

## Module manual

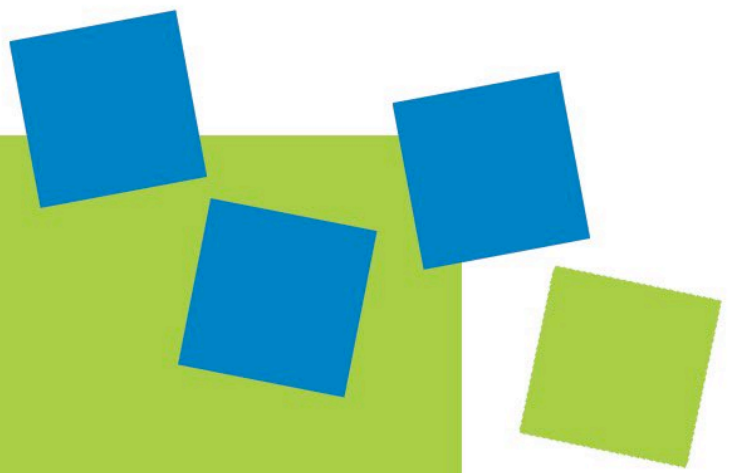
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*Smart Energy Systems (SPO WS 21/22)*

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*Faculty of Technology*

*07.05.2026*



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## 1 Introduction to the course of studies

| Smart Energy Systems  |  |                 |            |
|---|--|-----------------|------------|
| <b>Short form:</b>  | SES  | <b>SPO no.:</b> | HSAN-20212 |
| <b>Program Director:</b>  | Prof. Dr. Kerstin Weiß   |                 |            |
| <b>Study Counseling:</b>  | Prof. Dr. Kerstin Weiß   |                 |            |
| <b>ECTS:</b>  | 90 points  |                 |            |
| <b>Normal period:</b>   | 3 semesters  |                 |            |
| <b>Prerequisite for participation:</b>  | Successfully completed university degree in a relevant degree programme or an equivalent domestic or foreign degree with an overall examination grade of at least 2.3, the scope of which usually comprises 210 ECTS credits, but at least 180 ECTS credits, is required. Knowledge of English language at level B2 and German language at level A2. |                 |            |
| <b>Usability:</b>   | Master Smart Energy Systems  |                 |            |
| <b>Learning outcomes:</b>   |  |                 |            |
| <p>The general goal of the master's program Smart Energy Systems is to provide engineers and scientists with expert knowledge of energy systems and especially the interaction between the single components of the system as well as the optimization of the system.</p> <p>The master's program prepares students for the future work as managers or experts in the field of smart energy systems or related industries. Based on their previous studies, the students develop skills in order to meet the requirements of the energy sector and other energy related industries.</p> <p>The worldwide shift from fossil to renewable energy sources leads to a rising demand of experts in the field of smart energy systems. Graduates have comprehensive skills that directly address the demands of decarbonized, decentralized and digital energy systems. In addition to the energy technology and energy economy related skills, graduates also know how to deal with simulation systems, can understand and apply technologies in the field of artificial intelligence and have advanced programming skills for different target systems such as real-time devices. Besides that, graduates understand the use of IoT (Internet of Things) appliances and are able to transfer that knowledge to address energy related tasks. With their advanced skills in virtual power plants, blockchain and optimization in combination with their entrepreneurial training, graduates are prepared to develop new processes, products and business models in smart energy related industries as well as solve problems in the traditional energy industry.</p> <p>The course takes into account theoretical and practical background in a balanced way, which is taught in an application-oriented manner. Graduates are enabled to work in international energy and energy related companies and institutions, small and medium-sized companies, public authorities and energy suppliers. Graduates are also prepared to start a career as entrepreneur and open up a new start-up company as founder or co-founder as well as support start-up companies as employees such as manager or expert.</p> |  |                 |            |

| <b>Content:</b>   |
|---|
| <p>In the first semester, the Energy Systems / Energy Economics module teaches elementary technical knowledge about the components and participants of the energy system. The simulation of decentralised energy systems is one of a total of five digital modules in the first semester, in which the interaction of the individual participants in the energy system with each other is dealt with. In IoT Technologies and Data Interfaces, students learn how digitally networked, intelligent systems are created through sensor technology and inter-</p> |

net connection. With the basics of programming in LabVIEW, an easy-to-learn graphical programming environment, and the basics of artificial intelligence, the focus is on computer-based problem solving and analysis. A compulsory elective module allows a look at other exciting topics in both the first and second semesters.

In the second semester, Virtual Power Plant is concerned with another essential component for the energy systems of the future, namely the connection of decentralised energy producers with systems for storing or otherwise using surplus energy in so-called power-to-X plants for a reliable supply. How such systems communicate safely with each other and make decisions autonomously - without human intervention - is the topic of the module AI Applications in Energy Systems / Blockchain. Entrepreneurial thinking and action sheds light on energy entrepreneurship - new business models through digitalisation. Selected guest lecturers from the business world present their personal success stories as entrepreneurs and encourage students to realise their own ideas, for example in start-ups. Optimisation / Operations Research picks up on the knowledge and tools from the first semester in order to be able to optimally align and operate even complex systems using simulation. "Hands on!" is the motto in the project work - networked energy landscape, where students plan, implement and present their own project - an ideal preparation for later professional life.

The third semester allows students to deepen their knowledge of selected topics in the master's thesis, which is planned in cooperation with various companies. The master's seminar on scientific work accompanies the master's thesis, opens up the exchange between students in the form of lectures and provides the tools for a solid scientific approach.

According to the study plan and module plan the standard period is 3 semesters and comprises 90 credit points.

Student with a degree of 180 credit points must complete additional bridging semester comprising 30 credit points within the first year of the study. These credits can be achieved through additional electives, internship reports or scientific reports about work experience of minimum 1 year in a relevant field.

The first and the second semester consist each of 5 mandatory modules (5 ECTS each) and one compulsory elective. The third semester contains the master's thesis and the master's seminar scientific work, that supports the scientific exchange and provides additional skills during the period of the master's thesis.

**Graduation / Academic degree:**

Master of Engineering (M.Eng.)

## 2 Description of Modules

## 2.1 Compulsory modules

| <b>Energy Systems &amp; Energy Economy</b>   |  |                    |                 |
|--|--|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SES-EnergySystemsEnEconomy                                   | <b>Reg.no.:</b>    | 1               |
| <b>Curriculum:</b>   | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|  | Smart Energy Systems (SPO WS 21/22)                          | compulsory module  | 1               |
| <b>Responsible for module:</b>   | Prof. Dr. Georg Rosenbauer                                   |                    |                 |
| <b>Lecturers:</b>  | Prof. Dr. Georg Rosenbauer                                   |                    |                 |
| <b>Language of instruction:</b>  | English  |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>   | Contact hours:   |                    | 45 h            |
|  | Self-study:  |                    | 105 h           |
|  | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>   | Energy Systems & Energy Economy (SES-EnergySystemsEnEconomy) |                    |                 |
| <b>Lecture types:</b>  | SU, Ü: seminar-based teaching, exercise                      |                    |                 |
| <b>Examinations:</b>   | written exam, 90 minutes                                     |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |  |                    |                 |
| According to study and examination regulations and study plan  |  |                    |                 |
| <b>Recommended prerequisites:</b>  |  |                    |                 |
| None   |  |                    |                 |
| <b>Objectives:</b>   |  |                    |                 |
| <p>Technical and methodological competence:<br/>Students gain an overview on electricity market designs and understand the methods of grid operation in deregulated markets.</p> <p>Professional action competence:<br/>Students can develop investment and operating decisions based on the appropriate economic data.</p> <p>Social skills:<br/>In a comprehensive business simulation game students will cooperate to develop business strategies and coordinate their subtasks.</p>  |  |                    |                 |
| <b>Content:</b>  |  |                    |                 |
| <p>Energy balances: physical energy balance, energy process chains and Sankey diagrams, primary energetic evaluation in statistics.</p> <p>Basic terms of plant operation: equivalent operating hours, load duration curves.</p> <p>Investment calculation: financial mathematics, static and dynamic methods, financial planning models, balance sheet.</p> <p>Economical aspects of power plant operation: fixed vs. variable costs, marginal costs, contribution margin, impact on operating decisions and investment decisions.</p> <p>Aspects of grid operation: simultaneity, economies of scale, portfolio benefits, natural monopolies, vertically integrated utilities.</p> <p>Distributed generation: economic drivers, distribution grid issues, concepts of grid friendly operation.</p> |  |                    |                 |

Deregulated electricity markets: unbundling, TPA, forward vs. spot markets, pay as bid vs. market clearing price, merit order.

Grid operation in deregulated markets: portfolio management, load balancing, congestion management.

Smart energy: flexibility demand, sector coupling, sources of flexibility, optimization strategies.

**Literature:**

- KONSTANTIN, Panos and Margarete KONSTANTIN, 2018. *Power and Energy Systems Engineering Economics: Best Practice Manual*. Cham: Springer. ISBN 978-3-319-72383-9
- STERNER, Michael and Ingo STADLER, 2019. *Handbook of energy storage: demand, technologies, integration*. Translation of 2. edition. Berlin: Springer. ISBN 978-3-662-55503-3

| <b>Simulation of Energy Systems</b>   |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-SimulationEnergySystems                                | <b>Reg.no.:</b>    | 2               |
| <b>Curriculum:</b>  | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                        | compulsory module  | 1               |
| <b>Responsible for module:</b>  | Prof. Dr. Haresh Vaidya                                    |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Haresh Vaidya                                    |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>  | Contact hours:   |                    | 45 h            |
|   | Self-study:  |                    | 105 h           |
|   | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>  | Simulation of Energy Systems (SES-SimulationEnergySystems) |                    |                 |
| <b>Lecture types:</b>   | SU, Ü: seminar-based teaching, exercise                    |                    |                 |
| <b>Examinations:</b>  | projekt work, 10-20 pages                                  |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan   |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| none  |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• know the basic components of a centralized and decentralized energy systems</li> <li>• understand how the basic components of a centralized and distributed energy systems interact</li> <li>• are able to simulate simple centralized and decentralized energy systems</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able to build simulation for simple energy systems</li> <li>• are able to check simulation results of simple energy systems for plausibility</li> <li>• are able to optimize simple energy systems to a target value</li> <li>• able to transform real energy systems into simulation models</li> </ul> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able to gain knowledge and sum up the key facts independently</li> <li>• can present technical knowledge in a professional way</li> </ul> |  |                    |                 |

**Content:**

- Operation of industry standard simulation software
- Programming of closed-loop and open-loop control systems
- plausibility checks
- Modeling

**Literature:**

- will be specified during lecture

| <b>IoT Technologies and Data Interfaces</b>  |   |                    |                 |
|--|---|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SES-TechnologiesDataInterfaces  | <b>Reg.no.:</b>    | 3               |
| <b>Curriculum:</b>   | <b>Programme</b>  | <b>Module type</b> | <b>Semester</b> |
|  | Smart Energy Systems (SPO WS 21/22)                                   | compulsory module  | 1               |
| <b>Responsible for module:</b>   | Prof. Dr. Haresh Vaidya   |                    |                 |
| <b>Lecturers:</b>  | Prof. Dr. Kerstin Weiß  |                    |                 |
| <b>Language of instruction:</b>  | English   |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS  |                    |                 |
| <b>Workload:</b>   | Contact hours:  |                    | 45 h            |
|  | Self-study:   |                    | 105 h           |
|  | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>   | IoT Technologies and Data Interfaces (SES-TechnologiesDataInterfaces) |                    |                 |
| <b>Lecture types:</b>  | SU, Ü: seminar-based teaching, exercise                               |                    |                 |
| <b>Examinations:</b>   | written exam, 60 minutes  |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |   |                    |                 |
| According to study and examination regulations and study plan  |   |                    |                 |
| <b>Recommended prerequisites:</b>  |   |                    |                 |
| none   |   |                    |                 |
| <b>Objectives:</b>   |   |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>know the functionality of a variety of IoT (Internet of Things) devices</li> <li>understand the communication technologies and data interfaces that are used to transfer data between different devices, servers and other infrastructure</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>are able to apply smart technologies to energy production, consumption and storage technologies and value added services</li> <li>can evaluate how IoT-Technologies can lead to new or improved processes or even new products and services in the energy sector</li> </ul> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>are able to gain knowledge and sum up the key facts independently</li> <li>can present technical knowledge in a professional and entertaining way</li> </ul> |   |                    |                 |
| <b>Content:</b>  |   |                    |                 |
| <ul style="list-style-type: none"> <li>Internet of Things devices and their Hardware and Software</li> </ul>   |   |                    |                 |

- Data Interfaces and Data communication
- IoT-server and infrastructure

**Literature:**

- will be specified during lecture

| <b>LabVIEW Programming</b>  |   |                    |                 |
|---|---|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-LabVIEW Programming                       | <b>Reg.no.:</b>    | 4               |
| <b>Curriculum:</b>  | <b>Programme</b>                              | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)           | compulsory module  | 1               |
| <b>Responsible for module:</b>  | Prof. Dr. Kerstin Weiß                        |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Kerstin Weiß                        |                    |                 |
| <b>Language of instruction:</b>   | English                                       |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS                                |                    |                 |
| <b>Workload:</b>  | Contact hours:                                |                    | 45 h            |
|   | Self-study:                                   |                    | 105 h           |
|   | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>  | LabVIEW Programming (SES-LabVIEW Programming) |                    |                 |
| <b>Lecture types:</b>   | SU, Ü: seminar-based teaching, exercise       |                    |                 |
| <b>Examinations:</b>  | written exam, 60 minutes                      |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |   |                    |                 |
| According to study and examination regulations and study plan   |   |                    |                 |
| <b>Recommended prerequisites:</b>   |   |                    |                 |
| Basic programming skills in any programming language  |   |                    |                 |
| <b>Objectives:</b>  |   |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Know basic techniques of software development and programming</li> <li>• Understand the particularities of LabVIEW programming</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Are able to apply their programming skills to develop software applications with LabVIEW</li> <li>• Can analyze, test and debug LabVIEW VIs (virtual instruments)</li> </ul> <p>Within the modules students have the possibility to get the industry certificate "Certified LabVIEW Associate Developer – CLAD"</p> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Can independently work on programming tasks</li> </ul> |   |                    |                 |
| <b>Content:</b>   |   |                    |                 |
| <ul style="list-style-type: none"> <li>• LabVIEW Programming environment</li> </ul>   |   |                    |                 |

- Creating applications
- Debugging and Troubleshooting
- Using Loops
- Using Decision-making-structures
- Modularity
- Accessing files in LabVIEW
- Sequential and state-based designs
- Variables and the communication of data between parallel loops
- Design patterns
- Controlling the user interface
- File IO techniques
- Creating and distributing applications

**Literature:**

- LabVIEW Core 1 participant guide
- LabVIEW Core 2 participant guide
- Nation Instruments online Knowledge Database: [www.ni.com](http://www.ni.com)

| <b>Artificial Intelligence Basics</b>   |   |                    |                 |
|---|---|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-ArtificialIntelligenceBasics                                  | <b>Reg.no.:</b>    | 5               |
| <b>Curriculum:</b>  | <b>Programme</b>  | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                               | compulsory module  | 1               |
| <b>Responsible for module:</b>  | Prof. Dr. Sigurd Schacht  |                    |                 |
| <b>Lecturers:</b>   | Sudarshan Kamath Barkur   |                    |                 |
| <b>Language of instruction:</b>   | English   |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS  |                    |                 |
| <b>Workload:</b>  | Contact hours:  |                    | 45 h            |
|   | Self-study:   |                    | 105 h           |
|   | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>  | Artificial Intelligence Basics (SES-ArtificialIntelligenceBasics) |                    |                 |
| <b>Lecture types:</b>   | SU: seminar-based teaching  |                    |                 |
| <b>Examinations:</b>  | written exam, 60 minutes  |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |   |                    |                 |
| According to study and examination regulations and study plan   |   |                    |                 |
| <b>Recommended prerequisites:</b>   |   |                    |                 |
| None  |   |                    |                 |
| <b>Objectives:</b>  |   |                    |                 |
| <p>Technical and methodological competence:</p> <ul style="list-style-type: none"> <li>• Fields of application and example applications of AI</li> <li>• Data science - fundamentals and methods for discovering patterns in large data</li> <li>• Challenges and limits of AI</li> </ul> <p>Professional action competence:</p> <ul style="list-style-type: none"> <li>• Analysing, planning and selecting AI and data science methods according to requirements</li> <li>• Effective and efficient implementation of the methods (configuration of methods, etc.) with appropriate tools</li> <li>• Evaluation of the success of the applications and identification of optimization measures</li> </ul> <p>Social skills:</p> <ul style="list-style-type: none"> <li>• Communication and presentation skills, regarding the new, complex, and dynamic AI terminology, to be able to communicate with both users (business understanding) and technical AI experts (group work, case studies).</li> <li>• Ability to work in a team in interdisciplinary project teams</li> </ul> |   |                    |                 |
| <b>Content:</b>   |   |                    |                 |
| In the module "Basic AI" the following contents are taught:   |   |                    |                 |

- Overview of application areas of AI (industries, subject areas, business areas).
  - Introduction to data science tools and analysis languages and frameworks (Knime, Jupyter, Python & Pandas, Scikit-Learn, Tensorflow).
  - Areas of Artificial Intelligence in detail, especially Machine Learning, Deep Learning
  - Data Science I - meaning and basics
  - Data Science II - approach, methods and tools (e.g. CRISP-DM (Cross Industry Standard Process for Data Mining): Business Understanding, Data Understanding, Data Preparation Modeling, Evaluation, Deployment)
  - Data Science III - A machine learning project from A-Z
  - Data Science IV - Methods of Supervised Learning - explained using practical examples
  - Data Science V - Methods of Unsupervised Learning - Explained with practical examples like Anomaly Detection of Machine Learning
  - Data Science V – Simple Introduction Deep Learning
  - Challenges in the implementation of AI projects
- In addition to teaching the content through seminar-style classes and practical examples using Python, we work together in a Scrum like Learning-Approach (Agile study).

**Literature:**

- GÉRON, Aurélien, September 2019. *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: concepts, tools, and techniques to build intelligent systems*. S. edition. Beijing ; Boston ; Farnham ; Sebastopol ; Tokyo: O'Reilly. ISBN 978-1-492-03264-9, 1-492-03264-6
- MCKINNEY, Wes, October 2017. *Python for data analysis: data wrangling with Pandas, NumPy, and IPython*. S. edition. Beijing ; Boston ; Farnham ; Sebastopol ; Tokyo: O'Reilly. ISBN 978-1-491-95766-0
- Selected scientific papers on the topics of the course (the papers for the course will be provided in Moodle)

| <b>Virtual Power Plants</b>  |   |                    |                 |
|--|---|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SES-VirtualPowerPlants                        | <b>Reg.no.:</b>    | 7               |
| <b>Curriculum:</b>   | <b>Programme</b>                              | <b>Module type</b> | <b>Semester</b> |
|  | Smart Energy Systems (SPO WS 21/22)           | compulsory module  | 2               |
| <b>Responsible for module:</b>   | Prof. Dr. Kerstin Weiß                        |                    |                 |
| <b>Lecturers:</b>  | Prof. Dr. Kerstin Weiß                        |                    |                 |
| <b>Language of instruction:</b>  | English                                       |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS                                |                    |                 |
| <b>Workload:</b>   | Contact hours:                                |                    | 45 h            |
|  | Self-study:                                   |                    | 105 h           |
|  | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>   | Virtual Power Plants (SES-VirtualPowerPlants) |                    |                 |
| <b>Lecture types:</b>  | SU: seminar-based teaching                    |                    |                 |
| <b>Examinations:</b>   | written exam, 60 minutes                      |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |   |                    |                 |
| According to study and examination regulations and study plan  |   |                    |                 |
| <b>Recommended prerequisites:</b>  |   |                    |                 |
| Basic knowledge about energy economy and energy technologies   |   |                    |                 |
| <b>Objectives:</b>   |   |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Know the structure of virtual power plants</li> <li>• Understand which technologies are used in virtual power plants</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Are able to apply the idea of virtual power plants to different scenarios of energy producers and consumers</li> <li>• Can analyze different technical and economical use-cases for virtual power plants</li> </ul> |   |                    |                 |
| <b>Content:</b>  |   |                    |                 |
| <ul style="list-style-type: none"> <li>• Motivation: Why do we need virtual power plants?</li> <li>• Introduction to virtual power plants, their basic structure and use-cases</li> <li>• Energy production, energy consumption and energy storage technologies</li> <li>• Sector coupling and Power-to-X technologies</li> <li>• Demand-Side-Management</li> <li>• Marketing opportunities for virtual power plants</li> </ul>  |   |                    |                 |

- Power plant operations strategies
- Connectivity and Remote Control
- Practical examples of virtual power plants

**Literature:**

- DOLESKI, Oliver D., KAISER, Thomas, METZGER, Michael, NIESSEN, Stefan, THIEM, Sebastian, 2022. *Digital Decarbonization: Achieving climate targets with a technology-neutral approach* [online]. Wiesbaden: Springer Fachmedien Wiesbaden PDF e-Book. ISBN 978-3-658-33330-0. Available via: <https://doi.org/10.1007/978-3-658-33330-0>.

| <b>Energy Entrepreneurship</b>  |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-EnergyEntrepreneurship                           | <b>Reg.no.:</b>    | 8               |
| <b>Curriculum:</b>  | <b>Programme</b>                                     | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                  | compulsory module  | 2               |
| <b>Responsible for module:</b>  | Prof. Johannes Hähnlein                              |                    |                 |
| <b>Lecturers:</b>   | Prof. Johannes Hähnlein                              |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS                                       |                    |                 |
| <b>Workload:</b>  | Contact hours:                                       |                    | 45 h            |
|   | Self-study:  |                    | 105 h           |
|   | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>  | Energy Entrepreneurship (SES-EnergyEntrepreneurship) |                    |                 |
| <b>Lecture types:</b>   | SU: seminar-based teaching                           |                    |                 |
| <b>Examinations:</b>  | presentation, 15 minutes                             |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan   |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| None  |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <p>By participating in the module energy entrepreneurship, the students gain specific and practice-oriented specialist knowledge as well as modern methods for developing and founding their own business. This includes the core areas of trend identification, idea generation, business design and go-to-market, specifically in the energy industry.</p> <p>The module is designed as a practice-oriented workshop format in which the participants can apply the methods and specialist knowledge they have learned directly to their own project in a team and gradually develop their own founding idea and a corresponding business concept.</p> <p>The aim of the course is that the participants, working in founding teams of 3-5 team members each, develop their own business concept and present it to an expert jury as part of a final pitch.</p> <p>The module is characterized in particular by the following aspects:</p> <ul style="list-style-type: none"> <li>• <b>Practical relevance:</b> The module deliberately does not work with fictitious case studies, but is intended to get the participants to develop their own product and business ideas in teams, which they can ideally pursue, develop and even put into practice beyond the event.</li> <li>• <b>Competence expansion:</b> As participants in the module, students not only have the opportunity to apply the technical skills they have learned so far in a practical manner, but also to acquire skills that go beyond the technical and methodological competence, including product and business design as well as marketing and sales aspects.</li> </ul> |  |                    |                 |

- Innovation power: Exciting and creative methods combined with a structured setup of the module will promote the innovation power of the participating students and create a business concept based on their own marketable ideas as a relevant and realistic career option.
- Team competence: The participating students have to organize themselves independently in project teams and take on different roles, e.g. as team leader, technician, innovator or designer.
- Additional added value: The course can not only be included as a study module of the participating students, but can also include additional added value, such as
  - o Participation in the live pitch in front of a top-class jury,
  - o the opportunity to participate at the “Campus der Löwen” live-pitch event
  - o a spot for the winning team in the existence program; and
  - o the chance of further support through public funded programmes in case of a promising concept.

Acquired professional action competence:

- In the course, the students go through a realistic process of business design using state-of-the-art methods and skills;
- This initially includes the basic composition of a team;
- In the further course, the identification and systematization of methods and tools in the field of trend and innovation management, ideation, prototyping as well as market research takes place;
- The students also learn methods for generating product or service ideas, identifying fields of application, validation and business modelling;
- The students also learn and deepen key skills in the area of project management, problem-solving methods, business sub-disciplines, teamwork and communication skills as well as presentation techniques;
- By attending the event, the students can also assess an innovation process and go through it themselves in corresponding project teams.

Acquired social skills:

- Creation, structuring and work coordination of business teams;
- Team-oriented work and content-related coordination of work;
- Focused and goal-oriented work under time pressure and focusing on the essential elements of product development;
- Demonstration and application of presentation skills through interim presentations and live pitches.

**Content:**

- Teambuilding
- Trend management
- Ideation
- Business Design
- Research & Development
- Validation
- Prototyping

- Startup Finance
- Marketing & Communications
- Pitching

**Literature:**

- OSTERWALDER, Alexander and others, 2020. *The invincible company: dieses Buch ist Ihr Guide zu den besten Geschäftsmodellen der Welt. Nutzen Sie es, um Ihr Ideen-Portfolio aufzufrischen und sich neu zu erfinden. So schaffen Sie eine Kultur der Innovation und Transformation, die Ihr Unternehmen unbesiegbar macht* : [strategyzer.com/invincible](http://strategyzer.com/invincible). Frankfurt: Campus. ISBN 978-3-593-44477-2
- CHRISTENSEN, Clayton M., 2016. *The innovator's dilemma: when new technologies cause great firms to fail*. Boston, Massachusetts: Harvard Business Review Press. ISBN 978-1-4221-9602-1, 978-1-63369-178-0
- OSTERWALDER, Alexander and others, 2014. *Value proposition design: how to create products and services customers want*. Hoboken: John Wiley & Sons. ISBN 978-1-118-96806-2, 1-118-96806-9

| <b>Optimization of Energy Systems</b>   |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-OptimizationEnergySystems                                  | <b>Reg.no.:</b>    | 9               |
| <b>Curriculum:</b>  | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                            | compulsory module  | 2               |
| <b>Responsible for module:</b>  | Prof. Dr. Mathias Moog   |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Mathias Moog, Prof. Dr. Kerstin Weiß                 |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>  | Contact hours:   |                    | 45 h            |
|   | Self-study:  |                    | 105 h           |
|   | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>  | Optimization of Energy Systems (SES-OptimizationEnergySystems) |                    |                 |
| <b>Lecture types:</b>   | SU, Ü: seminar-based teaching, exercise                        |                    |                 |
| <b>Examinations:</b>  | written exam, 90 minutes                                       |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan.  |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| Energy Systems and Energy Economy, Simulation of Energy Systems   |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>The students know different optimization methods with their advantages and disadvantages. They are familiar with the application of optimization methods in energy technology.</p> <p>Professional action competence:</p> <p>The students can convert energy technology issues into mathematical models and carry out optimizations.</p> <p>Social skills:</p> <p>During the practical training, students learn to work in groups on energy-related optimization issues.</p> |  |                    |                 |
| <b>Content:</b>   |  |                    |                 |
| <p>The module consists of lectures including practical training. The following topics will be covered:</p> <ul style="list-style-type: none"> <li>• Mathematical modelling</li> <li>• Optimization procedures</li> <li>• Use of optimization methods with computer support</li> <li>• Apply optimization methods to energy-related issues</li> </ul> <p>In the practical training, the optimization is mainly tested with Excel.</p>  |  |                    |                 |
| <b>Literature:</b>  |  |                    |                 |
| <ul style="list-style-type: none"> <li>• GERSHENFELD, Neil A., 2003. <i>The nature of mathematical modeling</i>. R. edition. Cambridge [u.a.]: Cambridge Univ. Press. ISBN 0-521-57095-6</li> </ul>   |  |                    |                 |

- GIORGI, Giorgio, Angelo GUERRAGGIO and Jörg THIERFELDER, 2004. *Mathematics of optimization: smooth and nonsmooth case*. 1. edition. Amsterdam [u.a.]: Elsevier. ISBN 0-444-50550-4
- RAVINDRAN, A., Gintaras V. REKLAITIS and K. M. RAGSDELL, 2006. *Engineering optimization: methods and applications*. 2. edition. Hoboken, N.J.: Wiley. ISBN 978-0-471-55814-9, 0-471-55814-1
- GUERRERO, Hector, 2010. *Excel data analysis: modeling and simulation*. Berlin [u.a.]: Springer. ISBN 978-3-642-10834-1, 978-3-642-10835-8

| <b>Project Course - Smart Energy Systems</b>  |   |                    |                 |
|---|---|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-ProjectCourse   | <b>Reg.no.:</b>    | 10              |
| <b>Curriculum:</b>  | <b>Programme</b>  | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                       | compulsory module  | 2               |
| <b>Responsible for module:</b>  | Prof. Dr. Kerstin Weiß                                    |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Kerstin Weiß                                    |                    |                 |
| <b>Language of instruction:</b>   | English   |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS  |                    |                 |
| <b>Workload:</b>  | Contact hours:  |                    | 45 h            |
|   | Self-study:   |                    | 105 h           |
|   | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>  | Project Course - Smart Energy Systems (SES-ProjectCourse) |                    |                 |
| <b>Lecture types:</b>   | Pra: practical training                                   |                    |                 |
| <b>Examinations:</b>  | presentation, 15 minutes                                  |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |   |                    |                 |
| According to study and examination regulations and study plan   |   |                    |                 |
| <b>Recommended prerequisites:</b>   |   |                    |                 |
| Basic LabVIEW Programming Skills  |   |                    |                 |
| <b>Objectives:</b>  |   |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• know how to program and use real-time devices as NI myRIO</li> <li>• understand how to develop distributed applications and remote controllable software on computers and real-time devices</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able apply real-time hardware and their self developed software to energy related applications</li> <li>• can evaluate possible use-cases for real-time hardware to create new processes, functions or even products in the energy sector</li> </ul> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• know how to work together and organize in a team to reach a common goal in case of software development</li> <li>• understand how to define processes and interfaces to put together single elements and sub-tasks to a project</li> </ul> |   |                    |                 |

**Content:**

- introduction to real-time hardware – NI myRIO
- developing stand alone applications for NI myRIO
- using remote frontpanels
- using and developing web services
- structured application development
- final projects: using NI myRIO in smart energy systems

**Literature:**

- LabVIEW Core 3 participant guide
- Additional online sources are published during the lecture

| <b>AI Applications in Energy Systems</b>   |   |                    |                 |
|--|---|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SES-AIApplicationsEnergySystems                                     | <b>Reg.no.:</b>    | 11              |
| <b>Curriculum:</b>   | <b>Programme</b>  | <b>Module type</b> | <b>Semester</b> |
|  | Smart Energy Systems (SPO WS 21/22)                                 | compulsory module  | 2               |
| <b>Responsible for module:</b>   | Prof. Dr. Sigurd Schacht  |                    |                 |
| <b>Lecturers:</b>  | Sudarshan Kamath Barkur   |                    |                 |
| <b>Language of instruction:</b>  | English   |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS  |                    |                 |
| <b>Workload:</b>   | Contact hours:  |                    | 45 h            |
|  | Self-study:   |                    | 105 h           |
|  | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>   | AI Applications in Energy Systems (SES-AIApplicationsEnergySystems) |                    |                 |
| <b>Lecture types:</b>  | SU: seminar-based teaching  |                    |                 |
| <b>Examinations:</b>   | written exam, 60 minutes  |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |   |                    |                 |
| According to study and examination regulations and study plan  |   |                    |                 |
| <b>Recommended prerequisites:</b>  |   |                    |                 |
| None   |   |                    |                 |
| <b>Objectives:</b>   |   |                    |                 |
| <p>Technical and methodological competence:</p> <ul style="list-style-type: none"> <li>• Example Applications and Implementations in the Field of Energy Systems</li> <li>• Technical Understanding of Deep Neural Networks and Distributed Ledger Technology</li> <li>• Methods to implement and test own AI Applications</li> <li>• Challenges and limits of ANN and DTL</li> </ul> <p>Professional action competence:</p> <ul style="list-style-type: none"> <li>• Analysis, planning and selection of AI and Data Science methods according to requirements.</li> <li>• Effective and efficient implementation of the methods (configuration of methods, etc.) with appropriate tools</li> <li>• Evaluation of the success of the applications and identification of optimization measures</li> </ul> <p>Social skills:</p> <ul style="list-style-type: none"> <li>• Communication and presentation skills, regarding the new, complex and dynamic AI terminology and DTL Communication, to be able to implement own ideas as a prototype</li> <li>• Ability to work in a team in interdisciplinary project teams</li> </ul> |   |                    |                 |

**Content:**

The subject consists of two main topics: AI, especially Deep Learning, as well as Distributed Ledger Technology.

In the first part of the course, deep neural networks are taught in the form of an in-depth study of the subject Basic AI.

- What is a neural network
- How does it work
- How do neural networks learn
- Which components are necessary? (network definition, backpropagation, optimizer)

Subsequently, different network typologies are explained in depth and internalized by means of common implementations from the field of Smart Energy Systems.

- Different network architectures of artificial neural networks
- Recurrent neural networks
- LSTMs
- Convolutional neural networks
- Transformers

In the second part of the course, the Distributed Ledger Technology will be discussed:

- What is meant by blockchain and distributed ledger technology.
- What is the consensus mechanism
- Application purposes of the DLT
- What are the advantages and disadvantages
- Application potentials in the field of smart energy systems

**Literature:**

- GALEONE, Paolo, 2019. *Hands-on neural networks with TensorFlow 2.0: understand TensorFlow, from static graph to eager execution, and design neural networks*. first published: September 2019. edition. Birmingham: Packt Publishing Ltd.. ISBN 978-1-78961-555-5, 1-78961-555-0
- BUDUMA, Nikhil and Nicholas LOCASCIO, June 2017. *Fundamentals of deep learning: designing next-generation machine intelligence algorithms*. F. edition. Beijing ; Boston ; Farnham ; Sebastopol ; Tokyo: O'Reilly. ISBN 978-1-491-92561-4, 1-491-92561-2
- SCHACHT, Sigurd and Carsten LANQUILLON, 2019. *Blockchain und maschinelles Lernen: wie das maschinelle Lernen und die Distributed-Ledger-Technologie voneinander profitieren*. Berlin: Springer Vieweg. ISBN 978-3-662-60407-6
- Selected scientific papers on the topics of the course (the papers for the course will be provided in Moodle)

| <b>Master's seminar Scientific Work</b>   |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-MastersSeminar ScientificWork                                    | <b>Reg.no.:</b>    | 13              |
| <b>Curriculum:</b>  | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                                  | compulsory module  | 3               |
| <b>Responsible for module:</b>  | Prof. Dr. Haresh Vaidya  |                    |                 |
| <b>Lecturers:</b>   | Kanav Bhalla   |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>  | Contact hours:   |                    | 45 h            |
|   | Self-study:  |                    | 105 h           |
|   | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>  | Master's seminar Scientific Work (SES-MastersSeminar ScientificWork) |                    |                 |
| <b>Lecture types:</b>   | SU: seminar-based teaching   |                    |                 |
| <b>Examinations:</b>  | participation + presentation 15 -20 min                              |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan   |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| none  |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Know the principles of scientific work and related skills</li> <li>• understand how to structure and manage a project in the field of smart energy systems</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able apply basic techniques of project management to a energy related problem</li> <li>• can analyze the state of the art of a specific topic in the field of smart energy systems and develop a solution for a specific problem</li> </ul> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able to find solutions for application- or research orientated tasks using appropriate resources and applying previously gained knowledge</li> <li>• are able to summarize the most important content of a project and present the results to a professional audience</li> </ul> |  |                    |                 |
| <b>Content:</b>   |  |                    |                 |
| <ul style="list-style-type: none"> <li>• scientific work</li> </ul>   |  |                    |                 |

- presentation skills

**Literature:**

- Will be specified at the beginning

| <b>Master's Thesis</b>  |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-MastersThesis  | <b>Reg.no.:</b>    | 14              |
| <b>Curriculum:</b>  | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                          | compulsory module  | 3               |
| <b>Responsible for module:</b>  | all professors   |                    |                 |
| <b>Lecturers:</b>   | all professors   |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 25 ECTS / 0 SWS  |                    |                 |
| <b>Workload:</b>  | Contact hours:   |                    | 0 h             |
|   | Self-study:  |                    | 750 h           |
|   | Total:   |                    | 750 h           |
| <b>Subjects of the module:</b>  | Master's Thesis (SES-MastersThesis)                          |                    |                 |
| <b>Lecture types:</b>   | MA - master thesis   |                    |                 |
| <b>Examinations:</b>  | master's thesis 60-80 pages (outside the examination period) |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan   |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| NONE  |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• Know the principles of scientific work and related skills</li> <li>• Have advanced knowledge in a specific topic of smart energy systems</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• understand how to structure and manage a project in the field of smart energy systems</li> <li>• get in touch with a problem in the field of smart energy systems and developing a solution</li> </ul> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• know how to structure a project and independently work on it, using additional sources and getting support from external persons and supervisors</li> <li>• are able to summarize the most important content of a project and present the results to a professional audience</li> </ul> |  |                    |                 |
| <b>Content:</b>   |  |                    |                 |
| <p>A supervising professor will provide a topic and accompany and support the work on the thesis.</p> <p>The workload should include following steps:</p>   |  |                    |                 |

- Analysis and structuring of the problem
- Embedding of the problem into scientific context in the field of smart energy systems
- Formulation and implementation of a solution
- Design, execution and evaluation of suitable experiments/field tests/simulations
- Documentation, discussion and presentation of the results

**Literature:**

- Will be specified at the beginning

## 2.2 Elective modules I & II

| <b>Energy System Technology</b>   |   |                    |                 |
|---|---|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-EnergySystemTechnology                            | <b>Reg.no.:</b>    | 6               |
| <b>Curriculum:</b>  | <b>Programme</b>                                      | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22)                   |                    | 1               |
| <b>Responsible for module:</b>  | Prof. Dr. Alexander Buchele                           |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Alexander Buchele                           |                    |                 |
| <b>Language of instruction:</b>   | English   |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS  |                    |                 |
| <b>Workload:</b>  | Contact hours:  |                    | 45 h            |
|   | Self-study:   |                    | 105 h           |
|   | Total:  |                    | 150 h           |
| <b>Subjects of the module:</b>  | Energy System Technology (SES-EnergySystemTechnology) |                    |                 |
| <b>Lecture types:</b>   | SU, Ü: seminar-based teaching, exercise               |                    |                 |
| <b>Examinations:</b>  | written exam, 60 minutes                              |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |   |                    |                 |
| According to study and examination regulations and study plan   |   |                    |                 |
| <b>Recommended prerequisites:</b>   |   |                    |                 |
| none  |   |                    |                 |
| <b>Objectives:</b>  |   |                    |                 |
| <p>Technical/methodical competence:<br/>The students have an overview of the technical properties of renewable energy systems. You know the physico-chemical modeling principles for energy conversion and storage. They understand the application potential of the energy sources sun, wind, hydropower, biomass and geothermal energy, as well as hydrogen and thermal storage systems.</p> <p>Action competence:<br/>The students can calculate the technical application potential of different renewable energy systems. They understand the necessary modeling paragraphs and can assess the results. They can apply the theoretical basics they have learned to real technical systems.</p> <p>Social skills:<br/>In the exercises accompanying the lectures, the students learn how to independently calculate technical design data for renewable energy systems. If they have problems, they can ask your fellow students or the lecturer.</p> |   |                    |                 |
| <b>Content:</b>   |   |                    |                 |
| <ol style="list-style-type: none"> <li>1. Introduction and Thermodynamic Basics</li> <li>2. Energy Transformation and Sources <ol style="list-style-type: none"> <li>a. Solar</li> <li>b. Wind</li> <li>c. Hydro</li> <li>d. Biomass</li> </ol> </li> </ol>   |   |                    |                 |

- e. Geothermal
- 3. Energy Storage
  - a. Hydrogen
  - b. Thermal
- 4. Selected Operation Units

**Literature:**

- Quaschnig, V. (2016). Understanding Renewable Energy Systems. In Understanding Renewable Energy Systems. Routledge. <https://doi.org/10.4324/9781315769431>
- Stolten, D., & Emonts, B. (2016). Hydrogen Science and Engineering : Materials, Processes, Systems and Technology (Vols. 1–2). Wiley-VCH Verlag GmbH & Co. KGaA. <https://doi.org/10.1002/9783527674268>
- Dinçer, İ., & Rosen, M. A. (2021). Thermal Energy Storage. Wiley. <https://doi.org/10.1002/9781119713173>
- Leipertz, A. (2011). Technische Thermodynamik für Maschinenbauer, Fertigungstechniker, Verfahrenstechniker und Chemie- und Bioingenieure (4. Aufl.). ESYTEC.
- Lund, P. D., Byrne, J., Haas, R., & Flynn, D. (2019). Advances in Energy Systems: The Large-scale Renewable Energy Integration Challenge. Wiley. <https://books.google.de/books?id=cA6GDwAAQBAJ>

| <b>German I</b>   |                                     |                    |                 |
|---|-------------------------------------|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SES-German I                        | <b>Reg.no.:</b>    | 6               |
| <b>Curriculum:</b>  | <b>Programme</b>                    | <b>Module type</b> | <b>Semester</b> |
|   | Smart Energy Systems (SPO WS 21/22) |                    | 1               |
| <b>Responsible for module:</b>  | Prof. Dr. Haresh Vaidya             |                    |                 |
| <b>Lecturers:</b>   | N.N                                 |                    |                 |
| <b>Language of instruction:</b>   | German/English                      |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS                      |                    |                 |
| <b>Workload:</b>  | Contact hours:                      |                    | 45 h            |
|   | Self-study:                         |                    | 105 h           |
|   | Total:                              |                    | 150 h           |
| <b>Subjects of the module:</b>  | German I (SES-German I)             |                    |                 |
| <b>Lecture types:</b>   | SU: seminar-based teaching          |                    |                 |
| <b>Examinations:</b>  | written exam, 60 minutes            |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |                                     |                    |                 |
| According to study and examination regulations and study plan   |                                     |                    |                 |
| <b>Recommended prerequisites:</b>   |                                     |                    |                 |
| None  |                                     |                    |                 |
| <b>Objectives:</b>  |                                     |                    |                 |
| <p>Technical and methodological competence:</p> <p>The students get the communication basics for everyday life in Germany and for their studies. Through practicing of speaking and writing they get insights into the German culture and language and consolidate their previous knowledge. They expand their knowledge of vocabulary and structures of the German language and improve their pronunciation by getting confident with the sound, the rhythm and melody of the foreign language.</p> <p>Professional action competence:</p> <p>The students are able to master simple communicative situations in German. They understand dialogues and basic information regarding everyday's life and can interact and speak about their personal experience and their needs.</p> <p>Social skills:</p> <p>The students gain self-confidence for interaction in German in different situations outside the classroom and improve also general communications skills like active listening, empathy, interaction in groups. They get familiar with the German culture and "way of life", so that they can feel at home in the new environment.</p> |                                     |                    |                 |
| <b>Content:</b>   |                                     |                    |                 |
| The students bring their topics, moods and situations into the lectures. In framework activities that alternate individual support and work group, they practice and improve their language and communication skills. In the following reflection phase, they get theoretical impulses to the grammar and language structures and   |                                     |                    |                 |

their questions are answered. The assimilation of the new skills takes place through practicing the language in authentic situations outside the classroom.

**Literature:**

- DENGLER, Stefanie and others, 2020. *Netzwerk neu A2.2: Kursbuch mit Audios und Videos*. 1. edition. Stuttgart: Ernst Klett Sprachen. ISBN 978-3-12-607164-2

| <b>German II</b>   |  |                    |                 |
|--|--|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SES-German II                                  | <b>Reg.no.:</b>    | 12              |
| <b>Curriculum:</b>   | <b>Programme</b>                               | <b>Module type</b> | <b>Semester</b> |
|  | Smart Energy Systems (SPO WS 21/22)            | elective module    | 2               |
| <b>Responsible for module:</b>   | Prof. Dr. Haresh Vaidya                        |                    |                 |
| <b>Lecturers:</b>  | N.N.   |                    |                 |
| <b>Language of instruction:</b>  | German   |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS                                 |                    |                 |
| <b>Workload:</b>   | Contact hours:                                 |                    | 45 h            |
|  | Self-study:                                    |                    | 105 h           |
|  | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>   | German II (SES-German II)                      |                    |                 |
| <b>Lecture types:</b>  | SU: seminar-based teaching                     |                    |                 |
| <b>Examinations:</b>   | project work + presentation, 10 pages + 15 min |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |  |                    |                 |
| According to study and examination regulations and study plan  |  |                    |                 |
| <b>Recommended prerequisites:</b>  |  |                    |                 |
| None   |  |                    |                 |
| <b>Objectives:</b>   |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>The students are proficient in communication in German, in a private as well as in a professional environment. They are familiar with different kind of written texts (newspaper articles, literature, e-mails and social media...) and acquainted with typical business situations with their specific language and social rules.</p> <p>Professional action competence:</p> <p>The students develop the ability to communicate appropriately and professionally in typical situations in private and public life. They connect to the topics of their SES studies and learn to discuss and present them in German. They acquire the competences to present a known topic to an audience and to take part to discussions expressing in a simple way their opinions and argumentations.</p> <p>Social skills:</p> <p>The students learn to communicate clearly and intelligibly in German. They build communication capabilities for different situations and are able to work in a group interacting in German. They develop awareness for intercultural differences and can communicate in an appropriate way according to the given context.</p> |  |                    |                 |
| <b>Content:</b>  |  |                    |                 |
| The focus is on interaction and group work on given topics. In an action phase the students practice the written and spoken language and various communications skills. In the reflection phase they analyze the used language with the support of the trainer and get theoretical impulses to improve and strengthen their proficiency in communication in German.  |  |                    |                 |

**Literature:**

- DENGLER, Stefanie and others, 2021. *Netzwerk neu B1.2: Kurs- und Übungsbuch mit Audios und Videos*. 1. edition. Stuttgart: Ernst Klett Sprachen. ISBN 978-3-12-607171-0, 978-3-12-607191-8

| <b>Photovoltaics Engineering</b>   |  |                    |                 |
|--|--|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SES-PhotovoltaicsEngineering                             | <b>Reg.no.:</b>    | 12              |
| <b>Curriculum:</b>   | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|  | Smart Energy Systems (SPO WS 21/22)                      | elective module    | 2               |
| <b>Responsible for module:</b>   | Prof. Dr. Mathias Moog                                   |                    |                 |
| <b>Lecturers:</b>  | Prof. Dr. Mathias Moog                                   |                    |                 |
| <b>Language of instruction:</b>  | English  |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>   | Contact hours:   |                    | 45 h            |
|  | Self-study:  |                    | 105 h           |
|  | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>   | Photovoltaics Engineering (SES-PhotovoltaicsEngineering) |                    |                 |
| <b>Lecture types:</b>  | SU, Ü: seminar-based teaching, exercise                  |                    |                 |
| <b>Examinations:</b>   | written exam, 90 minutes                                 |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |  |                    |                 |
| According to study and examination regulations and study plan  |  |                    |                 |
| <b>Recommended prerequisites:</b>  |  |                    |                 |
| None   |  |                    |                 |
| <b>Objectives:</b>   |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>The course is based on self-conducted experiments and investigations executed partly in labs, partly as outdoor research. Students not only learn to use different lab measuring devices but also how to handle typical measurement tools that are in practical use with the photovoltaics industry. Students learn to design a simple software-based plant layout and evaluate its economic efficiency. They get familiar with widely-used software in the field of photovoltaics.</p> <p>Professional action competence:</p> <p>Presentation skills: Experiment results will regularly be presented and discussed in plenary sessions. Thus the students' ability to give presentations will be improved.</p> <p>Lab skills: During the entire workshop, a range of typical measurement devices (partially not PV-specific) will be used.</p> <p>Social skills:</p> <p>The experiments are done in self-organised teams with 3 to 4 students. Coordination, joint decision making and discussions of experiment results strengthen the social skills.</p> |  |                    |                 |
| <b>Content:</b>  |  |                    |                 |
| <ul style="list-style-type: none"> <li>• Solar insolation, Three-Component-Model</li> <li>• Measurement of U-I curves using different methods</li> <li>• Evaluate the Performance Ratio of an outdoor PV setup</li> <li>• Analysis of the effects of partial shadowing scenarios</li> </ul>  |  |                    |                 |

- Evaluation of potential locations for application
- Plant design with regard to technical and economical aspects
- Evaluation of data gained from a commercial photovoltaic plant, fault analysis
- IR-based fault analysis of single modules

**Literature:**

- MERTENS, Konrad, 2019. *Photovoltaics: fundamentals, technology, and practice*. S. edition. New York: Wiley. ISBN 978-1-119-40104-9

| <b>Building Physics</b>   |   |                    |                 |
|---|---|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SBS-BuildingPhysics                         | <b>Reg.no.:</b>    | 1               |
| <b>Curriculum:</b>  | <b>Programme</b>                            | <b>Module type</b> | <b>Semester</b> |
|   | Sustainable Building Systems (SPO WS 23/24) | compulsory module  | 1               |
| <b>Responsible for module:</b>  | Prof. Dr. Haresh Vaidya                     |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Haresh Vaidya                     |                    |                 |
| <b>Language of instruction:</b>   | English                                     |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS                              |                    |                 |
| <b>Workload:</b>  | Contact hours:                              |                    | 45 h            |
|   | Self-study:                                 |                    | 105 h           |
|   | Total:                                      |                    | 150 h           |
| <b>Subjects of the module:</b>  | Building Physics                            |                    |                 |
| <b>Lecture types:</b>   | SU, Ü: seminar-based teaching, exercise     |                    |                 |
| <b>Examinations:</b>  | written exam, 90 minutes                    |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |   |                    |                 |
| According to study and examination regulations and study plan   |   |                    |                 |
| <b>Recommended prerequisites:</b>   |   |                    |                 |
| none  |   |                    |                 |
| <b>Objectives:</b>  |   |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• have extensive knowledge in the field of physical principles of heat, moisture, sound, and fire protection.</li> <li>• are proficient in assessing existing buildings according to their special constructions and working out basic renovation proposals-</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able to provide standard-compliant proofs of building physics for the above-mentioned topics.</li> <li>• Understand the environmental implications of building physics decisions and can design solutions that align with ESG principles, prioritizing energy efficiency and resource conservation.</li> <li>• are aware of the interdependencies in building physics and know how to positively influence these for creating sustainable buildings.</li> <li>• know how to assess the thermal and hygric behavior of buildings and building constructions.</li> </ul> <p>Social skills:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able to gain knowledge and sum up the key facts independently.</li> </ul> |   |                    |                 |

**Content:**

The course introduces different topics in building physics such as:

- Indoor and outdoor climate
- Heat transfer including introduction to energy use in buildings.
- Moisture transfer, acoustics, and lighting.

**Literature:**

- will be specified during lecture

| <b>Sustainability (lecture series)</b>   |  |                    |                 |
|--|--|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SBS-Sustainability (lecture series)                      | <b>Reg.no.:</b>    | 12              |
| <b>Curriculum:</b>   | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|  | Sustainable Building Systems (SPO WS 23/24)              | compulsory module  | 1               |
| <b>Responsible for module:</b>   | Prof. Dr. Haresh Vaidya                                  |                    |                 |
| <b>Lecturers:</b>  | FH-Deggendorf Prof. Dr. Robert Feicht                    |                    |                 |
| <b>Language of instruction:</b>  | English  |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>   | Contact hours:   |                    | 45 h            |
|  | Self-study:  |                    | 105 h           |
|  | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>   | Sustainability (lecture series)                          |                    |                 |
| <b>Lecture types:</b>  | Online coursework offered by Virtuelle Hochschule Bayern |                    |                 |
| <b>Examinations:</b>   | written exam, 60 minutes                                 |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |  |                    |                 |
| According to study and examination regulations and study plan  |  |                    |                 |
| <b>Recommended prerequisites:</b>  |  |                    |                 |
| none   |  |                    |                 |
| <b>Objectives:</b>   |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• get a holistic view of the most important sustainability models and analysis methods for sustainable development</li> <li>• are acquainted with the basic methods for a fair distribution of environmental goods as well as environmental policy instruments from environmental and resource economics as well as tools for sustainable spatial design</li> <li>• in reference to ESG "E" understanding sustainability models and economic tools empowers students to design solutions that promote environmental stewardship, optimize resource use, and contribute to the development of sustainable systems.</li> <li>• have a basic understanding of current technologies and developments and assess measures in the field of renewable energy systems in the context of grid expansion, energy distribution and storage technologies.</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>• are able to select renewable raw materials for the production of materials and products, the recycling or pollutant-free landfilling of existing products and materials</li> <li>• can optimize natural processes from a material and energy point of view.</li> </ul> |  |                    |                 |

**Social skills:**

By the end of this course, students

- are able to gain knowledge and sum up the key facts independently
- can present technical knowledge in a professional and entertaining way
- in reference to ESG "S" these skills contribute to effective communication and collaborative problem-solving, enhancing teamwork and promoting responsible decision-making in sustainable design and development.

**Content:**

- General principles of sustainability: Students learn about the interrelationships of social, ecological and economic factors and actors and apply basic sustainability models and analysis methods.
- Economic framework of sustainability: Students learn methods of environmental and resource economics and assess the use of sustainability policy instruments.
- Materiality and sustainability: Students understand the material cycles of the earth and learn about the production of materials from renewable raw materials and the recycling and disposal of products.

**Literature:**

- will be specified during lecture

| <b>AI-powered Innovation Management</b>   |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SBS-AI-powered Innovation Management   | <b>Reg.no.:</b>    | 4               |
| <b>Curriculum:</b>  | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|   | Sustainable Building Systems (SPO WS 23/24)  | Elective modules   | 1               |
| <b>Responsible for module:</b>  | Prof. Johannes Hähnlein  |                    |                 |
| <b>Lecturers:</b>   | Prof. Johannes Hähnlein  |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>  | Contact hours:   |                    | 45 h            |
|   | Self-study:  |                    | 105 h           |
|   | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>  | AI-powered Innovation Management   |                    |                 |
| <b>Lecture types:</b>   | Blended learning: Seminar und workshop-based teaching and online-based (self-learning) |                    |                 |
| <b>Examinations:</b>  | Portfolio (presentation/project paper 30/70 %), 15 min/30 pages                        |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan   |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| none  |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <ul style="list-style-type: none"> <li>• ...</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> <li>• ..</li> </ul> |  |                    |                 |
| <b>Content:</b>   |  |                    |                 |
| ..  |  |                    |                 |



| <b>Building Information Modeling</b>  |  |                    |                 |
|---|--|--------------------|-----------------|
| <b>Module abbreviation:</b>   | SBS-Building Information Modeling                            | <b>Reg.no.:</b>    | 7               |
| <b>Curriculum:</b>  | <b>Programme</b>   | <b>Module type</b> | <b>Semester</b> |
|   | Sustainable Building Systems (SPO WS 23/24)                  | compulsory module  | 2               |
| <b>Responsible for module:</b>  | Prof. Dr. Haresh Vaidya                                      |                    |                 |
| <b>Lecturers:</b>   | Prof. Dr. Haresh Vaidya                                      |                    |                 |
| <b>Language of instruction:</b>   | English  |                    |                 |
| <b>Credit points / SWS:</b>   | 5 ECTS / 4 SWS   |                    |                 |
| <b>Workload:</b>  | Contact hours:   |                    | 45 h            |
|   | Self-study:  |                    | 105 h           |
|   | Total:   |                    | 150 h           |
| <b>Subjects of the module:</b>  | Building Information Modeling                                |                    |                 |
| <b>Lecture types:</b>   | SU, Ü: seminar-based teaching, exercise                      |                    |                 |
| <b>Examinations:</b>  | project work, 10 - 20 pages (outside the examination period) |                    |                 |
| <b>Prerequisites according examination regulation:</b>  |  |                    |                 |
| According to study and examination regulations and study plan   |  |                    |                 |
| <b>Recommended prerequisites:</b>   |  |                    |                 |
| none  |  |                    |                 |
| <b>Objectives:</b>  |  |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students</p> <ul style="list-style-type: none"> <li>possess the ability to create intricate digital models using parametric and free form modelling techniques.</li> <li>in reference to ESG "E" these skills enable the creation of optimized building designs that enhance sustainability and minimize resource use.</li> <li>are capable of assessing and implementing different levels of detail in BIM models according to project requirements (BIM Maturity Levels and Levels of Development).</li> <li>will demonstrate expertise in utilizing data exchange formats for seamless communication and interoperability in BIM workflows.</li> <li>have the skills to develop and execute comprehensive plans for integrating BIM processes throughout the project lifecycle.</li> <li>have proficiency in using software tools for digital modelling, analysis, and visualization within the context of BIM.</li> </ul> <p>Professional action competence:</p> <p>By the end of this course, students</p> |  |                    |                 |

- apply technical knowledge and methodological skills to real-world scenarios, demonstrating the ability to manage projects effectively.
- can communicate ideas, findings, and solutions professionally through written reports and oral presentations.
- in reference to ESG "G" this promotes transparent and responsible communication in project management, ensuring environmental, social, and governance considerations are effectively addressed.

#### Social skills:

By the end of this course, students

- work effectively in teams, demonstrating strong teamwork, communication, and cooperation in group projects.
- engage in productive collaboration with professionals from diverse fields to address complex challenges and achieve common goals in the context of construction projects.

#### Content:

The course provides a comprehensive overview of different aspects of Building Information Modeling, ranging from technical skills to methodological approaches and software applications such as:

- Parametric Modelling: Techniques and principles of parametric modelling in BIM.
- Free form Modelling: Methods for creating complex, organic shapes, and structures in BIM.
- BIM Maturity Levels: Understanding the levels of maturity in BIM adoption and implementation.
- Levels of Development (LOD): Detailed exploration of LOD and its significance in BIM models.
- Industry Foundation Classes (IFC): Overview and application of the IFC data exchange format for interoperability in BIM.
- Building Collaboration Format (BCF): Understanding and utilizing BCF for communication and issue tracking in BIM projects.
- BIM-Execution Plan (BEP): Planning and executing BIM processes effectively throughout the project lifecycle.
- Exemplary Software Systems: Introduction to software tools used in BIM workflows, including their features and functionalities.
- Digital Modelling of Environment: Techniques for modelling both natural and built environments digitally.
- Model-Based Planning: Concepts and methods for digital model-based planning of construction projects.
- Computer-Aided Design (CAD): In-depth exploration of CAD methods and tools within the context of BIM.
- Data Exchange Formats: Understanding various data exchange formats used in BIM, including IFC, BCF, and others.

#### Literature:

- will be specified during lecture

| <b>Smart Building Controls</b>   |   |                    |                 |
|--|---|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SBS-Smart Building Controls                 | <b>Reg.no.:</b>    | 10              |
| <b>Curriculum:</b>   | <b>Programme</b>                            | <b>Module type</b> | <b>Semester</b> |
|  | Sustainable Building Systems (SPO WS 23/24) | compulsory module  | 2               |
| <b>Responsible for module:</b>   | Prof. Dr. Mathias Moog                      |                    |                 |
| <b>Lecturers:</b>  | Prof. Dr. Mathias Moog                      |                    |                 |
| <b>Language of instruction:</b>  | English                                     |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS                              |                    |                 |
| <b>Workload:</b>   | Contact hours:                              |                    | 45 h            |
|  | Self-study:                                 |                    | 105 h           |
|  | Total:                                      |                    | 150 h           |
| <b>Subjects of the module:</b>   | Smart Building Controls                     |                    |                 |
| <b>Lecture types:</b>  | SU, Ü: seminar-based teaching, exercise     |                    |                 |
| <b>Examinations:</b>   | written exam, 90 minutes                    |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |   |                    |                 |
| According to study and examination regulations and study plan  |   |                    |                 |
| <b>Recommended prerequisites:</b>  |   |                    |                 |
| None   |   |                    |                 |
| <b>Objectives:</b>   |   |                    |                 |
| <p><b>Knowledge:</b> The students know bus systems and software for building control. They know about smart buildings and how the building automation interacts with sustainability. In reference to ESG "E" this knowledge enables students to contribute to the development of more efficient and sustainable smart building solutions.</p> <p><b>Professional skills:</b> The students can use existing systems and add new functionality to them. They can develop new services for smart buildings. In reference to ESG "E" developing new services promotes the adoption of renewable energy and energy-saving technologies in building automation.</p> <p><b>Social skills:</b> The students can talk to specialist planners about building automation. They can work in a team on building automation topics. In reference to ESG "G" students are able to work in teams on building automation topics to address complex challenges, ensuring that automated systems align with sustainability and performance goals.</p> |   |                    |                 |
| <b>Content:</b>  |   |                    |                 |
| <p>The module consists of seminar-based instruction and practical work. The following Topics will be covered:</p> <ul style="list-style-type: none"> <li>• Terms and concepts (room automation, building automation, smart building, smart home)</li> <li>• Hardware (microcontrollers, embedded systems, networks)</li> <li>• Bus systems in building automation (KNX, BacNET, MODBUS, ...)</li> <li>• Software for building automation and smart buildings</li> <li>• Building automation life cycle (commissioning, maintenance, data analysis, adjustment of the system)</li> </ul>  |   |                    |                 |

- Practical examples (networking of technical building systems across protocol and network boundaries, integration into the building management system)

Free software such as openHAB, MariaDB, Octave and the Arduino IDE are mainly used for the lecture and the practical course. This software is used during the presence time and for preparation and follow-up during the self-study time.

**Literature:**

- Merz, Hanseman, Hübner. Gebäudeautomation. Hanser Fachbuchverlag, 2016
- Aschendorf. Energiemanagement durch Gebäudeautomation. Springer Fachmedien Wiesbaden, 2014
- Gröger. Energiemanagement mit Gebäudeautomationssystemen. expert verlag, 2004.
- Heidemann. Nachhaltigkeit durch Gebäudeautomation. TGA Verlag, 2013
- openHAB [www.openhab.org](http://www.openhab.org)

| <b>Sustainable HVAC</b>  |   |                    |                 |
|--|---|--------------------|-----------------|
| <b>Module abbreviation:</b>  | SBS-Sustainable HVAC                        | <b>Reg.no.:</b>    | 6               |
| <b>Curriculum:</b>   | <b>Programme</b>                            | <b>Module type</b> | <b>Semester</b> |
|  | Sustainable Building Systems (SPO WS 23/24) | compulsory module  | 2               |
| <b>Responsible for module:</b>   | Prof. Dr. Haresh Vaidya                     |                    |                 |
| <b>Lecturers:</b>  | Prof. Dr. Haresh Vaidya                     |                    |                 |
| <b>Language of instruction:</b>  | English                                     |                    |                 |
| <b>Credit points / SWS:</b>  | 5 ECTS / 4 SWS                              |                    |                 |
| <b>Workload:</b>   | Contact hours:                              |                    | 45 h            |
|  | Self-study:                                 |                    | 105 h           |
|  | Total:                                      |                    | 150 h           |
| <b>Subjects of the module:</b>   | Sustainable HVAC                            |                    |                 |
| <b>Lecture types:</b>  | SU, Ü: seminar-based teaching, exercise     |                    |                 |
| <b>Examinations:</b>   | written exam, 90 minutes                    |                    |                 |
| <b>Prerequisites according examination regulation:</b>   |   |                    |                 |
| According to study and examination regulations and study plan  |   |                    |                 |
| <b>Recommended prerequisites:</b>  |   |                    |                 |
| Basic knowledge about energy economy and energy technologies   |   |                    |                 |
| <b>Objectives:</b>   |   |                    |                 |
| <p>Technical and methodological competence:</p> <p>By the end of this course, students can</p> <ul style="list-style-type: none"> <li>analyze the required capacity for renewable energy supply and heat storage.</li> <li>In reference to ESG "E" this skill supports the integration of renewable energy technologies into building systems, contributing to the transition towards more sustainable energy solutions.</li> <li>analyze the required capacity for technical installations for ventilation, heating, cooling, and domestic hot water.</li> <li>In reference to ESG "G" accurate analysis of these systems ensures effective energy management and governance, promoting sustainability and reducing carbon footprints.</li> <li>deliver descriptions of system solutions for renewable energy supply, heat storage, ventilation, tempering of rooms, domestic water supply, sewerage, and the preparation of domestic hot water - use dynamic simulation programs for dimensioning of energy supply and air conditioning systems, and evaluation of indoor climate and energy efficiency.</li> </ul> <p>Professional action competence:</p> <ul style="list-style-type: none"> <li>Design and optimize systems that balance energy supply and demand for sustainable building operation.</li> <li>Evaluate the economic and technical feasibility of renewable energy and energy efficiency measures in real-world applications.</li> </ul> |   |                    |                 |

- in reference to ESG "S" this analysis supports socially equitable solutions that maximize energy access and efficiency for all communities.

**Content:**

- Introduction to HVAC Systems
  - Basics of heating, ventilation, and air conditioning.
  - Energy demands in buildings and sustainability challenges.
- Energy Efficiency in HVAC
  - High-efficiency equipment and components.
  - Smart HVAC controls and automation.
  - Retrofitting existing systems for improved efficiency.
- Renewable Energy Integration
  - Solar thermal heating and cooling.
  - Ground-source heat pumps and geothermal systems.
  - Hybrid HVAC systems with renewable inputs.
- Indoor Environmental Quality (IEQ)
  - Thermal comfort and air quality standards.
  - Balancing energy use with occupant health and well-being.
- Life Cycle Assessment and Environmental Impact
  - Carbon footprint analysis for HVAC systems.
  - Design strategies for reducing lifecycle emissions.
- Simulation and Practical Applications
  - HVAC performance modelling using software tools.
  - Real-world case studies of sustainable HVAC systems

**Literature:**

- Roger W. Haines, P.E., AP Michael E., Myers, P.E., HVAC Systems Design Handbook, 2010, ISBN: 9780071622974