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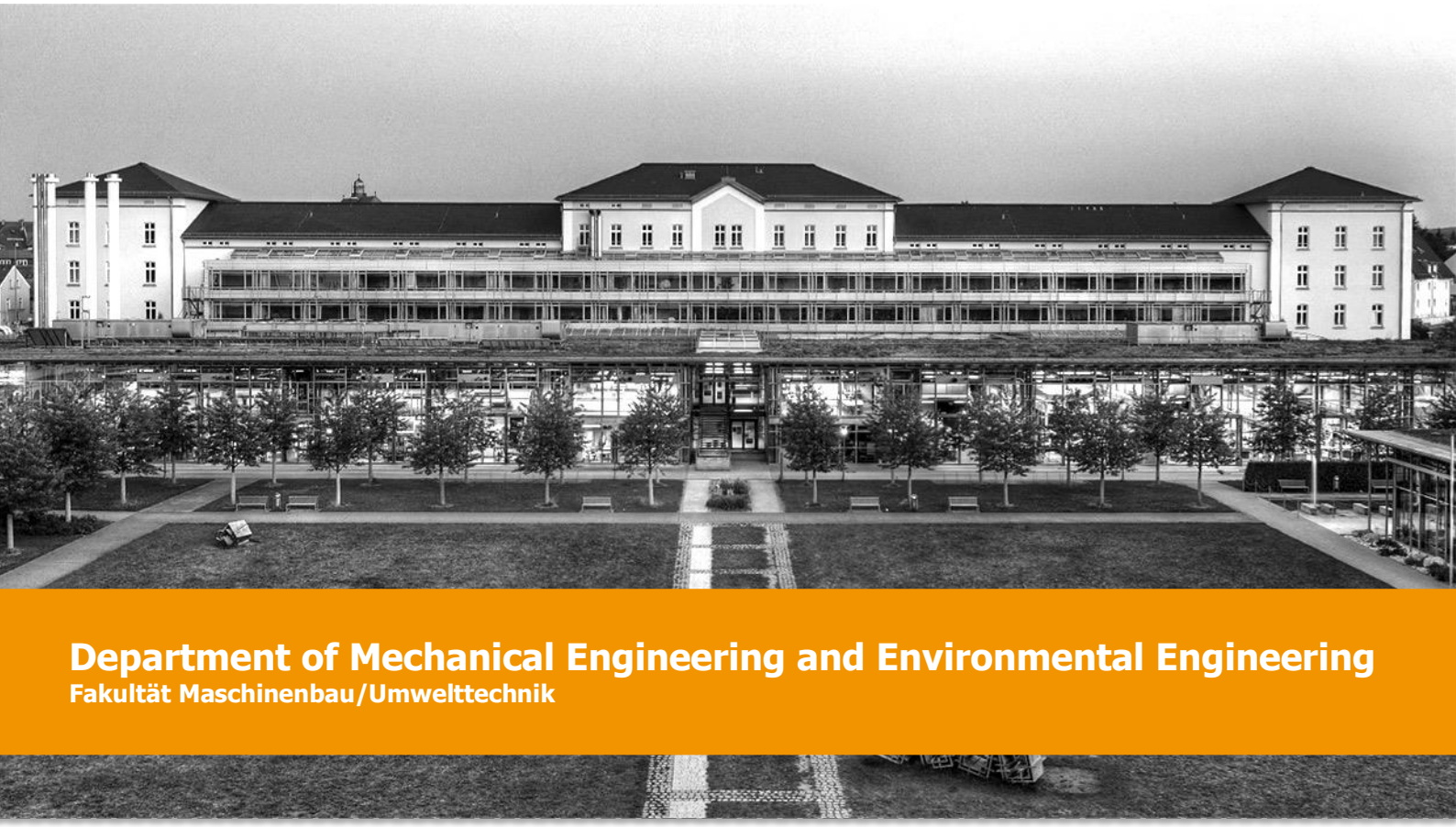
Ostbayerische Technische Hochschule
Amberg-Weiden

Course Catalogue

Modulhandbuch

International Energy Engineering

International Energy Engineering



Department of Mechanical Engineering and Environmental Engineering
Fakultät Maschinenbau/Umwelttechnik

Master of Engineering (M.Eng.)

Master of Engineering (M.Eng.)

Created by: Prof. Frank Späte / Silke Fersch
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Preliminary notes

Vorbemerkungen

- **Note:**

Please take special note of the Program and Examination Regulations of this degree program in their current version.

- **Study structure:**

The programme comprises a standard period of study of 3 semesters.

- **Registration formalities:**

All examinations must be registered with the Students' Office (through PRIMUSS). Additional formalities are listed in the module descriptions.

- **Abbreviations:**

ECTS = The European Credit Transfer and Accumulation System (ECTS) is a credit point system for accreditation of course achievements.
SWS = Semesterwochenstunden = Semester hours per week

- **Workload:**

According to the Bologna Process, a credit point is based on a workload of 25-30 hours. The number of hours includes the time spent at the university, the time spent preparing for and following up on courses, the time spent writing papers or preparing for examinations.

Example calculation of workload (course with 4 SWS, 5 ECTS credits):

Workload: 5 ECTS x 30 h/ECTS = 150 h

- Lecture (4 SWS x 15 weeks) = 60 h
- Self study = 60 h
- Exam preparation = 30 h

= 150 h

- **Accreditation of course achievements:**

Please observe all relevant application procedures via the Students' Office.

Curriculum

The module overview for the Master's programme International Energy Engineering can be found in the programme documents on the homepage.

Modules

1. Compulsory modules

1.1 Simulation of Energy Systems (SES)
Simulationen in der Energietechnik

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Compulsory module	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Werner Prell	Prof. Dr. Stefan Beer, Prof. Dr. Werner Prell

Voraussetzungen*
Prerequisites

Thermodynamics, fluid mechanics, heat and mass transfer, energy process engineering

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Availability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up, Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Know mathematical models for describing energetic systems, be able to create new ones, connect them, apply them and evaluate the results obtained.
- **Methodological competence**: Skills for software-aided analysis and optimisation of energetic systems and for carrying out typical calculations. Be able to correctly allocate and combine knowledge and skills from basic modules in order to derive and develop new solutions for practical engineering tasks.
- **Personal competence (social competence and self-competence):** In small groups, students recognise and improve their own ability to work in a team. They can independently acquire new knowledge and transfer known contexts to new problems.

Inhalte der Lehrveranstaltungen
Course Content

Steady-state and transient methods for describing energy systems (e.g. CHP plants, CRC and ORC processes) and components (e.g. heat exchangers, thermal storage, process engineering apparatus, piping systems) using mathematical models and the problem-adapted use of software.

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur Teaching Material / Reading
Lecture notes, tutorials on the software used
Internationalität (Inhaltlich) Internationality

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Module work	Module work consisting of (*) a case analysis (70 %) with presentation (30 %)	Professional competence, methodological competence

(*) In justified exceptional cases, the contents of the examination can be changed in consultation with the head of the study programme. The deadlines set by the relevant regulations must be observed.

1.2 Scientific Research and Methods (SRM)

Wissenschaftliches Arbeiten und Forschungsmethoden

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Compulsory modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Mandy Hommel	Prof. Dr. Mandy Hommel

Voraussetzungen*
Prerequisites

Mathematics for Engineers I

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Availability	Lehrformen Teaching Methods	Workload
	Seminar	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- The students know the basics of scientific research and apply them to their own delimited projects.
- They work out a research problem and formulate research questions and hypotheses.
- They differentiate possibilities of data collection and choose suitable methods depending on the research objective.
- The students use basic methods of data analysis and evaluation for qualitative and quantitative data.
- The students distinguish between qualitative and quantitative research and understand the possibilities of increasing the gain of knowledge through mixed methods and triangulation.
- They understand quality criteria of research and assess the quality of different methodological approaches criteria-based and based on theory.
- They collaboratively design small research projects and apply concrete methods of data collection exemplarily.
- The students formulate essential aspects of their approach in an "extended abstract" and present the essential contents by means of a scientific poster.

Inhalte der Lehrveranstaltungen
Course Content

The content of the course comprises research logic processes that are addressed across disciplines. Further emphasis is on quantitative and qualitative empirical methods. In addition, the focus is on the application in research. In the sense of research-based learning, students become familiar with the research logic of empirical investigations as well as with methods of data collection and data analysis. Technical tools for data analysis for both qualitative and quantitative research are addressed.

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

APA (2020). *Publication Manual of the American Psychological Association. The Official Guide to APA Style* (7th Ed.) Washington.
Carlson, K. A. & Winquist, J. R. (2017). *An Introduction to Statistics. An Active Learning Approach*. SAGE.
Creswell, J. W. & Plano Clark, V. L. (). *Designing and Conducting Mixed Methods Research* (3rd. Ed.). SAGE.
Denzin, N. K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research, 6*(2), 80–88.
Field, A. (2017). *Discovering Statistics Using IBM SPSS Statistics*. SAGE.
IEEE (2020). *IEEE Editorial Style Manual for Authors*. IEE Publishing Operations. Piscataway.
Krippendorff, K. H. (2018). *Content Analysis. An Introduction to Its Methodology* (4th Ed.). SAGE.

Internationalität (Inhaltlich)
Internationality

The contents of the module consider international contributions and findings.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
ModA	Project work / 100 %	Professional competence, methodological competence, social and personal competence

1.3 Innovation Management and Communication (IMC)

Innovationsmanagement und Kommunikation

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Compulsory module	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	German/English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Späte	Prof. Dr. Thomas Tiefel, Marian Mure

Voraussetzungen*
Prerequisites

none

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Availability	Lehrformen Teaching Methods	Workload
Can be credited in the following study programmes: • Global Research in Sustainable Engineering • International Energy Engineering	Seminar-based teaching	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** The students understand the importance of innovations as a success factor on a micro- and macroeconomic level. They can explain basic terms and contexts, fundamental problems and task fields as well as interdisciplinary aspects of innovation management. In addition, they deepen a foreign language (German for English-speaking students and English for German-speaking students).
- **Methodological competence**: Students are able to describe and analyse practical problem areas with the help of selected theories, models, concepts and instruments of innovation management. They are able to express themselves better in a foreign language (German or English).
- **Personal competence (social competence and self-competence):** Students gain the ability to act in an interdisciplinary and interculturally sensitive manner. They have expanded their ability to change perspectives and are able to communicate with different nationalities.

Inhalte der Lehrveranstaltungen
Course Content

- Basic terms and contexts of innovation management
- Strategic innovation management
- Innovation as a factor influencing macroeconomic, societal and sociocultural change
- Different national approaches to dealing with digital and economic transformation
- Consolidation of a foreign language (e.g. vhb course "DaF Strukturen und Kommunikation A2")

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Innovation management:
Lecture notes with fill in blanks
Articles from business, scientific and public journals
Internet-based teaching and illustrative material
Sample exam
Textbooks: Corsten et al. (eds.): Technologie- und Innovationsmanagement, current edition, Gerpott, T.: Strategisches Technologie-und Innovationsmanagement, current edition, Strebel, H. (eds.): Innovations-und Technologiemanagement, current edition; Schilling, M: Strategic Management of Technological Innovation, current edition
vhb-course
Menschen A1, Course book + Workbook, Deutsch als Fremdsprache, Hueber Verlag, L 13-24 ISBN 978-3-19-211901-9

Internationalität (Inhaltlich)
Internationality

Through the module, students are able to perform confidently and competently in an international environment in the context of the topic of innovation management. Language skills are expanded to improve communication between different nationalities.

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Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min	Professional competence, methodological competence, personal competence

1.4 International Energy Law and Energy Economics (ILE)

Internationales Energierecht und Energiewirtschaft

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Compulsory module	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Frank Späte	Prof. Dr. Lechner, Prof. Späte, LBA (Lehrbeauftragte/r = external lecturer)

Voraussetzungen*
Prerequisites

none

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload	
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) Self-study Preparation and follow-up Examination preparation	= 60 h = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:**
  Knowledge of important supranational and national regulations of energy and environmental law and official tasks as well as their practical implementation; knowledge of the most important sub-areas of European and international energy law and relevant environmental law; exemplary national regulations, economic aspects, energy management.

- **Methodological competence:**
  Ability to recognise legal problems in energy/environmental law, identification of the most important applicable regulations
  Independent application of regulations relevant to practice
  Ability to identify practice-relevant focal points of the regulations
  Ability to recognise overarching connections between different areas of supranational and national energy/environmental law and to evaluate them from a practical point of view.
  Evaluation and use of economic aspects in connection with legal regulations
  Knowledge and development of structures in corporate energy management

- **Personal competence (social competence and self-competence):**
  Developing solutions to problems through interdisciplinary thinking; self-organisation in the planning and implementation of projects in working life; cooperation in a team within the framework of practical exercises.

Inhalte der Lehrveranstaltungen
Course Content

- Fundamentals of international energy and environmental law, objectives and principles of European energy and climate policy in the structure of international energy/climate regulations: Aarhus Convention, United Nations Framework Convention on Climate Change, COP, etc.
- EU energy policy and energy law system: basic provisions on the Treaty on the Functioning of the European System (TFEU), liberalisation packages, Energy Efficiency, Renewable Energy Systems (RES), Taxonomy, etc.
- Functioning of energy markets in Europe: basic principles of functioning of the electricity and gas markets, as well as EU Emission Trading System (ETS), etc.
- Electricity market regulation: basic legal principles, regulation of distribution and transmission networks, etc.
- Gas market regulations: entry-exit system, suppliers, trading, etc.
- Fundamentals of the oil market
- Prospective energy markets, e.g. hydrogen economy, ammonia economy
- German energy laws and regulations regarding the German Energy Transformation (Energiewende): Erneuerbare Energien Gesetz (EEG), Kraft Wärme Kopplungs Gesetz (KWKG), Gebäude Energie Gesetz (GEG), etc.
- Operational Energy Management according to ISO 50001

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Script, Lecture notes
Legal texts of the European Union: https://european-union.europa.eu/institutions-law-budget/law/types-legislation_en
Online-service: www.umwelt-online.de
ISO 50001: Energy management systems
German laws in the web: https://www.gesetze-im-internet.de/
IEA Reports www.iea.org

Internationalität (Inhaltlich)
Internationality

Treatment of International, European and German laws and regulations on energy, climate and environment as well as international regulations on energy management.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min / 100 %	Professional competence, methodological competence, personal competence

1.5 Project with Seminar (PWS)
Projekt mit Seminar

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Compulsory module	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Frank Späte	verschiedene Dozenten

Voraussetzungen*
Prerequisites

none

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Project, seminar	150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Depending on the respective offer
- **Methodological competence:** Apply and transfer skills and knowledge acquired during studies to new problems, application of project management: ability to plan, implement, evaluate and document projects as well as present project results.
- **Personal competence (social competence and self-competence):** Independently plan, carry out, evaluate and document experiments while meeting deadlines, recognize and improve one's own ability to work in a team.

Inhalte der Lehrveranstaltungen
Course Content

Depending on the respective offer
The project is carried out in the form guided self-study and supplemented by a final seminar.

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Depending on the respective offer (reference books, publications …)

Internationalität (Inhaltlich)
Internationality

Depending on the respective offer

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a) Method of Assessment		
Prüfungsform	**Art/Umfang inkl. Gewichtung**	**Zu prüfende Lernziele/Kompetenzen**
Module work	Project work / 100 %	Professional competence, methodological competence, personal competence

2. Elective modules

Seven elective modules totalling 35 ECTS must be completed. The elective modules are to be selected from a given range. Students are requested to choose via the noticeboard. The module descriptions of the elective modules available for selection can be found in the course catalogue or are made available as part of the selection procedure.

There is no legal claim to the offer and implementation of certain elective modules. The specialisations offered in the respective semester are announced in the study plan.

2.1 Wind and Hydropower (WHP)

Windenergie und Wasserkraft

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Stefan Beer	Prof. Dr. Stefan Beer, Prof. Dr. Andreas P. Weiß

Voraussetzungen*
Prerequisites

Basic in Thermodynamics: gas laws, First and Second Law of Thermodynamics, cycles, real gases – properties and applications
Basics in Fluid Mechanics: conservation of mass, energy and momentum, viscous and compressible flows, aerodynamic drag and lift
Basic in turbomachinery: basic working principle, velocity triangles and Euler equation, efficiency and power, operational behaviour

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Know and be able to apply the calculation principles for wind/hydro power plants/turbines and evaluate the results obtained.
- **Methodological competence:** Be able to plan and develop an overall concept for wind/hydropower utilisation based on the determined characteristic data for turbine and plant.
- **Personal competence (social competence and self-competence):** Be able to correctly allocate and connect knowledge and skills from foundation modules to derive and develop new solutions for practical engineering tasks.

Inhalte der Lehrveranstaltungen
Course Content

Hydropower plants (HPPs): history, potentials and types of HPPs, examples of international HPPs, physical basics (flow and head, calculation of power and efficiency, cavitation), basics of hydraulics and hydrology (measuring and processing data, calculation of discharge hydrographs and discharge duration curves), plant concepts, turbine designs and their selection (calculation of specific speed), control, main components of low- and high-pressure plants, environmental impacts and their compensation.

Wind turbines (WT): International history of wind energy use, worldwide wind potential, classification of wind turbines (WT), aerodynamic design, control of WT, mechanical loading of WT, concepts for energy conversion (mechanical-electrical) especially for variable speed turbines, overall concepts of on- and offshore turbines, small wind turbines, wind measurement technology and energy yield calculation, international regulations.

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

American Society of Mechanical Engineers, The Guide to Hydropower Mechanical Design, ISBN 9780965176507, 1996
Raabe J., Hydropower - The design, use, and function of hydromechan., hydraul., and electr. Equipment, VDI Verlag, 1989, ISBN 3184006166
Giesecke, Jürgen et al., Wasserkraftanlagen, Springer-Verlag 2014
Pardalos et al., Handbook of Wind Power Systems, Springer, 2013

Internationalität (Inhaltlich)
Internationality

Wind and hydropower are used worldwide. The world's largest hydropower plants are in South America and China. China and the USA are also strongly expanding wind energy. Even though Germany has well-known manufacturers of wind turbines and WTGs, their clientele can be found all over the world. This means that an engineer in these sectors is active internationally.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min / 100 %	Professional competence, methodological competence

2.2 Solar and Bioenergy (SBE)

Solar- und Bioenergie

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Frank Späte	Prof. Dr. Mario Mocker, Prof. Frank Späte

Voraussetzungen*
Prerequisites

Mathematics, physics, thermodynamics, heat and mass transfer, electrical engineering

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload	
	Seminar-based teaching, project	Lecture (4 SWS x 15 weeks) Self-study/project Preparation and follow-up, Examination preparation	= 60 h = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** The students have knowledge of solar thermal and photovoltaic energy systems. They know the most important bioenergy sources, their specific properties, the effects of their use and conversion technologies suitable for them. They can apply this knowledge and acquire the ability to analyse, assess and evaluate solar and biomass-based energy systems both individually and in combination in larger grid or hybrid systems. This also includes the dimensioning of the systems incl. economic and ecological aspects.
- **Methodological competence**: The students learn the methods for energetic evaluation of solar thermal, photovoltaic and biomass-based energy systems in a wide range of applications, including the necessary tools (e.g. formulas, software tools). They recognise the correlations and methods for plausibility assessment. They apply the methods in a project work and evaluate the results.
- **Personal competence (social competence and self-competence):** The students learn to work in a team and thereby independently work out correlations, assess, evaluate, document and present the results.

Inhalte der Lehrveranstaltungen
Course Content

Solar energy

- Solar thermal energy systems: Areas of application, physical relationships in radiation conversion / thermal network solar collector, characteristic curves, system concepts, hydraulics, planning and dimensioning, integration into or coupling with conventional systems for heat supply, installation and operation.
- Photovoltaic energy systems: solar cell technologies, solar modules and solar generators, inverters, planning and dimensioning, grid feed-in, self-consumption, stand-alone systems, energy and life cycle assessments, installation and operation
- Project as group work

Bioenergy

- Types and supply chains of important bioenergy sources
- Determination and assessment of energy carrier-specific properties
- Conversion processes with emphasis on the thermal processes pyrolysis, gasification and combustion.
- Mass and energy balances of conversion reactions
- Construction and design of established and innovative conversion plants
- Integration into sectoral and cross-sectoral energy systems for the provision of electricity, heating, cooling and mobility
- Pollutant formation and flue gas cleaning, residue utilisation

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Lecture Notes
John Duffie, William Beckman: Solar Engineering of Thermal Processes, John Wiley & Sons, 3. Edition, 2006
John Duffie, William Beckman, Nathan Blair: Solar Engineering of Thermal Processes, Photovoltaics and Wind, John Wiley & Sons, 5. Edition, 2020
Konrad Mertens: Photovoltaics, Wiley, 2018
Daniela Thrän (Ed.): Smart Bioenergy, Springer, 2015
Anju Dahiya, Bioenergy, Academic Press, 2015

Internationalität (Inhaltlich)
Internationality

Solar and bioenergy are used worldwide and are expanding rapidly in many countries, such as China, India, the USA and Europe.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Presentation	100 %	Professional competence, methodological competence

2.3 Digital and Integrated Energy Systems (DIS)

Digitale Energiesysteme und Sektorkopplung

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Raphael Lechner	Prof. Dr. Raphael Lechner

Voraussetzungen*
Prerequisites

Fundamentals of electric and thermal power engineering
Fundamentals of computer science
Fundamentals of renewable energy systems and combined heat and power generation

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises, field trip	Lecture (4 SWS x 15 weeks) = 60 h Self-study/project Preparation and follow-up, Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Overview of current developments in the field of digital and sectorally coupled energy systems and outlook on energy systems of the future.
- **Methodological competence:** The students learn to think in systems. They can assess the possibilities and limits of digitalisation and sector coupling in the energy sector and critically evaluate current and future developments.
- **Personal competence (social competence and self-competence):** The students have the necessary basic understanding to discuss concepts of digitalisation and sector coupling in energy supply in an interdisciplinary manner at specialist and management level.

Inhalte der Lehrveranstaltungen
Course Content

- Energy sectors and energy market design
- Measures to ensure system stability in the electrical grid
- Sector coupling technologies
- Multisectoral energy systems (integrated energy systems)
- Cellular approach
- Demand Side Management
- Protocols, data formats and communication standards for smart grids
- Smart Meter and IoT in energy technology
- Excercises und field trips

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Lecture notes

Buchholz, Bernd M.; Styczynski, Zbigniew A. (2020): Smart Grids. Fundamentals and Technologies in Electric Power Systems of the future. 2nd ed. 2020. Berlin, Heidelberg: Springer Berlin Heidelberg; Imprint: Springer.

Internationalität (Inhaltlich)
Internationality

International approaches to the digitalisation of the energy system

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min / 100 %	Professional competence, methodological competence

2.4 Energy Storage (EST)
Energiespeicher

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Raphael Lechner	Prof. Dr. Raphael Lechner

Voraussetzungen*
Prerequisites

Fundamentals of electrochemistry, mechanics and thermodynamics.
Fundamentals of electric power engineering and thermal power engineering.

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload	
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) Self-study/Projekt Preparation and follow-up, Examination preparation	= 60 h = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Understanding, selection, design and calculation of storage systems, which are essential for managing the global energy transition.
- **Methodological competence:** The students are able to critically and independently evaluate different storage and energy systems and assess the relevance of the selected systems for the respective application in terms of performance, costs and ecological impact.
- **Personal competence (social competence and self-competence):** The students are able to combine knowledge and skills from the basic modules to derive and develop new solutions. The have the competence to discuss issues related to energy storage in interdisciplinary working groups at expert and management level.

Inhalte der Lehrveranstaltungen
Course Content

- Electrical energy storage: mechanical, electrochemical and chemical storage
- Thermal energy storage: sensible and latent heat storage, thermochemical storage
- Isentropic and non-isentropic storage
- Energy management and flexible power generation with storage systems
- Selection and dimensioning of suitable storage technologies based on energy demand, load profile and required storage duration
- Economic and ecological assessment
- Excercises und field trips

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Lecture notes

Sterner, Michael; Stadler, Ingo: Handbook of Energy Storage. Demand, Technologies, Integration. Berlin, s.l.: Springer Berlin in the current edition.

Komarnicki, Przemyslaw; Lombardi, Pio; Styczynski, Zbigniew: Electric Energy Storage Systems. Flexibility Options for Smart Grids. Berlin, Heidelberg, s.l.: Springer Berlin Heidelberg in the current edition.

Internationalität (Inhaltlich)
Internationality

Energy storage and energy supply chains in an international context

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min / 100 %	Professional competence, methodological competence

2.5 Electrochemical Energy Converters and Hydrogen Technology (EEH)

Elektrochemische Energiewandler und Wasserstofftechnik

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Peter Kurzweil	Prof. Dr. Peter Kurzweil

Voraussetzungen*
Prerequisites

Basic knowledge of chemistry

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload	
	Seminar-based teaching, excercises, practical training	Lecture (4 SWS x 15 weeks) Self-study Preparation and follow-up, Examination preparation	= 60 h = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Understand the structure and functionality of electrochemical energy converters and evaluate their technical features, applications and materials.
- **Methodological competence:** Selecting and applying digital, electrochemical measurement techniques; apply relevant calculation methods.
- **Personal competence (social competence and self-competence):** Recognize and use chemistry as the basis of natural and technical processes; Carry out and evaluate practical measurements in a team.

Inhalte der Lehrveranstaltungen
Course Content

1. Basics of electrochemical energy storage
a. Electrochemical cells: electrode materials, separators, electrolytes, potentials and reference electrodes, redox processes, chemical thermodynamics, electrode kinetics, double layer.
b. Electrochemical measurement methods: charge-discharge characteristics, potentiometry, amperometry, conductometry, coulometry, transient methods, cyclic voltammetry, impedance spectroscopy, corrosion measurement, electrochemical sensors, insight into microsystem technology.
c. Electrochemical storage and converters: supercapacitors, batteries, fuel cells, hybrid systems, redox flow cells, electrolysis, electrolyte systems, photoelectrochemistry.

2. Systems and processes in electrochemical energy technology
a. Hydrogen generation from fossil and renewable sources, gas cleaning, hydrogen storage.
b. Properties and technical uses of hydrogen: Power-to-X applications, synthetic fuels, safety technology, futuristic applications.
c. Electrochemistry of the elements: industrial processes related to energy technology

3. Practical training
Measurement on electrochemical energy converters, programming of measuring devices, experiments with hydrogen.

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur Teaching Material / Reading
Script Encyclopedia of Electrochemical Power Sources, Elsevier Electrochemical Energy Storage, Mc Graw Hill
Internationalität (Inhaltlich) Internationality

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	**Art/Umfang inkl. Gewichtung**	**Zu prüfende Lernziele/Kompetenzen**
Written exam	60 min / 100 %	Professional competence, methodological competence

2.6 Energy Efficiency (EFF)
Energieeffizienz

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective Modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Markus Brautsch	Prof. Dr. Markus Brautsch

Voraussetzungen*
Prerequisites

Thermodynamics, Power Engineering

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, exercises, excursion	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:**
  Students are familiar with different processes and technologies for evaluating and improving energy efficiency. A distinction is made between methods for improving electrical and thermal energy efficiency in industry, commerce and households. They are able to perform independent efficiency calculations, CO2 balances (carbon footprint) and dimensioning of efficiency measures**.**
- **Methodological competence:**
  Students are able to conduct energy, environmental and economic assessments of energy efficiency systems. They are able to develop and present energy efficiency solutions for complex systems.
- **Personal competence (social competence and self-competence):**
  Students are able to work out, assess, discuss specific issues and apply case studies independently and in small groups. They present express their point of view in a presentation held freely presentations. The self-developed solutions will be verified by different field trips.

The contents of the course can be taught in presence and/or in virtual form.

Inhalte der Lehrveranstaltungen
Course Content

Basics of efficiency assessment: primary energy, secondary energy, final energy, useable energy. Key figures for efficiency evaluation. Energy efficiency classes of appliances and machines. Methods for increasing energy efficiency in industry, commerce and households. Heat recovery and waste heat utilization. Cross-sectional technologies. Economic efficiency considerations, CO2 accounting, case studies.
The contents of the course can be taught in presence and/or in virtual form.

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Martínez, D.M.; Ebenhack, B.W., Wagner, T.P.: Energy Efficiency – Concepts and Calculations. Elsevier 2018. ISBN 978-0-12-812111-5
International Energy Agency (IEA): Energy Efficiency 20xx. Yearly update on global developments in energy efficiency (https://www.iea.org/)
German Federal Ministry for Economic Affairs and Energy (BMWi): Green Paper on Energy Efficiency. September 2016.

Internationalität (Inhaltlich)
Internationality

European and international framework for energy efficiency

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min / 100 %	Professional competence, methodological competence

2.7 Sustainable Building Technology (SBT)

Nachhaltige Gebäudetechnik

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Frank Späte	Prof. Dr. Gerald Pirkl, Prof. Frank Späte

Voraussetzungen*
Prerequisites

Mathematics, physics, thermodynamics, heat and mass transfer, electrical engineering, programming (Python)

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, project	Lecture (4 SWS x 15 weeks) = 60 h Self-study/project Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Students have knowledge of sustainable building technology such as heating, ventilation and cooling systems. They can apply this knowledge and acquire the ability to analyse, assess and evaluate these systems both individually and in interaction with the building envelope. This also includes the dimensioning of the systems incl. economic and ecological aspects.
- **Methodological competence**: Students learn the methods for evaluating technical building systems. They identify the correlations and methods for plausibility assessment. They apply the methods in a project study work and interpret the results.
- **Personal competence (social competence and self-competence):** The students learn to work in a team and thereby develop correlations, assess, evaluate, document and present the results.

Inhalte der Lehrveranstaltungen
Course Content

- Heating, ventilation and cooling systems: Areas of application, physical relationships, system concepts, hydraulics, planning and dimensioning, integration into buildings as well as existing building technology, installation and operation.
- Communication structures (bus systems, centralised / decentralised control of devices)
- Example of bus system (KNX or similar, components, addressing and control options)
- Sensor-based status detection (device status, presence of persons, activities)
- Prediction models for electricity consumption and generation
- Project study work "Climate-neutral buildings": Implementation of a project in a group work

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Ursula Eicker: Low Energy Cooling for Sustainable Buildings, Wiley, 2009
John W. Mitchell, James E. Braun: Principles of Heating, Ventilation and Air Conditioning in Buildings, Wiley, 2012
EN 18599: Energy efficiency of buildings - Calculation of the net, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting

Internationalität (Inhaltlich)
Internationality

Buildings are the largest energy consumer worldwide and therefore eminently important with regard to climate protection. Climate-neutral buildings are a global issue.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Presentation	100 %	Professional competence, methodological competence

2.8 Advanced Heat Power Cycles (HPC)

Fortschrittliche Thermische Energiewandlungssysteme

Zuordnung zum Curriculum Classification	**Modul-ID** Module ID	**Art des Moduls** Kind of Module	**Umfang in ECTS-Leistungspunkte** Number of Credits
		Elective modul	5

Ort Location	**Sprache** Language	**Dauer des Moduls** Duration of Module	**Vorlesungsrhythmus** Frequency of Module	**Max. Teilnehmerzahl** Max. Number of Participants
Amberg	English	1 semester	yearly/summer semester	50

Modulverantwortliche(r) Module Convenor	**Dozent/In** Professor / Lecturer
Prof. Dr. Andreas P. Weiß	Prof. Dr. Marco Taschek, Prof. Dr. Andreas P. Weiß

Voraussetzungen* Prerequisites

Basic in Thermodynamics: gas laws, First and Second Law of Thermodynamics, cycles, real gases – properties and applications
Basics in Fluid Mechanics: conservation of mass, energy and momentum, viscous and compressible flows, basics of turbomachinery

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	**Lehrformen** Teaching Methods	**Arbeitspensum** Workload
	Seminar-based teaching, practical training	Lecture (4 SWS x 15 weeks) = 60 h Self-study/Projekt Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Knowledge, understanding and ability to thermodynamic and fluid mechanical modelling of advanced and novel cycle and plant concepts for sustainable, climate-neutral energy supply and storage (electricity, heat, cooling). Selection and calculation of suitable power and working machines.
- **Methodological competence:** Select and combine the appropriate, learned calculation and design methods for thermal systems for energy conversion and storage in order to be able to analyze, assess and classify them independently.
- **Personal competence (social competence and self-competence):** Be able to correctly allocate and combine gained knowledge and skills in order to independently derive and develop new solutions for practical engineering tasks. Independent organisation and implementation of engineering tasks (internship) in a team - in cooperation with other international teams in order to achieve the (internship) goal together.

Inhalte der Lehrveranstaltungen
Course Content

- History and importance of thermal machines and plants such as power plants, engines, gas turbines, heat pumps, etc.
- Design, function and calculation of advanced (combined) gas turbine processes e.g. hydrogen fired
- Design, function and calculation of advanced (combined) Rankine power processes e.g. in geothermal energy, solar thermal energy or for waste heat power generation
- Design, function and calculation of advanced chiller/heat pump processes
- Design, function and calculation of advanced combination processes/plant for thermal storage of electrical energy (Carnot battery, P2H2P = Power-to-Heat-to-Power)
- Basic principle of turbomachines, velocity triangles, Euler equation, power and efficiency
- Basic principle of positive displacement machines, design, power and efficiency
- Types of turbines, engines, pumps, blowers and compressors, their operating behaviour and limits

The contents of the course can be taught in presence and/or in virtual form. Attendance is compulsory for the practical training.

Lehrmaterial / Literatur
Teaching Material / Reading

Pauken M., Thermodynamics for Dummies, ISBN 1118002911, http://site.ebrary.com/lib/academiccompletetitles/home.action
DiPippo R., Geothermal power plants - Principles, applications, case studies and environmental impact, ISBN 9780081008799
Macchi E., Organic Rankine Cycle (ORC) Power Systems [electronic resource], ISBN 978-0081005101
Tanuma T., Advances in steam turbines for modern power plants, ISBN 9780081003145
Wilson D. G., The Design of High-Efficiency Turbomachinery and Gas Turbines, ISBN 0-262-23114-X
Heywood J.B. Internal Combustion Engine Fundamentals, ISBN 0-07-100499-8

Internationalität (Inhaltlich)
Internationality

Energy and power plant technology was already a completely international industry in the 20th century. The challenges of the energy transition and climate change will force international cooperation all the more in the future. Young engineers therefore have the opportunity and are required to work internationally, regardless of their nationality and mother tongue.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam Module work	90 min / 75 % Practical training report / 25 %	Professional competence, methodological competence, personal competence

2.9 Plant and Equipment Design in Energy Technology (PED)

Anlagen- und Apparatebau in der Energietechnik

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective module	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Werner Prell	Prof. Dr. Werner Prell

Voraussetzungen*
Prerequisites

Process engineering, fluid mechanics, thermodynamics, heat and mass transfer, engineering mechanics, design, materials engineering

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Availability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises, practical training	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Students acquire the ability to plan projects efficiently and to work through them in a structured and cost-oriented manner. They get to know the most important materials and plant components and can therefore select and design equipment such as pumps, compressors or heat exchangers specifically for special purposes, as well as pipelines and fittings in order to link the individual equipment sensibly into a functional system.
- **Methodological competence:** Recording, describing, designing and optimising processes and procedures. Transferring laboratory results to technical problems in order to solve them. Critical evaluation of experimental and calculation results as well as plant data and other process information.
- **Personal competence (social competence and self-competence):** Independently plan, carry out and evaluate experiments while adhering to deadlines. Recognising and improving of students own ability to work in a team when working in small groups.

Inhalte der Lehrveranstaltungen
Course Content

- Basics of project management and project planning
- Unit cost and investment calculation
- Understanding and drawing of flow sheets
- Materials and their applications
- Apparatus (pumps, compressors, vacuum pumps, heat exchangers)
- Piping and fittings

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

- Lecture notes (including additional literature references)
- Sattler; Kasper: Verfahrenstechnische Anlagen – Planung, Bau und Betrieb; Wiley VCH Verlag 2000
- Klapp: Apparate- und Anlagentechnik; Springer-Verlag 2002
- Hirschberg: Verfahrenstechnik und Anlagenbau; Springer-Verlag 1999
- Thier: Apparate; Vulkan-Verlag 1997-Böge: Handbuch Maschinenbau; Springer-Vieweg 2015

Internationalität (Inhaltlich)
Internationality

Modulprüfung (ggf. Hinweis zu Multiple Choice -APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	60 min / 100 %	Professional competence, methodological competence

2.10 Concepts of Combined Heat, Power and Cooling (CHPC)

Konzepte der Kraft-Wärme-Kälte-Kopplung

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Markus Brautsch	Prof. Dr. Markus Brautsch; Prof. Dr. Marco Taschek

Voraussetzungen*
Prerequisites

Thermodynamics, Energy Technology

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Availability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:**
  The students know different processes and technologies of combined heat, power and cooling as well as renewable and conventional energy sources as input. They are able to perform independent efficiency calculations, CO2 balances and dimensioning for industrial, municipal and commercial applications, also in sectorally coupled systems.
- **Methodological competence:**
  Students are able to perform energy, environmental and economic assessments of CHP systems with conventional and renewable energy systems. They are able to identify different application fields of CHP and develop complex solutions.
- **Personal competence (social competence and self-competence):**
  Students are able to work out, assess, discuss specific issues and application cases independently in small groups. They will present their point of view in a freely held talk.

Inhalte der Lehrveranstaltungen
Course Content

Energy sources of CHP; processes of CHP; prime movers, heat exchangers, absorption and adsorption chillers, thermodynamic parameters; methods of economic analysis; CO2 balancing; allocation methods; dimensioning of CHP systems; sector coupling; application examples from industry and residential construction

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Pauken M., Thermodynamics for Dummies, ISBN 1118002911, http://site.ebrary.com/lib/academiccompletetitles/home.action
Whitman, M., Thermodynamics: Basic Principles and Engineering Applications, ISBN 978-3-030-25221-2
Badea N., Design for Micro-Combined Cooling, Heating and Power Systems, ISBN 978-1-4471-6253-7
Bartnik R., Bryn Z., Hnydiuk-Stefan A., Investment Strategy in Heating and CHP, ISBN 978-3-319-61023-8
Cogen Europe, The European Association for the Promotion of Cogeneration. http://www.cogeneurope.eu

Internationalität (Inhaltlich)
Internationality

Deployment of CHP in the EU and China. Deployment of CHP in hybrid grids.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam	90 min / 100 %	Professional competence, methodological competence

2.11 Sustainable Mobility (SMO)
Nachhaltige Mobilität

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Marco Taschek	Prof. Dr. Andreas P. Weiß, Prof. Dr. Marco Taschek

Voraussetzungen*
Prerequisites

Fundamentals of thermodynamics, fundamentals of fluid mechanics, fundamentals of electrical engineering, thermal machines and systems.

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Availability	Lehrformen Teaching Methods	Arbeitspensum Workload
	Seminar-based teaching	Lecture (4 SWS x 15 weeks) = 60 h Self-study Preparation and follow-up Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Knowledge, understanding and ability to analyze and evaluate advanced and novel drives and propulsion systems for sustainable, climate-neutral mobility (transportation and individual traffic). Selection and calculation of suitable propulsion systems for different applications.
- **Methodological competence:** Selecting and combining the appropriate, learned calculation and design methods for sustainable drive systems to be able to analyze, evaluate and classify them independently.
- **Personal competence (social competence and self-competence**): Correctly allocate and combine knowledge and skills from basic modules in the bachelor's degree program to independently derive and develop new solutions for given engineering tasks.

Inhalte der Lehrveranstaltungen
Course Content

- History and significance of mobility for the individual, society and the economy.
- Energy sources and energy storage for drive systems.
- Energy and pollutant balancing of propulsion systems
- Structure, function, conception of advanced propulsion systems for air vehicles
- Structure, function, conception of advanced propulsion systems for water vehicles
- Structure, function, conception of advanced propulsion systems for land vehicles
- Advanced mobility concepts

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Wilson D. G., The Design of High-Efficiency Turbomachinery and Gas Turbines, ISBN 0-262-23114-X
Heywood J. B., Internal Combustion Engine Fundamentals, ISBN 0-07-100499-8
J. Liebl, Der Antrieb von morgen 2019, ISBN 978-3-658-26056-9 (Artikel im Buch in English)
Achenbach W. Hilgers M., Fuel Consumption and Consumption Optimization ISBN 978-3-662-60841-8
Ehsani M., Wang F., Brosch G. L., Transportation Technologies for Sustainability, ISBN 978-1-4614-5843-2
Biancolini, M. E., Cella U.,Flexible Engineering Toward Green Aircraft ISBN 978-3-030-36513-4
Friedemann, A. J. When Trucks Stop Running Energy and the Future of Transportation, ISBN 978-3-319-26373-1
Palocz-Andresen M., Decreasing Fuel Consumption and Exhaust Gas Emissions in Transportation,
Platzer, M. F., Srigul-Klijn N., The Green Energy Ship Concept, ISBN 978-3-030-58243-2
Sulaiman, S. A., Energy Efficiency in Mobility Systems, ISBN 978-981-15-0101-2

Internationalität (Inhaltlich)
Internationality

Mobility is worldwide a basic social need, it allows international trade and makes international cooperation possible. However, since negative environmental impacts and pollutants are also mobile, it is important to convey a global understanding of the importance of sustainable mobility in the various areas. In the course young engineers have the opportunity to work internationally, regardless of their nationality and mother tongue.

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Written exam Module work	60 min / 100 % Term paper	Professional competence, methodological competence

2.12 Methods of Life Cycle Assessment (LCA)

Methoden der Ökobilanzierung

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Burkhard Berninger	Prof. Dr. Burkhard Berninger

Voraussetzungen*
Prerequisites

none

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) = 60 h Preparation and follow-up Self-study Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Knowledge of the environmental relevance of industrial processes and products. Knowledge of the environmentally relevant properties of products. Knowledge of the basic assessment methods of the environmental properties of products (life cycle assessments, environmental product declarations, eco-labels).
- **Methodological competence:** Independent assessment of the environmental impact of industrial production processes and products. Development and application of assessment criteria. Development of a rough concept for a product life cycle assessment. Product evaluation using expert software. Qualified evaluation of the results obtained.
- **Personal competence (social competence and self-competence):** Developing solutions to problems through interdisciplinary thinking. Self-organisation in the planning and implementation of projects in working life. Cooperation in a team within the framework of practical exercises.

Inhalte der Lehrveranstaltungen
Course Content

Creation of environmental burdens in production processes, especially energy consumption and efficiency
Criteria for energy- and resource-efficient product design
Comprehensive assessment methods (technology assessment according to VDI 3780, sustainability assessment according to VDI 4605)
Life cycle assessment: methodology, calculation models for impact assessment, regulations (ISO 14040 / 14044)
Product carbon footprint, product environmental declarations and labelling
Independent preparation of a life cycle assessment for a simple product using an expert software (e.g. GaBi, ecoinvent, openLCA)

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Script, lecture notes, internship guide
VDI 2243: Recycling-oriented product development
VDI 3780: Technology assessment - Concepts and foundations
VDI 4605: Evaluation of sustainability
ISO 14040 und 14044: Life cycle assessment — Requirements and guidelines
Ressource Germany (VDI Zentrum Ressourceneffzienz) :https://www.resource-germany.com

Internationalität (Inhaltlich)
Internationality

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Module work	Term paper / 100 %	Professional competence, methodological competence, personal competence

2.13 Energy Management with AI-Methods (EAI)

Energiemanagement mit KI-Methoden

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Elective modul	5

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English	1 semester	yearly/winter semester	50

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Dr. Raphael Lechner	Prof. Dr. Raphael Lechner

Voraussetzungen*
Prerequisites

Fundamentals of mathematics incl. linear equations
Fundamentals of computer science, procedural and object-oriented programming, data types
Fundamentals of electric and thermal power engineering

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
	Seminar-based teaching, excercises	Lecture (4 SWS x 15 weeks) = 60 h Preparation and follow-up Self-study Examination preparation = 90 h = 150 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:** Basic knowledge in the use of scripting languages (Python) for data analysis, energy system modelling and simulation and data forecasting.
- **Methodological competence:** The students learn methods for the analysis and interpretation of energy-relevant data. They understand the basic principles of energy system modelling and can transfer the knowledge to practical problems. They can critically evaluate the results.
- **Personal competence (social competence and self-competence):** The students can combine knowledge and skills from energy and information technology to develop new solutions. They have the necessary basic understanding to discuss topics of energy data analysis and energy system modelling in an interdisciplinary way.

Inhalte der Lehrveranstaltungen
Course Content

- Introduction to programming with Python for data analysis and modelling
- Visualisation and analysis of energy data
- Time series analysis
- Modelling and simulation of energy systems
- Forecasts using machine learning
- Scheduling of power generation units
- Exercises and term paper

The contents of the course can be taught in presence and/or in virtual form.

Lehrmaterial / Literatur
Teaching Material / Reading

Lecture notes

Nagel, Jane (2019): Optimization of Energy Supply Systems. Modelling, Programming and Analysis. Cham: Springer International Publishing (Lecture Notes in Energy, 69).

Internationalität (Inhaltlich)
Internationality

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a)
Method of Assessment

Prüfungsform	Art/Umfang inkl. Gewichtung	Zu prüfende Lernziele/Kompetenzen
Module work	Seminar paper / 100 %	Professional competence, methodological competence

3. Master Thesis (MT)

Master Thesis
Masterarbeit

Zuordnung zum Curriculum Classification	Modul-ID Module ID	Art des Moduls Kind of Module	Umfang in ECTS-Leistungspunkte Number of Credits
		Master thesis	30

Ort Location	Sprache Language	Dauer des Moduls Duration of Module	Vorlesungsrhythmus Frequency of Module	Max. Teilnehmerzahl Max. Number of Participants
Amberg	English		every semester	1

Modulverantwortliche(r) Module Convenor	Dozent/In Professor / Lecturer
Prof. Frank Späte	various

Voraussetzungen*
Prerequisites

50 ECTS from the present course of study in the current Master's degree programme

***Note: Please also observe the prerequisites according to examination regulations law in the current version of the SPO**

Verwendbarkeit Usability	Lehrformen Teaching Methods	Workload
		900 h

Lernziele / Qualifikationen des Moduls
Learning Outcomes

After completing this module successfully, students will have the following professional, methodological and personal competences:

- **Professional competence:**
  Depending on the respective topic
- **Methodological competence:**
  Apply and transfer skills and knowledge acquired during studies to new problems.
  Application of project management: ability to plan, implement, evaluate and document projects
  Presentation of project results
- **Personal competence (social competence and self-competence):**
  Independently plan, implement, evaluate and document project activities and results while meeting deadlines

Inhalte der Lehrveranstaltungen
Course Content

Depending on the respective offer

Lehrmaterial / Literatur
Teaching Material / Reading

Depending on the respective offer (reference books, publications, ...)

Internationalität (Inhaltlich)
Internationality

Modulprüfung (ggf. Hinweis zu Multiple Choice - APO §9a) Method of Assessment		
Prüfungsform	**Art/Umfang inkl. Gewichtung**	**Zu prüfende Lernziele/Kompetenzen**
Master thesis	Written elaboration / 100 %	Professional competence, methodological competence, personal competence

Update directory

Aktualisierungsverzeichnis

Nr	Reason	Date
0	Source document	16.06.2021
1	1.4 International Energy Law and Energy Economics: Modul conventer Prof. Frank Späte (instead of Prof. Dr. Berninger), Lecturer Prof. Späte and Prof. Dr. Lechner (instead of Prof. Dr. Berninger)	16.11.2021
2	1.4 International Energy Law and Energy Economics: Change in the items "Course Content", "Teaching Material" and "Internationality"	27.01.2022
3	2.13 Energy Management with AI-Methods: Change in the item "Method of Assessment" Previous: Written exam 70 %, Seminar paper 30 % Modified: Seminar paper 100 %	07.07.2022
4		
5		
6		