Yuval Noah, 2024. *Nexus: a brief history of information networks from the Stone Age to AI*. New York: Random House. ISBN 978-0-593-73422-3, 059373422X
- FREDRICKSON, Barbara, 2011. *Positivity: groundbreaking research to release your inner optimist and thrive*. Richmond: Oneworld. ISBN 978-1-85168-790-9, 1-85168-790-4
- JOSEPH, Stephen, 2015. *Positive psychology in practice: promoting human flourishing in work, health, education, and everyday life* [online]. Hoboken, New Jersey: Wiley. PDF e-Book. ISBN 978-1-118-75725-3, 978-1-118-75717-8. Verfügbar unter: https://doi.org/10.1002/9781118996874.
- HAYASHI, Arawana und Otto SCHARMER, 2021. *Social presencing theater: the art of making a true move*. Cambridge, MA: PI Press (Presencing Institute). ISBN 978-0-9997179-7-4
- KABAT-ZINN, Jon, 2013. *Full catastrophe living: how to cope with stress, pain and illness using mindfulness meditation*. London: Piatkus. ISBN 978-0-7499-5841-1
- BEANE, Matthew Ian, 2024. *The skill code: how to save human ability in an age of intelligent machines*. New York, NY: HarperBusiness. ISBN 9780063337794, 0063337797
- HARI, Johann, 2022. *Stolen focus: why you can't pay attention - and how to think deeply again*. New York: Crown. ISBN 978-0-593-13851-9
- SCHARMER, Claus Otto, 2018. *The essentials of theory U: core principles and applications*. Oakland: Berrett-Koehler Publishers, Incorporated. ISBN 978-1-5230-9444-8, 1-5230-9444-3

Additional remarks:

The assessment focuses on the application and reflection of course concepts, individual practices and group exercises. It does not assess memorization or reproduction of predefined content, no final presentation but self-defined sharing. There are no “right” or “wrong” personal answers — every experience counts. Individual reflections are treated confidentially. Grading is based on reflective depth, connection, and transfer to future personal and professional contexts.

The specific learning settings, working formats and thematic priorities may be discussed with students at the beginning of the semester to support meaningful engagement.

Students may earn up to 9 bonus points through additional course-related activities announced in class. Bonus activities are time-bound and require timely sign-up.

Metallische Leichtbauwerkstoffe

Module abbreviation:	MetLb_M-WR	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Kerschenlohr, Annegret	
Lecturers:	Kerschenlohr, Annegret	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Metallische Leichtbauwerkstoffe (MetLb_M-WR)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - schriftliche Prüfung, 90 Minuten (MetLb_M-WR)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- schließen aus dem inneren Aufbau metallischer Werkstoffe für Leichtbau- und Hochtemperaturanwendungen auf die mechanischen und physikalischen Eigenschaften der Werkstoffe und schätzen deren Eignung für spezifische Anwendungen ein.
- hinterfragen die Zusammenhänge zwischen Legierungselementen, Mikrostruktur und Werkstoffeigenschaften und bewerten deren Wechselwirkungen.
- beurteilen Möglichkeiten zur ressourcenschonenden Gestaltung und Optimierung bestehender Werkstoffe unter Berücksichtigung technischer Anforderungen.
- wählen Werkstoffe für spezifische Fertigungsverfahren aus und evaluieren den Einfluss von Legierungselementen sowie Nachbehandlungen auf die resultierenden Eigenschaften.
- übertragen und reflektieren die erworbenen Kenntnisse auf weitere Werkstoffsysteme und beurteilen deren Anwendungs- und Optimierungspotenziale.

Content:

- Analyse des Aufbaus, der Eigenschaften und der Anwendungsfelder ausgewählter metallischer Konstruktionswerkstoffe für Leichtbau- und Hochtemperaturanwendungen unter Berücksichtigung von Nachhaltigkeit und Ressourceneffizienz
- Vertiefte Betrachtung von aluminium-, titan- und magnesiumbasierten Legierungssystemen hinsichtlich ihrer werkstofftechnischen Eigenschaften
- Untersuchung des Einflusses von Legierungselementen auf Struktur-, Phasen- und Gefügeausbildung metallischer Werkstoffe

- Bewertung der Zusammenhänge zwischen Mikrostruktur und den resultierenden mechanischen sowie physikalischen Eigenschaften
- Analyse biologischer Materialsysteme und deren funktionaler Eigenschaften als Vorbild für technische Hochleistungswerkstoffe
- Übertragung natürlicher Struktur- und Wirkprinzipien auf die nachhaltige Entwicklung und Optimierung technischer Werkstoffsysteme

Literature:

Verpflichtend:

- OETTEL, Heinrich, Gaby KETZER-RAICHLE und Hermann SCHUMANN, 2025. *Schumann Metallographie*. 16. Auflage. Weinheim: Wiley-VCH. ISBN 978-3-527-35106-0

Empfohlen:

- KAMMER, Catrin, 2009. *Aluminium-Taschenbuch*. 16. Auflage. Düsseldorf: Alu Media GmbH. ISBN 978-3-942486-10-1, 978-3-87017-295-4
- KAMMER, Catrin, 2000. *Magnesium-Taschenbuch: Mg*. Düsseldorf: Aluminium-Verl.. ISBN 3-87017-264-9
- MAIER, Hans Jürgen, Thomas NIENDORF und Ralf BÜRGEL, 2019. *Handbuch Hochtemperatur-Werkstofftechnik: Grundlagen, Werkstoffbeanspruchungen, Hochtemperaturlegierungen und -beschichtungen*. Wiesbaden: Springer Vieweg. ISBN 978-3-658-25313-4
- PETERS, Manfred, 2002. *Titan und Titanlegierungen* [online]. Weinheim: Wiley-VCH. PDF e-Book. ISBN 978-3-527-61108-9. Verfügbar unter: https://online-library.wiley.com/doi/book/10.1002/9783527611089.

Additional remarks:

Bonussystem:

- Im Rahmen der Lehrveranstaltung führen die Studierenden praktische Versuche zur Werkstoffcharakterisierung durch. Die Ergebnisse werden in wissenschaftlichen Berichten dokumentiert, analysiert, interpretiert und präsentiert.
- Darüber hinaus analysieren die Studierenden biologische Materialsysteme und bewerten deren funktionale Eigenschaften hinsichtlich ihres Potenzials als Vorbild für technische Hochleistungswerkstoffe. Die gewonnenen Erkenntnisse werden dokumentiert, interpretiert und vorgestellt.
- Die Ausarbeitung der Berichte wird qualitativ bewertet. Entsprechend der Qualität der eingereichten Leistungen können Bonuspunkte vergeben werden, die auf die Prüfungsleistung angerechnet werden.
- Die maximal erreichbare Anzahl an Bonuspunkten beträgt 5% der in der Prüfungsleistung erreichbaren Gesamtpunktzahl.

Werkstofftechnologie

Module abbreviation:	Wtech_M-WR	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems	Individual Elective	
Module attributes:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Kerschenlohr, Annegret	
Lecturers:	Kerschenlohr, Annegret	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours	47 h
	Self-study	78 h
	Total	125 h
Subjects of the module:	Werkstofftechnologie (Wtech_M-WR)	
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung	
Examinations:	LN - schriftliche Prüfung, 90 Minuten (Wtech_M-WR)	
Special features of the examination performance:	Keine	

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- leiten aus metallurgischen Vorgängen resultierende Bauteileigenschaften ab und evaluieren Möglichkeiten zu deren Optimierung.
- bewerten die metallurgischen Zusammenhänge unterschiedlicher spanloser Fertigungsverfahren hinsichtlich ihrer Auswirkungen auf den Prozess und die Bauteileigenschaften.
- beurteilen Potenziale zur ressourcenschonenden Gestaltung von Fertigungsprozessen unter werkstofftechnischen und nachhaltigkeitsbezogenen Gesichtspunkten.
- wählen für spezifische Fertigungsprozesse geeignete Legierungen aus und optimieren diese hinsichtlich ihrer verfahrens- und anwendungsrelevanten Eigenschaften.
- übertragen und reflektieren die erworbenen Kenntnisse auf weitere Fertigungsverfahren und bewerten deren werkstofftechnische Besonderheiten.

Content:

- Analyse der Eigenschaften und Qualitätsmerkmale metallischer Schmelzen sowie deren Einfluss auf Erstarrung und Gefügeausbildung beim Formguss
- Bewertung der Auswirkungen thermischer und kinetischer Prozessgrößen auf die Gefügeentwicklung metallischer Gusswerkstoffe
- Analyse der Eigenschaften metallischer Pulver sowie deren Bedeutung für nachfolgende Verarbeitungsprozesse in der Pulvermetallurgie und additiven Fertigung
- Untersuchung von Sinter- und Schmelzvorgängen sowie der damit verbundenen Gefügeausbildung unter Einfluss prozessspezifischer Parameter

- Bewertung der Gefügeentwicklung und der resultierenden Bauteileigenschaften in der additiven Fertigung in Abhängigkeit zentraler Prozessgrößen
- Analyse der Verfahren der Einkristallherstellung sowie der resultierenden Kristalleigenschaften und deren Bedeutung für technische Anwendungen

Literature:

Verpflichtend:

- KÖNIG, Wilfried, KLOCKE, Fritz, 2018. *Fertigungsverfahren* [online]. PDF e-Book. ISBN 978-3-662-54728-1. Verfügbar unter: https://doi.org/10.1007/978-3-662-54728-1.

Empfohlen:

- CAMPBELL, John, 2003. *Castings: [the new metallurgy of cast metals]* [online]. Oxford u.a.: Butterworth Heinemann. PDF e-Book. ISBN 0-7506-4790-6, 978-0-7506-4790-8. Verfügbar unter: http://www.sciencedirect.com/science/book/9780750647908.
- SCHATT, Werner, 2007. *Pulvermetallurgie: Technologien und Werkstoffe*. Berlin [u.a.]: Springer. ISBN 3-540-23652-X, 978-3-540-23652-8

Additional remarks:

Bonussystem:

- Studierende erarbeiten ein Modell für den Formguss und stellen entsprechende Abgüsse her. Die Ergebnisse werden in wissenschaftlichen Berichten dokumentiert, analysiert, interpretiert und präsentiert.
- Studierende führen praktische Versuche zur Materialcharakterisierung durch. Die Ergebnisse werden ebenfalls in wissenschaftlichen Berichten dokumentiert, analysiert, interpretiert und präsentiert.
- Die Ausarbeitung der Berichte wird qualitativ bewertet. Entsprechend der Qualität der eingereichten Leistungen können Bonuspunkte vergeben werden, die auf die Prüfungsleistung angerechnet werden.
- Die maximal erreichbare Anzahl an Bonuspunkten beträgt 5 % der in der Prüfungsleistung erreichbaren Gesamtpunktzahl.