HOCHSCHULE ANSBACH

Module manual

Sustainable Building Systems (SPO WS 23/24)

Faculty of Technology

Content

Sustainable Building Systems			
Short form:	SBS	**SPO no.:**	HSAN-20212
Program Director:	Vaidya, Haresh		
Study Counseling:	Vaidya, Haresh, Mathias, Moog		
ECTS:	90 points		
Normal period:	3 semesters		
Prerequisite for participation:	Successfully completed university degree in a relevant degree programme or an equivalent domestic or foreign degree with an overall examination grade of at least 2.5, 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 A1.		
Usability:	Master Sustainable Building Systems		

Learning outcomes:

Graduates of the Sustainable Building Systems program will emerge equipped with a multifaceted understanding of sustainable construction practices. They will demonstrate proficiency in conceptualizing, designing, and implementing environmentally conscious building solutions that prioritize energy efficiency and renewable energy integration.

Through a comprehensive curriculum, students will delve into the intricacies of building technology, gaining insights into building physics, heating, ventilation, and air conditioning (HVAC) systems, sustainability and building automation. Additionally, they will develop a holistic perspective on the environmental, economic, and social implications of construction activities, enabling them to make informed decisions that contribute to long-term sustainability. Armed with a diverse skill set, including interdisciplinary collaboration and effective communication, graduates will be poised to lead initiatives aimed at reducing the carbon footprint of the built environment while meeting the evolving demands of the global construction industry.

Sustainability in buildings is not just a trend, it’s the only way forward. The global commitment to offer sustainable and affordable built environments will include a transition towards CO2-neutral solutions for both new and existing buildings. This task is not only challenging but also requires lots of motivated people with expertise in the field of building energy efficiency and that are aware of the interdependencies in building physics and know how to positively influence these for creating sustainable buildings.

The course prioritizes the integration of energy-efficient technologies and renewable energy sources into building design and construction. It emphasizes interdisciplinary collaboration, considers lifecycle impacts, and addresses regulatory frameworks and social considerations. Through practical application and real-world challenges, students are prepared to lead the development of environmentally responsible building solutions in professional settings.

Content:

In the first semester, elementary technical knowledge about the components and participants of the system is imparted through the module "Electrical Engineering for Energy Applications". "Simulation of Building Energy Concepts" is one of the five digital modules in the first semester that deals with the interaction of the individual participants in the energy system. "Building Physics and Energy System Technologies" teaches students about physical phenomena affecting buildings, including the behaviour of heat, air, and moisture, and their impact on energy efficiency, indoor air quality, and human comfort. In “Photovoltaics engineering”, students learn the basics of solar and go through the design, development, and implementation of

technologies that convert sunlight into electricity using semiconductor materials. An elective module allows students to explore other exciting topics in the first and second semesters."

In the second semester, the “Virtual Power Plant” deals with another essential component for the building energy systems of the future, namely the combination of decentralized energy producers with systems for storing or otherwise using excess energy in so-called Power- to -X systems for a reliable supply. “Sustainable HVAC” (heating, ventilation, and air conditioning) involves the design, installation, and operation of HVAC systems that reduce energy consumption, minimize environmental impact, and enhance indoor air quality and human comfort. “Smart Building Controls” refers to the use of automated systems and technology to optimize the performance of building systems, including HVAC, lighting, and security, to enhance energy efficiency, occupant comfort, and operational effectiveness. With “BIM (Building Information Modeling)” students learn digital representation of a building's physical and functional characteristics that facilitates collaboration and information exchange among project stakeholders. With "Basics Sustainability" students learn the most important sustainability models and analysis methods for sustainable development. From environmental and resource economics, basic methods for a fair distribution of environmental goods as well as environmental policy instruments and tools for sustainable spatial design are presented.

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 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.)

1 Description of Modules

1.1 Compulsory modules

Building Physics

Module abbreviation:	SBS-BuildingPhysics	**Reg.no.:**	1
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	1

Responsible for module:	Vaidya, Haresh
Lecturers:	Vaidya, Haresh
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	1: Building Physics
Lecture types:	SBS-BuildPhys: seminar-based teaching
Examinations:	written exam, 90 minutes None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:
By the end of this course, students

- have extensive knowledge in the field of physical principles of heat, moisture, sound, and fire protection.
- are proficient in assessing existing buildings according to their special constructions and working out basic renovation proposals-

Professional action competence:
By the end of this course, students

- are able to provide standard-compliant proofs of building physics for the above-mentioned topics.
- Understand the environmental implications of building physics decisions and can design solutions that align with ESG principles, prioritizing energy efficiency and resource conservation.
- are aware of the interdependencies in building physics and know how to positively influence these for creating sustainable buildings.
- know how to assess the thermal and hygric behavior of buildings and building constructions.

Social skills:
By the end of this course, students

- are able to gain knowledge and sum up the key facts independently.

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

Electrical Engineering for Energy Applications

Module abbreviation:	SBS-Electrical Engineering for Energy Applications	**Reg.no.:**	3
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	1

Responsible for module:	Weiherer, Stefan
Lecturers:	Esmaili, Babak
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	1: Electrical Engineering for Energy Applications
Lecture types:	SBS- Electrical Engineering for Energy Applications: seminar-based teaching
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

none

Objectives:

Technical competence:

Students acquire a sound knowledge of electrical fundamentals and gain an overview of three-phase current technology as well as correlations in installation technology. Using practical examples, they learn the basic functions of important electrical components used in modern and sustainable buildings.

Students understand how to design and implement electrical systems that prioritize energy efficiency and renewable energy sources, supporting ESG goals for reducing environmental impact and promoting resource sustainability.

Methodological skills:

This course focuses on the interrelationships between electrical engineering concepts and electrical engineering standards, in particular VDE 100. Practical examples are integrated into the lessons to deepen understanding.

Action competence:

Students acquire necessary methodological competencies for engineering approaches and installation planning. Specifically, they learn how electrical systems in modern buildings are affected by various sources and what measures, considerations and devices should be applied in each case to combat these impairments.

Social Skills:

Acquired knowledge is reinforced through several practical examples. Students will have the opportunity to formulate and analyze problems within group work, first considering relevant standards and laws. As the

course progresses, students are encouraged to identify critical points of an electrical system, dimension or improve the system accordingly, and clearly document the results in reports.

Content:

The module consists primarily of 4 SWS of seminar-style instruction. Appropriate instructional resources such as textbooks, VDE 100 practice bookers, and online sources will be introduced throughout the semester, and self-direction and problem diagnosis will also be practiced.

Content Emphasis:

- Introduction to electrical engineering
- Three-phase current technology
- Standards and regulations
- Planning of electrical installations, installation technology
- Protection concepts, low-voltage protection devices
- Transmission means, properties of electrical cables.
- Basic rules of cable dimensioning
- Voltage drops in electrical installations.
- Lightning protection systems, switchgear
- Installation technology and regulations
- Planning of a residential building

Literature:

- "Electrical Engineering for Architects, Civil Engineers and Building Technicians" Kasikci, I. (2013).
- "Sustainable Building Systems: An Introduction" by Elizabeth A. Plummer and Mary Ann Lazarus.
- "Sustainable Building Design" by Paul Burkinshaw.
- "Green Building: Project Planning and Cost Estimating" by R. Dodge Woodson
- "Sustainable Building: A Design Guide" by William D. Browning
- "Sustainable Building: Materials and Design" by Chris Magwood and Jen Feigin

Energy System Technology

Module abbreviation:	SBS-Energy System Technology	**Reg.no.:**	2
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	1

Responsible for module:	Buchele, Alexander
Lecturers:	Buchele, Alexander
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	2: Energy System Technology
Lecture types:	SU/Ü - tuition in seminars/exercise
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

None

Recommended prerequisites:

none

Objectives:

Technical/methodical competence: The students have an overview of the technical properties of renewable energy systems. You know the physic-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.

In reference to ESG "E" this knowledge ensures the development of energy systems that contribute to a sustainable, low-carbon future.

Action competence: 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.

Social skills: 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.

Content:

1. Introduction and Thermodynamic Basics
2. Energy Transformation and Sources

a. Solar

b. Wind

c. Hydro

d. Biomass

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

Literature:

- Quaschning, V. (2016). Understanding Renewable Energy Systems. In Understanding Renewable Energy Sys-tems. 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

Simulation of Building Energy Concepts

Module abbreviation:	SBS-Simulation of Building Energy Con.	**Reg.no.:**	5
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	1

Responsible for module:	Vaidya, Haresh
Lecturers:	Vaidya, Haresh
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	5: Simulation of Building Energy Concepts
Lecture types:	Simulation of energy systems: seminar-based teaching
Examinations:	project work, 10 - 20 pages (outside the examination period) None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:

By the end of this course, students

- know the basic components of a centralized and decentralized energy systems
- understand how the basic components of a centralized and distributed energy systems interact
- in reference to ESG "E" students are able to simulate and understand simple centralized and decentralized energy systems that helps to create energy solutions that promote efficiency and sustainability, contributing to global decarbonization efforts.
- are able to simulate simple centralized and decentralized energy systems

Professional action competence:

By the end of this course, students

- are able to build simulation for simple energy systems
- are able to check simulation results of simple energy systems for plausibility
- are able to optimize simple energy systems to a target value
- able to transform real energy systems into simulation models

- in reference to ESG "E" optimizing energy systems aligns with sustainability goals by ensuring systems operate at peak efficiency, reducing environmental impact and promoting resource conservation.

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 professionally
- in reference to ESG "S" effective communication and the ability to share technical knowledge contribute to a collaborative and socially responsible approach to the energy transition.

Content:

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

Literature:

- will be specified during lecture

Sustainability (lecture series)

Module abbreviation:	SBS-Sustainability (lecture series)	**Reg.no.:**	12
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	1

Responsible for module:	Vaidya, Haresh
Lecturers:	
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	12: Sustainability (lecture series)
Lecture types:	Online coursework offered by Virtuelle Hochschule Bayern
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:
By the end of this course, students

- get a holistic view of the most important sustainability models and analysis methods for sustainable development
- 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
- 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.
- 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.

Professional action competence:
By the end of this course, students

- 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

- can optimize natural processes from a material and energy point of view.

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

Building Information Modeling

Module abbreviation:	SBS-Building Information Modeling	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	2

Responsible for module:	Vaidya, Haresh
Lecturers:	Vaidya, Haresh
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	7: Building Information Modeling
Lecture types:	SBS-BIM: seminar-based teaching
Examinations:	project work, 10 - 20 pages (outside the examination period) According to study and examination regulations and study plan

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:
By the end of this course, students

- possess the ability to create intricate digital models using parametric and free form modelling techniques.
- in reference to ESG "E" these skills enable the creation of optimized building designs that enhance sustainability and minimize resource use.
- are capable of assessing and implementing different levels of detail in BIM models according to project requirements (BIM Maturity Levels and Levels of Development).
- will demonstrate expertise in utilizing data exchange formats for seamless communication and interoperability in BIM workflows.
- have the skills to develop and execute comprehensive plans for integrating BIM processes throughout the project lifecycle.
- have proficiency in using software tools for digital modelling, analysis, and visualization within the context of BIM.

Professional action competence:
By the end of this course, students

- 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

Photovoltaics Engineering

Module abbreviation:	SBS-Photovoltaics Engineering	**Reg.no.:**	9
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	2

Responsible for module:	Rosenbauer, Georg
Lecturers:	Kiefer, Richard; Moog, Mathias; Rosenbauer, Georg
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	9: Photovoltaics Engineering
Lecture types:	SBS-PhotovoltaicsEngineering: seminar-based teaching
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

None

Objectives:

Technical and methodological competence: The course is based on self-conducted experiments and investigations executed partly in labs, partly as outdoor research. In reference to ESG "E" hands-on experimentation allows students to develop practical knowledge of sustainable technologies, contributing to responsible energy solutions. Students not only learn to use different lab measuring devices, but also how to handle typical measurement tools that are in practical use with photovoltaics industry. Students learn to design a simple software-based plant layout and evaluate its economic efficiency. In reference to ESG "E" this encourages students to integrate efficiency considerations into their designs, ensuring that solar energy systems are both environmentally and economically sustainable. They get familiar with widely used software in the field of photovoltaics.

Professional action competence: Presentation skills: Experiment results will regularly be presented and discussed in plenary sessions. Thus, the students' ability to give presentations will be improved.

Lab skills: during the entire workshop, a range of typical measurement devices (partially not PV-specific) will be used.

In reference to ESG "E" familiarity with different tools enhances the students ability to implement diverse energy solutions, aligning with sustainability goals.

Content:

- Solar insolation, Three-Component-Model
- Measurement of U-I curves using different methods
- Evaluate the Performance Ratio of an outdoor PV setup.

- Analysis of the effects of partial shadowing scenarios
- Evaluation of potential locations for application
- Plant design with regard to technical and economic aspects
- Evaluation of data gained from a commercial photovoltaic plant, fault analysis.
- IR based fault analysis of single modules

Literature:

- Mertens: Photovoltaics: Fundamentals, Technology, and Practice. Wiley 2018.

Smart Building Controls

Module abbreviation:	SBS-Smart Building Controls	**Reg.no.:**	10
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	2

Responsible for module:	Moog, Mathias
Lecturers:	Moog, Mathias
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	10: Smart Building Controls
Lecture types:	SU/Pr - tuition in seminars/practical training
Examinations:	written exam, 90 minutes None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

Knowledge: 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.

Professional skills: 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.

Social skills: 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.

Content:

The module consists of seminar-based instruction and practical work. The following Topics will be covered:

- Terms and concepts (room automation, building automation, smart building, smart home)
- Hardware (microcontrollers, embedded systems, networks)
- Bus systems in building automation (KNX, BacNET, MODBUS, …)
- Software for building automation and smart buildings
- Building automation life cycle (commissioning, maintenance, data analysis, adjustment of the system)

- 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

Virtual Power Plants

Module abbreviation:	SBS-Virtual Power Plants	**Reg.no.:**	11
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	2

Responsible for module:	Vaidya, Haresh
Lecturers:	Hofmann, Gerd
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	11: Virtual Power Plants
Lecture types:	seminar-based teaching
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

None

Recommended prerequisites:

Basic knowledge about energy economy and energy technologies

Objectives:

Technical and methodological competence: By the end of this course, students

- Know the structure of virtual power plants.
- In reference to ESG "E" understanding virtual power plants aligns with advancing the integration of renewable energy sources, contributing to more sustainable energy solutions.
- Understand which technologies are used in virtual power plants.

Professional action competence:
By the end of this course, students

- Are able to apply the idea of virtual power plants to different scenarios of energy producers and consumers.
- Can analyze different technical and economical use-cases for virtual power plants
- In reference to ESG "G" students can analyze different technical and economic use-cases for virtual power plants, considering sustainability, efficiency, and profitability.

Content:

- Motivation: Why do we need virtual power plants?
- Introduction to virtual power plants, their basic structure, and use-cases

- Energy production, energy consumption and energy storage technologies
- Sector coupling and Power-to-X technologies
- Demand-Side-Management
- Marketing opportunities for virtual power plants
- 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.

Sustainable HVAC

Module abbreviation:	SBS-Sustainable HVAC	**Reg.no.:**	6
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	2

Responsible for module:	Vaidya, Haresh
Lecturers:	Vaidya, Haresh
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	6: Sustainable HVAC
Lecture types:	Seminar-based teaching
Examinations:	project work, 10 - 20 pages (outside the examination period) None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

Basic knowledge about energy economy and energy technologies

Objectives:

Technical and methodological competence:
By the end of this course, students can

- analyze the required capacity for renewable energy supply and heat storage.
- 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.
- analyze the required capacity for technical installations for ventilation, heating, cooling, and domestic hot water.
- In reference to ESG "G" accurate analysis of these systems ensures effective energy management and governance, promoting sustainability and reducing carbon footprints.
- 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.

Professional action competence:

- Design and optimize systems that balance energy supply and demand for sustainable building operation.

- Evaluate the economic and technical feasibility of renewable energy and energy efficiency measures in real-world applications.
- 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

Master's seminar Scientific Work

Module abbreviation:	SBS-Master's seminar Scientific Work	**Reg.no.:**	13
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	3

Responsible for module:	Vaidya, Haresh
Lecturers:	Vaidya, Haresh
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	13: Master's seminar Scientific Work
Lecture types:	SU/Ü - tuition in seminars/exercise
Examinations:	project work and presentation, 20 minutes None

Prerequisites according examination regulation:

none

Recommended prerequisites:

none

Objectives:

Technical and methodological competence: By the end of this course, students

- Know the principles of scientific work and related skills.
- understand how to structure and manage a project in the field of smart energy systems.

Professional action competence:
By the end of this course, students

- are able to apply basic techniques of project management to an energy related problem.
- 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.

Social skills: By the end of this course, students

- are able to find solutions for application- or research orientated tasks using appropriate resources and applying previously gained knowledge.
- Are able to summarize the most important content of a project and present the results to a professional audience

Content:

This course develops essential scientific writing skills, including:

- Conducting online research, literature search, and management, and planning the writing process.
- Outlining, editing for clarity, effective signposting, and drafting scientific papers.
- Writing key sections such as methods, results, discussion, and conclusions with proper language use.
- Incorporating visuals, proper citations, and effective data analysis techniques.
- Preparing for journal submissions, navigating peer-review processes, and delivering oral or poster presentations.
- Emphasizing research ethics, avoiding plagiarism, diversifying sentence structure, and promoting ethical conduct.

Literature:

- Will be specified at the beginning

Master's Thesis

Module abbreviation:	SBS-Master's Thesis	**Reg.no.:**	14
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	compulsory module	3

Responsible for module:	
Lecturers:	
Language of instruction:	English
Credit points / SWS:	25 ECTS / 0 SWS
Workload:	Contact hours: 0 h Self-study: 750 h Total: 750 h
Subjects of the module:	14: Master's Thesis
Lecture types:	MAr - master thesis
Examinations:	master's thesis (outside the examination period) None

Prerequisites according examination regulation:

None

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:
By the end of this course, students

- Know the principles of scientific work and related skills
- Have advanced knowledge in a specific topic of smart energy systems

Professional action competence:
By the end of this course, students

- understand how to structure and manage a project in the field of smart energy systems
- get in touch with a problem in the field of smart energy systems and developing a solution

Social skills: By the end of this course, students

- know how to structure a project and independently work on it, using additional sources and getting support from external persons and supervisors
- are able to summarize the most important content of a project and present the results to a professional audience

Content:

A supervising professor will provide a topic and accompany and support the work on the thesis. The workload should include the following steps:

• 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

1.2 Elective modules I

Artificial Intelligence Basics

Module abbreviation:	SBS-ArtificialIntelligenceBasics	**Reg.no.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	1

Responsible for module:	Schacht, Sigurd
Lecturers:	Kamath Barkur, Sudarshan
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	4: Artificial Intelligence Basics
Lecture types:	Seminar-based teaching
Examinations:	projekt work, 10 pages None

Prerequisites according examination regulation:

None

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:

- Fields of application and example applications of AI
- Data science - fundamentals and methods for discovering patterns in large data.
- Challenges and limits of AI

Professional action competence:

- Analysing, planning, and selecting AI and data science methods according to requirements
- Effective and efficient implementation of the methods (configuration of methods, etc.) with appropriate tools
- Evaluation of the success of the applications and identification of optimization measures

Social skills:

- 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).
- Ability to work in a team in interdisciplinary project teams

Content:

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 & Pan-das, 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 Modelling, 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 ; Sebas-topol ; 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 IPy-thon. 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 Moo-dle)

German I

Module abbreviation:	SBS-German I	**Reg.no.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	1

Responsible for module:	Vaidya, Haresh
Lecturers:	Baudracco-Kastner, Monica
Language of instruction:	German
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	4: German I
Lecture types:	
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The students bring their topics, moods and situations in 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 Technical and methodological competence: 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.

Professional action competence: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

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

Content:

The students bring their topics, moods and situations in 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 get answered. The assimilation of the new skills takes place through practicing the language in authentic situations outside the classroom.
Literature:
• S. Dengler, T. Mayr-Sieber, P. Rusch, H. Schmitz, Netzwerk neu A2 Deutsch als Fremdsprache Kursbuch mit Audios und Videos, Klett Verlag, ISBN 978-3-12-607164-2

IoT Technologies and Data Interfaces

Module abbreviation:	SBS-IoT Technologies&DataInterfaces	**Reg.no.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	1

Responsible for module:	Vaidya, Haresh
Lecturers:	Vaidya, Haresh
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	4: IoT Technologies and Data Interfaces
Lecture types:	SU - tuition in seminars
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

None

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:
By the end of this course, students

- know the functionality of a variety of IoT (Internet of Things) devices.
- understand the communication technologies and data interfaces that are used to transfer data between different devices, servers, and other infrastructure.

Professional action competence: By the end of this course, students

- are able to apply smart technologies to energy production, consumption and storage technologies and value-added services.
- can evaluate how IoT-Technologies can lead to new or improved processes or even new products and services in the energy sector social skills:
  1. By the end of this course, students
  2. are able to gain knowledge and sum up the key facts independently.
  3. can present technical knowledge in a professional and entertaining way

Content:

- Internet of Things devices and their Hardware and Software

• Data Interfaces and Data communication • IoT-server and infrastructure
Literature:
• will be specified during lecture

LabVIEW Programming

Module abbreviation:	SBS-LabVIEW Programming	**Reg.no.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	1

Responsible for module:	Vaidya, Haresh
Lecturers:	Hofmann, Gerd
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	4: LabVIEW Programming
Lecture types:	
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

Basic programming skills in any programming language

Recommended prerequisites:

Basic programming skills in any programming language

Objectives:

Technical and methodological competence:
By the end of this course, students

- Know basic techniques of software development and programming.
- Understand the particularities of LabVIEW programming.

Professional action competence: By the end of this course, students

- Are able to apply their programming skills to develop software applications with LabVIEW.
- Can analyze, test and debug LabVIEW VIs (virtual instruments)

Within the modules students have the possibility to get the industry certificate “Certified LabVIEW Associate Developer – CLAD” Social skills: By the end of this course, students.

- Can independently work on programming tasks

Content:

- LabVIEW Programming environment
- 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

1.3 Elective modules II

AI Applications in Energy Systems

Module abbreviation:	SBS-AI Applications in Energy Systems	**Reg.no.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	2

Responsible for module:	Schacht, Sigurd	
Lecturers:	Kamath Barkur, Sudarshan; Schacht, Sigurd	
Language of instruction:	English	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours: Self-study: Total:	45 h 105 h 150 h
Subjects of the module:	8: AI Applications in Energy Systems	
Lecture types:	SU - tuition in seminars	
Examinations:	projekt work, 10 pages None	

Prerequisites according examination regulation:

None

Recommended prerequisites:

none

Objectives:

Technical and methodological competence:

- Example Applications and Implementations in the Field of Energy Systems
- Technical Understanding of Deep Neural Networks and Distributed Ledger Technology
- Methods to implement and test own AI Applications
- Challenges and limits of ANN and DTL

Professional action competence:

- Analysis, planning and selection of AI and Data Science methods according to requirements.
- Effective and efficient implementation of the methods (configuration of methods, etc.) with appropriate tools
- Evaluation of the success of the applications and identification of optimization measures

Social skills:

- 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.
- Ability to work in a team in interdisciplinary project teams

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)

Energy Entrepreneurship

Module abbreviation:	SBS-Energy Entrepreneurship	**Reg.no.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	2

Responsible for module:	Hähnlein, Johannes
Lecturers:	Hähnlein, Johannes
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	8: Energy Entrepreneurship
Lecture types:	Seminar-based and workshop-based teaching
Examinations:	presentation, 15 minutes (outside the examination period) None

Prerequisites according examination regulation:

none

Recommended prerequisites:

None

Objectives:

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.

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.

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.

The module is characterized in particular by the following aspects:

- Practical relevance: 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.
- Competence expansion: 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.

- 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 must 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:

Acquired professional action competence:
Acquired social skills:

- Participation in the live pitch in front of a top-class jury,
- the opportunity to participate at the “Campus der Löwen” live pitch event.
- a spot for the winning team in the existence program; and
- the chance of further support through public funded programmes in case of a promising concept.
- 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 around 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 them-selves in corresponding project teams.
- 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 bes-ten Geschäftsmodellen der Welt. Nutzen Sie es, um Ihr Ideen-Portfolio aufzufrischen und sich neu zu erfin-den. So schaffen Sie eine Kultur der Innovation und Transformation, die Ihr Unternehmen unbesiegbar macht : 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

German II

Module abbreviation:	SBS-German II	**Reg.no.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	2

Responsible for module:	Vaidya, Haresh
Lecturers:	Baudracco-Kastner, Monica
Language of instruction:	German
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	8: German II
Lecture types:	SBS-German II: seminar-based teaching
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

According to study and examination regulations and study plan

Recommended prerequisites:

Objectives:

The students bring their topics, moods and situations in 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 Technical and methodological competence: 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.

Professional action competence: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

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

Content:

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:
• S. Dengler, T. Mayr-Sieber, P. Rusch, H. Schmitz, Netzwerk neu B1/B2 Deutsch als Fremdsprache Kursbuch mit Audios und Videos, Klett Verlag, ISBN 978-3-12-607164-2

Optimization of Energy Systems

Module abbreviation:	SBS - Optimization of Energy Systems	**Reg.no.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	2

Responsible for module:	Moog, Mathias
Lecturers:	Moog, Mathias
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	8: Optimization of Energy Systems
Lecture types:	Seminar-based teaching
Examinations:	written exam, 60 minutes None

Prerequisites according examination regulation:

None

Recommended prerequisites:

Energy Systems and Energy Economy, Simulation of Energy Systems

Objectives:

Technical and methodological competence: The students know different optimization methods with their advantages and disadvantages. They are familiar with the application of optimization methods in energy technology.

Professional action competence: The students can convert energy technology issues into mathematical models and carry out optimizations.

Social skills: During the practical training, students learn to work in groups on energy-related optimization issues.

Content:

The module consists of lectures including practical training. The following topics will be covered:

- Mathematical modelling
- Optimization procedures
- Use of optimization methods with computer support
- Apply optimization methods to energy-related issues.

In the practical training, the optimization is mainly tested with Excel.

Literature:

- GERSHENFELD, Neil A., 2003. The nature of mathematical modeling. R. edition. Cambridge [u.a.]: Cambridge Univ. Press. ISBN 0-521-57095-6
- 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

Project Course - Smart Energy Systems

Module abbreviation:	SBS- Project Course - SES	**Reg.no.:**	8
Curriculum:	**Programme**	**Module type**	**Semester**
	Sustainable Building Systems (SPO WS 23/24)	Elective modules	

Responsible for module:	Vaidya, Haresh
Lecturers:	Hofmann, Gerd
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 45 h Self-study: 105 h Total: 150 h
Subjects of the module:	8: Project Course - Smart Energy Systems
Lecture types:	Pr - practical training
Examinations:	presentation, 15 minutes (outside the examination period) None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

Technical and methodological competence: By the end of this course, students

- know how to program and use real-time devices as NI myRIO.
- understand how to develop distributed applications and remote controllable software on computers and real-time devices.
- Professional action competence:
- By the end of this course, students
- are able apply real-time hardware and their self-developed software to energy related applications.
- can evaluate possible use-cases for real-time hardware to create new processes, functions or even products in the energy sector.
- Social skills:
- By the end of this course, students
- know how to work together and organize in a team to reach a common goal in case of software development.
- understand how to define processes and interfaces to put together single elements and sub-tasks to a project

Content:
• introduction to real-time hardware – NI myRIO • developing standalone applications for NI myRIO • using remote front panels • 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