

# Module Handbook

## WS 2026/27

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Energy Systems and Renewable Energies

Bachelor

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Faculty of Mechanical Engineering

Study and examination regulation: WS 2021/22

as of: 2026-07-06

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# 1 Overview

|                          |                                                   |
|--------------------------|---------------------------------------------------|
| Name of the study course | Energy Systems and Renewable Energies             |
| Degree & type of program | Bachelor of Engineering (B.Eng.); fulltime course |
| First start of program   | October 1, 2021                                   |
| Programme duration       | 7 semesters (210 ECTS, 150 SWS)                   |
| Place of study           | THI Ingolstadt                                    |
| Teaching Language        | English                                           |

## Academic Director:

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## 2 Introduction

## 2.1 Objective of the course

The Energy Systems and Renewable Energies degree program aims to provide an education based on scientific knowledge and methods through practice - oriented teaching, which enables students to work independently as engineers in the field of energy systems/energy technology.

Students will be able to develop, design and implement future - oriented products and services in an international environment with a responsible and sustainable use of resources.

In addition, the program promotes personal development, cooperation in international teams in which English is the language of communication and the ability to work in a multicultural environment.

Social and methodological skills are taught in addition to technical skills in order to promote personal development and leadership qualities.

The social skills acquired in internships, seminars or the project enable students to work as part of a team or lead a project group.

In view of the breadth and diversity of the field of energy systems/energy technology, students are to be enabled to quickly familiarise themselves with one of the numerous fields of application through comprehensive training in the basic subjects.

In the course of their studies, students learn in detail about different systems, such as building energy systems and industrial supply systems, the various regenerative energy sources, the corresponding energy technology, new concepts for mobility, the networking of all areas from generation to consumption as well as the economic assessment of energy supply concepts. Special areas such as Artificial Intelligence are also integrated into several subjects in the curriculum.

International aspects also prepare and enable students to face the increasingly global challenges and demands and also to hold their own in global markets.

The completed bachelor's program also provides the basis for further academic qualification in a subsequent master's program.

Graduates of the course are prepared for specialist and managerial tasks in the following areas:

- Sustainable energy generation and distribution
- Development, production and operation of energy technology plants and energy systems
- Planning of energy systems and energy consulting
- In Germany and worldwide, as multipliers, so to speak, who make a contribution to global activities against the climate crisis with their acquired knowledge and skills

**Description of the program / Contents:**

Limiting climate change is one of the biggest worldwide challenges of the 21<sup>st</sup> century. Implementing smart, integrated energy solutions and developing new and clean technologies helps meeting this key objective.

Therefore there is a need for engineers specialized on Energy Systems and Renewable Energies and the integration of these technologies in the energy system.

The Bachelor “Energy Systems and Renewable Energies” meets these demands. This bachelor is taught in English and welcomes both German and international students.

**Main Contents:**

- Specialized contents in renewable energies with high practical orientation
- Science Fundamentals like Thermodynamics, Mechanics, Fluid-Mechanics, Electrical Engineering
- Fundamentals of Mechanical Engineering: Mechanical Design, CAD, Material Science, Product Development
- Energy Fundamentals (Generation): Solar Energy, Wind Energy, Hydro Energy, Biomass, Geothermal Energy
- Energy Systems: Smart Cities, Industry Supply Systems, Smart Buildings; Energy Markets, Sector Coupling, Artificial intelligence
- Actuators in Energy Systems: Combined Heat and Power Plants, Heat Pumps, Batteries, Fuel Cells
- New energy carriers and conversions: E-Mobility, Biomethane, Hydrogen, Power to Gas, Power to Heat

At the same time, the students acquire the ability to carry out economic assessments of energy supply concepts in order to prepare investment decisions. These economic analyses together with the knowledge of entrepreneurship enable them to found and/or lead a company.

As a student, you will get an insight into various methods of digital engineering. You will use 3D-CAD (computer-aided design) software for mechanical design. You will learn to simulate thermodynamic and fluid dynamic processes, energy-technical plants and energy systems with commercial simulation tools.

All these innovative contents will allow the student to understand complex energy systems in an international context. This is the backbone needed for solving the demanding challenges of future Energy systems.

## 2.2 Admission Requirements

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

- Study and examination regulations for the Bachelor study course Energy Systems and Renewable Energies (SPO ESYS)
- General Examination Regulations (APO) of Technische Hochschule Ingolstadt
- Matriculation Regulations of Technische Hochschule Ingolstadt.

In addition, the study program requires practical training or a preparatory internship. The duration for the required training at the Faculty of Mechanical Engineering is specified in accordance with §9 of the THI Matriculation Regulation and has to be completed either before the start of the study course or at the latest before the start of the 4<sup>th</sup> Semester (completion during the semester breaks).



## 2.3 Target Group

The course of study addresses:

- People interested in sustainable energy generation, energy supply and energy consulting and who intend to work in these fields
- People that want to contribute to counteracting climate change
- People with technical and scientific interests

## 2.4 Structure of the course

The standard period of study is seven semesters. The course breaks down into two phases. The first study phase comprises two theoretical semesters. The second study phase comprises four theoretical semesters and one internship semester, which is the fifth semester of study. From the sixth semester onward, the curriculum allows for individual customization and specialization by taking a total of three elective courses. These are described in a cross-program module handbook.

The following chart represents the course of study graphically:

|                                           |                                     |                                            |
|-------------------------------------------|-------------------------------------|--------------------------------------------|
| <b>1. Semester</b>                        |                                     |                                            |
| Engineering Mathematics 1                 | Computer Science in Engineering     | Basics of Mechanical Design                |
| Statics                                   | Electrical Engineering              | Energy Systems and Energy Economics        |
| <b>2. Semester</b>                        |                                     |                                            |
| Engineering Mathematics 2                 | Material Science                    | Mechanics of Materials                     |
| Thermodynamics 1                          | Energy Storage                      | Entrepreneurship and Sustainability        |
| <b>3. Semester</b>                        |                                     |                                            |
| Product Development and CAD               | Measurement Engineering             | Machine Elements                           |
| Thermodynamics 2                          | Fluid Mechanics                     | Thermal Energy Technology and Power Plants |
| <b>4. Semester</b>                        |                                     |                                            |
| Project Design and Development            | Control Engineering                 | Energy Distribution and CHP Plants         |
| Building Technology and Smart Homes       | Solar Energy Technologies           | Cost and Investment Management             |
| <b>5. Semester</b>                        |                                     |                                            |
| Practical Seminar                         | Internship                          | Project and Quality Management             |
| <b>6. Semester</b>                        |                                     |                                            |
| Project                                   | Elective                            | Elective                                   |
| Solar Buildings and Energy Consulting     | Energy Markets and Coupling Sectors | Smart Grids and Wind Energy                |
| <b>7. Semester</b>                        |                                     |                                            |
| Elective                                  | Bachelor's Thesis and Seminar       |                                            |
| Energy from Biomass and Biogenic Residues | Mobility within the Energy System   |                                            |

## 2.5 Advancement prerequisites

The following advancement prerequisites must be met (see SPO and APO for further details):

- Only those students who have acquired at least 42 ECTS credits from the modules of the first program phase are entitled to enter the second phase.
- Only those students who have achieved at least “sufficient” as a grade in all examinations and have acquired all relevant course-related credits of the first study section and have earned at least 20 ECTS credits from the compulsory modules of the second study phase are entitled to enter the internship as part of the practical semester.

## 2.6 Conception and Advisory Board

The course was developed, among other things, on the basis of discussions with company representatives, whose requirements were particularly taken into account. The alignment of the course with a focus on energy systems and renewable energies, including a high level of practical relevance, digitization and entrepreneurship resulting in a mix of subjects, arose not only because of the relevance of these topics for the economy but also for global development.

The training is intended to enable our bachelor's graduates to be the driving force in companies when it comes to tackling future challenges.

### 3 Qualification profile

### 3.1 Concept

Upon completion of their studies, students will have a wide range of knowledge of power engineering technologies - with a high level of practical applicability - as well as good business contacts to the industry and the opportunity to gain international experience.

During their studies, students acquire deeper knowledge in a range of different systems such as building energy systems, off-grid systems, industry supply systems and energy systems in general. The related energy sources are solar power, biomass, wind power and geothermal energy. The course also covers other important fields of studies such as cogeneration technology, heat pumps and energy storage systems for controlling energy generation and consumption capacities. As part of these different modules, the mechanical and electrical engineering aspects that were introduced in the first semesters are specifically deepened.

In addition, new concepts for mobility (e-mobility, biomethane, power to gas - hydrogen and methane) are part of the curriculum. These new concepts lead to additional energy consumers that need to be efficiently integrated into the overall energy system. It is to be expected that in the future it will be possible to increasingly supply heat and cold sinks using heat pump systems, power to heat, solar heat and absorption chillers or renewable gases. In this context, students learn the skillfull use of these technologies and their flexibility potential for the integration of fluctuating renewable energies such as wind and sun.

In the “Energy Systems and Renewable Energies” course, one focus is on the integration and interaction within all areas from energy generation to consumption. Therefore, intelligent physical energy distribution (SmartGrids, heating networks, gas networks, digitization of communication) and virtual energy trading on the individual energy markets also play an important role.

At the same time, the students acquire the ability to carry out economic assessments of energy supply concepts in order to prepare investment decisions. These economic analyses together with the knowledge of entrepreneurship enables them to found and/or lead a company.

Students get an insight into various methods of digital engineering. They will use 3D-CAD (computer-aided design) software for mechanical design. They will learn to simulate thermodynamic and fluid dynamic processes, energy-technical plants and energy systems with commercial simulation tools, because the integration of different energy systems requires a high degree of digitization.

Therefore, graduates of the course are prepared for specialist and managerial tasks in various areas of energy systems and renewable energies. They take their social responsibility actively in their actions and help to shape a sustainable future and limiting climate change.

## 3.2 Study Objective

### 3.2.1 Specialist skills of the course

The following specialist skills are acquired:

- Knowledge of the basic contents of renewable energies and energy systems
- Knowledge of situational and relevant behavior in practice
- Selected skills in renewable energies and energy systems
- Capability to work scientifically as an engineer by applying basic engineering methods
- Selected skills in different methods of digitization
- Ability to apply and prove the basics learned during a semester-accompanying project as well as in the practical semester
- Opportunity to build on academic education with a Master's program
- Ability to plan and coordinate and carry out interdisciplinary projects on a budget, applying methods of modern quality management and recognizing potential for entrepreneurship



### 3.2.2 Interdisciplinary skills of the course

The following interdisciplinary skills are of particular importance for the study course:

Methodological Competences, Social- and Personal skills:

- Apply knowledge of basic principles of scientific work
- Being able to analyse problems and to recognize interdisciplinary correlations
- Apply engineering-scientific knowledge and methodologies in solving practical problems; evaluate solutions technically and economically and prepare decision memos
- Being able to solve tasks in small groups, while communicating and explaining professionally
- Familiarize yourself independently and in a team with defined topics and discuss them professionally
- Manage effectively areas of responsibility assigned to you and recognize connections with and impact on similar and subsequent areas of responsibility
- Develop methodological and social skills in areas such as teamwork, teambuilding, communication skills, project- and time management
- Communicate and present results
- Apply analytical and solution-oriented thinking skills to complex issues
- To shape their actions in the context of social processes in a critical, reflective and responsible manner with regard to a sustainable, climate-friendly future

### 3.2.3 Examination concept of the course

The examinations are based on the defined competences and the desired learning outcomes of a module, whose successful imparting will be checked.

The imparting of the basic knowledge is essential, especially in the basic subjects. In these fields it is important to check the extend to which the participants have mastered this broad knowledge by testing this as comprehensively as possible. Particularly suitable for this are written and oral examinations.

In the specializing subjects of the degree the focus is on imparting current specialist knowledge and its application in practice, as well as improving interdisciplinary skills. Especially suitable for this are examinations hold in terms of seminar- and term papers and project theses.

### 3.2.4 Application of the study course

When the course curriculum was drafted, the aspect of practical application was given a high priority.

The development of the course took place in alignment with practical relevance of the topics. There is an interdisciplinary transfer of skills including applicational reference. During the study program projects with a focus on practical experience and transfer take place. Bachelor thesis topics originate from professional practices or practical research.

### 3.2.5 Contribution of individual modules to the course objectives

In the compulsory modules, the course imparts mathematical, scientific and engineering expertise with subjects such as engineering mathematics, statics, mechanics of materials, basics of mechanical design, material science, computer science and digitization in engineering, thermodynamics, basics of electrical engineering and electronics, methods of product development and CAD, as well as basic business-management content with subjects such as cost and investment management and a project for the organization and establishment of sustainable businesses.

The students acquire expertise in the field of energy systems and renewable energies in energy-specific subjects such as "Energy Systems and Energy Economics", "Energy Storage", "Thermal Energy Technology and Power Plants", "Energy Distribution and CHP Plants", "Building Technology and Smart Homes", "Solar Energy Technologies" etc.

By working on projects (sustainability and entrepreneurship, project design and development, engineering project in the 6th semester) in small groups as well as in the internship and in the bachelor thesis, the students acquire both methodological, social and personal skills.

**Methodological skills:** On the basis of selected case studies and practical tasks the students expand their methodological skills. This enables the students, among other things, to present skillfully, to structure processes and to carry out projects successfully. They have the ability to acquire new knowledge independently. They will learn to plan, coordinate and carry out projects on a budget in an interdisciplinary manner and to apply methods of modern quality management.

**Social skills:** In small groups, the students not only strengthen their communication and teamwork skills, but also their ability to deal with conflicts. During regular attendance periods, as well as independent of time and location students will work collaboratively on complex topics and problems. They are used to giving and receiving constructive feedback. The students embed their specialist knowledge in an interdisciplinary context and also build up an extensive network from which they benefit beyond their studies.

**Personal skills:** The students are open to new ideas, pursue their goals persistently and with determination. Even under a heavy workload, they can set priorities, delegate tasks and make and enforce decisions courageously. The students question facts critically and reflect on their own actions with a view to their social responsibility.

### 3.3 Job profiles

The demand for qualified specialists in the field of energy systems in general and in the area of renewable energy forms in particular is enormous, as there is currently a lack of suitably qualified experts.

The graduates future fields of activity focus on the following sectors:

- Solar energy/ bio-energy /building energy/wind power
- Energy system technology, energy consulting and planning
- Graduates with a degree in energy technology are sought wherever energy is generated, stored and used – nowadays in all industries and companies
- All companies and local authorities as well as private and public institutions that pursue a sustainability strategy and/or want to become CO<sub>2</sub>-neutral

Graduates of the course are prepared for specialist and managerial tasks in the following areas:

- Sustainable energy generation and distribution
- Development, production and operation of energy technology plants and energy systems
- Planning of energy systems and energy consulting
- In Germany and worldwide, as multipliers, so to speak, who make a contribution to global activities against the climate crisis with their acquired knowledge and skills

Common career paths include recruitment by energy supply companies, jobs in the industry or with engineering service providers or planning offices, as well as the job profile of an independent consultant. In addition, it is not uncommon for graduates to find employment in medium-sized companies or official bodies

## 4 Dual Studies

A dual degree is not possible in this degree program.

**5      Description of Modules**

## 5.1 Compulsory subjects



| Engineering Mathematics 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                    |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | EMath1_ESYS                                        | SPO-No.:           | 1                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Programme                                          | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Energy Systems and Renewable Energies              | Compulsory Subject | 1                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Language of instruction                            | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | English                                            | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Horak, Jiri                                        |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Salamat, Babak                                     |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5 ECTS / 5 SWS                                     |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Contact hours                                      | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Self-study                                         | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Total                                              | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Engineering Mathematics 1 (EMath1_ESYS)            |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | SU/Ü - lecture with integrated exercises           |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | schrP120 - written exam, 120 minutes (EMath1_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | None                                               |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                    |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                    |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>develop their ability to recognize which questions in engineering can be answered using mathematics and can ask such questions themselves.</li><li>understand logical reasoning, recognize condition, consequence and rule, and can build a chain of reasoning in the context of engineering applications.</li><li>recognize known types of tasks in known and new contexts, can solve these tasks using known procedures.</li><li>understand the mathematical language used in engineering literature and can describe their own reasoning and solution approaches orally and in writing.</li><li>are able to deal confidently with the mathematical methods presented.</li><li>possess a basic knowledge of number systems, the notion of convergence, differential and integral calculus of functions of one variable, elementary differential equations, and their applications in engineering.</li></ul> |                                                    |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                    |                    |                    |
| <ul style="list-style-type: none"><li>Functions: basics, continuity, applications</li><li>Differentiation in R: basics, rules, applications</li><li>Integration in R: basics, methods of integration, applications</li><li>Complex numbers: basics, rules, applications</li><li>Ordinary differential equations: basics, solution methods, applications</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                    |                    |                    |

**Literature:**

## Compulsory:

- STRANG, Gilbert, 2017. *Calculus*. Wellesley, MA: Wellesley-Cambridge Press. ISBN 978-0-9802327-5-2.
- STEWART, James, 2021. *Calculus: early transcendentals*. Australia: Cengage Learning. ISBN 978-0-357-11351-6.

## Recommended:

- STROUD, Kenneth Arthur and Dexter J. BOOTH, 2021. *Engineering mathematics*. New York; London; Oxford; New Delhi; Sydney: Bloomsbury Academic. ISBN 978-1-352-01027-5.

**Additional remarks:**

None

| Engineering Mathematics 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                     |                    |                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | EMath_2_ESYS                                        | SPO-No.:           | 2                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Programme                                           | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Energy Systems and Renewable Energies               | Compulsory Subject | 2                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Language of instruction                             | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | English                                             | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Horak, Jiri                                         |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Kotonski, Julia                                     |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5 ECTS / 5 SWS                                      |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Contact hours                                       | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Self-study                                          | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total                                               | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Engineering Mathematics 2 (EMath_2_ESYS)            |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SU/Ü - lecture with integrated exercises            |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | schrP120 - written exam, 120 minutes (EMath_2_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None                                                |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                     |                    |                    |
| Engineering Mathematics 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                     |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                     |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• further develop their ability to recognize which questions in engineering can be answered using mathematics and can ask such questions themselves.</li><li>• understand logical reasoning, recognize condition, consequence and rule, and can build a chain of reasoning in the context of engineering applications.</li><li>• recognize known types of tasks in known and new contexts, can solve these tasks using known procedures.</li><li>• understand the mathematical language used in engineering literature and can describe their own reasoning and solution approaches orally and in writing.</li><li>• are able to deal confidently with the mathematical methods presented.</li><li>• possess a basic knowledge of series, matrices, differential and integral calculus of functions of several variables, and their applications in engineering.</li></ul> |                                                     |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                     |                    |                    |
| <ul style="list-style-type: none"><li>• Series: basics, power and Taylor Series, applications</li><li>• Matrices: basics, determinants, eigenvalues and eigenvectors, applications</li><li>• Differentiation in <math>\mathbb{R}^n</math>: basics, rules, applications</li><li>• Integration in <math>\mathbb{R}^n</math>: basics, methods of integration, applications</li><li>• Introduction to vector calculus</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                     |                    |                    |

**Literature:**

## Compulsory:

- STRANG, Gilbert, 2017. *Calculus*. Wellesley, MA: Wellesley-Cambridge Press. ISBN 978-0-9802327-5-2.
- STEWART, James, 2021. *Calculus: early transcendentals*. Australia: Cengage Learning. ISBN 978-0-357-11351-6.

## Recommended:

- STROUD, Kenneth Arthur and Dexter J. BOOTH, 2021. *Engineering mathematics*. New York; London; Oxford; New Delhi; Sydney: Bloomsbury Academic. ISBN 978-1-352-01027-5.

**Additional remarks:**

None

| Computer Science in Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | CScEng_ESYS                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SPO-No.:           | 3                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Energy Systems and Renewable Energies                                                                                                                                                                                                                                                                                                                                                                                                                                              | Compulsory Subject | 1                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Language of instruction                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | English                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Lange, Marlene                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Lange, Marlene (CScEng_ESYS)<br>Lange, Marlene (CScEngAR_ESYS)                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 5 ECTS / 4 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Contact hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Self-study                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Computer Science in Engineering (CScEng_ESYS)<br>Computer Science in Engineering (admission requirement) (CScEngAR_ESYS)                                                                                                                                                                                                                                                                                                                                                           |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SU: 2 contact hours seminar-based teaching<br>Ü/Pr: 2 contact hours exercise course / laboratory                                                                                                                                                                                                                                                                                                                                                                                   |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | schrP90 - written exam, 90 minutes (CScEng_ESYS)<br>LN - prA - participation with/without success (CScEngAR_ESYS)                                                                                                                                                                                                                                                                                                                                                                  |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Admission to the module examination requires the successful completion of a continuous assessment during the semester.<br><br>The continuous assessment consists of 4 to 6 programming assignments to be completed independently and submitted during the semester. Each programming assignment must be graded as “passed” in order to obtain admission to the module examination.<br><br>The specific contents and requirements will be announced at the beginning of the course. |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                    |
| After attending the course, students <ul style="list-style-type: none"><li>are familiar with fundamental concepts of digital information processing, in particular the representation, storage, and processing of data in computer systems.</li><li>are familiar with different number systems and methods for numerical and character encoding and are able to interpret and convert information between different representations.</li><li>are able to develop algorithms for solving engineering-related problems and represent them using pseudocode and flowcharts.</li><li>are able to develop programs in Python and apply fundamental language constructs such as variables, data types, conditional statements, loops, functions, and data structures effectively.</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                    |

- are able to structure programs, define interfaces using functions, parameters, and return values, and use them to decompose problems into smaller subproblems.
- understand the fundamental concepts of object-oriented programming and are able to use classes and objects to model engineering-related problems.
- are able to apply the fundamental Python libraries NumPy, Pandas, and Matplotlib to solve engineering-related tasks.
- are able to understand, test, and evaluate source code generated by generative AI systems with respect to the requirements of a given task.

The goal of the admission requirement is that the students learn to practically apply the theory of the computer science course. They learn:

- to develop and implement simple algorithms.
- to write, execute and debug a computer program.
- the basic syntax and semantics of a programming language.

#### Content:

- History and development of computer science
- Representation and processing of information in computer systems
- Numerical and character encoding (e.g., number systems, binary encoding, two's complement, ASCII, Unicode)
- Algorithms and algorithmic problem solving; representation of algorithms using pseudocode and flowcharts
- Introduction to programming with Python:
  - Variables, data types, operators, and expressions
  - Control structures (conditional statements and loops)
  - Program structuring through the definition and use of interfaces based on functions, parameters, and return values
  - Fundamental data structures (lists, dictionaries)
  - Fundamentals of object-oriented programming: classes, objects, attributes, and methods
  - Application of object-oriented concepts in Python for program development and structuring
- Fundamentals of Data Science for engineering applications:
  - Numerical computations using NumPy
  - Reading, processing, and analyzing data with Pandas
  - Data visualization using Matplotlib

The students have to solve a given number of tasks from the area of computer science. Depending on the level of task completion they are admitted to the final exam, or not.

#### Literature:

Compulsory:

None

Recommended:

- CORMEN, Thomas H. and others, 2009. *Introduction to algorithms*. Cambridge, Massachusetts; London, England: The MIT Press. ISBN 978-0-262-27083-0.
- MATTHES, Eric, 2023. *Python crash course: a hands-on, project-based introduction to programming*. San Francisco: No Starch Press. ISBN 978-1-7185-0270-3.
- STEINKAMP, Veit, 2024. *Python for engineering and scientific computing*. Boston: Rheinwerk Publishing. ISBN 978-1-4932-2559-0, 1-4932-2559-6.
- INDEN, Michael, 2022. *Python Challenges: 100 proven programming tasks designed to prepare you for anything*. New York, NY: Apress. ISBN 978-1-4842-7397-5.

#### Additional remarks:

None

| Material Science                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                             |                    |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | MatSc_ESYS                                                  | SPO-No.:           | 4                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Energy Systems and Renewable Energies                       | Compulsory Subject | 2                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Oberhauser, Simon                                           |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Oberhauser, Simon                                           |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Material Science (MatSc_ESYS)                               |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SU/Ü/Pr - seminar based teaching/exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | schrP90 - written exam, 90 minutes (MatSc_ESYS)             |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                             |                    |                    |
| <p>After successful completion of the module, students are able to:</p> <ul style="list-style-type: none"><li>• explain atomic bonding, metallic crystal structures and lattice imperfections, and relate them to relevant material properties.</li><li>• understand plastic deformation and strengthening mechanisms in metals using dislocations, defects and microstructural features.</li><li>• explain diffusion processes, solidification phenomena and phase transformations with respect to their time and temperature dependence.</li><li>• interpret binary phase diagrams, in particular the iron-carbon diagram, and derive consequences for the microstructure and properties of metallic alloys.</li><li>• describe martensitic transformation, precipitation reactions and heat-treatment-related strengthening mechanisms in metallic materials.</li><li>• select and interpret basic methods of materials testing and characterization for typical engineering materials.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                             |                    |                    |
| <ul style="list-style-type: none"><li>• Atomic structure and the nature of chemical bonding</li><li>• Structures of solids, especially metals</li><li>• Imperfections in real crystals</li><li>• Plastic deformation in ideal and real crystals, strengthening mechanisms by imperfections</li><li>• Diffusion – mechanism, meaning and applications</li><li>• Phases and phase diagrams and iron-carbon diagram</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |

- solidification, nucleation, crystal growth and microstructure formation
- solid state reactions – martensitic transformation and precipitation hardening
- Materials testing and material characterization

**Literature:**

Compulsory:

- ASKELAND, Donald R. and others, 2022. *The science and engineering of materials*. Boston, MA: Cengage. ISBN 978-0-357-44786-4, 978-0-357-44788-8.

Recommended:

- CALLISTER, William D. and David G. RETHWISCH, 2020. *Materials science and engineering: an introduction*. 10. edition. Hoboken, NJ: Wiley. ISBN 978-1-119-45391-8.

**Additional remarks:**

None



| Energy Systems and Energy Economics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                |                    |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ESaEE_ESYS                                                                                                                     | SPO-No.:           | 5                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Programme                                                                                                                      | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Energy Systems and Renewable Energies                                                                                          | Compulsory Subject | 1                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Language of instruction                                                                                                        | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | English                                                                                                                        | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Huber, Matthias                                                                                                                |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Feuchter, Fabian; Huber, Matthias; Jain, Rushabh Bansilal (ESaEE_ESYS)<br>NN, (ESaEEAR_ESYS)                                   |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 5 ECTS / 5 SWS                                                                                                                 |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Contact hours                                                                                                                  | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Self-study                                                                                                                     | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Total                                                                                                                          | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Energy Systems and Energy Economics (ESaEE_ESYS)<br>Energy Systems and Energy Economics (admission requirement) (ESaEEAR_ESYS) |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory                                                                    |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | schrP90 - written exam, 90 minutes (ESaEE_ESYS)<br>LN - prA - participation with/without success (ESaEEAR_ESYS)                |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Aids in the exam: will be announced in the lecture                                                                             |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                |                    |                    |
| none                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>understand today's energy supply (heat, electricity, and mobility) and are capable to evaluate it.</li><li>are capable to judge the importance of the different forms of renewable energies in today's and future energy supply.</li><li>are capable to evaluate fossil energy sources with their impact on the climate.</li><li>understand the international and German energy and climate protection policy and the corresponding legislation.</li><li>understand the economic aspects and market structures of the European and German energy supply.</li></ul> <p>The students</p> <ul style="list-style-type: none"><li>actively contribute to the module's contents.</li><li>have an overview of current developments related to (renewable) energies and energy systems.</li><li>gain experience in doing (desk) research of current developments related to (renewable) energies and energy systems.</li></ul> |                                                                                                                                |                    |                    |

- gain experience in presenting and discussing current developments related to (renewable) energies and energy systems.

**Content:**

## Energy Systems Today and Tomorrow

- Basics of energy and energy-related terminology
- Energy consumption and supply worldwide / in Germany
- Energy efficiency
- Fossil fuels / nuclear energy
- Energy and climate
- Overview of renewable energies worldwide / in Germany

## Energy Economics, Policies and Legislation

- Energy and climate protection policies worldwide / in Europe / in Germany
- Energy legislation in Europe / in Germany
- Renewable energies as an economic factor
- research of current developments related to (renewable) energies and energy systems
- presentation and discussion of current developments related to (renewable) energies and energy systems

**Literature:**

## Compulsory:

None

## Recommended:

- QUASCHNING, Volker, EPPEL, Herbert, 2020. *Renewable energy and climate change* [online]. Chichester, West Sussex, UK: Wiley. PDF e-Book. ISBN 978-1-119-51490-9. Available via: <https://doi.org/10.1002/9781119514909>.
- QUASCHNING, Volker, 2016. *Understanding renewable energy systems* [online]. London and New York: Routledge. PDF e-Book. ISBN 978-1-315-76943-1, 978-1-317-66942-5. Available via: <https://doi.org/10.4324/9781315769431>.
- HOSSAIN, Eklas, PETROVIC, Slobodan, 2021. *Renewable Energy Crash Course: A Concise Introduction* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-030-70049-2. Available via: <https://doi.org/10.1007/978-3-030-70049-2>.
- BIGERNA, Simona, BOLLINO, Carlo Andrea, MICHELI, Silvia, 2015. *The sustainability of renewable energy in Europe* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-319-12343-1, 978-3-319-12342-4. Available via: <https://doi.org/10.1007/978-3-319-12343-1>.

**Additional remarks:**

None

| Basics of Mechanical Design                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                      |                    |                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | BMDesign_ESYS                                        | SPO-No.:           | 6                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Programme                                            | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Energy Systems and Renewable Energies                | Compulsory Subject | 1                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Language of instruction                              | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | English                                              | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Moll, Klaus-Uwe                                      |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Burger, Uli                                          |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 5 ECTS / 4 SWS                                       |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Contact hours                                        | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Self-study                                           | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Total                                                | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Basics of Mechanical Design (BMDesign_ESYS)          |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | SU/Ü - lecture with integrated exercises             |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | schrP120 - written exam, 120 minutes (BMDesign_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | None                                                 |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                      |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                      |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• know which standards have to be taken into account for the creation of technical drawings.</li><li>• can use these standards to create complete and standardized graphic representations of constructions.</li><li>• can use various projection methods.</li><li>• know which tolerances exist and can apply this knowledge correctly.</li><li>• can apply their knowledge of the representation of various machine elements in technical drawings.</li><li>• can develop new components and assemblies by linking their knowledge and design them for production.</li></ul>                           |                                                      |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                      |                    |                    |
| <ul style="list-style-type: none"><li>• Contents of technical drawings</li><li>• Symbolic representations used</li><li>• Projection methods for the graphic representation of technical products</li><li>• Sectional representations, cutouts, views, details</li><li>• Dimensioning, dimensioning rules, edge symbols</li><li>• Geometrical Product Specification in accordance to ISO</li><li>• ISO tolerance system, surface information, shape and position tolerances, tolerance calculation</li><li>• Typical machine elements and standard parts and their graphic representation</li><li>• Design guidelines for various manufacturing processes</li></ul> |                                                      |                    |                    |

- Creation of freehand sketches

**Literature:**

## Compulsory:

- GOMERINGER, Roland and others, 2018. *Mechanical and Metal Trades Handbook*. Haan-Gruiten: Verlag Europa-Lehrmittel, Nourney, Vollmer GmbH & Co. KG. ISBN 978-3-8085-1915-8, 3-8085-1915-0.
- ISO, 2020. *ISO 128-1:2020: Technical product documentation (TPD) — General principles of representation — Part 1: Introduction and fundamental requirements*. Berlin: Beuth.
- ISO, 2022. *ISO 128-2:2022: Technical product documentation (TPD) - General principles of representation - Part 2: Basic conventions for lines*. Berlin: Beuth.
- ISO, 2022. *ISO 128-3:2022: Technical product documentation (TPD) - General principles of representation - Part 3: Views, sections and cuts*. Berlin: Beuth.
- ISO, 2020. *ISO 128-100:2020: Technical product documentation - General principles of representation - Part 100: Index*. Berlin: Beuth.
- DIN EN ISO, 2013. *ISO 286-1:2010 + Cor 1:2013: Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 1: Basis of tolerances, deviations and fits*. Berlin: Beuth.
- DIN EN ISO, 2013. *ISO 286-2:2010 + Cor 1:2013: Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*. Berlin: Beuth.

## Recommended:

None

**Additional remarks:**

None

| Statics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                              |                    |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ST_ESYS                                      | SPO-No.:           | 7                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Programme                                    | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Energy Systems and Renewable Energies        | Compulsory Subject | 1                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Language of instruction                      | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | English                                      | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Feifel, Elke                                 |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Feifel, Elke                                 |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 5 ECTS / 4 SWS                               |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Contact hours                                | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Self-study                                   | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Total                                        | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Statics (ST_ESYS)                            |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | SU/Ü - lecture with integrated exercises     |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | schrP90 - written exam, 90 minutes (ST_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | None                                         |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                              |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                              |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                              |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>understand the principles and methods of the statics of rigid bodies and can apply these to mechanical engineering tasks.</li><li>are able to convert real components and structures into simplified mechanical equivalent models.</li><li>are able to analyze the loads acting on a mechanical system.</li><li>are able to calculate the bearing reactions and internal loads of statically determined structures under static loads.</li><li>are able to work on three-dimensional problems.</li><li>can calculate centers of gravity of lines, areas and volumes.</li><li>understand the basic concept of friction and can solve problems relating to this.</li><li>know the basic concepts of statics and can express themselves competently in the subject area.</li><li>are able to confidently apply mathematical principles to calculations.</li><li>have a capacity for abstraction and can solve tasks independently and in a team in a structured manner.</li></ul> |                                              |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                              |                    |                    |
| <ul style="list-style-type: none"><li>Introduction to the basics of statics (bars, beams, plates, bearings and hinges, equilibrium conditions)</li><li>Central and common force systems</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                              |                    |                    |

- Analysis of mechanical structures, including trusses
- Forces, moments, resultants, support reactions
- Internal forces and moments
- Spatial mechanical systems
- Center of gravity
- Friction

**Literature:**

Compulsory:

None

Recommended:

- GROSS, Dietmar and others, 2013. *Engineering Mechanics Statics*. Dordrecht: Springer. ISBN 978-3-662-53853-1.
- HIBBELER, Russel C., 2016. *Engineering Mechanics: Statics in SI Units*. 14. edition. Hoboken: Pearson. ISBN 1-292-08923-7, 978-1-292-08923-2.
- KESSEL, Siegfried and Dirk FRÖHLING, 2012. *Technische Mechanik - Engineering Mechanics Zweisprachiges Lehrbuch zu Grundlagen der Mechanik fester Körper - Bilingual Textbook on the Fundamentals of Solid Mechanics*. Wiesbaden: Springer. ISBN 978-3-8348-1719-8.

**Additional remarks:**

Bonus system: During the course, students may complete and present assignments, which, depending on the quality of their preparation and presentation, will result in bonus points that are added to their final exam mark. In relation to the total marks available in the exam, a maximum of 10 per cent can be awarded as bonus points. There is no guarantee that the bonus system will be implemented in any given semester.

| Mechanics of Materials                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                   |                    |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | MechMat_ESYS                                      | SPO-No.:           | 8                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Programme                                         | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Energy Systems and Renewable Energies             | Compulsory Subject | 2                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Language of instruction                           | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | English                                           | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Dallner, Rudolf                                   |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Burger, Uli                                       |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 5 ECTS / 4 SWS                                    |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Contact hours                                     | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Self-study                                        | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Total                                             | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Mechanics of Materials (MechMat_ESYS)             |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | SU/Ü - Seminar-based teaching with exercises      |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | schrP90 - written exam, 90 minutes (MechMat_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | None                                              |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                   |                    |                    |
| successful participation in the module statics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                   |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                   |                    |                    |
| The students                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                   |                    |                    |
| <ul style="list-style-type: none"><li>are able to analyze and evaluate the stresses on machine parts and structures under static mechanical loads and to dimension these components.</li><li>are able to calculate stresses and strains resp. deformations that occur in components as a result of loads such as tension/compression, bending, torsion or combined loading and evaluate them using strength hypotheses.</li><li>can calculate deformations on beam-like components for statically determinate and indeterminate systems.</li><li>understand the concept of stress tensor and can perform coordinate transformations and calculate principal stresses.</li><li>can evaluate multiaxial stress states using equivalent stresses.</li><li>are able to analyze columns under buckling.</li><li>are familiar with the concept of stress concentration problems.</li><li>are familiar with the basic concepts of elastostatics and are able to express themselves competently in the field of mechanics of material.</li><li>are able to discuss and explain calculated results in a professional manner.</li><li>are able to apply mathematical principles to calculations with confidence.</li><li>have a capacity for abstraction and can solve tasks independently and in a team in a structured manner.</li></ul> |                                                   |                    |                    |

**Content:**

- Introduction to the basic concepts of mechanics of materials like stress and strain, Hooke's law and tension-compression as well as thermal expansion and thermal stresses
- Multiaxial stress states, transformation relations, stress tensor, principal stresses; Mohr's circle
- Linear elastic constitutive law for plane stress conditions and in the three-dimensional case
- Moments of inertia
- different types of loading, such as tension-compression, bending, torsion and the resulting stresses and deformations
- Deflections of beams under statically determinate and indeterminate conditions
- Combined loading and resulting stresses and deformations
- Equivalent stresses and stress evaluation, strength verification
- stress concentration problems
- Buckling of columns
- Extensive exercise examples of practical engineering applications according to the course of study

**Literature:**

Compulsory:

None

Recommended:

- HIBBELER, Russell C. and Jun Hwa LEE, 2024. *Statics and mechanics of materials*. Harlow: Pearson. ISBN 978-1-292-46020-8, 1-292-46020-2.
- GROSS, Dietmar, GROSS, Dietmar, HAUGER, Werner, SCHRÖDER, Jörg, WALL, Wolfgang A., BONET, Javier, Band 2[2018. *Engineering mechanics* [online]. Berlin [u.a.]: Springer. PDF e-Book. ISBN 978-3-662-56272-7. Available via: <https://doi.org/10.1007/978-3-662-56272-7>.
- GOMERINGER, Roland and others, 2018. *Mechanical and Metal Trades Handbook*. Haan-Gruiten: Verlag Europa-Lehrmittel, Nourney, Vollmer GmbH & Co. KG. ISBN 978-3-8085-1915-8, 3-8085-1915-0.

**Additional remarks:**

None



| Thermodynamics 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                             |                    |                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | TD1_ESYS                                                    | SPO-No.:           | 9                  |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Energy Systems and Renewable Energies                       | Compulsory Subject | 2                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Goldbrunner, Markus                                         |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Goldbrunner, Markus                                         |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Thermodynamics 1 (TD1_ESYS)                                 |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | schrP90 - written exam, 90 minutes (TD1_ESYS)               |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                             |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• know the properties of pure media (gases, liquids, homogenous mixtures) and the associated laws.</li><li>• are able to graphically represent and calculate changes of state of the model fluids "ideal gas" and "incompressible liquid" depending on the process control.</li><li>• are familiar with the laws of energy conversion (1st and 2nd law of thermodynamics).</li><li>• are able to describe the course of a thermodynamic process on the basis of the state variable entropy and to determine the energetic conversion quality of real state changes.</li><li>• can calculate and evaluate applied energetic single processes (compressor/turbine/heat exchanger).</li><li>• know the thermodynamic cycle processes of working and power machines and can thus make basic statements on the operating behaviour of these machines.</li><li>• are familiar with the basics of phase transformation in multiphase systems using water as an example.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                             |                    |                    |
| <ul style="list-style-type: none"><li>• Chapter 1: Fundamentals of thermodynamics</li><li>• Chapter 2: Exchange and conservation of energy (1st law of thermodynamics)</li><li>• Chapter 3: Exchange and generation of entropy (2nd law of thermodynamics)</li><li>• Chapter 4: Changes of state of model fluids</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |

**Literature:**

## Compulsory:

- WHITMAN, Alan M., 2023. *Thermodynamics: Basic Principles and Engineering Applications*. Cham: Springer International Publishing. ISBN 978-3-031-19538-9.
- ÇENGEL, Yunus A., Michael A. BOLES and Mehmet KANOĞLU, 2024. *Thermodynamics: an engineering approach*. New York, NY: McGraw Hill. ISBN 978-1-266-15211-5, 1-266-15211-3.
- PAUKEN, Michael, 2011. *Thermodynamics for dummies*. Hoboken, NJ: Wiley. ISBN 978-1-118-12098-9, 978-1-118-12100-9.

## Recommended:

- Will be announced in the lecture

**Additional remarks:**

None

| Electrical Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                               |                    |                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ETE_ESYS                                      | SPO-No.:           | 10                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Programme                                     | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Energy Systems and Renewable Energies         | Compulsory Subject | 1                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Language of instruction                       | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | English                                       | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Navarro Gevers, Daniel                        |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Navarro Gevers, Daniel                        |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5 ECTS / 4 SWS                                |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Contact hours                                 | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Self-study                                    | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Total                                         | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Electrical Engineering (ETE_ESYS)             |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | SU/Ü - lecture with integrated exercises      |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | schrP90 - written exam, 90 minutes (ETE_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | None                                          |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                               |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                               |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                               |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• know and use specialist terminology confidently.</li><li>• know the basic physical laws of electrical engineering and their connection.</li><li>• know the boundary conditions of particular laws of physics.</li><li>• are able to select the appropriate laws defining a given problem.</li><li>• are proficient in calculations with appropriate units.</li><li>• are proficient in methods calculating direct current and alternate current networks.</li><li>• know the electrical field quantities and are able to calculate them.</li><li>• know the magnetic field quantities and are able to calculate simple magnetic circuits.</li><li>• know simple circuits with a transistor.</li><li>• know basic circuits with an operational amplifier and are able to calculate those.</li><li>• know measuring instruments for electric quantities and know their possible uses.</li><li>• are able to familiarise themselves with subjects regarding electrical engineering self-reliant and within a team and are able to discuss these matters competently.</li></ul> |                                               |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                               |                    |                    |
| <ul style="list-style-type: none"><li>• Direct current circuits: voltage, current, Ohm’s law, energy, power, Kirchhoff’s laws, Thevenin equivalent</li><li>• Norton equivalent circuit, series connection, parallel connection, maximum power transfer, calculation of networks</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                               |                    |                    |

- Electric field: electric field quantities, capacitance, energy in the electrostatic field, forces in the electrostatic field, switching operations
- Magnetic field: magnetic field quantities, coil inductance, magnetic circuit, magnetic flux law, magnetic energy of the coil, forces in the magnetic field, induction law, self-induction, switching operations
- Alternate current circuit: sinusoidal change of electric quantities, circuit analysis of alternate current networks using complex numbers, power
- Semiconductors: diode, transistor, operational amplifier, basics of electric circuits; digital circuits
- Measuring electric quantities

**Literature:**

## Compulsory:

- HACKER, Viktor and Christof SUMEREDER, 2020. *Electrical engineering: fundamentals*. München; Wien: De Gruyter Oldenbourg. ISBN 9783110521023.
- KORIES, Ralf and Heinz SCHMIDT-WALTER, 2003. *Electrical Engineering: A Pocket Reference*. Berlin, Heidelberg: Springer. ISBN 978-3-540-43965-3.

## Recommended:

- Further literature will be announced in the lecture.

**Additional remarks:**

None

| Energy Storage                                                                                                                                                                                                                                                                                                                                                                                                               |                                                             |                    |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                         | EnergStor_ESYS                                              | SPO-No.:           | 11                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                  | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                              | Energy Systems and Renewable Energies                       | Compulsory Subject | 2                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                           | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                              | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                      | Schrag, Tobias                                              |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                   | Reum, Tobias; Schmitt, David                                |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                         | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                    | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                              | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                              | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                      | Energy Storage (EnergStor_ESYS)                             |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                               | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                | schrP90 - written exam, 90 minutes (EnergStor_ESYS)         |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                             | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• can judge the need of storage according to the energy economic situation.</li><li>• can differentiate between base load and peak load storage.</li><li>• can evaluate different storages technologies according to a variety of criteria.</li><li>• can estimate the economic benefit of a storage system.</li><li>• can dimensionate storage systems.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                             |                    |                    |
| <ul style="list-style-type: none"><li>• storage properties</li><li>• energy density</li><li>• storage cycles</li><li>• charging speed</li><li>• thermal energy storage</li><li>• hot tap water storages</li><li>• heating storage</li><li>• steam storage</li><li>• latent heat storage</li><li>• chemical storage</li><li>• dimensioning of storages</li><li>• electrical energy storages:</li></ul>                        |                                                             |                    |                    |

- battery basics
- charge control
- central vs decentral
- chemical storages
- gas storage hydrogen storage conversion efficiencies
- types of hydrogen storages
- mechanical storages
- pumped hydro
- compressed air storage

**Literature:**

Compulsory:

None

Recommended:

- MATHEW, V. K., HOTTA, Tapano Kumar, ALI, Hafiz Muhammad, SUNDARAM, Senthilarasu, 2023. *Energy Storage Systems: Optimization and Applications* [online]. Singapore: Springer Nature Singapore. PDF e-Book. ISBN 978-981-1945-02-1. Available via: <https://doi.org/10.1007/978-981-19-4502-1>.
- GUDE, Veera Gnanaswar, 2023. *Energy storage for multigeneration: desalination, power, cooling and heating applications*. London: Elsevier. ISBN 978-0-12-821921-8.
- NAMRATA, Kumari, SAINI, R. P., KOTHARI, D. P., 2024. *Wind and Solar Energy Systems* [online]. Singapore: Springer Nature Singapore. PDF e-Book. ISBN 978-981-9997-10-7. Available via: <https://doi.org/10.1007/978-981-99-9710-7>.
- BRUN, Klaus, Timothy ALLISON and Richard DENNIS, 2021. *Thermal, mechanical, and hybrid chemical energy storage systems*. London, United Kingdom: Academic Press, an imprint of Elsevier. ISBN 978-0-12-819892-6.

**Additional remarks:**

none

| Entrepreneurship and Sustainability                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                            |                    |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EntrSus_ESYS                                                                                                                               | SPO-No.:           | 12                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Programme                                                                                                                                  | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Energy Systems and Renewable Energies                                                                                                      | Compulsory Subject | 2                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Language of instruction                                                                                                                    | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | English                                                                                                                                    | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Lange, Marlene                                                                                                                             |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Rafique, Amber; Ramakrishna Babu Jai, Ganesh                                                                                               |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 5 ECTS / 5 SWS                                                                                                                             |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Contact hours                                                                                                                              | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Self-study                                                                                                                                 | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Total                                                                                                                                      | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Entrepreneurship and Sustainability (EntrSus_ESYS)                                                                                         |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | SU/Ü - lecture with integrated exercises                                                                                                   |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | StA+Coll. - student research project with colloquium, written 8-15 pages and presentation 15-20 pages; oral exam 10-15 min. (EntrSus_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | None                                                                                                                                       |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                            |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                            |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                            |                    |                    |
| The students                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                            |                    |                    |
| <ul style="list-style-type: none"><li>• have acquired basic knowledge in the areas of sustainability, sustainable development and sustainability management.</li><li>• have acquired an understanding of the main global challenges (such as climate change, resource scarcity) and understand the interactions between the dimensions of economy, ecology and social issues.</li><li>• understand what entrepreneurship means and which specific challenges are important for start-ups.</li><li>• are familiar with the basic concepts and methods of innovation management.</li><li>• are able to transfer the principle of sustainability to their study contents.</li><li>• are able to link innovation and sustainability.</li><li>• are able to develop a business idea under consideration of sustainability criteria, to elaborate and present in a business plan.</li><li>• are able to apply agile innovation and product development methods and tools.</li><li>• are able to discuss and present results competently.</li><li>• understand the interaction of different disciplines.</li><li>• possess methodological and social skills in areas such as teamwork, communication skills, creative techniques, project management and time management.</li></ul> |                                                                                                                                            |                    |                    |

**Content:**

Introduction: Understanding sustainability and sustainable development

- Fundamentals of sustainability and sustainable development
- Global challenges and risk posed by non-sustainability
- Opportunities of sustainable development
- Sustainability as a driver innovation
- Sustainable production and consumption

Theory of entrepreneurship

- What does "entrepreneurship" mean?
- Business models and the business model canvas
- Strategy, product development and marketing of start-ups
- Financing and selection of investors
- Contents of business plans

Theory of innovation management

- Definition and goals of innovation
- Types of innovations
- Sources/search fields for innovations
- Innovation strategy

Exercise Design Thinking: Sustainable Innovation and Business Model (development of a sustainable and feasible business idea in teamwork)

**Literature:**

Compulsory:

None

Recommended:

- SINEK, Simon, 2019. *Start with why: how great leaders inspire everyone to take action*. [London]: Penguin Business. ISBN 978-0-241-95822-3.
- RIES, Eric, 2017. *The lean startup: how today's entrepreneurs use continuous innovation to create radically successful businesses*. New York: Currency. ISBN 978-1-5247-6240-7.
- TIDD, Joseph and John R. BESSANT, 2021. *Managing innovation: integrating technological, market and organizational change*. Hoboken, NJ: Wiley. ISBN 978-1-119-71330-2.

**Additional remarks:**

None



| Machine Elements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                    |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | MachElem_ESYS                                      | SPO-No.:           | 13                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Programme                                          | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Energy Systems and Renewable Energies              | Compulsory Subject | 3                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Language of instruction                            | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | English                                            | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Fuchs, Daniel                                      |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Fuchs, Daniel                                      |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 5 ECTS / 4 SWS                                     |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Contact hours                                      | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Self-study                                         | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Total                                              | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Machine Elements (MachElem_ESYS)                   |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | SU/Ü - lecture with integrated exercises           |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | schrP90 - written exam, 90 minutes (MachElem_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | None                                               |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                    |                    |                    |
| Statics, Basics of Mechanical Design, Mechanics of Materials, Material Science                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                    |                    |                    |
| <p>At the end of the course, the students will be able to</p> <ul style="list-style-type: none"><li>• apply the terminology of the subject and discuss assignments with peers.</li><li>• to independently select and dimension the machine elements required for a design and to integrate it into an overall construction.</li><li>• apply the calculation and design methods for the treated machine elements on engineering level and to combine them with knowledge of statics, strength of materials, materials science and mechanical design.</li><li>• transfer the knowledge gained to other machine elements.</li></ul>                                                                                                                |                                                    |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                    |                    |                    |
| <ul style="list-style-type: none"><li>• Fastening screws (stress diagram, proof of strength statically and dynamically)</li><li>• Pins and bolts (load bearing capacity, shear stress)</li><li>• Springs (static and dynamic proof of strength for coil springs, disk springs, torsion springs)</li><li>• Axles and shafts (design and fatigue strength)</li><li>• Shaft-hub connections (positive and positive shaft-hub connections)</li><li>• Rolling bearings (service life calculation, design of storage and bearing point)</li><li>• Spur gears (gear law, design of spur gears and simple gears)</li><li>• Clutches (switchable and non-switchable clutches)</li><li>• seals and lubrication</li><li>• Other machine elements</li></ul> |                                                    |                    |                    |

**Literature:**

## Compulsory:

- DIN, 2021. *6885-1: Drive type fastenings without taper action, parallel keys, keyways - Deep pattern*. Berlin: Beuth.
- DIN, 2021. *6885-2: Drive type fastenings without taper action, parallel keys, keyways - Deep pattern for machine tools*. Berlin: Beuth.
- DIN, 2021. *6885-3: Drive type fastenings without taper action, parallel keys, keyways - Low pattern - Part 3: Dimensions, tolerances, mass*. Berlin: Beuth.
- DIN, 2012. *743-1: Calculation of load capacity of shafts and axles - Part 1: General*. Berlin: Beuth.
- DIN, 2012. *743-2: Calculation of load capacity of shafts and axles - Part 2: Theoretical stress concentration factors and fatigue notch factors*. Berlin: Beuth.
- DIN, 2012. *743-3: Calculation of load capacity of shafts and axles - Part 3: Strength of materials*. Berlin: Beuth.
- DIN, 2012. *743-4: Calculation of load capacity of shafts and axles - Part 4: Fatigue limit, endurance limit - Equivalently damaging continuous stress*. Berlin: Beuth.

## Recommended:

- DECKER, Karl-Heinz, Frank RIEG and Karlheinz KABUS, 2018. *Maschinenelemente - Funktion, Gestaltung und Berechnung: mit 871 Bildern, 164 Berechnungsbeispielen und einem Tabellenband mit 334 Tabellen und Diagrammen*. 20. edition. München: Hanser. ISBN 978-3-446-45029-5, 3-446-45029-7.
- NISBETT, J. Keith and Richard G. BUDYNAS, 2024. *Shigley's Mechanical Engineering Design*. 12. edition. New York: McGraw-Hill Education. ISBN 978-1266929892.

**Additional remarks:**

Bonus system: In the course, students can work on and present tasks, which leads to bonus points according to their qualitative preparation and presentation, which are additionally credited to the examination performance. In relation to the points achievable in the examination, a maximum of 10 percent bonus points is possible. There is no entitlement to the implementation of the bonus system in the respective semester.

| Thermal Energy Technology and Power Plants                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                              |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | TETPP_ESYS                                                                                                                                   | SPO-No.:           | 14                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Programme                                                                                                                                    | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Energy Systems and Renewable Energies                                                                                                        | Compulsory Subject | 3                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Language of instruction                                                                                                                      | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | English                                                                                                                                      | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Goldbrunner, Markus                                                                                                                          |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Goldbrunner, Markus (TETPP_ESYS)<br>Goldbrunner, Markus (TETPPAR_ESYS)                                                                       |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 5 ECTS / 5 SWS                                                                                                                               |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Contact hours                                                                                                                                | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Self-study                                                                                                                                   | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Total                                                                                                                                        | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Thermal Energy Technology and Power Plants (TETPP_ESYS)<br>Thermal Energy Technology and Power Plants (admission requirement) (TETPPAR_ESYS) |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | SU/Ü/Pr - seminar based teaching/exercise course/laboratory                                                                                  |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | schrP90 - written exam, 90 minutes (TETPP_ESYS)<br>LN - prA - participation with/without success (TETPPAR_ESYS)                              |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | None                                                                                                                                         |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                              |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                              |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                              |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• have an overview of thermal energy systems and the most important processes used here.</li><li>• have an overview of the most important types of heat generation and can carry out simple combustion calculations.</li><li>• are familiar with the operating principle, the theoretical principles and the structure of fluid flow machines and can calculate them.</li><li>• are familiar with heat-power processes and their components and can calculate them.</li><li>• are familiar with the operating principle, theoretical principles and design of heat engines, such as steam turbines, gas turbines and internal combustion engines.</li><li>• have an overview of the different fuel cell concepts with fuels such as natural gas and hydrogen and know their construction.</li><li>• know the operating principle, theoretical principles and design of refrigeration machines and heat pumps.</li><li>• can apply what they have learned to the conceptual design and layout of heat engines and processes.</li></ul> <p>Students are expected to apply the theoretical content they have learned to practical experiments and a simulation using a commercial software tool.</p> |                                                                                                                                              |                    |                    |

**Content:**

## Fundamentals of thermal energy systems

- Power and working machines
- Changes of state and cyclic processes
- Optimisation of cyclic processes

## Heat generation

- Combustion
- Solar, geothermal and nuclear heat generation

## Fundamentals of the fluid machine

- Structure
- Classification
- Energy conversion

## Steam power process

- Basics
- Steam generator and firing
- Flue gas cleaning
- Cooling
- Steam turbine
- Further components

## other processes with external heat generation

- ORC
- Kalina
- Stirling
- Steam engine

## Internal combustion engine

- Basics and operation
- Components
- Gas engines

## Gas turbine

- Fundamentals and mode of operation
- Components
- Micro gas turbines

## Fuel cell

- How it works
- Fuel cell types, basics and fuels such as hydrogen
- Construction, components and service life

## Working machines

- Basics
- Refrigerating machine
- Heat pump
- Simulation of a steam power plant with the software "Epsilon".
- Execution of an experiment on the laboratory steam power plant with recording of measured process values and evaluation of the measured values.
- Execution of an experiment on the laboratory combustion engine with recording of measured process values and evaluation of the measured values.

**Literature:**

## Compulsory:

- SARKAR, Dipak K., 2015. *Thermal power plant: design and operation*. Amsterdam: Elsevier. ISBN 978-0-12-801755-5, 0-12-801755-4.
- GAMBINI, Marco, VELLINI, Michela, 2021. *Turbomachinery: Fundamentals, Selection and Preliminary Design* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-030-51299-6. Available via: <https://doi.org/10.1007/978-3-030-51299-6>.
- STONE, Richard, 2012. *Introduction to internal combustion engines*. Basingstoke [u.a.]: Macmillan. ISBN 978-0-230-57663-6, 978-0-333-74013-2

## Recommended:

- Will be announced in the lecture.

**Additional remarks:**

None

## Product Development and CAD

|                         |                                                                                                                              |                    |                        |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------|
| Module abbreviation:    | ProdDevCAD_ESYS                                                                                                              | SPO-No.:           | 15                     |
| Curriculum:             | Programme                                                                                                                    | Module type        | Semester               |
|                         | Energy Systems and Renewable Energies                                                                                        | Compulsory Subject | 3                      |
| Module attributes:      | Language of instruction                                                                                                      | Duration of module | Frequency of offer     |
|                         | English                                                                                                                      | 1 semester         | winter and summer term |
| Responsible for module: | Moll, Klaus-Uwe                                                                                                              |                    |                        |
| Lecturers:              | Moll, Klaus-Uwe (ProdDevCAD_ESYS)<br>NN, (ProdDevCADAR_ESYS)                                                                 |                    |                        |
| Credit points / SWS:    | 5 ECTS / 4 SWS                                                                                                               |                    |                        |
| Workload:               | Contact hours                                                                                                                | 47 h               |                        |
|                         | Self-study                                                                                                                   | 78 h               |                        |
|                         | Total                                                                                                                        | 125 h              |                        |
| Subjects of the module: | Product Development and CAD (ProdDevCAD_ESYS)<br>Product Development and CAD (admission requirement)<br>(ProdDevCADAR_ESYS)  |                    |                        |
| Lecture types:          | SU/Ü/Pr - seminar based teaching/exercise course/laboratory                                                                  |                    |                        |
| Examinations:           | schrP90 - written exam, 90 minutes (ProdDevCAD_ESYS)<br>LN - prA - participation with/without success<br>(ProdDevCADAR_ESYS) |                    |                        |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Special features of the examination performance:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>Working with the 3D CAD system CATIA</p> <ul style="list-style-type: none"> <li>part design: design of cubic and cylindric parts, based on proper sketches, adaptive and parametric design of parts, mainly based on geometrical dependencies</li> <li>drafting of parts: views and sections views of parts, cutouts, detail views, dimensioning, introduction of ISO-tolerances, surface roughnesses, geometrical tolerances</li> <li>assembly design: generation of sub-assemblies based on constraints, check of proper assembly design by clash checks and manipulations and re-assemblies, generation of full assembly based on sub-assemblies and further (given) parts, development of additional parts in the full assembly</li> <li>drafting of assemblies: views and section views of assemblies, proper representation of different parts in assembly drawings</li> </ul> <p>Successful completion is a prerequisite for admission to the examination in the subject Methods of product development and CAD. The successful completion consists in the fact that CAD constructions are created, checked by the lecturer and certificates are awarded if they are free of errors. If all certificates are obtained, the prerequisite for participation in the examination is fulfilled. The extent of this will be announced in the course.</p> |
| <b>Recommended prerequisites:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Objectives:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <p>The students</p> <ul style="list-style-type: none"> <li>know the procedure of the systematic and method-based approach in product development.</li> <li>understand the relationships between development and construction and other specialist areas of a developing and manufacturing company.</li> <li>independently develop sophisticated products by applying the methods taught and using adequate work techniques.</li> <li>understand the communication required for product development in a company.</li> <li>apply the knowledge to be a functional and social member of a project team.</li> <li>independently develop components and assemblies with the 3D CAD system CATIA (creation of models, creation of assemblies, derivation of standard-compliant drawings).</li> </ul> <p>Students</p> <ul style="list-style-type: none"> <li>know approaches and procedures for the development of a 3d-model.</li> <li>develop on their own 3d-designs of parts and assemblies with the 3d-CAD-system CATIA.</li> <li>generate 2D-drawings of these parts and assemblies using CAD-system CATIA incl. complete dimensioning and tolerances.</li> <li>are able to make a quality check of their design work on their own.</li> <li>know procedures about generation of a specification tree and data management in CAD-system CATIA.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Content:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"> <li>basic phases of the product development process</li> <li>Requirement specification, functional specification, specification</li> <li>abstraction</li> <li>Functional structures</li> <li>Search for solutions and creativity techniques to find solutions</li> <li>Systematic preparation of solution approaches (morphology) and variation and combination techniques</li> <li>Evaluation of concepts and concept selection</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

- Creation of technical drafts, draft construction
- Basic design rules, guidelines and principles
- Basic construction elements
- Semester exercise to implement the material learned
- Working with the 3D CAD system CATIA (component design, assembly design, drawing generation)
- Sketcher: Generation, setup and parameterization of sketches as a starting point for the generation of 3D-parts in CATIA
- Part Design: Generation of 3D-parts, cubic and rotational
- Drafting (part 1): setup of worksheet, generation of drawing of parts with different views, cut-outs, detail views, dimensioning, introduction of ISO-tolerances, surface roughnesses, geometrical tolerances
- assembly design: generation of sub-assemblies based on constraints, check of proper assembly design by clash checks and manipulations and re-assemblies, generation of full assembly based on sub-assemblies and further (given) parts, development of additional parts in the full assembly
- drafting of assemblies: views and section views of assemblies, proper representation of different parts in assembly drawings

#### Literature:

##### Compulsory:

- PAHL, G., W. BEITZ and J. FELDHOUSEN, 2014. *Engineering Design: A systematic approach*. [s.l.]: Springer. ISBN 978-1447160250.
- LIST, Ronald, 2017. *CATIA V5 – Grundkurs für Maschinenbauer: Bauteil- und Baugruppenkonstruktion, Zeichnungsableitung* [online]. Wiesbaden: Springer Vieweg. PDF e-Book. ISBN 978-3-658-17333-3. Available via: <https://doi.org/10.1007/978-3-658-17333-3>.
- PLANTENBERG, Kirstie, 2009. *An introduction to CATIA V5: release 19; (a hands-on tutorial approach)*. [Mission, Kan.]: Schroff Development Corp.. ISBN 978-1-58503-534-2
- VDI, 2019. *2221: Design of technical products and systems - Model of product design*. Berlin: Beuth.
- VDI, 2019. *2221 Blatt 2: Design of technical products and systems - Configuration of individual product design processes*. Berlin: Beuth.

##### Recommended:

None

##### Compulsory:

- LIST, Ronald, 2017. *CATIA V5 – Grundkurs für Maschinenbauer: Bauteil- und Baugruppenkonstruktion, Zeichnungsableitung* [online]. Wiesbaden: Springer Vieweg. PDF e-Book. ISBN 978-3-658-17333-3. Available via: <https://doi.org/10.1007/978-3-658-17333-3>.

##### Recommended:

None

#### Additional remarks:

Bonus system: In the course, students can work on and present tasks, which leads to bonus points according to their qualitative preparation and presentation, which are additionally credited to the examination performance. In relation to the points achievable in the examination, a maximum of 10 percent bonus points is possible. There is no entitlement to the implementation of the bonus system in the respective semester.



| Project Design and Development                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                 |                    |                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------|------------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ProjDesDev_ESYS                                                                 | SPO-No.:           | 16                     |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Programme                                                                       | Module type        | Semester               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Energy Systems and Renewable Energies                                           | Compulsory Subject | 4                      |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Language of instruction                                                         | Duration of module | Frequency of offer     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | German/English                                                                  | 1 semester         | winter and summer term |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Binder, Thomas                                                                  |                    |                        |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Lohr, Christoph; Suchandt, Thomas                                               |                    |                        |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 5 ECTS / 4 SWS                                                                  |                    |                        |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Contact hours                                                                   | 47 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Self-study                                                                      | 78 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Total                                                                           | 125 h              |                        |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Project Design and Development (ProjDesDev_ESYS)                                |                    |                        |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | S/Pr - seminar/laboratory                                                       |                    |                        |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Proj - Project report (5-25 pages) and presentation (15 min.) (ProjDesDev_ESYS) |                    |                        |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | None                                                                            |                    |                        |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                 |                    |                        |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                 |                    |                        |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                 |                    |                        |
| <p>The students</p> <ul style="list-style-type: none"><li>are able to work independently and successfully on a complex development and design task in a team over the course of one semester.</li><li>acquire the skills and methods to apply basic engineering and technical knowledge to concrete engineering tasks, e.g. development, design and construction of vehicle parts and components, also development methods, e.g. digital twin.</li><li>are able to independently familiarize themselves with a topic of a constructive nature that is new to them and systematically work on it using engineering methods.</li><li>are capable of executing designs according to functional, technical-economic, manufacturing and environmental criteria.</li><li>are able to competently discuss, present and document achieved project results in accordance with technical standards.</li><li>understand the interaction of different disciplines in the design process.</li><li>possess methodological and social competence in areas such as teamwork, communication skills, creative techniques, project management and time management.</li></ul> <p>After attending the course, the dual students are able to deal with the offered topic in greater detail and solve more complex tasks due to the broader experience gained through the practical phases and the application of the theoretical content in the companies.</p> |                                                                                 |                    |                        |

**Content:**

- Working on a practical, constructive study project in a team; the tasks vary from semester to semester; usually several topics are offered, from which one is selected.
- Getting to know and applying methodical construction
- Getting knowledge about modern development methods like a digital twin

Due to the practical experience already gained in the dual company, dual students have a better starting position for developing the course content. The practical experience is actively integrated in the internship, dual students can contribute their knowledge and already acquired competences.

Adapted courses for dual students:

- Optional: Crediting of project tasks from company practice with proof through appropriate documentation in accordance with the planned examination performance.
- Increased complexity of the project task in existing courses
- Consideration of the in-depth applicability of the contents

**Literature:**

Compulsory:

- ULRICH, Karl T., Steven D. EPPINGER and Maria C. YANG, 2026. *Product design and development*. New York, NY: McGraw-Hill. ISBN 978-1-265-25226-7, 1-265-25226-2.
- PROJECT MANAGEMENT INSTITUTE, 2021. *The Project Management and A Guide to the Project Management Body of Knowledge (PMBOK Guide)*. ISBN 978-1-62825-664-2.
- Further topic-specific literature will be specified at the beginning of the course

Recommended:

None

**Additional remarks:**

The project work is a group work in which several students work on a common task in a team and present the results orally and in writing. Each student has to contribute individually to the joint task and deliver an oral presentation of 15 minutes. The written part has a length of approx. 5-25 pages per student.

| Energy Distribution and CHP Plants                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                             |                       |                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | En-<br>ergDistCHPP_ESYS                                     | SPO-No.:              | 17                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Programme                                                   | Module type           | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Energy Systems and<br>Renewable Energies                    | Compulsory<br>Subject | 4                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Language of<br>instruction                                  | Duration of<br>module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | English                                                     | 1 semester            | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Huber, Matthias                                             |                       |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Denter, Niklas; Sander, Peter                               |                       |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5 ECTS / 4 SWS                                              |                       |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Contact hours                                               | 47 h                  |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Self-study                                                  | 78 h                  |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Total                                                       | 125 h                 |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Energy Distribution and CHP Plants (EnergDistCHPP_ESYS)     |                       |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | SU/Ü/PR - seminar based teaching/Exercise course/laboratory |                       |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | schrP90 - written exam, 90 minutes (EnergDistCHPP_ESYS)     |                       |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | None                                                        |                       |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                             |                       |                    |
| Combination with other lectures/topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                       |                    |
| Builds on and deepens other lectures:<br>Energy economics and renewable energies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                             |                       |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                             |                       |                    |
| The students                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                       |                    |
| <ul style="list-style-type: none"><li>gain extensive knowledge of CHP technology, its operation and economic influences, taking into account the relevant fuels.</li><li>are able to evaluate CHP plants as energy centers at different locations. They know their economic influencing variables, as well as the allocation methods to evaluate the CO2 reduction.</li><li>learn about CHP technology as a plannable and flexible energy supply technology.</li><li>have an overview of the possibilities to distribute heat and cold.</li><li>they deal in depth with the topic of heat networks and are able to design them.</li><li>gain knowledge about hydrogen as an energy carrier.</li><li>know the interactions between the different heat sources and the heat network (temperature levels) and their effect on operating costs as well as energy losses.</li><li>get an introduction into sector coupling energy system planning.</li></ul> |                                                             |                       |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                             |                       |                    |
| CHP (electricity and heat supply by means of gas-fired CHP):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                       |                    |

- CHP technology
- Efficiencies, influencing factors, utilization rates, efficiency
- CO<sub>2</sub> reduction, allocation methods for CO<sub>2</sub> reduction evaluation
- Cost structure: heat supply costs, electricity supply costs
- Operating modes: historical, current and future
- Efficient integration of CHP (heat and power) into the energy system
- Permitting aspects (exhaust emissions, installation site, noise)
- Legal framework for CHP operation
- Design of future sites
- "Green" hydrogen as an energy carrier

Heat distribution (deeper insight into energy distribution by means of heat network):

- Heat sinks (demand profiles)
- Losses
- Flow/return temperature
- Heat storage, hydraulic separator
- Transfer systems
- Influencing variables
- Cold networks and heat pumps
- Integration of solar thermal energy into heating networks
- Large solar thermal fields
- Heat storage especially in connection with solar thermal energy
- Economic efficiency of solar thermal energy

Basics of gas networks (energy distribution by means of gas network):

- pipeline-based energy transport (transport capacity, capacity price, working prices)
- Basics and basic terms (gaseous transport)
- gas quality (natural gas, hydrogen, biomethane, e-gas)
- Structure and components of a gas pipeline
- Transport network in Europe / Germany
- DVGW regulations

Basics of electricity grids (regulatory and energy industry):

- Historical development
- Electricity distribution structures
- Technical overview (voltage levels, tasks, responsibilities, structures)
- European / German power grid
- Current developments (network development plan, etc.)

#### Literature:

Compulsory:

- SCHMIDT, Dietrich, 2023. *Guidebook for the digitalisation of district heating: transforming heat networks for a sustainable future: final report; Annex TS4, Digitalisation of district heating, optimised operation and maintenance of district heating and cooling systems via Digital Process Management*. Frankfurt am Main: AGFW-Project Company. ISBN 3-89999-096-X.
- BREEZE, Paul, 2018. *Combined heat and power*. London; San Diego; Cambridge, MA; Kidlington, Oxford: Elsevier. ISBN 978-0-12-812908-1, 0128129085.
- FREDERIKSEN, Svend and Sven WERNER, 2013. *District heating and cooling*. Lund: Studentlitteratur. ISBN 978-91-44-08530-2.
- HORLOCK, . *Cogeneration-combined heat and power (CHP): thermodynamics and economics*.
- HORLACHER, HELBIG and AIGNER, *Hydro- und Gasdynamik*.
- KERSTING, William H., 2002. *Distribution system modeling and analysis*. Boca Raton [u.a.]: CRC Press. ISBN 0-8493-0812-7.

- GÖNEN, Turan, Chee-Wooi TEN and Ali MEHRIZI-SANI, 2024. *Electric power distribution engineering*. Boca Raton: CRC Press. ISBN 978-0-367-65495-5, 978-0-367-65499-3.

Recommended:

- Further literature will be announced in lecture.

**Additional remarks:**

A technically and economically optimized concept for a district heating network in a specifically defined village is to be developed using the software nPro. The results are to be summarized and presented in a presentation of approximately 10 minutes, supported by meaningful graphics. Successful completion of this additional task may account for up to 10% of the overall examination performance in the form of bonus points.

The module is not selectable if Energieverteilung and Blockheizkraftwerke is/was completed.

| Smart Grids and Wind Energy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | SmGrWiEnerg_ESYS                                            | SPO-No.:           | 18                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Energy Systems and Renewable Energies                       | Compulsory Subject | 6                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Navarro Gevers, Daniel                                      |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Navarro Gevers, Daniel; Scherer Farina, Anneliese           |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Smart Grids and Wind Energy (SmGrWiEnerg_ESYS)              |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | schrP90 - written exam, 90 minutes (SmGrWiEnerg_ESYS)       |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• know the function of the most important network operating resources in the power grid. The functionality and communicative networking and control of power generators, consumers and storage systems are known and can be described.</li><li>• can differentiate between energy transmission networks and distribution networks and distinguish between their main tasks.</li><li>• learn which intelligent solutions are available or possible in the future for the grid integration of renewable energy sources into the power grid.</li><li>• can reproduce control structures such as load control, frequency control or voltage control.</li><li>• will be able to analyze and understand wind data. They can assume a distribution and perform probability calculations.</li><li>• can calculate the annual energy yield of a wind farm at a given location.</li><li>• will be able to prepare a technical specification for a wind turbine.</li><li>• will be able to select specific wind turbines on the market that meet the project specifications.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                             |                    |                    |
| <p>1. Network resources, generators and consumers:</p> <ul style="list-style-type: none"><li>• Generators/consumers</li><li>• Transformers</li><li>• Generators</li><li>• Storage facilities</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                             |                    |                    |

- Smart metering, intelligent meters
- Converter technology
- Grid topologies
- 2. Grid stability strategies
  - Grid integration, grid stability
  - Forecasting methods
  - Load control/load shifting
- 3. Energy systems of the future
  - Smart grids
- 4. Wind Power
  - Technical basics of a wind turbine
  - Evaluating wind data
  - Energy calculation
  - Selection of a wind turbine
  - Use of artificial intelligence in the maintenance strategy
  - Rudiments of power electronics

**Literature:**

Compulsory:

None

Recommended:

- HAU, Erich, 2013. *Wind turbines: fundamentals, technologies, application, economics; 41 tables* [online]. Berlin [u.a.]: Springer. PDF e-Book. ISBN 978-3-642-27151-9. Available via: <https://doi.org/10.1007/978-3-642-27151-9>.
- REKIOUA, Djamila, 2024. *Wind Power Electric Systems: Modeling, Simulation, Control and Power Management Control* [online]. Cham: Springer Nature Switzerland. PDF e-Book. ISBN 978-3-031-52883-5. Available via: <https://doi.org/10.1007/978-3-031-52883-5>.
- SGUAREZI, Alfeu and others, 2024. *Smart grids - renewable energy, power electronics, signal processing and communication systems applications*. Cham, Switzerland: Springer. ISBN 978-3-031-37908-6, 978-3-031-37911-6.

**Additional remarks:**

The lecture is held in attendance and online.

| Solar Energy Technologies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                 |                    |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | SoIET_ESYS                                                                                                      | SPO-No.:           | 19                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Programme                                                                                                       | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Energy Systems and Renewable Energies                                                                           | Compulsory Subject | 4                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Language of instruction                                                                                         | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | English                                                                                                         | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Weitz, Klaus Peter                                                                                              |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Trinkl, Christoph; Weitz, Klaus Peter (SoIET_ESYS)<br>Trinkl, Christoph; Weitz, Klaus Peter (SoIETAR_ESYS)      |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5 ECTS / 5 SWS                                                                                                  |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Contact hours                                                                                                   | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Self-study                                                                                                      | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total                                                                                                           | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Solar Energy Technologies (SoIET_ESYS)<br>Solar Energy Technologies (admission requirement) (SoIETAR_ESYS)      |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SU/Ü/PR - seminar based teaching/Exercise course/laboratory                                                     |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | schrP90 - written exam, 90 minutes (SoIET_ESYS)<br>LN - prA - participation with/without success (SoIETAR_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None                                                                                                            |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                 |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                 |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                 |                    |                    |
| The students                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                 |                    |                    |
| <ul style="list-style-type: none"><li>• have a theoretical and practical understanding of the direct use of the sun as an energy source.</li><li>• have an overview of the status and framework conditions of solar heat utilisation as well as the potentials, possible applications and challenges.</li><li>• understand the generation of solar heat in small and large solar systems for different applications.</li><li>• are familiar with the components and system configurations of solar useful heat generation.</li><li>• understand design methods and tools and are able to use them in project planning.</li><li>• are able to simulate a solar thermal system and carry out an ecological and economic evaluation.</li><li>• know and understand the development of photovoltaics in recent years, they can interpret and classify the current status.</li><li>• understand the different components, the physical principles, the manufacturing processes and the functioning of solar cells and photovoltaic systems.</li><li>• can design and plan photovoltaic systems.</li><li>• understand the integration of photovoltaic systems into the building technology and can simulate self-consumption and self-production of electricity.</li></ul> |                                                                                                                 |                    |                    |



**The students**

- understand functionalities and energy flows in solar thermal systems.
- can evaluate the efficiency and practical behaviour of solar thermal systems.
- understand solar collector efficiency testing procedures.
- can evaluate collector efficiency under different operational conditions.
- have a thorough understanding of functionalities, characteristics, potentials and limitations of different testing facilities for solar collectors and systems.

**Content:**

- Basics of solar energy:
  - Solar energy resources, solar irradiation on earth, calculation of the position of the sun, solar irradiation on inclined planes, shading, measurement methods
- Solar thermal energy in the energy mix of the future
  - Use of solar thermal energy globally, at European and national level, perspectives of solar thermal energy in the energy mix
- Solar thermal systems (incl. laboratory course)
  - System variants and components for solar thermal domestic hot water, space heating, thermosiphon and solar air systems, design and operational strategies of solar thermal systems, solar yield and costs, area of application, design, and special features of large solar systems
- Solar thermal collectors (incl. laboratory course)
  - Conversion of solar radiation into heat, efficiency of thermal collectors, collector types, design, installation, and operation of collector arrays
- Modelling and simulation of solar thermal systems (incl. simulation workshop)
  - Opportunities and limitations of solar system simulation, areas of application and available software, modelling, parameter definition, simulation and results interpretation by means of application examples in the Polysun software suite
- Photovoltaic
  - Development of photovoltaics in Germany and the world, the German Renewable Energy Act and the photovoltaic market
  - Function and manufacturing process of a solar cell
  - Functionality and tasks of an inverter
  - Planning of a photovoltaic system (roof layout, inverter design, statics, ...)
  - Installation, cleaning and maintenance of photovoltaic systems
  - Self-consumption of electricity (consumption profile, supply profile, consumption adoption, battery storage)
  - Other forms of photovoltaic systems (tracking systems, off-grid systems, ground-mounted systems)
- Experimental analysis of functionalities and energetic performance of solar thermal systems: System components and their functionalities, energy flows, storage tank behaviour, collector efficiency
- Solar collector testing according to EN ISO 9806: Solar irradiance and collector optics, testing procedures and facilities, efficiency testing and evaluation

**Literature:****Compulsory:**

None

**Recommended:**

- QUASCHNING, Volker, 2016. *Understanding renewable energy systems* [online]. London and New York: Routledge. PDF e-Book. ISBN 978-1-315-76943-1, 978-1-317-66942-5. Available via: <https://doi.org/10.4324/9781315769431>.

- EICKER, Ursula, ©2003. *Solar technologies for buildings* [online]. Chichester: Wiley. PDF e-Book. ISBN 978-1-60119-550-0, 1-60119-550-8. Available via: <https://onlinelibrary.wiley.com/doi/book/10.1002/0470868341>.
- DUFFIE, John A., BECKMAN, William A., 2013. *Solar engineering of thermal processes* [online]. Hoboken, NJ: Wiley. PDF e-Book. ISBN 978-1-118-67160-3, 978-0-470-87366-3. Available via: <https://onlinelibrary.wiley.com/doi/book/10.1002/9781118671603>.
- TIWARI, G. N., TIWARI, Arvind, SHYAM, 2016. *Handbook of Solar Energy: Theory, Analysis and Applications* [online]. Singapore: Springer Singapore. PDF e-Book. ISBN 978-981-10-0807-8. Available via: <https://doi.org/10.1007/978-981-10-0807-8>.
- ALEXOPOULOS, Spiros, KALOGIROU, Soteris A., 2022. *Solar Thermal Energy* [online]. New York, NY: Springer US. PDF e-Book. ISBN 978-1-07-161422-8. Available via: <https://doi.org/10.1007/978-1-0716-1422-8>.

**Additional remarks:**

None

| Thermodynamics 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                    |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ThermDyn2_ESYS                                              | SPO-No.:           | 20                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Energy Systems and Renewable Energies                       | Compulsory Subject | 3                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | English                                                     | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Bschorer, Sabine                                            |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Bschorer, Sabine                                            |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Thermodynamics 2 (ThermDyn2_ESYS)                           |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | schrP90 - written exam, 90 minutes (ThermDyn2_ESYS)         |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                             |                    |                    |
| <p>After attending the module courses, participants will be able to</p> <ul style="list-style-type: none"><li>• derive the differential equations of heat conduction on a volume element and solve these with given local/temporal boundary conditions.</li><li>• characterize fluids using similarity parameters in order to calculate the heat transfer coefficient by means of appropriate Nusselt correlations.</li><li>• plot temperature profiles in heat exchangers depending on the operating conditions and use characteristic diagrams to design heat exchangers or to evaluate feasible exit temperatures.</li><li>• apply the principles of electro-magnetic heat radiation and of black and grey body radiation formula in order to approximate the heat transport of high temperature solids.</li><li>• apply heat transfer mechanisms in the practical laboratory course.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |
| <p>Heat exchange by heat conduction</p> <ul style="list-style-type: none"><li>• Fourier differential equation (heat conduction equation)</li><li>• One-dimensional steady heat conduction</li><li>• One-dimensional transient heat conduction</li></ul> <p>Heat transfer by convection</p> <ul style="list-style-type: none"><li>• Basics of thermo fluid dynamics</li><li>• Forced convection</li><li>• Natural convection</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                             |                    |                    |

- Heat exchangers

Heat transfer by radiation

- Basic concepts of radiation
- Solid body radiation

Practical laboratory course

- Test preparation
- Test realisation
- Test evaluation

#### Literature:

Compulsory:

None

Recommended:

- INCROPERA, Frank P. and others, 2017. *Incropera's principles of heat and mass transfer*. Hoboken, NJ: Wiley. ISBN 978-1-119-38291-1, 1-119-38291-2.
- KARWA, Rajendra, 2020. *Heat and Mass Transfer* [online]. Singapore: Springer Singapore. PDF e-Book. ISBN 978-981-153-988-6. Available via: <https://doi.org/10.1007/978-981-15-3988-6>.
- VENKATESHAN, S.P., 2021. *Heat Transfer* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-030-58338-5. Available via: <https://doi.org/10.1007/978-3-030-58338-5>.
- NELLIS, G. F. and S. A. KLEIN, 2021. *Introduction to engineering heat transfer*. Cambridge: Cambridge University Press. ISBN 978-1-107-17953-0.

#### Additional remarks:

None

| Fluid Mechanics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | FluMech_ESYS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SPO-No.:           | 21                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Energy Systems and Renewable Energies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Compulsory Subject | 3                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Language of instruction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | English                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Bschorer, Sabine                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Bschorer, Sabine (FluMech_ESYS)<br>Bschorer, Sabine (FluMechAR_ESYS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 5 ECTS / 5 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Contact hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Self-study                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Fluid Mechanics (FluMech_ESYS)<br>Fluid Mechanics (admission requirement) (FluMechAR_ESYS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | schrP90 - written exam, 90 minutes (FluMech_ESYS)<br>LN - prA - participation with/without success (FluMechAR_ESYS)                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | LN = admission requirement for the exam (Leistungsnachweis)<br>Within a practical course a total of 5 experiments is carried out in the laboratory. The students prepare an experimental protocol for each experiment. In addition, an exercise task must be presented in class. Proof of performance (grade 'passed') is achieved if the experiments have been carried out successfully and the presentation of the task has been carried out satisfactorily.<br><br>Successful participation in 5 laboratory sessions and presentation of one exercise as a group |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |
| After attending the module courses, participants will be able to <ul style="list-style-type: none"><li>understand and use the technical terms.</li><li>calculate analytically and evaluate either incompressible and compressible flow through pipes and around bodies.</li><li>estimate analytically pressure losses and energy consumption of fluid mechanics problems.</li><li>describe roughly the flow simulation (Computational Fluid Dynamics), in other words the digitalization in the field of fluid mechanics.</li><li>use flow measuring devices independently and to evaluate experiments.</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                    |

The students deepen the lecture material during laboratory hours (learning by doing), to use flow measuring devices independently and to evaluate experiments.

#### Content:

- Introduction and basic concepts
- Properties of fluids (density, viscosity)
- Hydrostatics and aerostatics
- Conservation equations (continuity, Bernoulli, lateral pressure, momentum conservation and Navier-Stokes-equations)
- Dimensionless quantities: Re, Ma-number
- Incompressible flow through bodies: viscous pipe flow, laminar vs. turbulent, pressure loss, pipe friction, non-circular sections, losses in pipeline elements (manifolds, nozzle)
- Incompressible flow around bodies: laminar vs. turbulent boundary layer, pressure and frictional resistance, aerodynamic forces on vehicles and aerofoils, Magnus effect
- Compressible flow: fundamental equations, pipe flow, process of outflow, de Laval nozzle
- Overview of flow simulation (approach, base equations, examples of use)
- Laboratory work about the topics as wind tunnel, flow around and through bodies
- Laboratory work about the topics: Wind tunnel, external and internal flow, wind turbine, super-sonic flow
- Calculation of an exercise and presenting it to the group

#### Literature:

Compulsory:

None

Recommended:

- ÇENGEL, Yunus A., John M. CIMBALA and Mehmet KANOĞLU, 2020. *Fluid mechanics: fundamentals and applications*. [Singapore]: McGraw-Hill. ISBN 978-981-315-788-0, 981-315-788-7.
- JANNA, William S., 2016. *Introduction to fluid mechanics*. Boca Raton, Fla. [u.a.]: CRC Press, Taylor & Francis Group. ISBN 978-1-4822-1161-0.
- KUNDU, Pijush K., Ira M. COHEN and David R. DOWLING, 2016. *Fluid mechanics*. Amsterdam [u.a.]: Elsevier/Academic Press. ISBN 0-12-405935-X, 978-0-12-405935-1.
- FALKOVICH, Gregory, 2018. *Fluid mechanics* [online]. Cambridge: Cambridge University Press. PDF e-Book. ISBN 978-1-316-41660-0. Available via: <https://doi.org/10.1017/9781316416600>.
- FALKOVICH, Gregory, 2018. *Fluid mechanics*. Cambridge; New York, NY; Melbourne, VIC ; New Delhi ; Singapore: Cambridge University Press. ISBN 978-1-107-12956-6.
- HUTTER, Kolumban, WANG, Yongqi, 2016. *Fluid and Thermodynamics: Volume 1: Basic Fluid Mechanics* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-33633-6, 978-3-319-33632-9. Available via: <https://doi.org/10.1007/978-3-319-33633-6>.
- HUTTER, Kolumban, WANG, Yongqi, 2016. *Fluid and Thermodynamics: Volume 2: Advanced Fluid Mechanics and Thermodynamic Fundamentals* [online]. Cham: Springer. PDF e-Book. ISBN 978-3-319-33636-7, 978-3-319-33635-0. Available via: <https://doi.org/10.1007/978-3-319-33636-7>.
- HUTTER, Kolumban and Yongqi WANG, 2016. *Fluid and thermodynamics*. [Cham]: Springer.

#### Additional remarks:

None

| Measurement Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                             |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | MeasmEng_ESYS                                               | SPO-No.:           | 22                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Energy Systems and Renewable Energies                       | Compulsory Subject | 3                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | English                                                     | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Müller, Dieter                                              |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Schwerd, Simon                                              |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Measurement Engineering (MeasmEng_ESYS)                     |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | schrP90 - written exam, 90 minutes (MeasmEng_ESYS)          |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                             |                    |                    |
| Engineering mathematics 1 and 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                             |                    |                    |
| <p>Students will</p> <ul style="list-style-type: none"><li>• know the basic terms of measurement technology.</li><li>• know important measuring sensors and their characteristics for frequently occurring measured quantities in mechanical engineering.</li><li>• understand data sheets of measuring elements and devices.</li><li>• can select suitable measuring elements and devices for measuring tasks.</li><li>• can estimate, determine and evaluate measurement deviations.</li><li>• can apply the distribution function, also beyond measurement technology.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                    |                    |
| <ul style="list-style-type: none"><li>• Basic terms of measurement technology</li><li>• Measurement deviations including:</li><li>• Statistical principles for the treatment of random deviations.</li><li>• Error propagation, - linear regression, - dynamic behaviour and dynamic deviations of measuring elements</li><li>• Measurement of mechanical quantities</li><li>• Measurement of electrical quantities, digital measurement, measurement systems</li><li>• Temperature measurement</li><li>• Flow measurement</li><li>• Special sensors</li></ul>                      |                                                             |                    |                    |

**Literature:**

Compulsory:

None

Recommended:

- MATILDA, S. and others, 2021. *Basic Electrical Electronics and Measurement Engineering*. Chennai: Ugam Books. ISBN 8194482543.
- BALAYI, B. and others, 2021. *Basic Electrical, Electronics and Instrumentation Engineering*. Chennai: Ugam Books. ISBN 8194482550.

**Additional remarks:**

Note on bonus system for lab reports:

In the course, lab experiments can be set (in the laboratory or digitally), which must be completed and documented in written reports. Depending on the quality of the reports, bonus points can be earned for examination performance. A maximum of 6 percent bonus points referred to the achievable points can be credited in the final examination.



| Control Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                    |                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | ContrEng_ESYS                                               | SPO-No.:           | 23                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Energy Systems and Renewable Energies                       | Compulsory Subject | 4                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Navarro Gevers, Daniel                                      |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Braun, Julian; Navarro Gevers, Daniel                       |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 5 ECTS / 5 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Contact hours                                               | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Self-study                                                  | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Control Engineering (ContrEng_ESYS)                         |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | schrP90 - written exam, 90 minutes (ContrEng_ESYS)          |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                    |                    |
| Mathematics and Electrical Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                             |                    |                    |
| <div>The students</div> <ul style="list-style-type: none"><li>• know the basic concepts of control engineering.</li><li>• know the descriptions of linear control elements (dgl. and transfer function).</li><li>• model simple systems.</li><li>• know the behaviour of common control elements.</li><li>• understand the functioning of a control loop.</li><li>• know common controller types and can adjust the controllers.</li><li>• can design controllers in the frequency range and using root locus curves.</li><li>• can design pilot controls.</li><li>• can analyse the behaviour of non-linear control loops.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                             |                    |                    |
| <div>The control loop</div> <ul style="list-style-type: none"><li>• Detailed introductory example with simulation practical course</li><li>• Linear control loop elements with simulation practical course</li><li>• Stability</li><li>• Laplace transformation</li><li>• Frequency response</li><li>• Control loop analysis</li><li>• Controller design, also with Matlab (practical course)</li></ul>                                                                                                                                                                                                                               |                                                             |                    |                    |

- Nonlinear control loops
- rudiments of artificial intelligence

**Literature:**

Compulsory:

None

Recommended:

- OGATA, Katsuhiko, 2010. *Modern control engineering*. Boston [u.a.]: Pearson. ISBN 978-0-13-713337-6, 0-13-713337-5.
- NISE, Norman, *Nise's control systems engineering*. ISBN 978-1-119-38297-3.

**Additional remarks:**

The lecture is held in attendance and online.

The module is not selectable if Regelungs- und Steuerungstechnik is/was completed.

| Cost and Investment Management                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                        |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CostInvManag_ESYS                                      | SPO-No.:           | 24                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Programme                                              | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Energy Systems and Renewable Energies                  | Compulsory Subject | 4                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Language of instruction                                | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | English                                                | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Weitz, Klaus Peter                                     |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Busche, Annika                                         |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5 ECTS / 4 SWS                                         |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Contact hours                                          | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Self-study                                             | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Total                                                  | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Cost and Investment Management (CostInvManag_ESYS)     |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | SU/Ü - lecture with integrated exercises               |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | schrP90 - written exam, 90 minutes (CostInvManag_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | None                                                   |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                        |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                        |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                        |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>understand the fundamentals of cost management and cost control in an international and sustainability-oriented business environment.</li><li>can read and interpret balance sheets, income statements, and cash flow statements of companies.</li><li>understand the structure and tasks of internal accounting systems and how sustainability considerations can be integrated into managerial accounting.</li><li>recognize their own responsibility in product development for product costs, life-cycle costs, and ESG performance along the value chain.</li><li>recognize factors influencing product costs and methods for reducing costs.</li><li>understand the necessities and challenges of investment decisions and assess the profitability of investments.</li><li>identify challenges in integrating sustainability criteria into financial markets and corporate investment decisions and apply these insights to real investment projects.</li><li>perform financial and non-financial calculations to support investment decisions that meet both economic and ESG requirements.</li></ul> |                                                        |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                        |                    |                    |
| <ul style="list-style-type: none"><li>Buyer and sales motivation, importance of customer value, and customer orientation</li><li>External accounting: Balance sheet, profit and loss statement, cash flow statement, key performance indicator, including how ESG-related disclosures are reflected in corporate reporting</li><li>Tasks of internal accounting and differences compared to external accounting</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                        |                    |                    |

- Implementation of internal accounting, cost type, cost center and product cost accounting, including the integration of sustainability-driven cost factors (e.g., resource efficiency, carbon costs, circularity)
- Identifying challenges in integrating sustainability into financial markets and investment decisions and applying these insights to practical investment assessments
- Methods of calculating product costs, including the consideration of sustainability-related cost drivers (e.g., resource efficiency, energy use, material selection)
- Necessity of cost management, especially in balancing economic performance with ecological and social requirements
- Responsibility and influence of product development on product and life cycle costs.
- Methods of cost control in product development, integrating sustainability KPIs (e.g., CO<sub>2</sub> footprint, recyclability, durability)
- Methods of cost reduction in product development
- Influence of complexity and number of variants on product costs, including sustainability implications (e.g., resource use, waste, production efficiency), and related methods of sustainable cost reduction
- Investment management and investment processes, including sustainability as a strategic investment criterion
- Methods for investment calculation

**Literature:**

## Compulsory:

- EHRENSPIEL, Klaus, KIEWERT, Alfons, LINDEMANN, Udo, 2007. *Cost-Efficient design* [online]. Berlin [u.a.]: Springer. PDF e-Book. ISBN 3-540-34647-3, 978-3-540-34648-7. Available via: <https://doi.org/10.1007/978-3-540-34648-7>.
- SULLIVAN, William G., Elin M. WICKS and C. Patrick KOELLING, 2020. *Engineering economy*. New York, NY: Pearson. ISBN 978-1-292-26496-7.

## Recommended:

- Further literature will be announced in lecture.

**Additional remarks:**

None

| Project                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                           |                    |                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------|------------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Proj_ESYS                                                                 | SPO-No.:           | 25                     |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Programme                                                                 | Module type        | Semester               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Energy Systems and Renewable Energies                                     | Compulsory Subject | 6                      |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Language of instruction                                                   | Duration of module | Frequency of offer     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | German/English                                                            | 1 semester         | winter and summer term |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Gaul, Andreas                                                             |                    |                        |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Fuchs, Daniel; Müller, Dieter; NN,                                        |                    |                        |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 5 ECTS / 4 SWS                                                            |                    |                        |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Contact hours                                                             | 47 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Self-study                                                                | 78 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Total                                                                     | 125 h              |                        |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Project (Proj_ESYS)                                                       |                    |                        |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | S/Pr - seminar/laboratory                                                 |                    |                        |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Proj - Project report (5-25 pages) and presentation (15 min.) (Proj_ESYS) |                    |                        |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | None                                                                      |                    |                        |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                           |                    |                        |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                           |                    |                        |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                           |                    |                        |
| <p>Students work one semester on their own responsibility on a self-contained, complex task. They are able to</p> <ul style="list-style-type: none"><li>tackle complex tasks as a team during the course of one semester.</li><li>quickly acquaint themselves with new topics and challenges.</li><li>analyze, break down and solve topics which include both engineering as well as commercial aspects, leveraging methods and tools learnt during their basic studies.</li><li>apply project management methods and work successfully together as team.</li><li>structure and prioritize problems and create relevant solutions to the satisfaction of the project sponsor.</li><li>apply soft skills and methods such as communication, teamwork, leadership, creativity techniques, conflict management and time management.</li><li>convincingly discuss, present and document their project's results.</li></ul> |                                                                           |                    |                        |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                           |                    |                        |
| <ul style="list-style-type: none"><li>A given topic will be tackled by a team during the course of one semester</li><li>The topics differ from semester to semester</li><li>Typically, students select a topic out of a given list of topics</li><li>Topics are typical interdisciplinary, engineering &amp; management challenges with practical relevance</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                           |                    |                        |

**Literature:**

Compulsory:

None

Recommended:

- PEDRO YOBANIS PIÑERO PÉREZ, JANUSZ KACPRZYK, RAFAEL BELLO PÉREZ, and ILIANA PÉREZ PUPO, 2024. *Computational Intelligence in Engineering and Project Management*. Switzerland: Springer. ISBN ISBN: 978-3-031-50495-2.
- YAZDI, MOHAMMAD, 2024. *Progressive Decision-Making Tools and Applications in Project and Operation Management : Approaches, Case Studies, Multi-criteria Decision-Making, Multi-objective Decision-Making, Decision under Uncertainty*. Switzerland: Springer. ISBN ISBN: 978-3-031-51719-8.

**Additional remarks:**

None

| Building Energy Technology and Smart Homes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | BETSH_ESYS                                                  | SPO-No.:           | 27                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Energy Systems and Renewable Energies                       | Compulsory Subject | 4                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Schrag, Tobias                                              |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Akbar, Shariq; Reum, Tobias                                 |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Building Energy Technology and Smart Homes (BETSH_ESYS)     |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | schrP90 - written exam, 90 minutes (BETSH_ESYS)             |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                             |                    |                    |
| <div>The students</div> <ul style="list-style-type: none"><li>• know different building envelope constructions and can calculate their thermal qualities.</li><li>• know the energy balance of a building and understand the underlying building physics principles.</li><li>• know the relevance and influences of thermal comfort.</li><li>• know about supply and distribution of thermal energy in buildings.</li><li>• know the available systems and components for thermal energy supply by fossil and renewable sources.</li><li>• know about thermal energy storage in buildings.</li><li>• know about principles, constraints and planning of heat pumps.</li><li>• know devices for heat transfer in buildings and can dimension them.</li><li>• know the basics of ventilation systems.</li><li>• know energy standards in new and existing buildings.</li><li>• know how to calculate the size of a thermal energy supply system.</li><li>• can compare Smart Homes to traditional control concepts.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                             |                    |                    |
| <div>Constraints about buildings</div> <ul style="list-style-type: none"><li>• overview of building types and energy consumption in buildings</li><li>• heat consumption for warm water and heating</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                             |                    |                    |

- thermal comfort: influences from inside and outside, calculation mechanism
- Overview of building energy law and building energy certificates
- basic about ventilation systems
- heat supply systems and their dimensioning
- plant- and system technique natural gas and oil boilers
- plant- and system technique gas and el. heat pumps
- plant- and system technique wood pellet boilers
- plant- and system technique wood chip boilers
- system technique district heating systems
- Radiators
- floor heating systems
- Basic HVAC Design
- Smart Home /building information systems
- Actors und sensors in buildings

#### Literature:

Compulsory:

None

Recommended:

- HENS, Hugo, 2024. *Building physics - heat, air and moisture: fundamentals, engineering methods, material properties and exercises*. Berlin, Germany: Ernst & Sohn. ISBN 978-3-433-03422-4, 3-433-03422-2.
- AGARWAL, Parul, MITTAL, Mamta, AHMED, Jawed, IDREES, Sheikh Mohammad, 2022. *Smart Technologies for Energy and Environmental Sustainability* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-030-80702-3. Available via: <https://doi.org/10.1007/978-3-030-80702-3>.
- KHAZAILI, Javad, 2014. *Energy-efficient HVAC design: an essential guide for sustainable building* [online]. Cham: Springer International Publishing. PDF e-Book. ISBN 978-3-319-11047-9, 978-3-319-11046-2. Available via: <https://doi.org/10.1007/978-3-319-11047-9>.
- JAIN, Arpit, SHARMA, Abhinav, JATELY, Vibhu, AZZOPARDI, Brian, 2024. *Sustainable energy solutions with artificial intelligence, blockchain technology, and internet of things* [online]. Boca Raton: CRC Press. PDF e-Book. ISBN 978-1-003-35663-9. Available via: <https://doi.org/10.1201/9781003356639>.
- MORENO-MUÑOZ, Antonio and Neomar GIACOMINI, 2023. *Energy smart appliances: applications, methodologies, and challenges*. Piscataway, NJ: IEEE Press. ISBN 978-1-119-89945-7, 9781119899440.

#### Additional remarks:

The module is not selectable if Gebäudeenergiechnik und Smart Homes is/was completed.



| Energy Markets and Coupling Sectors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                             |                    |                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | EngMaCS_ESYS                                                | SPO-No.:           | 28                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Energy Systems and Renewable Energies                       | Compulsory Subject | 6                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Huber, Matthias                                             |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Chu, Jiahe; Huber, Matthias; Mokeke, Sebota                 |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 5 ECTS / 5 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Contact hours                                               | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Self-study                                                  | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Energy Markets and Coupling Sectors (EngMaCS_ESYS)          |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | schrP90 - written exam, 90 minutes (EngMaCS_ESYS)           |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
| Basic knowledge of energy economics<br>Basic knowledge of energy production<br>Basic knowledge of business administration<br><br>Combination with other lectures/topics<br><br>Builds on and deepens other lectures:<br>Energy Distribution and CHP<br>SmartGrids and Wind Energy<br>Energy economics and renewable energies                                                                                                                                                                                                                                                                                                                                                                                                                |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                             |                    |                    |
| The students <ul style="list-style-type: none"><li>understand the individual energy markets and the interactions through sector coupling.</li><li>know the influence of the power grids and system security requirements.</li><li>have an overview of the technologies that are relevant for sector coupling and know their economic opportunities.</li><li>will be able to evaluate individual technologies from an economic and technical point of view and with regard to their environmental impact and will be familiar with the factors that influence economically successful operation.</li><li>will be able to formulate, analyze and solve linear programming problems both analytically and using computational tools.</li></ul> |                                                             |                    |                    |

**Content:**

## Energy markets and regulatory framework:

- Fundamentals of markets, supply and demand curves, pricing
- Levelized Costs of Electricity
- How does the electricity market work, electricity prices
  - Electricity exchange, energy only markets
  - Influence of renewable energies, funding schemes
  - Influence of power grid and system security
  - Interaction with neighbouring countries
  - Electricity demand, electricity generation
- The heat market, heat prices, developments, influences
  - Heat demand
  - Heat generation
- The gas market, gas prices, developments, influences
- System services Electricity grid operation
- Fuel markets
- New markets: local electricity markets, hydrogen market in the mobility sector

## Power System Operation Basics

- Power system structure
- Load flow
- Power system stability
  - Voltage
  - Frequency
  - Rotor
- Operational issues
  - Balancing-Frequency control and support
  - Power transfer limits
  - Voltage Control and support
  - System Restoration
  - Reliability resources
  - Stability Services

## Secure electricity transport in the public grid as an additional market:

- Generation structures (effect of RES generation, flexibility of power plants, profile electricity generation with renewables).
- Power distribution structures
- Measures for system security
  - System services (control power, reactive power, islanding and black start capability)
  - Capacity reserves, cold reserves
  - Disconnectable loads
  - Feed-in management
  - Smart markets

## Renewable Support Schemes

## Overview of sector coupling technologies

- Definition and Background
- Why sector coupling
- Benefits
- Storage
- Batteries in electric vehicles

- Heat pump
- Power to Heat
- Power to Gas (methane, hydrogen)
- Power to Liquid
- CHP
- Energy hubs
- Smart Home (as controllable load)
- Industrial processes (system efficiency)
- Electric cars

The individual technologies are evaluated according to their technical characteristics:

- Responsiveness
- Energy to power ratio (full load hours, utilization capability)
- Demand response capability

Introduction to linear programming:

- Fundamentals of optimization
  - Types of optimization problems
  - Objective functions
  - Constraints
  - Decision variables
  - Parameters
- Mathematical formulation of linear programming problems
- Manual mathematical solution of basic linear programming problems
- Application of linear programming to solve a dispatch problem using Pyomo

#### Literature:

Compulsory:

- STOFT, Steven, 2010. *Power system economics: designing markets for electricity*. Piscataway, NJ: IEEE Press. ISBN 0-471-15040-1, 978-0-471-15040-4.
- BRADFORD, Travis, 2018. *The energy system: technology, economics, markets, and policy*. Cambridge, MA: The MIT Press. ISBN 978-0-262-03752-5.
- BHATTACHARYYA, Subhes C., 2019. *Energy economics: concepts, issues, markets and governance* [online]. London: Springer. PDF e-Book. ISBN 978-1-4471-7468-4. Available via: <https://doi.org/10.1007/978-1-4471-7468-4>.

Recommended:

- Will be announced in lecture

#### Additional remarks:

*As bonus project, students will develop a concept for a practical sector-coupling application (e.g., electric mobility) using computational methods. The project may be carried out using specialized software such as nPro or programming-based optimization frameworks such as Pyomo. Students will model, analyze, and optimize the selected system considering relevant technical and economic parameters. The results should be summarized and presented in a presentation of approximately 10 minutes, supported by clear and meaningful graphics. Successful completion of this additional task may contribute up to 10% of the overall examination performance in the form of bonus points.*

| Mobility within the Energy System                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                 |                    |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | MobES_ESYS                                                                                                                      | SPO-No.:           | 29                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Programme                                                                                                                       | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Energy Systems and Renewable Energies                                                                                           | Compulsory Subject | 7                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Language of instruction                                                                                                         | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | English                                                                                                                         | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Gelner, Alexander                                                                                                               |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Gelner, Alexander; Zade, Michel                                                                                                 |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5 ECTS / 4 SWS                                                                                                                  |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Contact hours                                                                                                                   | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Self-study                                                                                                                      | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total                                                                                                                           | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Mobility within the Energy System (MobES_ESYS)                                                                                  |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory                                                                     |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | SA - Seminar paper with oral presentation (15 min), written elaboration (8-15 pages) or presentation (15-20 pages) (MobES_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None                                                                                                                            |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                 |                    |                    |
| Basic understanding of energy systems (conversion chain primary → final/useful energy) and energy balances.<br>Fundamentals of electrical power systems (grid levels, AC frequency as stability indicator).<br>Introductory knowledge of e-mobility charging, batteries and basic energy economics/market organization.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                 |                    |                    |
| After completing the module, students are able to ... <ul style="list-style-type: none"><li>• explain the structure of energy systems from primary to final/useful energy and interpret energy balances (e.g., Sankey diagrams) in the context of mobility demand.</li><li>• analyze grid-related constraints for electrified mobility (transmission/distribution levels, congestion) and discuss mitigation measures using flexibility concepts.</li><li>• differentiate electricity market structures and actor roles (e.g., exchanges/OTC, spot vs futures; system and market participants) and assess implications for charging and flexibility.</li><li>• evaluate smart charging and V2X use cases (V2L/V2H/V2B/V2G) including basic EMS/CPMS concepts and derive suitable application scenarios (e.g., campus/site).</li><li>• apply an evaluation toolbox (e.g., LCA vs TCO, CO<sub>2</sub> pricing/EU ETS perspective) to compare mobility pathways and communicate key trade-offs transparently.</li><li>• work effectively in a small team to structure an open problem, align assumptions and responsibilities, and deliver a coherent result.</li></ul> |                                                                                                                                 |                    |                    |

- present and defend results in a professional manner, incorporating feedback and responding to critical questions appropriately.

**Content:**

- Mobility options in the energy system: energy carriers and powertrains, infrastructure/logistics and sustainability trade-offs
- Evaluation toolbox and estimation methods: LCA/TCO frameworks; Fermi estimation for infrastructure/transition scale
- Energy system structure and energy balances (primary → final/useful energy; Sankey diagrams and comparisons)
- Liberalization/unbundling and actor landscape in the energy sector
- Transmission & distribution grids: grid levels, integration challenges, congestion and preventive measures
- Storage capacities and flexibility: technology types, characteristics, and the role of EV batteries in system-level storage
- Stability: supply-demand balance, congestion management, reserves, and “flexumer” concepts / flexibility offerings
- Security of supply: blackout basics, black-start capability, SAIDI definition/scope and country comparisons
- Energy markets: spot vs futures, OTC vs exchange trading, products and motives of participants
- Emissions trading / CO<sub>2</sub> pricing: EU ETS logic, cap-and-trade mechanism and relevance for sector coupling
- End-customer perspective: tariff structures (constant/ToU/dynamic) and implications for automated demand adaptation (smart charging, EMS)

**Literature:**

## Compulsory:

- DOPPELBAUER, Martin, 2024. *Introduction to Electromobility*. 2025. edition. Wiesbaden: Springer. ISBN 978-3-658-45481-4.
- KLELL, Manfred, 2023. *Hydrogen in Automotive Engineering*. Wiesbaden: Springer. ISBN 978-3-658-45481-4.
- HEYWOOD, John, 2018. *Internal Combustion Engines Fundamentals*. New York: McGrawHill Education. ISBN 978-1-26-011610-6.

## Recommended:

- Further literature will be announced in the lecture.

**Additional remarks:**

None

| Energy from Biomass and Biogenic Residues                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                             |                    |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EBBR_ESYS                                                   | SPO-No.:           | 30                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Energy Systems and Renewable Energies                       | Compulsory Subject | 7                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | English                                                     | 1 semester         | only winter term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Goldbrunner, Markus                                         |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Goldbrunner, Markus                                         |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 5 ECTS / 5 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Contact hours                                               | 58 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Self-study                                                  | 67 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Energy from Biomass and Biogenic Residues (EBBR_ESYS)       |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | schrP90 - written exam, 90 minutes (EBBR_ESYS)              |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                             |                    |                    |
| Thermodynamics I, Thermal Energy Technologies and Power Plants                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                             |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>are able to classify and evaluate the importance of bioenergy in today's and future energy supply.</li><li>know the most important renewable raw materials, their properties and sources of supply.</li><li>know the most important process engineering principles of the use of biomass (combustion, gasification, fermentation, fuel production) and can apply them.</li><li>know the technical concepts and the most important details of the various bioenergy plants for heat, electricity and fuel production and can use them in plant planning and evaluation.</li><li>can conceptualise a bioenergy plant, evaluate it economically and present the concept.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
| <p>Introduction</p> <ul style="list-style-type: none"><li>Greenhouse effect and renewable energies (focus on biomass, cycle)</li><li>Properties and cultivation of renewable raw materials, problems</li><li>Pathways of biomass use</li><li>Organic residues, food waste and biowaste as feedstocks for energy use</li><li>Basic economic considerations</li><li>Aspects of licensing law</li></ul> <p>Heat generation</p> <ul style="list-style-type: none"><li>Combustion concepts for large-scale plants</li></ul>                                                                                                                                                                                                                    |                                                             |                    |                    |

- Combustion concepts for small-scale plants
- Heat grids

#### Power generation through combustion

- Fundamentals of combustion
- Emissions
- Special features and design of the firing system
- Plant technology
- Use of waste wood and other residues

#### Power generation through thermal gasification

- Fundamentals of gasification, reaction kinetics
- Gasifier concepts
- Plant technology
- Utilisation of the gas
- Emissions

#### Power generation through fermentation (biogas)

- Substrate preparation / utilisation
- Basics of fermentation
- Plant technology
- Biogas pre-treatment, drying, cleaning (desulphurisation), special features of organic residues
- Gas treatment to natural gas quality (CO<sub>2</sub> separation, different processes)

#### Fuels from renewable raw materials

- Basics of fuel production, synthesis
- Biomethane as fuel, filling stations for agriculture (biogas filling stations)
- 1st generation fuels
- 2nd generation fuels

#### Seminar: Planning a bioenergy production plant

- Plant planning according to HOAI
- Economic efficiency calculation according to VDI 2067
- Conceptual design and presentation of the concept
- Approval

#### Literature:

##### Compulsory:

- 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* [online]. Berlin: Springer Berlin. PDF e-Book. ISBN 978-3-642-02856-4. Available via: <https://doi.org/10.1007/978-3-642-02856-4>.

##### Recommended:

- Further literature will be announced in the lecture.

#### Additional remarks:

None

| Solar Buildings and Energy Consulting                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                    |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | SolBuEC_ESYS                                                | SPO-No.:           | 31                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Programme                                                   | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Energy Systems and Renewable Energies                       | Compulsory Subject | 6                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Language of instruction                                     | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | English                                                     | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Schrag, Tobias                                              |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Feuchter, Fabian; Schrag, Tobias                            |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 5 ECTS / 4 SWS                                              |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Contact hours                                               | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Self-study                                                  | 78 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Total                                                       | 125 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Solar Buildings and Energy Consulting (SolBuEC_ESYS)        |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | SU/Ü/Pr - seminar based teaching/Exercise course/laboratory |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | mdIP - oral exam, 15 minutes (SolBuEC_ESYS)                 |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | None                                                        |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                             |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                             |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>• know different building concepts like passive houses, solar active houses or plus energy houses.</li><li>• can apply the rules of energetic refurbishment and energy consulting.</li><li>• learn the calculation of the heat energy demand, end energy and primary energy consumption according to DIN18599.</li><li>• analyse the thermal weaknesses of a building and define an individual refurbishment concept.</li><li>• know about building simulation through practical experience.</li><li>• can use KPIs for evaluation autonomy and economy of building related PV installations.</li><li>• know about energy plus district concepts and the integration of advanced technologies like PVT, ice storages or dual source heat pumps.</li><li>• know the differences of energy concepts for residential and non-residential buildings and know about HVAC concepts for office buildings.</li></ul> |                                                             |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                             |                    |                    |
| <ul style="list-style-type: none"><li>• application of the German building energy law</li><li>• heat bridges in new and existing buildings</li><li>• deficits and inefficiencies of heating systems</li><li>• energy certificates</li><li>• low investment refurbishment measures</li><li>• comparison of calculated and measured heat energy consumption</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                             |                    |                    |



- ventilation concepts
- investment calculation according to VDI 2067

**Literature:**

Compulsory:

None

Recommended:

- BEAUSOLEIL-MORRISON, Ian, 2021. *Fundamentals of building performance simulation*. New York; London: Routledge. ISBN 978-1-00-016928-7, 978-1-003-05527-3.
- HACHEM-VERMETTE, Caroline, 2020. *Solar buildings and neighborhoods: design considerations for high energy performance*. Cham, Switzerland: Springer. ISBN 978-3-030-47018-0.
- YUDELSON, Jerry, 2009. *Green building trends: Europe*. Washington, DC: Island Press. ISBN 978-1-61091-134-4, 1-61091-134-2.
- EICKER, Ursula, 2014. *Energy efficient buildings with solar and geothermal resources*. Chichester, West Sussex, United Kingdom: John Wiley & Sons Inc. ISBN 978-1-118-35224-3, 978-1-118-70707-4.

**Additional remarks:**

None

| Internship                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |                    |                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--------------------|------------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Intsh_ESYS                            | SPO-No.:           | 33                     |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Programme                             | Module type        | Semester               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Energy Systems and Renewable Energies | Compulsory Subject | 5                      |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Language of instruction               | Duration of module | Frequency of offer     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | English                               | 1 semester         | winter and summer term |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Kerschenlohr, Annegret                |                    |                        |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |                    |                        |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 24 ECTS / 0 SWS                       |                    |                        |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Contact hours                         | 0 h                |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Self-study                            | 600 h              |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Total                                 | 600 h              |                        |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Internship (Intsh_ESYS)               |                    |                        |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Pr - laboratory (Intsh_ESYS)          |                    |                        |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | PrB - Internship report (Intsh_ESYS)  |                    |                        |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                         | None                                  |                    |                        |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |                    |                        |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                       |                    |                        |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                       |                    |                        |
| <p>The students</p> <ul style="list-style-type: none"><li>• Receive an introduction to engineering-related work based on specific tasks.</li><li>• Obtain an insight into technical interrelations, working methods and operational processes of a company with reference to possible fields of application for future graduates.</li><li>• Enhance and put to use their technical skills from the course.</li></ul>                                                                                     |                                       |                    |                        |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                       |                    |                        |
| <ul style="list-style-type: none"><li>• Independent participation on projects and problems, whose topics are closely related to the degree program or represent a valuable addition. Exemplary problems come from the following areas: energy supply, energy plant production, energy system solutions, energy management, energy consulting, energy management.</li><li>• Application and deepening of knowledge, methods and procedures that are taught and imparted in theoretical studies.</li></ul> |                                       |                    |                        |
| Literature:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                       |                    |                        |
| <p>Compulsory:</p> <p>None</p> <p>Recommended:</p> <ul style="list-style-type: none"><li>• Company-specific</li></ul>                                                                                                                                                                                                                                                                                                                                                                                    |                                       |                    |                        |

**Additional remarks:**

Additional information:

- The internship can be carried out at approved companies only.
- The professional qualification of the supervisor should correspond to the relevant bachelor's degree.
- Universities and affiliated institutes are not permitted.

Study and examination achievements:

- Internship contract
- The practical semester of the second part of the program covers a period of 20 weeks and is accompanied by courses.
- Transcript
- Internship report

| Practical Seminar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | PracSem_ESYS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | SPO-No.:           | 34                     |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Module type        | Semester               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Energy Systems and Renewable Energies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Compulsory Subject | 5                      |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Language of instruction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Duration of module | Frequency of offer     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | English                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1 semester         | winter and summer term |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Gelner, Alexander                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    |                        |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | NN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                    |                        |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2 ECTS / 2 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    |                        |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Contact hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 23 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Self-study                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 27 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Total                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 50 h               |                        |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Practical Seminar (PracSem_ESYS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |                        |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | S - seminar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                    |                        |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | LN - participation without/with success (PracSem_ESYS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                    |                        |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>The course assessment is completed as part of the practical seminar. It may consist, in particular, of active participation in seminar sessions, workshops, exercises, field trips, or professional development sessions, as well as the completion, documentation, presentation, or reflection on a practice-oriented assignment. The specific format of the course assessment will be announced at the beginning of the course.</p> <p>The course requirement is considered “successfully completed” if students have fully fulfilled the required seminar-related contributions and demonstrate through their contributions that they can apply the learning outcomes targeted in the module to a specific career-oriented or practice-based issue.</p> |                    |                        |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                        |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                        |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                        |
| <p>This practical seminar teaches the professional skills relevant to the work of an engineer. Upon completion of the module, students will be able to</p> <ul style="list-style-type: none"><li>contextualize career-oriented tasks from the practical semester within the context of engineering practice and identify the technical, organizational, and social requirements involved.</li><li>structure technical and interdisciplinary tasks within a team, coordinate tasks, and independently develop results.</li><li>apply the technical knowledge gained during their studies to specific practical problems and critically reflect on the limitations of their own solutions.</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                        |

- apply methods of collaboration, facilitation, presentation, communication, and conflict resolution appropriately in a professional or project-related context.
- systematically reflect on their own practical experiences and draw conclusions from them regarding their further studies, personal professional development, and future career as an engineer.
- discuss technical decisions and professional practices while taking into account responsibility, ethics, sustainability, quality, and economic constraints.
- effectively use digital tools, learning platforms, and collaborative work environments to work on, document, and present practical assignments.

Because of their extensive practical experience, dual-track students already possess in-depth knowledge of field-specific competencies. In the selected seminars, it is therefore possible to delve deeper into the topics covered or to specifically choose modules that can be further developed.

#### Content:

- Working on practical technical or organizational tasks as part of a team
- Communication, facilitation, presentation, and public speaking in the technical field
- Teamwork, conflict management, feedback, and self-organization
- Scientific work, technical documentation, and structured reflection on practical experiences
- Ethical, social, and sustainability-related issues in technical decision-making
- Entrepreneurship, innovation, project work, quality, and economic constraints in a technical environment
- Use of digital tools, alternative teaching and learning platforms, and collaborative work methods
- Workshops, seminars, field trips, continuing education courses, or comparable seminar-style formats related to career-oriented competencies

#### Literature:

Compulsory:

None

Recommended:

- DOBELLI, Rolf, 2014. *The Art of Thinking Clearly*. New York: Harper Collins Publ. USA. ISBN 9780062343963.
- STRUNK JR., William and E. B. WHITE, 1999. *The elements of style*. Munich: B & T. ISBN 978-0-205-31342-6.
- Additional literature will be announced in the specific lecture.

#### Additional remarks:

- The list of seminars is updated each semester and announced along with information on the instructors, specific topics, course content, media formats, assessment methods, and required reading.
- This course is typically held at the end of each semester as a three-day intensive session.
- Students must register for the practical seminar when they register for exams, prior to the start of the intensive session.
- For dual-track students as well as for students with documented relevant practical experience, a modified version of the practical seminar may be arranged. Relevant practical experience may also result from qualified work within student initiatives, from an active role in recognized university mentoring programs, such as the BayernMentoring program, or from tutoring activities, provided that the scope, content, and level of responsibility are suitable for establishing a connection to the learning outcomes of the practical seminar. Relevant practical experience must be documented with appropriate evidence. In this case, an alternative format—such as a one-day intensive session or a series of several short sessions from an external, company- or university-related seminar or training program totaling at least six net hours—is acceptable as the minimum required duration of the external seminar or training component, provided that the learning outcomes, content, contact or accompanying components, workload requirements, and performance assessments of the practical seminar are achieved or fulfilled to an equivalent

degree. The total workload of the module is determined by the external seminar or training component, supplementary university-based support, and appropriate preparation and/or follow-up, documentation, or reflection.

- An external, company-related, or university-related seminar or training program can only be considered if it has been coordinated in advance with the person responsible for the module or the relevant department of the faculty and if equivalence with the learning outcomes of the practical seminar has been demonstrated. Insofar as this involves the recognition or credit transfer of previously acquired competencies, this is carried out in accordance with the APO THI.

| Project- and Quality-Management                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                               |                    |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|--------------------|--------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | PQM_ESYS                                      | SPO-No.:           | 35                 |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Programme                                     | Module type        | Semester           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Energy Systems and Renewable Energies         | Compulsory Subject | 5                  |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Language of instruction                       | Duration of module | Frequency of offer |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | English                                       | 1 semester         | only summer term   |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Weitz, Klaus Peter                            |                    |                    |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Bauer, Rudolf                                 |                    |                    |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4 ECTS / 4 SWS                                |                    |                    |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Contact hours                                 | 47 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Self-study                                    | 53 h               |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Total                                         | 100 h              |                    |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Project- and Quality-Management (PQM_ESYS)    |                    |                    |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | SU/Ü - lecture with integrated exercises      |                    |                    |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | schrP90 - written exam, 90 minutes (PQM_ESYS) |                    |                    |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | None                                          |                    |                    |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                               |                    |                    |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                               |                    |                    |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                               |                    |                    |
| <p>The students</p> <ul style="list-style-type: none"><li>learn basic terms and use subject-specific terminology confidentlygain an overview of the inter-relationships of project business and process thinking.</li><li>obtain deep knowledge in the areas of communication, leadership and consequent customer orientation.</li><li>can calculate and evaluate project structures and networking plans.</li><li>learn the correct use of tools such as MS-Project.</li><li>are able to assess the functionality of modern, innovative projects and quality management.</li><li>develop principles of action and methods for project managers and quality representatives.</li></ul> |                                               |                    |                    |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                               |                    |                    |
| <ul style="list-style-type: none"><li>Project definition and project organization</li><li>Work breakdown structure, planning of schedules, operation chart (CPM, MPM)</li><li>Planning of cost and efforts, Milestones, project control through e.g. earned value method and mile-stone trend analyses</li><li>Risk management in projects, FMEA</li><li>Claim and change management</li><li>Project completion techniques and acceptance procedures</li><li>Development of quality understanding, TQM philosophy, BSC</li><li>Quality management systems, QM implementation, ISO 9001</li><li>Q methods such as FTA, TRIZ, SPC and QFD</li></ul>                                      |                                               |                    |                    |

- Process management with selected tools
- lean six sigma

**Literature:**

Compulsory:

None

Recommended:

- SCHELLE, Heinz, Roland OTTMANN and Astrid PFEIFFER, 2006. *Project manager*. Nuremberg: GPM. ISBN 978-3-924841-30-0, 3-924841-30-6.
- KERZNER, Harold, 2022. *Project management: a systems approach to planning, scheduling, and controlling*. Hoboken, New Jersey: Wiley. ISBN 978-1-119-80537-3.

**Additional remarks:**

None



| Bachelor's Thesis Seminar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                         |                    |                        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|--------------------|------------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | BaThesSem_ESYS                                          | SPO-No.:           | 32                     |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Programme                                               | Module type        | Semester               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Energy Systems and Renewable Energies                   | Compulsory Subject | 7                      |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Language of instruction                                 | Duration of module | Frequency of offer     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | English                                                 | 1 semester         | winter and summer term |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Navarro Gevers, Daniel                                  |                    |                        |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                         |                    |                        |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3 ECTS / 2 SWS                                          |                    |                        |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Contact hours                                           | 23 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Self-study                                              | 50 h               |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Total                                                   | 75 h               |                        |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Bachelor Thesis Seminar (BaThesSem_ESYS)                |                    |                        |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | S - seminar                                             |                    |                        |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Coll - colloquium to graduation thesis (BaThesSem_ESYS) |                    |                        |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | None                                                    |                    |                        |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                         |                    |                        |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                         |                    |                        |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                         |                    |                        |
| <p>Students taking part of this module</p> <ul style="list-style-type: none"><li>• deepen the methods of scientific work in engineering.</li><li>• are enabled to conduct methodical literature research.</li><li>• develop a clear outline in short periods of time as a basis for the bachelor's thesis.</li><li>• lead professional discussions on the thematic structure.</li></ul>                                                                                                                                                                                                                                                                                  |                                                         |                    |                        |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                         |                    |                        |
| <p>Introduction/information session on Moodle online course:</p> <p>Moodle/Faculty of Mechanical Engineering/Seminar Bachelor's Thesis.</p> <ul style="list-style-type: none"><li>• Scientific requirements for the bachelor's thesis ("Guidelines for bachelor theses")</li><li>• Legal framework for examinations</li><li>• Introduction to research and documentation techniques (short presentation of the services of the university library)</li></ul> <p>Search for a topic:</p> <ul style="list-style-type: none"><li>• Individual choice of topic and supervisor</li><li>• Independent contacting of companies and professors</li></ul> <p>Getting to know:</p> |                                                         |                    |                        |

- Individual contact with the supervising lecturer and topic proposal
- Elaboration and written formulation of the topic
- Preparation and coordination of a time schedule for the bachelor's thesis
- Preparing the outline of the bachelor's thesis
- Preparing the registration of the bachelor's thesis

**Literature:**

Compulsory:

None

Recommended:

- GULSUN KURUBACAK-MERIC, and SERAP SISMAN-UGUR, *Improving scientific communication for lifelong learners*. ISBN 1-79984-535-4.
- GILPIN, Andrea, *A Guide to Writing in the Sciences*. ISBN 9781442627611.

**Additional remarks:**

None

| Bachelor's Thesis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                       |                    |                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|--------------------|------------------------|
| Module abbreviation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | BT_ESYS                               | SPO-No.:           | 32                     |
| Curriculum:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Programme                             | Module type        | Semester               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Energy Systems and Renewable Energies | Compulsory Subject | 7                      |
| Module attributes:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Language of instruction               | Duration of module | Frequency of offer     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | English                               | 1 semester         | winter and summer term |
| Responsible for module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Navarro Gevers, Daniel                |                    |                        |
| Lecturers:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | All lecturers                         |                    |                        |
| Credit points / SWS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 12 ECTS / 0 SWS                       |                    |                        |
| Workload:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Contact hours                         | 0 h                |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Self-study                            | 300 h              |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Total                                 | 300 h              |                        |
| Subjects of the module:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Bachelor's Thesis (BT_ESYS)           |                    |                        |
| Lecture types:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                       |                    |                        |
| Examinations:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | BA - Bachelor's Thesis (BT_ESYS)      |                    |                        |
| Special features of the examination performance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | None                                  |                    |                        |
| Recommended prerequisites:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                       |                    |                        |
| None                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                       |                    |                        |
| Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                       |                    |                        |
| <p>With the bachelor's thesis, students should demonstrate that they have the skills to work on a problem from the field of engineering in a qualified manner using scientific methods within a reasonable period of time.</p> <p>The students should be able to solve a problem from the field of mechanical engineering using engineering methods independently, systematically and creatively.</p> <p>The thesis should preferably deal with practical problems in the company.</p> <p>The preparation of the bachelor's thesis is supervised and evaluated by a professor at Ingolstadt University.</p> |                                       |                    |                        |
| Content:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                       |                    |                        |
| Engineering graduation thesis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |                    |                        |
| Literature:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                       |                    |                        |
| <p>Compulsory:</p> <p>None</p> <p>Recommended:</p> <ul style="list-style-type: none"><li>KURUBACAK-MERIC, GULSUN; SISMAN-UGUR, SERAP (1981-), <i>Improving scientific communication for lifelong learners</i>. ISBN 1-79984-535-4.</li></ul>                                                                                                                                                                                                                                                                                                                                                                |                                       |                    |                        |

- GILPIN, ANDREA; PATCHET-GOLUBEV, PATRICIA, *A Guide to Writing in the Sciences*. ISBN 9781442627611.

**Additional remarks:**

Details on the preparation of the bachelor's thesis can be obtained via Moodle in the area of the Faculty of Mechanical Engineering and via the information in the bachelor's thesis seminar.