Program and Course Description

SS2025

Renewable Energy Systems (SPO WS 24/25)

Master

Study regulation: WS 24/25

as per: 30.01.2025

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 enable them to manage complex projects. The graduates have the intercultural and communicative competencies that an activity that are required in an international context. The master’s course also gives students the opportunity to pursue a doctoratal 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 a 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:

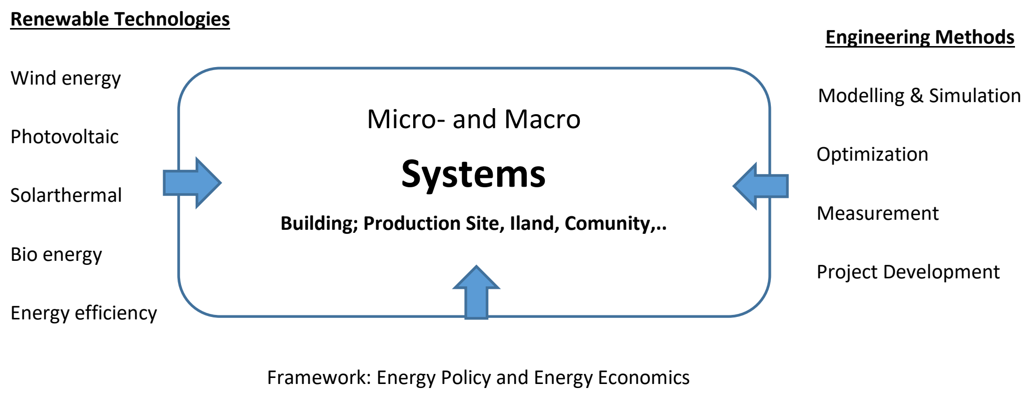

Fig.1: Conceptual representation of the RES master's course at THI

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	++	++	++	+		+				
Metho-	Simulation of complex systems and interpretation of simulation results	+	+	+	+	+	+	+	+	++	

	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
dological skills	Economic and ecological assessment of energy systems	+	+	+	+	++			++		
	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 partner 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 are 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 (SPO WS 24/25)	Compulsory Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Schrag, Tobias
Lecturers:	Reum, Tobias; Schrag, Tobias; Steger, Fabian
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	1: Introductory Laboratory Course (IntroLabC_M-RES)
Lecture types:	S - seminar (IntroLabC_M-RES)
Examinations:	PF - Portfolio Exam (IntroLabC_M-RES)
Special features of the examination performance	Portfolio exam consisting of: • moodle quizzes 20% • presentations 40% • report 40%
Usability for other study programs:	None

Prerequisites according examination regulation:

None

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 an 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 diffent teststands
- can evaluate different measurement methods as they know the advantages/disadvantages of different methods

- are 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 aim 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)

The experiments in small groups

PV-System: MPP-Tracking (elektrical 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:

Verpflichtend:

Keine

Empfohlen:

- 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 (SPO WS 24/25)	Compulsory Subject	1
Modulattribute:	**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:	Kontaktstunden: Selbststudium: Gesamtaufwand:	47 h 78 h 125 h
Subjects of the module:	2: System Analysis and Control (SysAnaCon_M-RES)	
Lecture types:	SU/Ü - lecture with integrated exercises (SysAnaCon_M-RES)	
Examinations:	schrP90 - written exam, 90 minutes (SysAnaCon_M-RES)	
Special features of the examination performance	None	
Usability for other study programs:	None	

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The students

- can model a physical system.
- Can characterize a control loop understanding what is the controller, 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:

Verpflichtend:

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

Empfohlen:

Keine

Additional remarks:

None

Energy Policies and Economies

Module abbreviation:	EnPolEc_M-RES	**SPO-No.:**	3
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Zörner, Wilfried
Lecturers:	Mehta, Kedar; Zörner, Wilfried
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	3: Energy Policies and Economies (EnPolEc_M-RES)
Lecture types:	S - seminar (EnPolEc_M-RES)
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
Usability for other study programs:	None

Prerequisites according examination regulation:

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:
Verpflichtend: Keine *Empfohlen:* Keine
Additional remarks:
None

Numerical Methods and Computational Simulation

Module abbreviation:	NumMetCS_M-RES	**SPO-No.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

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

Prerequisites according examination regulation:

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:

Verpflichtend:

Keine

Empfohlen:

- 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. Verfügbar unter: 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. Verfügbar unter: 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. Verfügbar unter: 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. Verfügbar unter: https://doi.org/10.1007/978-3-319-45304-0.

- ANDERSON, Dale A. und andere, 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. Verfügbar unter: https://doi.org/10.1007/978-3-319-16874-6.
- REDDY, Junuthula Narasimha und 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]. [Zugriff am:]. Verfügbar unter: 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 (SPO WS 24/25)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Goldbrunner, Markus
Lecturers:	Baldauf, Tobias; Goldbrunner, Markus
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	5: 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
Usability for other study programs:	None

Prerequisites according examination regulation:

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 consumptions 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 an their components
- basics and concepts of gasification
- Project
- Building an energy-efficient and environmentally friendly energy supply for an industrial company

Literature:

Verpflichtend:

Keine

Empfohlen:

- 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 (SPO WS 24/25)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Goldbrunner, Markus
Lecturers:	Baldauf, Tobias
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	6: 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
Usability for other study programs:	None

Prerequisites according examination regulation:

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 the energy consumptions, the 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:

Verpflichtend:

Keine

Empfohlen:

- 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 und 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 (SPO WS 24/25)	Compulsory Subject	1
Modulattribute:	**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:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	9: Hydrogen in Energy Technology and Energy Markets (HydETEM_M-RES)
Lecture types:	SU/Ü - lecture with integrated exercises (HydETEM_M-RES)
Examinations:	schrP90 - written exam, 90 minutes (HydETEM_M-RES)
Special features of the examination performance	None
Usability for other study programs:	None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The students

- can compare different hydrogen production/storage/logistic technologies
- know about the electricity generation with fossil and renewable energy sources as competing and complementing technologies.
- can differentiate current and future colors of hydrogen.
- 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 of electricity trading as well as technical boundaries.

Content:

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

• Possibilities and limits that hydrogen can play in future energy systems • Substitution potential of hydrogen in other sectores. • Market mechanism of gas trading as well as technical boundaries. • Market mechanism of of electricity trading as well as technical boundaries.
Literature:
Verpflichtend: • STOFT, Steven, . *Power system economics*. • SEDDON, Duncan , . *The Hydrogen Economy Fundamentals, Technology, Economics* . ISBN https://doi.org/10.1142/12593 • SUBHES, Bhattacharyya, . *Energy Economics*. • QASCHNING, Volker, . *Renewable energy and climate change* . *Empfohlen:* Keine
Additional remarks:
None

Master Thesis

Module abbreviation:	MA_RES	**SPO-No.:**	10
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Compulsory Subject	3
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Huber, Matthias
Lecturers:	All lecturers
Credit points / SWS:	30 ECTS / 0 SWS
Workload:	Kontaktstunden: 0 h Selbststudium: 750 h Gesamtaufwand: 750 h
Subjects of the module:	10: Master Thesis (MA_RES)
Lecture types:	MA - Master Thesis (MA_RES)
Examinations:	Master-Thesis (MA_RES)
Special features of the examination performance	None
Usability for other study programs:	None

Prerequisites according examination regulation:

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 correct.

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:

Verpflichtend:

Keine

Empfohlen:

- 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. Verfügbar unter: 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. Verfügbar unter: 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
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	General Elective Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Schrag, Tobias
Lecturers:	
Credit points / SWS:	10 ECTS / 8 SWS
Workload:	Kontaktstunden: 93 h Selbststudium: 157 h Gesamtaufwand: 250 h
Subjects of the module:	7.1: Building Energy System (BuildEnerSys_M-RES)
Lecture types:	S - seminar (BuildEnerSys_M-RES)
Examinations:	PF - Portfolio Exam (BuildEnerSys_M-RES)
Special features of the examination performance	Portfolio Exam: • Moodle quizz • Simulation exercise • Library course • Presentation • Report
Usability for other study programs:	None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The students

- are familiar with building energy systems for heat and cold supply such 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 in 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:

Verpflichtend:

Keine

Empfohlen:

- 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. Verfügbar unter: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119540328.
- KLEE, Harold und 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. Verfügbar unter: 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. Verfügbar unter: 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
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	General Elective Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Navarro Gevers, Daniel
Lecturers:	Ausin Calvo, Juan Carlos; Lwakatare, Bertha Phenias; Navarro Gevers, Daniel; Ngetuny, Joshua
Credit points / SWS:	10 ECTS / 8 SWS
Workload:	Kontaktstunden: 93 h Selbststudium: 157 h Gesamtaufwand: 250 h
Subjects of the module:	7.1: Off-Grid Energy System (Off-GridEnSy_M-RES)
Lecture types:	S - seminar (Off-GridEnSy_M-RES)
Examinations:	PF - Portfolio Exam (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%.
Usability for other study programs:	None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The students

- can model an offgrid electrical system Know the main components in an Offgrid System : 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 an control) to desigm an offgrid 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:

Verpflichtend:

Keine

Empfohlen:

- 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:	UrbanAreaEnerSys_M-RES	**SPO-No.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	General Elective Subject	1
Modulattribute:	**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; Summ, Thorsten; Weitz, Klaus Peter
Credit points / SWS:	10 ECTS / 8 SWS
Workload:	Kontaktstunden: 93 h Selbststudium: 157 h Gesamtaufwand: 250 h
Subjects of the module:	7.1: Urban Area Energy System (UrbanAreaEnerSys_M-RES)
Lecture types:	S - seminar (UrbanAreaEnerSys_M-RES)
Examinations:	PF - Portfolio Exam (UrbanAreaEnerSys_M-RES)
Special features of the examination performance	Portofolioprüfung: • Initial Simulation Task • Management paper • Library Course • Presentation • Report
Usability for other study programs:	None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The students

- are familiar with different energy systems for heat and cold supply such 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 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
- have an insight in 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:

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

Literature:

Verpflichtend:

Keine

Empfohlen:

- 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 und 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. Verfügbar unter: https://ieeexplore.ieee.org/book/10173467.

Additional remarks:

None

5.3 Individual Elective

Automatisiertes Fahren

Module abbreviation:	AutFahr_M-FT	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Individual Elective	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Bogenberger, Florian
Lecturers:	Bogenberger, Florian; Helmer, Thomas; Steininger, Udo
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 79 h Gesamtaufwand: 126 h
Subjects of the module:	8: Automatisiertes Fahren (AutFahr_M-FT)
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung (AutFahr_M-FT)
Examinations:	schrP90 - schriftliche Prüfung, 90 Minuten (AutFahr_M-FT)
Special features of the examination performance	Keine
Usability for other study programs:	Keine

Prerequisites according examination regulation:

Keine

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- kennen und verwenden die fachspezifische Terminologie sicher,
- kennen den Stand der Technik und Forschung zu automatisierten Fahrfunktionen, inkl. Potentiale und Grenzen,
- können aktuelle Entwicklungen und Trend qualifiziert einschätzen,
- verstehen die unterschiedlichen Anwendungsbereiche der Technologie und können deren Implikationen bewerten,
- besitzen das Hintergrundwissen, um Aussagen zur Funktionssicherheit zu machen,
- können die Grundprinzipien der Gebrauchssicherheit (SOTIF) anwenden,
- verstehen die Auswirkungen auf die Gestaltung der Mensch-Maschine-Schnittstelle
- können die Grundzüge der Zulassung wiedergeben und auf einen Anwendungsfall transferieren,
- kennen und verstehen unterschiedliche Test- und Absicherungsmethoden und können diese zielgerichtet anwenden,
- kennen die Besonderheiten in der Anwendung bei Zweirädern und Nutzfahrzeugen

Content:

- Fachspezifische Terminologie
- Automatisierten Fahrfunktionen, inkl. Potentiale und Grenzen (SAE L3 und L4)
- Anwendungsbereiche der Technologie (privat, Flottenbetrieb, Logistik, ...)
- Funktionale Sicherheit (ISO 26262)
- Gebrauchssicherheit (SOTIF)
- Mensch-Maschine-Schnittstelle
- Zulassung
- Test- und Absicherungsmethoden
- Anwendung bei Zweirädern und Nutzfahrzeugen

Literature:

Verpflichtend:

Keine

Empfohlen:

- WINNER, Hermann, HAKULI, Stephan, LOTZ, Felix, SINGER, Christina, 2019-. *Handbook of Driver Assistance Systems: Basic Information, Components and Systems for Active Safety and Comfort* [online]. Cham: Springer International Publishing PDF e-Book. ISBN 978-3-319-09840-1. Verfügbar unter: https://doi.org/10.1007/978-3-319-09840-1.
- BOTSCH, Michael, UTSCHICK, Wolfgang, 2020. *Fahrzeugsicherheit und automatisiertes Fahren: Methoden der Signalverarbeitung und des maschinellen Lernens* [online]. München: Hanser PDF e-Book. ISBN 978-3-446-46804-7. Verfügbar unter: https://doi.org/10.3139/9783446468047.
- MAURER, Markus, GERDES, J. Christian, LENZ, Barbara, WINNER, Hermann, 2016. *Autonomous driving: technical, legal and social aspects* [online]. Berlin: Springer-Verlag PDF e-Book. ISBN 978-3-662-48847-8. Verfügbar unter: https://doi.org/10.1007/978-3-662-48847-8.
- DI FABIO, Udo und andere, Juni 2017. *Ethik-Kommission Automatisiertes und Vernetztes Fahren: eingesetzt durch den Bundesminister für Verkehr und digitale Infrastruktur : Bericht*. Berlin: Bundesministerium für Verkehr und Digitale Infrastruktur.

Additional remarks:

Keine Anmerkungen

Engineering Processes in Automotive Industry

Module abbreviation:	EngineeProcAuto_M-APE	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Individual Elective	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Bednarz, Martin
Lecturers:	Neumann, Alexander; Triveni, Prashant
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	8: Engineering Processes in Automotive Industry (EngineeProcAuto_M-APE)
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung (EngineeProcAuto_M-APE)
Examinations:	schrP90 - schriftliche Prüfung, 90 Minuten (EngineeProcAuto_M-APE)
Special features of the examination performance	Keine
Usability for other study programs:	Keine

Prerequisites according examination regulation:

Keine

Recommended prerequisites:

Keine

Objectives:

The students

- Get to know the strongly networked and parallel processes in the product development of automobiles ("product process" and "product development process")
- Can recognise, assess and include in their work interactions between production and product in particular.
- Know the significance and working methods of Simultaneous Engineering (SE) including the involvement of suppliers in product design and product and process quality to meet the requirements of production.
- Can handle tools of project and process management (e.g. master product processes with structured levels of action in terms of decisions and themes, milestone definitions and synchronisation, levels of product maturity, EHPV, 3Ps „Production Preparation Process", etc.) and know the working methods and processes, for example, for networking, decision-making, escalation, theme contributions etc. in large automotive and supplier companies.
- Know the significance of prototype, pilot production and release processes, their tools (e.g. Meisterbock processes, audit scores, process capability evidence, VFF, PVS, etc.) as well as their involvement in the product and engineering process
- know about the significance of Lean Development

Content:

- Product development and quality management (during the product development process) in the automotive industry
- Project and process management in the product development process
- Prototype, pilot production and release processes
- Lean Development, generic principles and application

Literature:

Verpflichtend:

- STAMATIS, Diomidis H., 2001. *Advanced quality planning: a commonsense guide to AQP and APQP*. New York, NY: Productivity Press. ISBN 1-56327-258-X
- COOPER, Robert G., 2017. *Winning at new products: creating value through innovation*. New York, NY: Basic Books. ISBN 0-465-09332-9, 978-0-465-09332-8
- WOMACK, James P., Daniel T. JONES und Daniel ROOS, 2007. *The machine that changed the world: [how lean production revolutionized the global car wars]*. London [u.a.]: Simon & Schuster. ISBN 978-1-84737-055-6, 1-8473-7055-1
- WOMACK, James P. und Daniel T. JONES, 2003. *Lean thinking: banish waste and create wealth in your corporation*. London [u.a.]: Simon & Schuster. ISBN 978-0-7432-3164-0
- ROTHER, Mike und John SHOOK, 2009. *Learning to see: value-stream mapping to create value and eliminate muda*. Version 1. Auflage. Cambridge, Mass.: Lean Enterprise Inst.. ISBN 978-0-9667843-0-5, 0-9667843-0-8
- MORGAN, James M. und Jeffrey K. LIKER, 2006. *The Toyota product development system: integrating people, process, and technology*. New York, NY: Productivity Press. ISBN 1-56327-282-2, 978-1-563-27282-0
- REINERTSEN, Donald G., 2009. *The principles of product development flow: second generation lean product development*. Redondo Beach, Calif: Celeritas. ISBN 978-1-935401-00-1, 1-935401-00-9
- CHANG, Kuang-Hua, 2013. *Product manufacturing and cost estimating using CAD/CAE*. Amsterdam [u.a.]: Elsevier. ISBN 978-0-12-401745-0
- MITAL, Anil, 2014. *Product development: a structured approach to consumer product development, design, and manufacture*. Amsterdam [u.a.]: Elsevier. ISBN 978-0-12-799945-6

Empfohlen:

Keine

Additional remarks:

Bonus system:

In the course, tasks can be set that lead to bonus points for the examination performance for each qualitatively completed task. The maximum crediting of bonus points takes place according to the APO.

Korrosion- und Oberflächentechnik

Module abbreviation:	WModul-KorOT_M-RES	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Allgemeines Wahlpflichtfach	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Oberhauser, Simon
Lecturers:	Oberhauser, Simon
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	8: Korrosion- und Oberflächentechnik (WModul-KorOT_M-RES)
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung (WModul-KorOT_M-RES)
Examinations:	LN - schriftliche Prüfung, 90 Minuten (WModul-KorOT_M-RES)
Special features of the examination performance	Keine
Usability for other study programs:	Keine

Prerequisites according examination regulation:

Keine

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- kennen den Mechanismus der Korrosion einschließlich seiner relevanten thermodynamischen und kinetischen Einflussfaktoren, können verschiedene Korrosionsformen erkennen und den jeweiligen Korrosionsursachen zuordnen.
- kennen die wichtigsten Korrosionsprüfungen einschließlich elektrochemischer Methoden und können ihre Ergebnisse sinnvoll interpretieren.
- kennen wichtige korrosionsbeständige Werkstoffe aus der Gruppe der Leichtmetalle, der hochlegierten Stähle sowie der Nickel und Kupferbasiswerkstoffe. Sie kennen deren Einsatzmöglichkeiten und Grenzen und können auf dieser Basis für konkrete Anwendungsfälle eine technisch und wirtschaftlich sinnvolle Werkstoffauswahl treffen.
- sind informiert über die verbreitetsten Möglichkeiten, wenig korrosionsbeständige Werkstoffe mit Hilfe von Beschichtungen und Überzügen zu schützen. Sie kennen die einschlägigen Methoden und Prozesse und sind in der Lage zu entscheiden, welches Verfahren zu einem gegebenen Bauteil und den dort herrschenden Anforderungen passt.
- kennen die Grundregeln des konstruktiven Korrosionsschutzes und sind daher in der Lage korrosionsbedingte Schwachstellen bereits in der Konzept- und Konstruktionsphase zu vermeiden

Content:
• Theoretische Grundlagen Korrosion, Methoden der Elektrochemie, Korrosionsprüfung • Mechanische Einflüsse auf das Korrosionsgeschehen • Korrosionsbeständige Werkstoffe mit ihren Möglichkeiten, Grenzen und ihren Sonderkorrosionsformen • Korrosionsschutz durch Beschichtungen, Vorbehandeln und Vorbereiten, Beschichtungsprozesse, Beschichtungsstoffe • Korrosionsschutz durch Überzüge, Verfahren und Materialien • Grundbegriffe des konstruktiven Korrosionsschutzes • Fügetechnik und Korrosion
Literature:
Verpflichtend: • WENDLER-KALSCH, Elsbeth, GRÄFEN, Hubert, 1998. *Korrosionsschadenkunde* [online]. Berlin, Heidelberg: Springer Berlin Heidelberg PDF e-Book. ISBN 978-3-642-30431-6, 978-3-662-22074-0. Verfügbar unter: https://doi.org/10.1007/978-3-642-30431-6. *Empfohlen:* Keine
Additional remarks:
Prüfungsart gemäß der Anlage zur SPO Master WT und Master TE

Plant and equipment design in hydrogen technology

Module abbreviation:	PEDHT_M-WTW	**SPO-No.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Renewable Energy Systems (SPO WS 24/25)	Individual Elective	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	Deutsch	1 Semester	nur Wintersemester

Responsible for module:	Akgün, Ertan
Lecturers:	Schönberger, Manfred Stefan
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Kontaktstunden: 47 h Selbststudium: 78 h Gesamtaufwand: 125 h
Subjects of the module:	8: Plant and equipment design in hydrogen technology (PEDHT_M-WTW)
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung (PEDHT_M-WTW)
Examinations:	schrP90 - schriftliche Prüfung, 90 Minuten (PEDHT_M-WTW)
Special features of the examination performance	Keine
Usability for other study programs:	Keine

Prerequisites according examination regulation:

Keine

Recommended prerequisites:

Keine

Objectives:

Die Studierenden

- werden mit Darstellungen und Begriffen des Anlagenbaus vertraut gemacht
- lernen übliche Fertigungsverfahren des Apparatebaus kennen
- lernen verfahrenstechnische Grundoperationen kennen
- können Anlagenkonzepte der Wasserstoffkette aus verfahrenstechnischen Grundoperationen entwickeln
- lernen erforderliche Bestandteile im Anlagenbau aus dem Projektmanagement und der Vertragsgestaltung kennen
- verstehen den Projektablauf zur Herstellung einer verfahrenstechnischen Anlage
- können Equipment für Anlagen spezifizieren
- können Angebote für Anlagenkomponenten technisch/wirtschaftlich bewerten
- können ausgewähltes Equipment designen
- können Expediting durchzuführen
- lernen die spezifischen Sonderanforderungen an Wasserstoffanlagen und Equipment kennen

Content:

Grundlagen der Verfahrenstechnik:

- Einführung
- Dimensionslose Kennzahlen
- Strömungsmechanik (Bernoulli inkl. verlustbehaftete Strömung)
- Wärme und Stoffübertragung
- Grundoperationen Verfahrenstechnik
- Spezialgebiet Wasserstoff

Spezialgebiet Wasserstoff

- Nelson-Diagram zur Werkstoffauswahl
- Gefährdungen flüssiger Wasserstoff
- Methanol-Synthese
- Haber-Bosch-Verfahren
- Sabatier-Verfahren
- Methanisierung

Anlagenbau:

- Vertragsgestaltung (EPC, Lump-Sum-Turnkey-Vertrag…)
- Randbedingungen des Anlagenbaus
  - Projektlaufzeiten
  - Behördenengineering
  - Marktentwicklung
  - gesellschaftliche Akzeptanz
- Projektierung
- Scale-up
- Projektmanagement
- Dreieck des Projektmanagement; VDI 2222, Zeit und Resourcenplanung, Long Lead Items
- Darstellung von Chemieanlagen (Blockschema, P&ID, Aufstellungsplanung)
- Montageplanung und Montage

Apparatebau:

- Grundlagen Fertigungstechnik / Fertigungsverfahren
- Produktion von Halbzeugen, Umformung, Fügen, Prüfen etc.
- Rotation Equipment (Pumpen, Kompressoren/Verdichter, Turbinen)
- Static Equipment (Behälter, Wärmeaustauscher, Reaktoren, Membrantechnik, Rohrleitungen)

Literature:

Verpflichtend:

Keine

Empfohlen:

- CHRISTEN, Daniel S., 2010. *Praxiswissen der chemischen Verfahrenstechnik: Handbuch für Chemiker und Verfahrensingenieure*. Berlin [u.a.]: Springer. ISBN 978-3-540-88974-8, 978-3-540-88975-5
- STRYBNY, Jann, 2012. *Ohne Panik Strömungsmechanik!: ein Lernbuch zur Prüfungsvorbereitung, zum Auffrischen und Nachschlagen mit Cartoons* [online]. Wiesbaden: Vieweg & Teubner PDF e-Book. ISBN 978-3-8348-1791-4, 3-8348-1791-0. Verfügbar unter: https://doi.org/10.1007/978-3-8348-8341-4.
- WAGNER, Walter, 2023. *Festigkeitsberechnungen im Apparate- und Rohrleitungsbau*. 10. Auflage. Würzburg: Vogel Communications Group. ISBN 978-3-8343-3527-2, 3-8343-3527-4
- IGNATOWITZ, Eckhard und Fastert GERHARD, . *Chemietechnik*.

Additional remarks:
• Im Rahmen der Vorlesung können Gastvorträge vorgesehen werden. • Bonussystem: In der Lehrveranstaltung kann von Studierenden ein Thema bearbeitet und präsentiert werden, dass entsprechend seiner qualitativen Ausarbeitung und Präsentation zu Bonuspunkten führt, die zusätzlich auf die Prüfungsleistung angerechnet werden. Bezogen auf die in der Prüfung erreichbaren Punkte sind maximal 10 Prozent Bonuspunkte möglich. Es besteht kein Anspruch auf die Durchführung des Bonussystems im jeweiligen Semester.