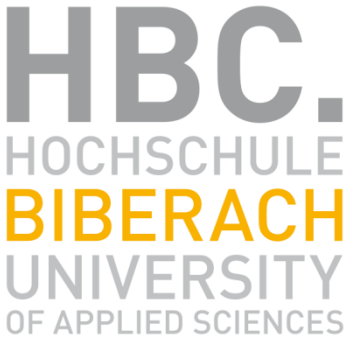
HOCHSCHULE BIBERACH



Module Handbook

Bachelor of Energy Engineering

Version:

07.04.2015

PO4

Contents

Foreword

The energy concept of the German Federal Government is based on two principles: to improve energy efficiency and expand the use of renewable energies. The "Energy Engineering" course teaches, with two specialisations, the competencies that are required for the implementation of this objective: With a focus on "building systems" the students specialise on the energy-efficient design and operation of buildings, the largest consumers of energy. In area "energy systems", they devise systems for renewable energy which ensure the sustainable supply of energy. Based on the common foundational engineering course, students receive, in one of the two areas of specialisation: "building systems" or "energy systems", specialised knowledge about the design of sustainable energy concepts.

Legend:

K	exam
mPu	ungraded oral exam
mPb	graded oral examination
Stu	ungraded research project (homework, laboratory or practical training report, technical drawing, computer program, etc., if necessary with an oral interview)
Stb	graded research project (homework , laboratory or practical training report, technical drawing, computer program, etc., if necessary with an oral interview)
SWS	semester week hours
LP	credits
PVL	prerequisite
PL	examination
KS	contact hours
ES	self-study
V	lecture
Ü	exercise
S	seminar:
L	laboratory practical training
P	practical training

1-1 Mathematics I

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	1
Prerequisites:	none	**Responsible for the module:**	Hofmann

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
1-1 Mathematics I	5	4	L + E		K 120 min	60 h	90 h	Hofmann

Learning objectives
Participants are familiar with the basic methods and approaches of analysis, linear algebra, complex analysis and statistics. This includes mastering real differential and integral calculus of one variable and the confident handling of the basics of linear algebra, complex analysis and statistics.

Contents
Basics of complex analysis, linear algebra, statistics, and ordinary differential equations, elementary functions, real one-dimensional differential and integral calculus and function approximation.

Special methodology
Peer instruction, inverted classroom

Literature
Thomas Rießinger: Mathematik für Ingenieure, Springer

Lothar Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vol. 1-3

Albert Fetzer und Heiner Fränkel: Mathematik. Lehrbuch für Fachhochschulen, Vol. 1-2

Regina Gellrich und Carsten Gellrich: Mathematik : ein Lehr- und Übungsbuch für Fachhochschulen, Fachoberschulen, Technikerschulen, Vol. 1-4

Wolfgang Brauch / Hans-Joachim Dreyer / Wolfhart Haacke: Mathematik für Ingenieure

1-2 Thermodynamics

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	1
Prerequisites:	none	**Responsible for the module:**	Siegismund

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
1-2 Thermodynamics	5	4	L + E	Stu	K 120 min	60 h	90 h	Siegismund

Learning objectives

The Thermodynamics course enables students to analyse problems of power engineering with the aid of thermodynamics, and with the basic equations of this science, describe solutions and discuss results. Students are able to calculate condition changes and processes with ideal gas and gas mixtures (for example moist air).

Contents

Basic equations of thermodynamics, with a brief look at gas dynamics and brief look at heat transfer, state variables, thermodynamic systems, equilibrium, ideal and real gases, energy concept, first law of thermodynamics (energy balance), enthalpy, internal energy, process variables, second law (limits of energy conversion), specific entropy and entropy changes, total entropy, reversible and irreversible processes, third law, clockwise and anticlockwise cyclic processes, exercises with laboratory demonstration.

Special methodology

Lecture with integrated exercises, laboratory

Literature

Cerbe, G., Wilhelms, G.: Technische Thermodynamik, 16th edition, Hanser Verlag, 2011

Böswirth, L.: Technische Strömungslehre, 6th edition, Vieweg Verlag, Braunschweig, 2005

Bohl, W.: Technische Strömungslehre, 12th edition, Vogel Verlag, Würzburg, 2001

Doering, E., Schedwill, H., Dehli, M.: Grundlagen der Technischen Thermodynamik : Lehrbuch für Studierende der Ingenieurwissenschaften, 7th edition, Vieweg+Teubner Verlag, 2012

Labuhn, D., Romberg, O.: Keine Panik vorThermodynamik! Erfolg und Spaß imklassischen "Dickbrettbohrerfach" des Ingenieurstudiums, 6th, updated edition, Wiesbaden : Springer Vieweg, 2012

1-3 Electrical technology

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	1
Prerequisites:	none	**Responsible for the module:**	Kasikci

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
1-3 Electrical technology	4	3	L + E		K 120 min	45 h	75 h	Eberle/ Schmidt
Electrical engineering laboratory	1	1	L		Stu	15 h	15 h	Schiller / Kiebler

Learning objectives

The objective of the module is to understand and apply the fundamentals of electrical engineering in order to gain detailed knowledge on this basis. Understanding the key topics of AC and DC networks and computing electric circuits are further objectives of the course, in particular skills regarding two and four terminal circuits are developed. In addition, the knowledge of how to analyse and calculate shifts in networks is gained.

Contents

Physical quantities and units, physical basic concepts, basic laws of electrical engineering,
Electrical sources, DC circuits, calculation of DC circuits, flow field, electric field, magnetic field, basics of AC technology, power in an AC circuit, circuits with two poles and four poles, switching operations.

Special methodology

Script, computer, laboratory

Literature

Kasikci, Ismail: Elektrotechnik für Architekten, Bauingenieure und Gebäudetechniker, Springer & Vieweg, 1st edition, 2013, ISBN 978-3-8348-0853-0

Fachkunde Elektrotechnik, Verlag Europa Lehrmittel, Europa-Nr.: 30138

Frohne, Löcherer, Müller: Grundlagen der Elektrotechnik, Teubner Verlag Stuttgart

Hagmann, Gerd: Grundlagen der Elektrotechnik , 15th edition, 2011, ISBN 978-3-89104-598-5,Aula-Verlag

1-4 Introduction to Building and Energy Systems

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	1
Prerequisites:	none	**Responsible for the module:**	Ast

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Introduction to energy and building systems	2	2	L + E		K 120 min	30 h	30 h	Entress
Systems and balancing	2	2	L + E			30 h	30 h	Ast
Scientific work	1	1	S		Stu	15 h	15 h	Haibel

Learning objectives

To know and understand the energy-economic fundamentals and the civilizing role of energy. To learn the balancing of energy conversion and utilisation systems. Independent handling of specialised topics and their analysis, written and oral presentation.

Contents

Basic concepts of the energy industry: energy production, energy conversion, energy networks, energy storage, centralised and decentralised energy supply, the national, European and global energy situation, energy demand by type of use, energy sources, energy supplies, static and dynamic ranges, renewable energies.
Using introductory examples, the students will learn to set up and analyse energy balances. Main concepts and terms are introduced and applied to examples: energy conservation, efficiency and utilisation, energy flow diagrams, electrical load demand curves, energy balance.
In the seminar the basics of scientific work, for example, the studying of scientific papers, are conveyed. Instructions for writing scientific reports. Presentation techniques.

Special methodology

Scripts

Literature

Handbuch der Elektrizitätswirtschaft, Leonhard Müller (Springer Verlag)

Sichere Energie im 21. Jahrhundert, Jürgen Petermann (Hoffmann & Campe, 2008)

Selected journal article for working on in the seminar

1-5 Transversal skills

Section:	Foundation course	**Credits:**	10
Offered:	every semester	**Semester:**	1
Prerequisites:	none	**Responsible for the module:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
General Studies	4	4			Stu	60 h	60 h	LA
Technical English	2	2	L + E		mPu 15 min	30 h	30 h	Siegismund
CAD	2	2	L + E		Stu	30 h	30 h	Pabst
Programming	2	2	L + E		Stu	30 h	30 h	Rall

Learning objectives

General Studies

Students acquire skills in the field of general education and key skills, depending on their choice.

Technical English

To provide and enhance the student's ability to converse and write on the subject at a competent level of fluency. Participants can understand a wide range of subject specific texts. Students are able to express themselves fluently and spontaneously without too much searching for expressions. They can use language flexibly and effectively for social, academic and professional purposes. Students can produce clear, well-structured, detailed text on complex subjects, showing controlled use of organisational patterns, connectors and cohesive devices.

CAD

Based on an exemplary, well-known program, students learn how to use and how to deal with CAD. They learn and practice the practical application based on project examples from real life. Aspects of graphic representation, for example by issuing plans, and in particular, the dimensioning of systems and components using CAD-integrated or complementary calculation tools as well as the meaningful integration in the planning process is conveyed. The skills include the basis for plan creation and calculations in the context of project work.

Programming

The students use these and other technical basics for independent solution of simple scientific engineering problems using a programming language, or to solve more complex issues, in dialogue with computer scientists. The focus of the applications is the analysis of measurement data and the application of numerical methods. In addition, students learn how to deal with applications for typesetting, word processing, spreadsheets and software programs for presentations.

Contents

Technical English

Basics in Maths and Physics (Energy, Power), describing graphs and diagrams, various energy systems (conventional, renewable), basics in technical related business English.

CAD

Basic knowledge of technical drawing: standardisation, plan content, presentation, dimensions, annotations, plan head, legend, plan types;

Program operation of CAD tool: features (simple geometric shapes, blocks, "intelligent" objects), input interfaces (keyboard, mouse, pen tablet) layer technology, reference plans, 2D/3D display, coordinate system, import, export/output, data structures, file formats;

Calculation: integrated calculation tools, interfaces to external software and planning attachments, supplemental calculation tools;

Integration into the planning process; data exchange with planning participants (BIM);

Programming
Tools for software development, variables, expressions, control structures, functions, namespaces, object orientation. Representation of numbers, data structures; introduction to software development with the programming language python

Special methodology

Text and audio material, planning exercises, software applications, computer work, impulse lectures, seminars

Literature

Technical English
Glendinning Eric, Glendinning Norman, Oxford English for Electrical and Mechanical Engineering, Oxford University Press, 1995

Jayendran A., Jayendran R, Englisch für Elektroniker, Vieweg Verlag, Wiesbaden, 1996

Möllerke, G.: Modern English Training for Mechanical Engineers, Carl Hanser Verlag, Munich, 2010

Schmitz, Albert, Schmitz, Edith, Toolbox - English for Technical Purposes, Vol. 1 and 2, Max Hueber Verlag, Munich, 1998

Zürl, Karl-Heinz, Modern English Training for Industry, Carl-Hanser Verlag, Munich, 2001

Current English language journals and journals from the (online) library

CAD
Frey, Hansjörg, Bautechnik, Technisches Zeichnen, Verlag Europa-Lehrmittel, Haan-Gruiten, 2010

Fritz, Andreas (ed.), Hoischen, Hans: Technisches Zeichnen, Cornelsen Verlag, Berlin, 2014

Software-specific literature and manuals

Programming
Hajji, Farid, Das Python-Praxisbuch, Addison-Wesley, Munich, 2008

Langtangen, Hans Petter, A Primer on Scentific Programming with Python, Springer Verlag, Heidelberg, 2012

Swaroop, C. H., A Byte of Python, Rev. 3.0, 2014, www.swaroopch.com/notes/python/

2-1 Mathematics II

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	2
Prerequisites:	1-1 Mathematics I	**Responsible for the module:**	Hofmann

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
2-1 Mathematics II	5	4	L + E		K 120 min	60 h	90 h	Hofmann

Learning objectives
Participants are familiar with the basic methods and approaches of analysis, linear algebra, complex analysis and statistics. This includes mastering real differential and integral calculus of more than one variable and the confident handling of the basics of linear algebra, complex analysis and statistics.

Contents
Fundamentals of complex analysis, linear algebra, statistics and ordinary differential equations, real multidimensional calculus.

Special methodology
Peer instruction, inverted classroom

Literature
Thomas Rießinger: Mathematik für Ingenieure, Springer

Lothar Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vol. 1-3

Albert Fetzer und Heiner Fränkel: Mathematik. Lehrbuch für Fachhochschulen, Vol. 1-2

Regina Gellrich und Carsten Gellrich: Mathematik : ein Lehr- und Übungsbuch für Fachhochschulen, Fachoberschulen, Technikerschulen, Vol. 1-4

Wolfgang Brauch / Hans-Joachim Dreyer / Wolfhart Haacke: Mathematik für Ingenieure

2-2 Refrigeration and Heat Pump Technology

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	2
Prerequisites:	1-2 Thermodynamics	**Responsible for the module:**	Siegismund

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Refrigeration and Heat pump technology	5	4	L + E		K 120 min	60 h	90 h	Siegismund

Learning objectives

To know and understand the common cooling systems and heat pump systems. Learning the (primary) energy evaluation of heat pump and cooling systems.

Contents

Difference between cooling unit and heat pump, thermally and mechanically driven cooling unit and heat pump, representation and calculation of the cold vapour machine process in the log p,h and t,s diagram, various system variants (single and two-stage compression) and their energy assessment, interpretation of cold vapour machines, environmental impact of coolants (TEWI consideration), system boundaries: cooling unit, cooling plant, cooling system.

Special methodology

Lectures with integrated exercises.
The lecture cooling and heat pump technology is, as desired and/or required (participation of international students), in English.

Literature

Pohlmann-Taschenbuch der Kältetechnik: Grundlagen, Anwendungen, Arbeitstabellen und Vorschriften, 21., revised and expanded edition., Berlin : VDE-Verl., 2013

Breidenbach: Der Kälteanlagenbauer Vol. 1 and 2,C.F. Müller Verlag, Heidelberg, 2003

Lehrbuch der Kältetechnik / Hrsg.: H. L. von Cube. Karlsruhe : C. F. Müller

2-3 Energy-Efficient Buildings

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	2
Prerequisites:	Introduction to Building and Energy Systems	**Responsible for the module:**	Gerber

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Building physics and energy balance of buildings	3	2	L + E	Stu	mPb 15 min	30 h	60 h	Bretzke / Gerber
Building heating	2	2	L + E	Stu		30 h	30 h	Floß

Learning objectives

Based on physical basics (gained from other modules) the basics and essential applications of thermal building physics and heating of buildings are taught and practiced. In the sub-module building physics, the students learn to understand the static and dynamic thermal behaviour of buildings with respect to the applicable regulations of the thermal protection. The focus here is on the energy balance and energy saving measures and the knowledge of the major construction methods and strategies to increase energy efficiency and comfort.
After completion of the module the students know and understand the customised heating of buildings of different use. In addition, they learn the evaluation of heating systems in terms of energy efficiency, comfort, convenience and cost.

Contents

Aspects of thermal comfort, energy and power balance of buildings, thermal building physics, monthly balance, annual consumption, annual load duration curves.
Factors affecting the users' feeling of comfort in rooms, importance of heating for the preservation of the building. History of heating technology, determination of the heating load and energy consumption of buildings, dividing of heating systems, space heating appliances and their dimensioning, installation of heat generators.

Special methodology

Lectures with integrated exercises.

Literature

Ch. Zürcher, Th. Frank: Bauphysik: Bau und Energie, vdf Hochschulvlg, 4th edition, 2014

Lohmeyer, Post, Bergmann: Praktische Bauphysik, current edition

Bläsi, Bauphysik, current edition

If necessary, Krass, Mitransky, Rupp: Grundlagen der Bautechnik, 2013

Ebook: Dämmstoffe im Überblick, Url: http://www.sanier.de/ebook-daemmstoffe-im-ueberblick-veroeffentlicht Abruf 15.1.2015

Tiator, Ingolf: Heizungsanlagen, Vogel Verlag dec. 2006, 3rd edition

Pistohl, Wolfram: Handbuch der Gebäudetechnik Vol. 2,

Heizung/Lüftung/Beleuchtung/Energiesparen; Werner Neuwied Verlag Sep. 2009, 7th edition

2-4 Thermodynamics and Fluid Mechanics

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	2
Prerequisites:	none	**Responsible for the module:**	Brose

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Heat transfer	3	3	L + E		K 120 min	45 h	45 h	Brose
Fluid Mechanics	2	2	L + E			30 h	30 h	Haibel

Learning objectives

The objective of the thermodynamics course is the understanding of and ability to calculate the basic heat transfer mechanisms. Students learn how the general theoretical approaches can be applied by specific solutions and simplifications to concrete technical and physical applications.
In the fluid dynamics course, laws and calculation methods enable students to tackle tasks involving flowing liquids and gases for example in devices, machinery and installations, and to put the results into practice.

Contents

Basic mechanisms of heat transfer; heat flow and temperature distribution in systems with stationary heat conduction, and for selected cases in transient heat conduction (e.g. ideal stirred tank, semi-infinite body); heat transfer with free and forced convection in single-phase systems; radiation exchange in simple systems; basic heat exchanger (e.g., plate, multi-tubular systems);
Basic properties and characteristics of fluids, basics of hydrostatics, basics of incompressible flows, pipe hydraulic friction-afflicted incompressible flows, viscous flows in open channels, friction-afflicted discharge from vessels, basics of aerodynamics and flow forces.

Special methodology

Computer, hand-outs

Literature

Baehr, H., Stephan, K.: Wärme- und Stoffübertragung, 8th edition, Springer Vieweg Verlag , Wiesbaden, 2013

Bohl, W.: Technische Strömungslehre, 15th edition, Vogel Verlag, Würzburg, 2014

Brauer, Heinz: Grundlagen der Einphasen- und Mehrphasenströmungen, Verlag Sauerländer, Frankfurt a.M., 1971

Elsner, Norbert: Grundlagen der technischen Thermodynamik, Vol. 2: Wärmeübertragung, Akademie Verlag, Berlin, 1993

Glück, B.: Zustands- und Stoffwerte Wasser Dampf Luft, 2nd edition, Verlag für Bauwesen, Berlin, 1991

Polifke, Wolfgang, Wärmeübertragung, Pearson Education, Munich, 2009

Strybny, J. , Romberg, O.; Ohne Panik – Strömungsmechanik, 5th edition, Vieweg Verlag, Braunschweig, 2012

Wagner,Walter: Wärmeübertragung, 7th edition, Vogl Buchverlag, Würzburg, 2011

2-5 Physics and Applied Numerics

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	2
Prerequisites:	Mathematics I, Electrical Engineering, Thermodynamics	**Responsible for the module:**	Gerber

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Physics and Applied Numerics	5	4	L + E		Stb	60 h	90 h	Gerber, Entress, Hofmann

Learning objectives
To understand and practice physical concepts and methods for solving engineering science issues. To understand and apply numerical methods to solve engineering science issues.

Contents
In the subsection physics, selected topics from the fields of mechanics, thermodynamics, electromagnetism and vibrations and waves are covered. In applied numerics, these issues are addressed, and techniques for analysing data, for the solution of linear and nonlinear systems of equations, for the solution of differential equations and for visualizing data are taught. Practical application of data acquisition, control and analysis methods with the help of single board computers or microcontrollers such as Raspberry Pi or Arduino.

Special methodology
Practical exercises and individual supervision during student research.

Literature
Hering, Martin, Stoher: Physik für Ingenieure, Springer 2012

Harten, Ulrich: Physik: Eine Einführung für Ingenieure und Naturwissenschaftler, Springer

Halliday, Resnick, Walker: Physik - Bachelor edition, Wiley VCH, Weinheim

Kuchling: Taschenbuch der Physik, Fachbuchverlag Leipzig, Weinheim

Hanke-Bourgeois, Grundlagen der numerischen Mathematik und des wissenschaftlichen Rechnens, Teubner, 2009

Langtangen, A primer on scientific programming with Python, Springer, 2012

Langtangen, Python scripting for computational science

2-6 Electrical Systems

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	2
Prerequisites:	none	**Responsible for the module:**	Kasikci

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Basics Electric. Systems	2	2	L + E		K 120 min	30 h	30 h	Kasikci
Machines and Drives	2	2	L + E			30 h	30 h	Kasikci
Laboratory for electrical Machines	1	1	L		Stu	15 h	15 h	Schiller/ Kiebler

Learning objectives

The objective of the module is to understand and apply system knowledge of electrical engineering in order to gain detailed knowledge on this basis. To understand and calculate the technology of electrical installations for the generation, transmission and distribution of electrical energy. The objectives of the sessions are also to understand and calculate the construction and operation of electrical machines and drives.

Contents

Basics of Electrical Systems:

Three-phase systems technology, complex calculation, power transmission, electrical networks, characteristics of electric lines, network forms, earthing in LV and HV networks, design of electrical wires and cables, voltage drop and power loss, short-circuit current calculation, switchgear, protection devices.

Electrical machines:

Effects of forces acting on current-carrying conductors, transformers, DC machines, induction machines, synchronous machines, EC motors.

Special methodology

Computer, laboratory

Literature

I. Kasikci: Projektierung von Niederspannungsanlagen, Hüthig&Pflaum Verlag, Heidelberg, 3rd edition, 2010

I. Kasikci: Kompendium Planung von Elektroanlagen, Theorie, Vorschriften, Praxis, 2nd edition, Springer, Heidelberg, 2015.

I.Kasikci: Projektierungshilfe elektrischer Anlagen in Gebäuden, 7th edition, Schriftenreihe 148, VDE-Verlag

I. Kasikci: Kurzschlussstromberechnung in elektrischen Anlagen, DIN VDE 0102, 4th edition 2013, Expert-Verlag

V. Crasten: Elektrische Energieversorgung 1 and 2, 2012, 2007, Springer

K. Heuck, K. Dettmann, D. Schulz: Elektrische Energieversorgung, Vieweg

Dietrich Oeding, Bernd R. Oswald: Elektrische Kraftwerke und Netze. Springer-Verlag, 2011

Rolf Fischer: Elektrische Maschinen, 11th edition, Hanser Verlag 2011

Fachkunde Elektrotechnik, Verlag Europa Lehrmittel

3-1 Measurement and control technology

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Becker

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Measurement and control technology	5	4	V+Ü+L	Stu	K 120 min	60 h	90 h	Becker

Learning objectives

The objective of the module is to learn and understand the basic concepts, principles and interrelationships of measurement and control technology in the context of building and energy technology. Using simple application examples (e.g. temperature control) technical control issues can be described and basic control principles formulated. Students are able to describe technical processes (e.g. plants, spaces, ...) in control circuit structures and to analyse as well as formulate and parameterise simple control and regulating concepts In addition, the students know the importance of measuring and sensor technology as an important part of a control chain or a control loop.

Contents

Overview of typical automation tasks, introduction to conventional and digital control technology, construction and programming of programmable logic controllers (PLCs), characterisation and description of dynamic systems, continuous and discontinuous controllers, controller design, PID controller parametrisation, controller optimisation, exercises on measurement, control and regulation technology, laboratory training on topics of measurement and control technology, application examples.

Special methodology

Laboratory, simulation tools, exhibits

Literature

Own scripts with Cloze

Arbeitskreis der Professoren für Regelungstechnik in der Versorgungstechnik: Regelungs- und Steuerungstechnik in der Versorgungstechnik. 7th edition, C.F. Müller-Verlag, 2014

Tröster, F.: Steuerungs- und Regelungstechnik für Ingenieure. Oldenbourg-Verlag, 3. A, 2010

Föllinger, O: Regelungstechnik. Hüthig-Verlag, 11th edition, 2013

3-2 Regenerative Energy Systems

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	Thermodynamics and Fluid Mechanics	**Responsible for the module:**	Gerber

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Solar Energy Systems	5	5	L + E		mPb 15 min	105 h	45 h	Gerber

Learning objectives

Students gain system expertise and in-depth knowledge of the energy-related use of solar energy. From the transducer to the entire system the ability to evaluate systems and applications, to balance and dimension, is developed. Another focus is on issues of system integration. Basic knowledge of radiation exchange and elements of optics is also learnt.

Contents

Thermal radiation and optics: black body, grey body, radiation exchange, interaction of solar radiation with matter, availability, characterisation and calculation of the solar radiation.

Photovoltaics: function, cells, modules, inverters, stand-alone systems, grid-connected systems. Planning, construction and operation of photovoltaic power systems: load analysis, energy yield in local operating conditions, design, storage of energy, maintenance.

Solar thermal systems: collector theory and storage, solar thermal systems for domestic hot water heating, space heating and process heat, components and system concepts as well as their evaluation, planning with the help of simulation tools.

Special methodology

Lecture with exercises

Literature

Baehr, Stephan, Wärme- und Stoffübertragung, Springer 2013

K. Mertens: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser, 2013

J.A. Duffie, W.A. Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, 2006

Kasper et. al.: Leitfaden Solarthermische Anlagen, Deutsche Gesellschaft für Sonnenenergie (DGS), Berlin, 2006

Ladener: Solaranlagen, Handbuch der thermischen Solarenergienutzung, Staufen, Freiburg, 2003

Leitfaden photovoltaische Anlagen, Deutsche Gesellschaft für Sonnenenergie, 3rd edition, 2006

3-3 Thermal Energy Systems

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Floß

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Hydraulics	3	2	V+Ü+L	Stu	mPb 15 min	30 h	60 h	Floß
Heat generator	2	2	L + E			30 h	30 h	Floß

Learning objectives
To know and understand the various types of heat generators as well as the importance of hydraulics on the energy performance of complete systems. To learn the (primary) energy evaluation of heating systems.

Contents
Final energy sources for heating systems, boilers, solar systems, heat pumps, CHPs, subdivision of boilers, installation of heat generators and fuel depots.
Hydraulic energy distribution (building distribution, local and district heating networks), pump design, hydraulic balancing, basic hydraulic circuits, technical safety equipment, venting/desludging.

Special methodology
Lectures with integrated exercises.

Literature
Albers, Joachim: Zentralheizungs- und Lüftungsbau für Anlagenmechaniker Dommel, Rainer: Handwerk und Technik Verlag Jul. 2009, 7th edition

VDI Bericht 1549: Hydraulik in der Heiz- und Raumlufttechnik, VDI Verlag, Düsseldorf 2000

3-4 Economics

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Bretzke

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Energy Industry and law	2	2	L + E		K 120 min	30 h	30 h	Bretzke / Entress, LA
Business administration and economy	3	2	L + E			30 h	60 h	LA

Learning objectives

Knowledge and understanding of the specific nature of energy as an economic good. Upon completion of the module the students have practical knowledge of the application of basic organisational, technical and processing methods regarding energy procurement, consumption recording and evaluation and related controlling and analysis instruments (smart grid, market). They understand the legal, macroeconomic and economic policy of the energy industry. They understand the central importance of the company's organisation and organisational design possibilities but also that of marketing. They understand the contents of the balance sheet and profit and loss account, and can apply basic instruments of accounting in a simple form. They have basic knowledge of economic analysis.

Contents

Basics of the energy industry (global, national, selected topics of energy conversion, grid-bound energy sources, primary energy, CO_2 and pollutant balance, energy industry in transition), and related law (liberalisation of the energy market, tax law, scope of regulatory authorities), foundations and mechanisms of price formation in energy production, trading, transportation and consumption, basics of energy services (e.g. contracting, LCP), structured preparation of measures for energy and cost savings, economic and investment appraisal (among others VDI 2067), economic principle of the market economy, economic policy institutions, corporate accounting, corporate planning, organisational and operational planning, with basics of management systems (DIN standards 50001 , 9001, 14001).

Special methodology

Exercises, external lecturers on special topics

Literature

Wöhe, Günter: Einführung in die allgemeine Betriebswirtschaftslehre, Vahlen-Verlag

Diverse literature on the energy industry and current studies each of which is current in ILIAS, including federal government, various programs and studies on EU requirements: among others NEEAP 2014 with accompanying documents, 10-point plan in 2014

BMWI, Monitoringbericht „Energie der Zukunft“ und Quellen, 2012 ff

UBA, Vollständig auf erneuerbaren Energien basierende Stromversorgung Deutschlands im Jahr 2050 auf Basis in Europa großtechnisch leicht erschließbarer Potentiale – Analyse und Bewertung anhand von Studien, und Quellen , 2013

3-5 Project planning and execution

Section:	Foundation course	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Brose

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Planning and execution	4	3	L + E		Stb	45 h	75 h	Brose
Project management	1	1	L + E			15 h	15 h	Hepp

Learning objectives
The objective is the ability to technically and organisationally implement planning processes including the essential legal and economic relationships. The integrated approach brings out the interplay of all possible specialist disciplines / technological areas involved in the planning. In exercises and research projects the knowledge is ingrained, so that students are able to use the "basic tools" for design, construction, commissioning and operation in a practical way.

Contents
Planning and organisation tools: project manual, structure plan, schedule, resource and capacity planning, cost calculation, cost tracking, profitability analysis, cost parameters;
Presentation of results and project documentation: protocol, project storage reporting, schedule content, CAD usage;
Preparing specifications/tenders/requests; procurement and service accounting; AVA program; supervision and acceptance of construction works / project-related services/supplies, commissioning of plants; quality assurance;
The content and nature of contracts; Fee Structure for Architects and Engineers (HOAI), contract procedures for construction works (VOB A/B/C);
Approval law (BImSchG / BImSchV, UVPG, LBO), feasibility study, land securement, land-use planning; relevant standards, regulations, laws for planning and operation;

Special methodology
Planning exercises, scripts

Literature
Ackerschott, H. et al., Technische Gebäudeausrüstung, Kommentar zu VOB Teil C, ATV DIN 18379,18380,18381, Beuth Verlag, Berlin, 2013

Bauch, U. et al., Baustellenorganisation Vol. 3, R. Müller Verlag, Cologne 2004

Ihle, Claus et al., Tabellenbuch Sanitär, Heizung, Klima/Lüftung, Bildungsverlag EINS, Trosdorf, 2011

Kapellmann, Klaus, et. al, Einführung in die VOB/B, Werner Verlag, Cologne, 2013

Kus, Alexander et. al, Einführung in die VOB/A, Werner Verlag, Cologne, 2013

Langen, Werner et. al, Bauplanung und Ausführung, Werner Verlag, Cologne, 2005

VOB A,B/ HOAI, Beck-Texte im dtv, Munich, 2013

Bayer. Landesamt für Umwelt (ed.), Praxis-Leitfaden ökolog. Gestaltung von PV-Freiflächenanlagen, Augsburg, 2014

German Institute for Building Technology (ed.), Hinweise für die Herstellung, Planung und Ausführung von Solaranlagen, Berlin, 2012

Gemeinsame Verwaltungsvorschrift des Ministeriums für Umwelt, Klima und Energiewirtschaft, des Ministeriums für Ländlichen Raum und Verbraucherschutz, des Ministeriums für Verkehr und Infrastruktur und des Ministeriums für Finanzen und Wirtschaft, Baden-Württemberg, Windenergieerlass Bad-Württemberg, Stuttgart, may 2012

Ministeriums für Umwelt, Klima und Energiewirtschaft Baden-Württemberg (ed.), Windatlas Baden-Württemberg, Stuttgart, 2011

Oberste Baubehörde im Bayer. Staatsministerium des Inneren (ed.), Planungshilfen für Bauleitplanung, Munich, 2012/2013

Siegfried Heier, Windkraftanlagen, Verlag Vieweg und Teubner, Wiesbaden, 2009

3-6 Electrical Building Services

Section:	Foundation Course: Building Systems	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Kasikci

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Electrical Building Services	5	4	L + E		K 120 min	60 h	90 h	Kasikci

Learning objectives

The objective of the lecture is to provide an overview of the most important areas of electrical building equipment and supply. Furthermore, it is intended to provide an insight into the legal provisions and the necessary background knowledge for the planning and design of electrical installations in buildings. After attending the course, the students are able to utilise the expertise and DIN VDE standards for electrical system planning.

Contents

Introduction to electrical installations, network construction of low voltage switchgear, overview of the standards and regulations, general information on the planning of electrical systems, protection against electric shock, protection of wires and cables, calculating the voltage drop, earthing systems, protective bonding conductors, protective conductor, short circuit calculations, excess current protection devices, selectivity and back-up protection, lightning protection, power factor correction, initial testing in electrical systems, security technology, application of calculation and CAD drawing programs.

Special methodology

Computer, laboratory

Literature

Auswahlordner für das Elektrohandwerk, DIN VDE 0100, VDE-Verlag, Berlin-Offenbach

I. Kasikci: Projektierung von Niederspannungsanlagen, Hüthig&Pflaum Verlag, Heidelberg, 3rd edition, 2010

I. Kasikci: Kompendium Planung von Elektroanlagen, Theorie, Vorschriften, Praxis, 2nd edition, Springer, Heidelberg, 2015.

I. Kasikci: Projektierungshilfe elektrischer Anlagen in Gebäuden, 7th edition, Schriftenreihe 148, VDE-Verlag

I. Kasikci: Kurzschlussstromberechnung in elektrischen Anlagen, DIN VDE 0102, 2nd edition 2005, Expert-Verlag

G. Kiefer, H. Schmolke: VDE 0100 und die Praxis, VDE Verlag, 14th edition

G. Pistore: Berechnung von Kurzschlussströmen und Spannungsfällen, VDE Verlag, Schriftenreihe 118

H. Schultke: ABC der Elektroinstallation, 14th edition, EW Medien

Fachkunde Elektrotechnik, Europa Verlag, 27th edition, Europa-Nr.: 30138

Schutz durch DIN VDE 0100, Europa Lehrmittel, Europa-Nr.: 30383

Praxis Elektrotechnik, Europa Lehrmittel, Europa-Nr.: 30812

de, Der Elektro- und Gebäudetechniker, Organ des ZVEH, Hüthig & Pflaum

3-7 Electrical networks and power electronics

Section:	Foundation Course: Energy Systems	**Credits:**	5
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Kasikci

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Electrical networks and Power Electronics	5	4	V+Ü+L	Stu	K 120 min	60 h	90 h	Kasikci/ Koch

Learning objectives

The objective of the lecture is to provide an overview of the most important areas of electrical networks and power supply. Focuses are: development of networks, neutral point treatment, protection, short circuit and load flow calculation. In addition, an overview of the structure and operation of the most important areas of power electronics shall be conveyed.

Contents

Electrical networks:

Introduction to energy supply, theory of symmetrical components, short circuit calculations, load flow calculation, simulation of electrical equipment, neutral point treatment, protective technology, sizing of cables and wires.

Power Electronics:

Power electronics components, terms of power electronics, line-commutated converters, AC and three-phase controller, self-commutated converters, load commutated inverters, converters, inverters, converter applications, power supplies, frequency converters, system perturbations and EMC.

Special methodology

Computer, laboratory

Literature

I. Kasikci: Projektierung von Niederspannungsanlagen, Hüthig&Pflaum Verlag, Heidelberg, 3rd edition, 2010

I. Kasikci: Kompendium Planung von Elektroanlagen, Theorie, Vorschriften, Praxis, 2nd edition, Springer, Heidelberg, 2015.

I. Kasikci: Projektierungshilfe elektrischer Anlagen in Gebäuden, 7th edition, Schriftenreihe 148, VDE-Verlag

I. Kasikci: Kurzschlussstromberechnung in elektrischen Anlagen, DIN VDE 0102, 4th edition 2013, Expert-Verlag

V. Crasten: Elektrische Energieversorgung 1 and 2, 2012, 2007, Springer

K. Heuck, K. Dettmann, D. Schulz: Elektrische Energieversorgung, Vieweg

Fachkunde Elektrotechnik, Verlag Europa Lehrmittel

D. Oeding, B. R. Oswald: Elektrische Kraftwerke und Netze. Springer-Verlag, 2011

R. Fischer: Elektrische Maschinen, 11th edition, Hanser Verlag 2011

J. Specovius: Grundlagen der Leistungselektronik, Grundkurs Leistungselektronik, Bauelemente, Schaltungen und Systeme

G. Hagmann: Leistungselektronik, Grundlagen und Anwendungen

4-1 Simulation Technology

Section:	Advanced Course	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	none	**Responsible for the module:**	Koenigsdorff

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Principles of Simulation technology	5	4	V+Ü+L	Stu	Stb	60 h	90 h	Koenigsdorff

Learning objectives

Students learn basic computing and simulation methods for the determination and assessment of energy requirements for buildings and their thermal behaviour and selected building installations for air conditioning and power supply.
They can perform basic simulations, comparisons and optimisations of the energy consumption of buildings and technical facilities at various levels of detail with selected simulation programs.

Contents

Introduction to concepts and applications of simulation technology,
System analytical description of simulation models for building and system simulation,
Fundamentals and application of simulation technology in building climate, building and energy technology
a) with RC models implemented in a programming language (e.g. Python)
b) with a building simulation program (choice of TRNSYS, Energy Plus, IDA-ICE, etc.)
c) with additional features of building simulation programs or an additional tool for system simulation.

Special methodology

Exercises, work with application & simulation software in computer rooms / simulation laboratory, seminar supervision

Literature

W. Feist: Thermische Gebäudesimulation, Verlag C. F. Müller, 1994

VDI 6020: Anforderungen an Rechenverfahren zur Gebäude- und Anlagensimulation: sheet 1 (Gebäudesimulation), may 2001

DIN EN ISO 13790:2008: Energieeffizienz von Gebäuden – Berechnung des Energiebedarfs für Heizung und Kühlung

VDI 6007: Berechnung des instationären Verhaltens von Räumen und Gebäuden. Part 1: Space model, October 2007

http://www.transsolar.com/__software/docs/trnsys/trnsys_uebersicht_de.htm

http://apps1.eere.energy.gov/buildings/energyplus/

http://www.equa.se/de/?page_id=3715

4-2 Building Automation

Section:	Advanced Course: Building Systems	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	Measurement and control technology	**Responsible for the module:**	Becker

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Principles of Automation technology	2	2	L + E		K 120 min	30 h	30 h	Becker
Principles of building automation	3	2	V+Ü+L	Stu		30 h	60 h	Becker

Learning objectives

Automation technology
The objective of the part module is to learn and understand the basic concepts, principles and interrelationships of automation technology in the context of building and energy technology. Students know the importance and the appropriate use of automation technology for energy-efficient and safe operation of plants, buildings and energy systems. They are able to understood the possibilities of, but also the limits to the use of automation technology.
Building Automation
The objective of this part-module is to learn and understand, based on the basics of automation technology, the special requirements for building automation. The students know the relevant standards and guidelines of building automation with room and plant automation in relation to the planning and execution in practice. The students are able to plan building automation (room automation, plant automation) using simple application examples. Furthermore, the students know the importance of the use of building automation for optimised operational management in connection with energy and building management and with the use of bus and communication systems.

Contents

Tasks of automation technology, measuring and sensor technology, control devices, bus and communication systems, energy and facility management, optimised operations management, project engineering of automation systems, tasks of building automation, plane models, structural models, room automation planning, plant automation planning, meshed control, planning exercises, demonstration in the technical dept., application examples.

Special methodology

Laboratory practical training

Literature

Litz, L.: Grundlagen der Automatisierungstechnik. Control Systems – Hybrid Systems. Oldenbourg-Verlag, 2. A, 2012

Bollin (ed.): Automation regenerativer Wärme- und Kälteversorgung von Gebäuden: Komponenten, Systeme, Anlagenbeispiele. Vieweg-Teubner, 1. A, 2009

Merz, H.; Hansemann, T.; Hübner, C.: Gebäudeautomation, Hanser-Verlag, 2.A, 2009

Heidemann, A.; Schmidt, P.: Raumfunktionen, TGA-Verlag, 1.A, 2012

Kranz, H.: BACnet Gebäudeautomation 1.12, cci Buch, 3.A, 2013

4-3 Construction Physics and Climate-friendly Construction

Section:	Advanced Course: Building Systems	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	Energy-efficient buildings, Thermodynamics and Fluid Mechanics	**Responsible for the module:**	Gerber

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Physics and Climate-friendly Construction	5	4	L + E		mPb 15 min	60 h	90 h	Gerber

Learning objectives

The objectives are the understanding and learning of the physical principles, their application to components and building constructions as well as the building-specific practical and normative requirements and conceptual implications. Students will be able to solve standard tasks in the fields of winter and summer heat and moisture protection by the end of the course. Computer-aided calculation methods are learnt and used for analysis.

Contents

Introduction to applications and scope of building physics: relation to the fundamentals of thermodynamics, heat transfer through components, heat conduction and heat transfer through multilayer (insulated) components, introduction to two-dimensional heat conduction, outdoor climatic / climatic conditions; Indoor climatic / thermal comfort, energy and power balance of buildings, introduction to the dynamic building behaviour, determination of internal and external loads, Summer/winter heat protection: requirements and methods of verification, technologies of passive cooling and integral building concepts for climate-friendly construction including demonstration of calculation/simulation tools, protection against moisture, condensation on and in structures, introduction to driving rain protection and waterproofing, ventilation and air-tightness: problems, requirements, analysis, design implementation, natural ventilation, passive solar energy use, building structures from a building physics point of view, consideration of climatic building concepts from a building physics point of view.

Special methodology

Simulation programs

Literature

Ch. Zürcher, Th. Frank: Bauphysik: Bau und Energie, vdf Hochschulverlag, 4th edition 2014

Lohmeyer, Post, Bergmann: Praktische Bauphysik, current edition

Bläsi, Bauphysik, current edition

If necessary, Krass, Mitransky, Rupp: Grundlagen der Bautechnik, 2013

Hausladen, Liedl: Klimagerecht Bauen: „Ein Handbuch“

4-4 Technical Building Equipment

Section:	Advanced Course: Building Systems	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	Thermodynamics, fluid mechanics	**Responsible for the module:**	Haibel

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Ventilation and air-conditioning technology	3	2	L + E		K 120 min	30 h	60 h	Haibel
Facility management	2	2	L + E			30 h	30 h	Ast

Learning objectives

In the "Technical Building Equipment" module, the physical, technological and organisational fundamentals, as well as the methods used for the operation, ventilation and air conditioning of buildings are presented and practised using practical examples. The students should be able to determine the necessary thermal and material loads in rooms and buildings with different types of use and requirements, select and dimension the technical building system necessary for their technological implementation, and apply the technical, economic and organisational methods and procedures. Practice is done by means of practical examples

Contents

Ventilation and air conditioning

- Determination of room loads
- Calculation of the air requirement for different usage requirements
- Presentation and analysis of air handling processes with the help of the hx diagram
- Representation of channel bound and unbound channel flow structures in airborne air conditioning systems
- Basics of air hygiene

Facility management

- Introduction to facility management (FM) based on executed projects
- Differences to conventional management of buildings
- Applicable standards and regulations
- FM in the planning with graphic examples and associated exercises arising from the module "project work".
- Life cycle costs and operating costs of buildings – methodological approaches with examples and exercises

Special methodology

Exercises

Literature

Recknagel et.al.; Taschenbuch für Heizung + Klimatechnik, Oldenbourg Industrie Verlag, 2015

Cerbe, G., Wilhelms, G.: Technische Thermodynamik, 17th edition, Hanser Verlag, 2014

Seifert, J; Repetitorium Raumlufttechnik, 1st edition, VDE Verlag, 2014

Gondring, Hanspeter / Wagner, Thomas: Facility Management, 2nd edition, Munich; Verlag Franz Vahlen GmbH, 2012

Otto, Dirk / Otto, Jens / Laun, Michael / Zeller, Jürgen: Leitfaden Instandhaltung 2011, Berlin: RealFM e.V. Association für Real Estate and Facility Managers, may 2011

DIN German Institute for Norms e.V.: DIN-Taschenbuch 255/2 – Gebäude- und Facility Management, Berlin: Beuth Verlag GmbH, 2009

4-5 Integral Building Design

Section:	Advanced Course: Building Systems	**Credits:**	10
Offered:	every semester	**Semester:**	4
Prerequisites:	none	**Responsible for the module:**	Ast

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
4-5 Integral Building Design	10	1	S		Stb	15 h	285h	Ast

Learning objectives
The students learn, using the example of a manageable complex project, to apply existing theory and existing knowledge. They acquire the ability to think integrally and to plan, to establish and implement new, innovative technologies, to see the point of view of various builders and planners and contractors, to contrast and evaluate possible solutions, as well as to document and present their work. Moreover, they will experience live working together in a small team.

Contents
Introduction to the project, issue of the duties and classification of groups, brainstorming, ecological, economic and innovative solutions, discussion and definition of possible solutions, intermediate delivery of basic evaluations and ideas for possible solutions, presentation of the planning task, planning for sanitary, heating, ventilation and air conditioning as well as electrical engineering and building automation together with the building envelope and its building physics and energetic properties, discussion of alternative solutions, evaluating the variants including investment as well as environmental and other non-monetary aspects, intermediate delivery of the pre-planning of all technological areas, draft planning of selected technological areas in specific areas with cost calculation for operation and investment, discussion of alternative solutions, preparing the presentation, final presentation of the project with colloquium and delivery of documents

Special methodology
Seminar with keynote speeches of teachers and meetings in smaller planning groups

Literature
Selected journal article for working on in the seminar

Project examples of previous semesters

4-6 Automation Energy Systems

Section:	Advanced Course: Energy Systems	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	none	**Responsible for the module:**	Becker

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Principles of Automation technology	2	2	L + E		K 120 min	30 h	30 h	Becker
Automation of energy systems:	3	2	V+Ü+L	Stu		30 h	60 h	N.N.

Learning objectives

Automation technology
The objective of the part module is to learn and understand the basic concepts, principles and interrelationships of automation technology in the context of energy systems. Students know the importance and the appropriate use of automation technology for energy-efficient and safe operation of plants and energy systems. They are able to understood the possibilities of, but also the limits to the use of automation technology.
Automation Energy Systems:
The objective of this part-module is to learn and understand, based on the fundamentals of automation technology, the special requirements for the automation of energy systems. The students know the relevant standards and guidelines in relation to the planning and execution in practice. The students are able to plan energy systems and systems based on simple application examples. Furthermore, the students know the importance of the use of automation technology for energy-efficient plant management in connection with energy management and with the use of bus and communication systems.

Contents

Tasks of automation technology, measuring and sensor technology, control devices, bus and communication systems, energy management, energy monitoring, optimised operations management, project engineering of automation systems, planning exercises, demonstrations and laboratory trainings in the smart grid laboratory, application examples of energy systems like wind turbines, photovoltaic systems, cogeneration, ...

Special methodology

Laboratory practical training

Literature

Litz, L.: Grundlagen der Automatisierungstechnik. Control Systems – Hybrid Systems. Oldenbourg-Verlag, 2. A, 2012

Bindel, T; Hofmann, D.: Projektierung von Automatisierungsanlagen, Vieweg-Teubner, 2. A, 2013

Buchholz, B.; Styczynski, Z.: Smart Grids, VDE-Verlag, 1. A, 2014

Bollin (ed.): Automation regenerativer Wärme- und Kälteversorgung von Gebäuden: Komponenten, Systeme, Anlagenbeispiele. Vieweg-Teubner, 1. A, 2009

Heier, S: Windkraftanlagen. Systemauslegung, Netzintegration und Regelung, Vieweg Teubner Verlag, 5.A, 2009

4-7 Thermal Power Plants

Section:	Advanced Course: Energy Systems	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	Thermodynamics and fluid mechanics	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Thermal power plants and biomass utilisation	5	4	L + E		K 120 min	60 h	90 h	LA, Entress

Learning objectives
Students gain system expertise and in-depth knowledge in two important forms of power conversion: thermal power plants, and biomass energy utilisation. From the transducer to the entire system, the ability to evaluate and balance systems and applications as well as estimate the dimensions of plants, is learnt.

Contents
Fundamentals of power plant engineering, conventional power plants, solar thermal and geothermal power plants, technology assessment in terms of efficiency, controllability, flexibility in fuel consumption, investment and fuel costs, applications
Energy policy and the energy industry conditions of biomass utilisation, potential of biomass for energy use, definition and characterisation of biomass, cultivation, harvesting and storage, basics of biomass utilisation: combustion, gasification and fermentation, emissions and waste gas treatment, approval of biomass plants.

Special methodology
Lecture with exercises

Literature
Energy Technology: systems for energy conversion. Kompaktwissen für Studium und Beruf; Richard Zahoransky, Vieweg+Teubner Verlag

Kraftwerkstechnik: Zur Nutzung fossiler, nuklearer und regenerativer Energiequellen; Karl Strauß, Springer Verlag

M. Kaltschmitt, H. Hartmann, H. Hofbauer: Energetische Nutzung von Biomasse, Springer Verlag Heidelberg, 2009

Fachagentur Nachwachsende Rohstoffe e.V. (FNR): Leitfaden Bioenergie, 2005

4-8 Wind and hydro power plants

Section:	Advanced Course: Energy Systems	**Credits:**	5
Offered:	every semester	**Semester:**	4
Prerequisites:	Fluid Mechanics	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Wind turbines and Hydroelectric power plants	5	4	L + E	Stu	K 60 min	60 h	90 h	Entress, Hutarew

Learning objectives
Students gain system expertise and in-depth knowledge in two important forms of energy conversion, wind and hydroelectric power utilisation. From the transducer to the entire system, the ability to evaluate and balance systems and applications as well as estimate the dimensions of plants, is learnt.

Contents
Development of wind, location influences and measurement of wind speed, types and components of wind turbines, site selection, planning, approval,
Hydropower plants, hydropower basics, approval process of construction and operation of hydroelectric power plants, hydroelectric power features, types and components of hydro power: high-middle-low pressure systems, maintenance.

Special methodology
Working with user software

Literature
R. Gach, J. Twele: Windkraftanlagen, Vieweg + Teubner, 2011

Mosoni Giesecke: Wasserkraftanlagen Springer-Verlag

Europäische **W**asser**R**ahmen**R**icht**L**inie aktueller Version (www4.um.badenwuerttemberg.de/servlet/is/3577/)

Renewable Energies Act (A law Granting Priority to Renewable Energy)

4-9 Integral Power Plant Planning

Section:	Advanced Course: Energy Systems	**Credits:**	10
Offered:	every semester	**Semester:**	4
Prerequisites:	Thermal Energy Systems Project planning and execution	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Integral Power plant planning	10	1	S		Stb	15 h	285 h	Entress

Learning objectives

In the course, the basics of the foundation course (e.g., thermal and electrical systems) are combined in an integral project planning. The students learn, building on the module "project planning and execution" in the 3rd semester, using the example of a complex, but manageable project, to apply existing theory and existing knowledge in the field of energy systems. They acquire the ability to think integrally and manage an overall technical planning, to develop and apply new, innovative techniques, to contrast and evaluate possible solutions, as well as documenting and presenting their work. They get to know the perspective of various builders as well as the designers and the contractors. In addition, they learn structured teamwork.

Contents

Introduction to the project, coordination of tasks and division into groups, brainstorming, ecological, economic and innovative solutions, discussion and definition of possible solutions.
Elaboration of planning services on the basis of services of the HOAI (German fee regulations for architects and engineers) for the creation of customer-oriented and market-oriented concepts with cost calculation for operation and investment.
Structured discussion of possible solutions as well as technical, economic and ecological assessment of the variants, taking minutes.
Preparing the presentation, final presentation of the project with colloquium, delivery report with documents

Special methodology

Seminar with keynote speeches of teachers and meetings in smaller planning groups

Literature

German construction contract procedures for building works Part A and B;

HOAI Verordnung über die Honorare für Leistungen der Architekten und der Ingenieure, Beck-Texte im DTV, 2013

Selected journal article for working on in the Seminar

Project examples of previous semesters

Report Template "Technical Reports"

5-1 Practical Module

Section:	Advanced Course	**Credits:**	30
Offered:	every semester	**Semester:**	5
Prerequisites:	none	**Responsible for the module:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Practical training	24		P		Stu		720 h	
1. laboratory practical training	4	2	L		Stu	30 h	90 h	various
User Software	2	2	L + E		Stu	30 h	30 h	LA

Learning objectives

The processing of engineering tasks shall convey local insight into the technical, organisational and social structure of a company and enable understanding of technical and scientific connections.
In the laboratory trainings provided, the practical application and the handling and evaluation of real working and measurement methods is learnt. The quantitative analyses are combined with previously acquired theoretical knowledge and enable students to transfer them to other applications or to develop optimisation and planning processes. Students are able to plan and carry out measurements and to document them in the form of (measurement) records and reports and to present and evaluate them.

Contents

Work on energy-related engineering tasks under specific operating conditions and applying problem-solving techniques. Applying knowledge and skills acquired in the course in the respective technical and operational practice, as well as the acquisition of knowledge and experience from the respective technical practice and learning and experiencing the laws of economic, legal and social business practice as well as the practising of social and key competencies.
The contents of the laboratory trainings are based on the available and already subscribed trainings. An overview of various, currently available laboratory trainings can be found in the annex of this module.
In the application software part of the course, the handling of application programs in the following areas will be practiced by way of example: U-value calculation, water vapour diffusion, the German energy saving ordinance (EnEV), heating load, radiator design, underfloor heating, cooling load, pipeline calculation, drinking water, wastewater, air duct calculation

Special methodology

Internship in companies, user software seminar block

Literature

Training materials of user software

6-1 Laboratory practical training II

Section:	Advanced Course	**Credits:**	4
Offered:	every semester	**Semester:**	6
Prerequisites:	none	**Responsible for the module:**	Head of IGE

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
2. laboratory practical training	4	2	L		Stu	30 h	90 h	various

Learning objectives

In the laboratory trainings provided, the practical application and the handling and evaluation of real working and measurement methods is learnt. The quantitative analyses are combined with previously acquired theoretical knowledge and enable students to transfer them to other applications or to develop optimisation and planning processes. Students are able to plan and carry out measurements and to document them in the form of (measurement) records and reports and to present and evaluate them.

Contents

The technical contents of the various laboratory offers are listed in the annex of the module "6-1 Laboratory training II".

Special methodology

Laboratory Practice

Literature

Subject-specific

1. Annex: Laboratory training - Electrical Systems

Courses offered	Repeat of the lecture "Electrical Devices and Systems" and the VDE regulations Introduction to the methods of measurement of electrical engineering Dealing with measuring instruments Measurements of electrical equipment
Learning objectives	The training objectives are structured as follows: • Overview of power supply, power distribution • Practical handling of measuring instruments • Design of test and measurement set-ups for electro-technical plants • Troubleshooting the experimental procedure • Hazards of electricity, protection measures against electric shock • Network systems, testing of TN, TT and IT systems • Short circuit, fault to frame, earth leakage • Testing of electrical installations according to currently applicable standards • Insulation measurement, earth measurement, loop resistance measurement, testing of RCDs • Rotating field check, protective conductor measurement, equipotential bonding measurement • Preparation of experiment and measurement results • Interpretation of experiment and measurement results • Documentation, handover and test report

2. Annex: Laboratory training - Facility Management

Courses offered	Acceptance of technical equipment based on the example of air conditioning systems Hygiene examination for HVAC systems and devices according to VDI 6022 Determining the energy efficiency of HVAC systems using the example of the SFP value of fans Operation and maintenance of equipment based on the example of air conditioning systems with RFID technology Applying CAFM systems using the example of the building climate in the tech. department.
Learning objectives	Theoretical and practical mastering of typical tasks of facility management Practical handling of measuring instruments Computer-aided analysis of measured results Troubleshooting the experimental procedure Preparation and evaluation of experiment and measurement results

3. Annex: Laboratory training - Automation Technology

Courses offered	In the laboratory for building automation, the contents of the lecture control technology and building automation are reinforced through practical laboratory experiments based on multiple practical training experiments. The laboratory is divided into three areas: regulation technology, control technology and bus systems. **Laboratory training 1**: Regulation technology (simulation): working with the control engineering software package WinFACT (simulation), controller design, modelling and comparative analysis of regulators. Integration of real controllers in a hardware in the loop environment (HIL environment), **Laboratory training 2**: Control technology (simulation); working with the programming system CoDeSys according to IEC 61131, application examples: control of a factory gate, controlling a ventilation system. **Laboratory training 3**: Engineering and configuring of bus systems, application examples: implementation of a light and blind control. For each laboratory training, a laboratory report shall be prepared which is then discussed together in a colloquium.
Learning objectives	Repetition and extension of the lecture using laboratory trainings. Learn to understand the practical aspects of automation technology Evaluation and presentation of measurement and experiment results

4. Annex: Laboratory training - ventilation and air conditioning systems

Courses offered	Introduction to the methods of measurement of air conditioning Qualitative and quantitative analysis of air flows in rooms Thermal analysis of buildings and building components with the aid of infrared thermography Measurement of comfort profiles in rooms Validation of HVAC systems
Learning objectives	Practical handling of measuring instruments (thermal probes, anemometers, pressure transducer, etc.) Practical handling of an IR camera Computer-aided evaluation of measurement results Design of experiment and measurement setups for ventilation and air conditioning technical tasks Troubleshooting the experimental procedure Preparation of experiment and measurement results Interpretation of experiment and measurement results

5. Annex: Laboratory training - Day-light technology and solar systems

5.1 Daylight and lighting

Courses offered	Measurement and simulation and evaluation of artificial and daylighting systems. Experiments on visual comfort with aspects of planning
Learning objectives	• Characterisation of lamps and lighting: lighting characteristics • Glare evaluation and visual comfort • Simulation of rooms for artificial and daylight design • Application of constraints set by standards • Practical dealing with various measuring instruments of lighting technology, with respect to the perception

5.2 Solar Systems

Courses offered	Experiments on the use of solar radiation for the generation of electricity and heat. Application of simulation tools
Learning objectives	• Understanding solar radiation available, measurements of solar radiation, solar altitude, shading • PV: the cell, the module and the system, characterisation, performance measurement, stand-alone systems, grid-connected systems, etc. • Solarthermics: from the collector to the system: characterisation of the collector and system, efficiency and coverage, etc.

6. Annex: Laboratory training - Cooling and heat pump technology

Courses offered	Temperature and heat quantity measurement Power control of a cooling system Operating behaviour of a large cooling system Operating behaviour of geothermal heat pump Performance of an air-ground-floor absorber
Learning objectives	The students learn on the basis of laboratory experiments • They carry out experiments, measurements and evaluations of real components, equipment and buildings, • Record cooling and heat pump systems metrologically, and assess energy-wise • Record and evaluate regenerative thermal energy

7. Annex: Laboratory training - Smart Grid

Courses offered	Wind turbines with DFIG Construction and operation of photovoltaic systems Power generation and distribution Active and reactive power management Electrical networks Energy management
Learning objectives	Understand the operating principles of different producers and consumers, electricity transmission and its coupling Computer-aided evaluation of experimental data Troubleshooting the experimental procedure Preparation of experiment and measurement results Interpretation of experiment and measurement results

8. Annex: Field laboratory training - Renewable energy systems

Courses offered	Evaluation of records of real power generation plants • Photovoltaics • Wind power • Biogas • Small-scale hydropower • Consumer / MS Networks
Learning objectives	To understand the real functional processes and principles of various renewable energy installations and consumers/networks Computer-aided selection and evaluation of measurement data Analysis and evaluation of experiment and measurement results Troubleshooting the experimental procedure Presentation of the evaluation of experiment and measurement results

9. Annex: Laboratory training in the technical department and hydraulics

Courses offered	Airtightness measurement In-situ determination of the performance of thermo-active building systems Thermal response test on a geothermal probe Pump and valve characteristics Hydraulic circuits Hydraulic balancing
Learning objectives	The students learn on the basis of laboratory experiments • to understand the thermal-energy and dynamic behaviour of component-integrated and geothermal systems and assessing them metrologically, • to measure the air tightness of buildings, • To record pump and valve characteristics metrologically • To understand the need for a hydraulic balance in terms of supply quality • To examine different hydraulic basic circuits practically

6-2 Project Work

Section:	Advanced Course	**Credits:**	10
Offered:	every semester	**Semester:**	6
Prerequisites:	none	**Responsible for the module:**	Floß/Bretzke

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Project Work	10	1	S		Stb	15 h	285h	various

Learning objectives

Students learn, after four university and one practical semester, to use their previously acquired skills in a new project of medium complexity. Precise technical communication and mutual provision of information (group work), independent handling of specialist topics and their analysis as well as technical development, written and oral presentation of the results.

Contents

The project contents may come from any area of the energy systems and building climate / technical building services and are usually integrated planning tasks going into detail in the various disciplines such as energy generation and supply, building physics, electrical and automation technology, thermal energy systems all the way to the field of lighting technology and energy management systems. The contents of the lectures of the economics and project planning and implementation modules should be applied.
All projects have great practical relevance; numerous projects are carried out in cooperation with partners from industry, councils or engineering / architecture firms.

Special methodology

Project Work

Literature

Topic-specific

6-3 Energy and Resource Efficiency

Section:	Advanced Course: Building Systems	**Credits:**	7
Offered:	every semester	**Semester:**	6
Prerequisites:	none	**Responsible for the module:**	Bretzke

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Energy management	3	3	L + E		K 120 min	45 h	45 h	Bretzke
Material Sciences	2	2	L + E			30 h	30 h	Haibel
Energy evaluation of buildings	2	2	S+L		Stu	30 h	30 h	Ast

Learning objectives

The overall learning objective of the module is the mastering basic methods and procedures for evaluating the energy and resource efficiency of buildings and facilities in terms of energy consumption and demand, as well as the use of materials.
Upon completion of the module the students have practical knowledge of the application of basic organisational, technical and processing methods regarding energy procurement, consumption recording and evaluation and related controlling and analysis instruments. They can use these methods to assess and analyse, in particular with regard to energy, management systems, processes, properties and companies, and develop targeted measures. Furthermore, they understand macroeconomic and economic policy connections and know important enterprise characteristics.
The students should be able to select and judge materials with regard to the required properties, processing methods and practicality, for building and energy technology applications. In addition, they should learn, from all major classes of materials, the composition and characteristics as well as how to purposefully influence and adapt them.
Students learn the application of computational methods to assess the energy efficiency of buildings and their technical installations on the demand level according to applicable standards and procedures of the German Energy Saving Ordinance (EnEV).

Contents

Basics of energy management, law, organisation, procedure, municipal energy management, industrial energy management, energy procurement, controlling, evaluation tools and methods, energy characteristics and including according to VDI 3807, preparation of energy analyses, energy consumption certificates, energy-related reports, structured preparation of measures for energy and cost savings, advanced operational management taking account of benchmarks and performance indicators, energy law with the energy market liberalisation and levies(EEG etc.), field of activity of the regulatory agencies, basics and mechanisms of price formation - the energy trade, and energy transport, basics of energy services,
Ways to material selection (balance between function, property and manufacturing), introduction to the basic properties, classifications and concepts of materials science of ferrous materials and non-ferrous materials (composition, structure, properties, steels and cast iron materials, alloys, application areas and manufacturing technologies), functional mechanisms in alloying and heat treatment processes, plastics and ceramic and mineral materials (composition, structure, adjustment of properties, bonding methods, manufacture, application examples), composites (objectives, structure, composition, properties, fibre composites and sandwich elements, application examples), corrosion and corrosion protection for various classes of materials. Practical examples of a resource-efficient material selection.

Normative energy evaluation of buildings, in particular in accordance with EnEV and DIN V 18599, associated software as well as processing of basic and application examples.

Special methodology

Exercises, work with application & simulation software in computer rooms / simulation lab, seminar supervision, external lecturers on special topics

Literature

BMU, UBA: Energiemanagementsysteme in der Praxis, ISO 50001: Leitfaden für Unternehmen und Organisationen, online

Deutscher Städtetag: Das Energiemanagement im Rahmen der kommunalen Gebäudewirtschaft, Hinweise zum kommunalen Energiemanagement des AK Energieeinsparung, online

AMEV, Energie 2009, Hinweise zum Energiemanagement in öffentlichen Gebäuden

Fünfgeld, C. (Fünfgeld 2005); Betriebliches Energiemanagement, BTU Forschungshefte Energie. 2005

various Literature from the HBC library on the subject,

Links in the lecture

Askeland, D.; Materialwissenschaften, 2010, Spektrum Akademischer Verlag Heidelberg

Seidel, W., Hahn, F.; Werkstofftechnik, 2014, Hanser Verlag Munich

Energy Saving Ordinance (EnEV)

DIN V 18599: Energy evaluation of buildings and associated standards

6-4 1. Elective module (specialisation Building Systems)

Section:	Advanced Course	**Credits:**	9
Offered:	every semester	**Semester:**	6
Prerequisites:	Foundation course	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Responsible for the submodule
Acoustics / Noise protection	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Interpretation of TGA components	(3)	(2)	L + E		K 60 min	30 h	60 h	Brose
Building Biology I	(3)	(2)	V+Ü+L		mPb 15 min	30 h	60 h	Haibel
Building Biology II	(3)	(2)	V+Ü+L		mPb 15 min	30 h	60 h	Haibel
Energy Optimisation still to be finalised	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Structural Engineering theory	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Climate-friendly Construction	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Lighting Technology	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Sanitary technology	(3)	(2)	L + E		K 60 min	30 h	60 h	Floss
Seminar: Building Systems-1	(3)	(2)	S		Stb	30 h	60 h	Entress
Seminar: Building Systems-2	(3)	(2)	S		Stb	30 h	60 h	Entress
Special section: Refrigeration technology	(3)	(2)	L + E		K 60 min	30 h	60 h	Siegismund
Special section Ventilation and Air-conditioning Systems	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Haibel
Thermo-active Component systems	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Koenigsdorff
Subject from Elective Module ES-1	(3)	(2)				30 h	60 h	
Subject from Elective Module ES-1	(3)	(2)				30 h	60 h	
Subject/module from course 1								
Subject/module from course 2								

Overarching learning objectives

The students should be given the opportunity to be able to individually go into depth in the elective subject. Learning objectives, contents, methods and literature are listed for the above-mentioned sub-modules as follows.

Acoustics / Noise protection

Learning objectives
The basics of acoustics are taught in compliance with the relevant building and room-acoustic requirements.

Contents
Introduction to acoustics and sound insulation: Principles of waves and vibrations, sound and vibration, acoustic tasks in the building, protection and planning aims and requirements, airborne sound insulation for interior and exterior components, impact sound insulation, room acoustics, introduction to acoustic testing and measurement methods incl. demonstration, special topics (building practice / interior construction, aircraft and traffic noise)

Special methodology
Blackboard presentation

Literature
Eva Veres, Wolfgang Fasold: Schallschutz und Raumakustik in der Praxis, Beuth 2015

Wolfgang M Willems, Kai Schild, Diana Stricker: Schallschutz: Bauakustik, Springer-Vieweg 2012

Ch. Nocke: Raumakustik im Alltag: Hören - Planen - Verstehen, Fraunhofer IRB 2014

Interpretation of TGA components

Learning objectives
The students learn quality characteristics and project-specific aspects of essential components of building technical systems and are able to select and dimension the components. The objective is the knowledge of the relevant calculation methods, calculation tools and an insight into marketable products.

Contents
Consideration of TGA components relating to: structure, function, quality features, dimensioning, efficient integration in higher-level overall system (hydraulics, building). Exemplary components: heat generator (boiler, CHP, heat pump, heat exchanger), safety equipment for heating systems (expansion vessel, safety valve), pumps, valves, piping, fans, air filters, air ducts, air outlets, fire dampers, cold generator, thermal insulation systems, fire protection systems.
Presentation of product-specific information sources (internet, product catalogues) and calculation methods.

Special methodology
Calculation exercises, product search (internet, literature)

Literature
Recknagel, Hermann (ed.) et. al., Taschenbuch für Heizung- und Klimatechnik 2013/14, Deutscher Industrieverlag, Munich, 2012

Pistohl, Wolfram et. al., Handbuch der Gebäudetechnik, Vol. 1 and 2, Werner Verlag, Cologne, 2013

Ihle, Claus et. al., Tabellenbuch Sanitär, Heizung, Klima/Lüftung, Bildungsverlag Eins, Cologne, 2015

Building Biology I

Learning objectives

The tasks of building biology are the creating and maintaining of a healthy, positive, and supporting living and working environment. It involves both the prevention, elimination and reduction of health risks and dangers as well as the adaption of the technology to the needs of residents and users.
The objective of the lecture is to get to know the topics "electric and magnetic fields", "sound fields" and "geological fields" with regard to their building biological relevance and go into them in depth using selected experiments.

Contents

Lecture:
Basic Introduction to building biology
Building biology assessment and working methods
Bio-climate and the effect on health
Fundamentals of electric and magnetic fields
Electrical and magnetic dc fields
Low-frequency electric and magnetic fields (LF)
High-frequency electric and magnetic fields (RF)
Environmental Radioactivity
Geological disturbances
Experimental program:
Long-term measurement of biologically relevant air quality parameters in permanently occupied working and living spaces
24-hour measurement of electric and magnetic LF fields in the resting/sleeping area
24-hour measurement of electromagnetic RF fields in living and working areas
Measurement of noise and infrasound load of energy and building facilities on living and working spaces
Measurement of radioactivity and geomagnetic anomalies in resting/sleeping areas

Special methodology

Lecture with integrated measurement exercises

Literature

Hartmann, F.; Baubiologische Haustechnik, VDE Verlag Berlin, 2015

Maes W. et. al.; Elektrosmog – Wohngifte – Pilze; Haug Verlag; 2003

Maes W.; Stress durch Strom und Strahlung; Schriftenreihe Gesundes Wohnen; Institut für Baubiologie und Ökologie; 2005

Building Biology II

Learning objectives

The tasks of building biology are the creating and maintaining of a healthy, positive, and supporting living and working environment. It involves both the prevention, elimination and reduction of health risks and dangers as well as the adaption of the technology to the needs of residents and users.
The objective of the lecture is to learn about the themes "water" and "air" in terms of their building biological relevance and go into them in depth using selected experiments.

Contents

Lecture:
Basic Introduction to building biology
Building biology assessment and working methods
Bio-climate and the effect on health (repeat)
Air quality indoors (CO_2, Air ions, etc.)
Air pollutants indoors (VVOC, SVOC, particles)
Microbial load indoors (moulds and yeasts)
Fundamentals of Air Pollution
Types, constituents and properties of water
Requirements and properties of drinking water
Inorganic, organic and microbiological contamination of water
Ecologically relevant characteristics of water supply
Experimental program:
Long-term measurement of biologically relevant air quality parameters in permanently occupied working and living spaces
Measurement of air pollutants in selected areas and environments
Determining the microbiological contamination of surfaces
Measurement of water constituents

Special methodology

Measurement exercises

Literature

Hartmann, F.; Baubiologische Haustechnik, VDE Verlag Berlin, 2015

Leitfaden zur Untersuchung und Sanierung bei Schimmelpilzwachstum in Innenräumen („Schimmelpilz-Leitfaden“), Umweltbundesamt; 2013

Pluschke P.; Luftschadstoffe in Innenräumen; Springer Verlag; 1996

Maes W. et. al.; Elektrosmog – Wohngifte – Pilze; Haug Verlag; 2003

Energy optimisation at the drafting stage

Learning objectives
The students gain insight into the developments of architecture and obtain knowledge regarding the key influencing factors of energy optimisation during the design phase.

Contents
Development of modern architecture since 1900
The main architectural trends since 1945
Discussion of present trends
Architectural building designs
Development of short biographies of important architects (coursework)

Special methodology
Lecture, overheads

Literature
Doreen E. Kalz, Jens Pfafferott: Thermal Comfort and Energy-Efficient Cooling of Nonresidential Buildings Springer, 2014

Voss Löhnert, Herkel, Wagner, Wambsganß: Bürogebäude mit Zukunft, TÜV-Verlag, 2005.

Structural Engineering Theory

Learning objectives
Knowledge and understanding of building concepts (structural engineering theory) and building construction.

Contents
Teaching on technical fundamental concepts and terms of structural engineering theory, system/user reference frame, indoor climate, accessibility, stairs, parking, fire protection, energy consumption, sustainability, introduction to the special methodology of drafting and impact on the cost, space, development and organisational concepts, accommodation considerations, building typologies, basics of certification (BNB, DGNB, etc.).
Historical development of building construction, fundamentals of design principles of solid and skeleton construction depending on various materials such as concrete, masonry, wood, steel, glass; interaction of construction, building physics, design and development, properties and application of insulating materials, costs and viability.

Special methodology
Lectures with integrated exercises.

Literature
Schenker, Martin: Sanitär-Anlagen; Vogel Buchverlag

Feurich, Hugo: Sanitärtechnik I und II; Krammer Verlag

Neufert: Bauentwurfslehre; Springer-Verlag

Schmitt, Heere: Hochbaukonstruktion; Vieweg Verlag

Climate-friendly Construction

Learning objectives
The learning objective is a more thorough understanding of the physics, its application to building components and constructions as well as the building-specific practical and normative requirements and conceptual implications. At the end of the course students will be able to handle tasks from the subject areas of winter and summer heat and moisture protection.

Contents
Applications and scope of building physics: relation to the fundamentals of thermodynamics, heat transfer through components, heat conduction and heat transfer through multilayer (insulated) components, introduction to two-dimensional heat conduction, outdoor climate / climatic conditions; indoor climate / thermal comfort, energy and power balance of buildings, introduction to the dynamic building behaviour, determination of internal and external loads, summer/winter heat protection: requirements and methods of verification, technologies of passive cooling and integral building concepts for climate-friendly construction including the demonstration of calculation/simulation tools, protection against moisture, condensation on and in structures, introduction to driving rain protection and waterproofing, ventilation and air-tightness: problems, requirements, analysis, design implementation, natural ventilation, passive solar energy use, building structures from a building physics point of view, consideration of climatic building concepts from a building physics point of view.

Special methodology
Application of simulation tools, seminar group work

Literature
Ch. Zürcher, Th. Frank: Bauphysik: Bau und Energie, vdf Hochschulvlg, 4th edition, 2014

Lohmeyer, Post, Bergmann: Praktische Bauphysik, current edition

Bläsi, Bauphysik, current edition

If necessary, Krass, Mitransky, Rupp: Grundlagen der Bautechnik, 2013

Hausladen, Liedl, Klimagerecht Bauen: Ein Handbuch

Lighting Technology

Learning objectives
Mastering the technical basics of lighting. Knowledge of light sources. Fundamentals of daylight and artificial light planning for interiors from the perspective of visual comfort and energy efficiency.

Contents
Photometric values, physiology of vision, day and artificial light planning, light sources, lamps, glare, visual comfort, energy efficiency, control and regulation, planning tools

Special methodology
Accompanying laboratory experiments, application planning software, seminar part

Literature
Ganslandt, Hofmann; Handbuch der Lichtplanung; Vieweg, www.erco.com

Brandi, Detail Praxis: Tageslicht Kunstlicht , Institut für internat. Arch. Dokum.

Rudolf Schricker, Licht-Raum Raum-Licht, DVA

Willfried Baatz Hrsg., Gestaltung mit Licht, Ravensburger

Schmidt/Töllner Hrsg., StadtLicht, Fraunhofer IRB Verlag

Bartenbach, Witting, Handbuch für Lichtgestaltung: Lichttechnische und wahrnehmungspsychologische Grundlagen Springer 2008

Witting, Licht. Vision. Gestalten.: Lichttechnische und wahrnehmungspsychologische Grundlagen für Architekten und Lichtdesigner, Birkhäuser 2014

Sanitary technology

Learning objectives
The lecture sanitary engineering provides an overview of the most important tasks areas of modern sanitary engineering. The objective is a knowledge and understanding of subject-specific problems, which subsequently facilitates the in-depth training in standards and literature.

Contents
Planning of sanitary and domestic connections, equipment of sanitation facilities, water supply, water hygiene, building drainage, rainwater utilisation.

Special methodology
Lectures with integrated exercises.

Literature
Schenker, Martin: Sanitär-Anlagen; Vogel Buchverlag

Feurich, Hugo: Sanitärtechnik Vol. 1 and 2; Kramer Verlag, Düsseldorf

Seminar: Building Systems 1 and 2

Learning objectives
The students gain a focused, in-depth understanding of comprehensive relations and interactions in the energy conception, planning, execution and operation of buildings and their technical systems.

Contents
Current or in-depth specific topics and examples in the field of building systems will be treated by alternating internal and external teachers and lecturers.

Special methodology
Seminar Course

Literature

Special section: Refrigeration Technology

Learning objectives
Application of the basic knowledge to selected plant systems (air conditioning, food storage, process cooling, etc.) Students learn the dimensioning of systems and components (compressors, re-cooling systems, cold storage, pipelines).

Contents
Application of cooling technology, system dimensioning

Special methodology
Lecture, blackboard demonstration

Literature
Breidenbach, K.: der Kälteanlagenbauer, Vol. 1, Grundkenntnisse, 6th edition, 2012, VDE Verlag, Berlin

Breidenbach, K.: der Kälteanlagenbauer, Vol. 2, Grundlagen der Kälteanwendung, 4th edition, 2010, VDE Verlag, Berlin

Special section Ventilation and Air-conditioning Systems

Learning objectives
The objective of the course is an in-depth presentation and extension of the contents of the basic course "ventilation and air conditioning technology".

Contents (choice)
Sound insulation and sound transmission in ventilation systems
Fire protection in ventilation systems
Formation of room airflows
Current topics from ventilation and air conditioning technology
Examples of planning practice ("Best Practice")

Special methodology
Lecture with exercises

Literature
Depending on topics

Thermo-active Component Systems

Learning objectives
Students are familiar with the different types of thermo-active building systems (TABS) and their constructive, thermal and energy, hydraulic and control engineering properties. In addition, they are able to design and plan thermo-active building systems in conjunction with the supplied building and the associated plant engineering.

Contents
Introduction: models, building types and basic properties of TABS
Standards for TABS
Performance of TABS under steady state and transient conditions
Performance requirements for TABS
Thermal and energy design and dimensioning incl. dynamic method (e.g. UBB procedure)
Hydraulic design and planning of TABS
Draft and implementation planning of TABS
Planning Exercise

Special methodology
Exercises based on the lecture as well as exercises and planning tasks to be worked on alone; laboratory experiment/measurement

Literature
Koschenz, M.; Lehmann, B.: *Thermoaktive Bauteilsysteme (tabs)*. Dübendorf: EMPA, 2000

Kalz, D.; Pfafferott, J.: *Thermoaktive Bauteilsysteme*. BINE Themeninfo. Fraunhofer IRB Verlag, Stuttgart, 2007

J. Pfafferott, D. Kalz, R. Koenigsdorff: Praxiserfahrungen und Anforderungen an thermoaktive Bauteilsysteme, Fraunhofer IRB Verlag, 2015

Tödtli, J.: *TABS Control*. Faktor-Verlag, Zürich, 2009

R. Koenigsdorff: Oberflächennahe Geothermie für Gebäude, Fraunhofer IRB Verlag, 2011

Product documentation of various manufacturers

Subject from elective module ES-1 and ES-2

Learning objectives
On the basis of selected subjects from other courses, the understanding and knowledge of other subject areas, beyond their own specialist subjects, shall be expanded, in order to support inter- and trans-disciplinary work.

Contents
Dependant on the respective course

Special methodology
Dependant on the respective course

Literature
Dependant on the respective course

Subject/module from course 1 and 2

Learning objectives
On the basis of selected subjects from other courses, the understanding and knowledge of other subject areas, beyond their own specialist subjects, shall be expanded, in order to support inter- and trans-disciplinary work.

Contents
Dependant on the respective course

Special methodology
Dependant on the respective course

Literature
Dependant on the respective course

6-5 Energy and Resource Efficiency

Section:	Advanced Course: Energy Systems	**Credits:**	7
Offered:	every semester	**Semester:**	6
Prerequisites:	none	**Responsible for the module:**	Bretzke

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Energy management	3	3	L + E		K 120 min	45 h	45 h	Bretzke
Material Sciences	2	2	L + E			30 h	30 h	Haibel
Plant and network simulation	2	2	S+L		Stu	30 h	30 h	Koenigsdorff

Learning objectives

The overarching learning objective of the module is the mastering of basic methods and procedures for evaluating the energy and resource efficiency of plant and building systems in terms of energy consumption, the use of materials, including the use of simulation methods.
Upon completion of the module the students have practical knowledge of the application of basic organisational, technical and processing methods regarding energy procurement, consumption recording and evaluation and related controlling and analysis instruments. They can use these methods to assess and analyse, in particular with regard to energy, management systems, processes, properties and companies, and develop targeted measures. Furthermore, they understand macroeconomic and economic policy connections and know important enterprise characteristics.
The students should be able to select and judge materials with regard to the required properties, processing methods and practicality, for building and energy technology applications. In addition, they should learn, from all major classes of materials, the composition and characteristics as well as how to purposefully influence and adapt them.
Based on the basics of system simulation learnt in simulation technology module, students acquire in-depth knowledge and experience in the thermal and energy plant and system simulation as a tool for evaluation and optimisation of the energy efficiency.

Contents

Basics of energy management, law, organisation, procedure, municipal energy management, industrial energy management, energy procurement, controlling, evaluation tools and methods, energy characteristics and including according to VDI 3807, preparation of energy analyses, energy consumption certificates, energy-related reports, structured preparation of measures for energy and cost savings, advanced operational management taking account of benchmarks and performance indicators, energy law with the energy market liberalisation and levies(EEG etc.), field of activity of the regulatory agencies, basics and mechanisms of price formation - the energy trade, and energy transport, basics of energy services,
Ways to material selection (balance between function, property and manufacturing), introduction to the basic properties, classifications and concepts of materials science of ferrous materials and non-ferrous materials (composition, structure, properties, steels and cast iron materials, alloys, application areas and manufacturing technologies), functional mechanisms in alloying and heat treatment processes, plastics and ceramic and mineral materials (composition, structure, adjustment of properties, bonding methods, manufacture, application examples), composites (objectives, structure, composition, properties, fibre composites and sandwich elements, application examples), corrosion and corrosion protection for various classes of materials. Practical examples of a resource-efficient material selection.

In-depth study of the methods of thermal-energy plant and system simulation using the example of thermal energy systems, application in the design and dimensioning as well as the preparation of plant operation.

Special methodology

Exercises, work with application & simulation software in computer rooms / simulation lab, seminar supervision, external lecturers on special topics

Literature

BMU, UBA: Energiemanagementsysteme in der Praxis, ISO 50001: Leitfaden für Unternehmen und Organisationen, online

Deutscher Städtetag: Das Energiemanagement im Rahmen der kommunalen Gebäudewirtschaft, Hinweise zum kommunalen Energiemanagement des AK Energieeinsparung, online

AMEV, Energie 2009, Hinweise zum Energiemanagement in öffentlichen Gebäuden

Fünfgeld, C. (Fünfgeld 2005); Betriebliches Energiemanagement, BTU Forschungshefte Energie. 2005

various Literature from the HBC library on the subject,

Links in the lecture

Askeland, D.; Materialwissenschaften, 2010, Spektrum Akademischer Verlag Heidelberg

Seidel, W., Hahn, F.; Werkstofftechnik, 2014, Hanser Verlag Munich

Andreas Hauer, Stefan Hiebler, Manfred Reuß: Wärmespeicher, Hrsg.: FIZ Karlsruhe, BINE Informationsdienst, Bonn; 5., fully revised edition. 2013, Fraunhofer IRB Verlag, ISBN 978-3-8167-8366-4

LowEx Fernwärme - Multilevel District Heating. Part Theme 4: Software to improve the potential for use of district heating systems, AGFW, Frankfurt, 2013

6-6 1. Elective module (specialisation Energy Systems)

Section:	Advanced Course	**Credits:**	9
Offered:	every semester	**Semester:**	6
Prerequisites:	Foundation course	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Responsible for the submodule
Energy Data Management	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
History of technology	(3)	(2)	L + E		Stb	30 h	60 h	Haibel
Principles of Geothermal power:	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Koenigsdorff
Industry Lecture-1	(3)	(2)	S		Stb	30 h	60 h	Floss
Industry Lecture-2	(3)	(2)	S		Stb	30 h	60 h	Floss
Pipeline construction and operation	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Koenigsdorff
Seminar: Energy Systems 1 and 2	(3)	(2)	S		Stb	30 h	60 h	Entress
Seminar: Energy Systems 1 and 2	(3)	(2)	S		Stb	30 h	60 h	Entress
Special section: Energy Industry	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Bretzke
Special section: Electr. systems	(3)	(2)	L + E		K 60 min	30 h	60 h	Kasikci
Special section: Thermodynamics	(3)	(2)	L + E		K 60 min	30 h	60 h	Haibel
Special section: Controlled Energy Systems	(3)	(2)	L + E		K 60 min	30 h	60 h	Gerber
Storage Technology	(3)	(2)	L + E		K 60 min	30 h	60 h	Siegismund
Subject/module from course 1								Entress
Subject/module from course 2								Entress

Overarching learning objectives

The students should be given the opportunity to be able to individually go into depth in the elective subject. Learning objectives, contents, methods and literature are listed for the above-mentioned sub-modules as follows.

Energy Data Management

Learning objectives
Overview of technologies and applications of data mining of energy data. Introduction with practical examples regarding persistence, analysis and visualisation

Contents
- Meaning of energy data management
- Concept of monitoring structured by systems
- Storing time series
- Filtering and compression
- Analysis
- Visualisation
- Web-based services

Special methodology
Practical exercises on selected procedures

Literature
Wes Mckinney: Python for Data Analysis

History of technology

Learning objectives
The history of building and energy technology will demonstrate to the students the concepts of sustainability and sustainable trade using historical examples. In addition, students will learn about the historical roots of the technological developments.

Contents
Milestones and developments in building technology, development trends in architecture, development trends in energy technology, history of the electric power, developments in house and building technology, introduction to the discourse "Technology and ethics", selected chapters of the history of technology (technical chemistry, aerospace, etc.)

Special methodology
Impulse lectures, seminar work, excursion

Literature
Propyläen Technik Geschichte, Propyläen Verlag

Basics of Geothermal Energy

Learning objectives
The students know the different types of near-surface, medium-depth and deep geothermal systems and their structure, essential components as well as basic geological, technical and energy properties. They can roughly dimension, with simple calculation methods, geothermal systems and apply plant engineering knowledge gained in the course so far, to geothermal energy plant technology.

Contents
Introduction: geothermics & heat pumps in the context of the energy revolution
Basic principles of geothermal energy use
Shallow geothermal source systems
Use of deep geothermal energy
Design and planning exercises
Visit to a geothermal plant

Special methodology
Lecture with lecture notes/presentations & use of the blackboard; exercises based on the lecture as well as exercises and planning tasks to be worked on alone; short excursions (site visit); laboratory experiment/measurement

Literature
VDI 4640, Blätter 1 - 5: Thermische Nutzung des Untergrunds

R. Koenigsdorff: Oberflächennahe Geothermie für Gebäude, Fraunhofer IRB Verlag, 2011
Federal states' guidelines for geothermal energy

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU): Tiefe Geothermie – Nutzungsmöglichkeiten in Deutschland, 3rd edition, 2011

Product documentation of various manufacturers

Industry Lecture 1 and 2

Learning objectives
In the interest of practical-oriented training, the university gives pro-active industrial companies and agencies the possibility to report on technical problems and their possible solutions the field of building technology / building climate. The objective of this event is to introduce students to problems and tasks from the wide field of building climate and energy systems. The students should learn to critically evaluate the problems and solutions presented.

Contents
- Façade technology
- Heating and Cooling Systems
- Hydraulic systems
- Ventilation and air conditioning systems
- Control and Automation Technology
- Facility Management
- Regenerative Energy Systems
- …

Special methodology
Lectures by external speakers

Literature

Pipeline construction and operation

Learning objectives
At the end of the course, the students will have basic knowledge on planning, construction and operation of pipelines and networks for the infrastructure provision at the various levels and size scales for liquid and gaseous media as well as electricity. In addition, they have learnt about current issues and problems in this area.

Contents
Introduction: grid-bound supply and networks
Pipelines and networks for liquids as well as heat and cold
Pipelines and networks for gases
Pipelines and networks for electricity
Design and planning exercises
Visit to a plant or a network operator

Special methodology
Exercises based on the lecture as well as exercises and tasks to be worked on alone; short excursion (site visit)

Literature
Federal Office for Building and Regional Planning: pipeline construction, well drilling, geothermal power. Scientific journal: Federal Department for wells, sewer and pipeline construction in the Federation of the German Construction Industry; Federal Expert Committee for wells, waterworks and pipeline construction in the Central Association of the German Construction Industry; Association of Companies in the Gas and Water Industries (FIGAWA); Pipeline Association (RBV); Association Gas & Water, ÖVGW

Standards, DVGW rules, VDI und VDE Guidelines regarding pipeline construction and management

Product documentation of various manufacturers

Seminar: Energy Systems 1 and 2

Learning objectives
Students gain a deeper understanding of comprehensive correlations in the conception, planning, execution and operation of energy-related components and systems and the interaction with the respective consumers.

Contents
Current or in-depth specific topics and examples in the field of energy systems will be treated by alternating internal and external teachers and lecturers.

Special methodology
Seminar Course

Literature

Special sections Energy: Sustainable Energy Systems

Learning objectives
Upon completion of the module the students know the essential aspects, influencing factors and (control) structures of energy production and energy consumption in the smart grid and how they are influenced (energy industry, law, funding, etc.). Also considered are aspects outside of energy production and application in buildings as well as industrial and production facilities. They know advanced concepts of the holistic approach and impact of energy production and consumption structures and can master the examples of analysis and implementation methods that were taught. They can apply knowledge compiled from examples in the course, and use it to analyse and transfer it to other areas as well as integrate it into energy and climate change concepts/strategies.

Contents
The learning objectives are developed by treatment and in-depth handling of individual specific topics such as: demand side management, Nega-Watt concepts / passive virtual power plants, smart grid / smart meter and balancing energy markets, energy consumption by private consumption and mobility, cumulative energy demand / grey energy / energy inventory, internalisation of external costs of energy (black, white, green certificates, fund models), advanced energy services, holistic, cross-sectoral energy analysis and mitigation concepts for energy consumption and emission of pollutants and CO2, intervention possibilities of policies (promotion, subsidies etc.)

Special methodology
Practical exercises / student research project on individual topics

Literature
Mostly provided via ILIAS as required; among else:

Energiekonzept und NEEAP (mit Anhang methodisches Begleitdokument) Deutschland, aktuelle Fassung, online

Lebensstile und globaler Energieverbrauch – Analyse und Strategieansätze zu einer nachhaltigen Energiestruktur, WBGU

GEMIS : http://www.iinas.org/gemis-de.html

Büchner, Buchholz, Probst , Neue DL und Geschäftsmodelle für Smart Distribution und Smart Market, VDE Kongress Smart Grid, Stuttgart 2012

http://www.e-energy.de/

http://www.lfu.bayern.de/umweltwissen/doc/uw_86_oekologischer_fussabdruck.pdf

Lebensstile und globaler Energieverbrauch – Analyse und Strategieansätze zu einer nachhaltigen Energiestruktur, WBGU 2003

Economic valuation of environmental damage. Methodenkonvention zur Schätzung externer Umweltkosten, UBA 2007

Öko-Institut, Fraunhofer ISI, Ecofys: Kosten-/Nutzen-Analyse der Einführung marktorientierter Instrumente zur Realisierung von Endenergieeinsparungen in Deutschland, Endbericht BMWi , 2012

Ökoinstitut, Prognos, WWF (AG): Endbericht Modell D, Klimaschutz bis 2050: Vom Ziel her denken. Anhang F, Basel-Berlin 2009

Climate protection in municipalities. Best practice guide. German Institute for Urban Studies (ed.) 2011

http://www.delta-q.de/cms/de/archiv_veroeffentlichungen/contracting.html

Special section Electrical Systems

Learning objectives
The objective is to describe the electrical systems in low- and high-voltage networks from the generator to the end consumer by means of equations. The network behaviour is modelled in both symmetrical and asymmetrical operating conditions and short-circuit currents are calculated, and the protection technology is considered. Because of their importance, the transformers and lines are briefly described here and the interaction of real and reactive power transportation is discussed. The focus is on the calculation and simulation of electrical systems.

Contents
Structure of energy supply, electrical networks, electrical equipment, symmetrical components, short circuit calculations, protection technology, simulation of networks

Special methodology
Exercises, software application

Literature
I. Kasikci: Projektierung von Niederspannungsanlagen, Hüthig&Pflaum Verlag, Heidelberg, 3rd edition, 2010

I. Kasikci: Kompendium Planung von Elektroanlagen, Theorie, Vorschriften, Praxis, 2nd edition, Springer, Heidelberg, 2015.

I. Kasikci: Projektierungshilfe elektrischer Anlagen in Gebäuden, 7th edition, Schriftenreihe 148, VDE-Verlag

I. Kasikci: Kurzschlussstromberechnung in elektrischen Anlagen, DIN VDE 0102, 4th edition 2013, Expert-Verlag

V. Crasten: Elektrische Energieversorgung 1 and 2, 2012, 2007, Springer

K. Heuck, K. Dettmann, D. Schulz: Elektrische Energieversorgung, Vieweg

Dietrich Oeding, Bernd R. Oswald: Elektrische Kraftwerke und Netze. Springer-Verlag, 2011

Special section Thermodynamics

Learning objectives
It is shown how real gases and vapours behave and how they can be used thermodynamically and for energy technology. Thereby, technically relevant applications such as steam power processes, cooling and heat pump processes are treated.
The objective of the course is that the thermodynamic cycles of steam power plants, cooling units and heat pumps can be calculated.

Contents
State variables of real gases and vapours
Equations of state of real gases
State changes in real gases
Steam power processes and their applications
Calculation of power cycle of thermal power plants
Basics of cold steam processes
Design and calculation of cooling processes and heat pump processes
Optimisation of heat pump processes

Special methodology
Lectures with integrated exercises.

Literature
Cerbe, G., Wilhelms, G.: Technische Thermodynamik, 17th edition, Hanser Verlag, 2013

Special section Renewable energy systems

Learning objectives
Better understanding of renewable energy systems in terms of technology and integration using examples of selected systems. Particular emphasis is placed on the system aspect

Contents
The sub-module serves as a platform for the treatment of renewable energy systems of various forms, such as hydropower, wind energy, tidal energy, deep geothermal energy, solar power, solar thermal and biomass. The systems expertise and knowledge of the technology is transferred to selected technologies.

Special methodology
Accompanying laboratory experiments, excursions, dealing with planning tools

Literature
V. Quaschning: Energiesysteme: Technologie - Berechnung – Simulation

V. Quaschning: Erneuerbare Energien und Klimaschutz: Hintergründe - Techniken und Planung - Ökonomie und Ökologie – Energiewende

M. Kaltschmitt: Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte

Th. Bührke, Robert Wengenmayr: Erneuerbare Energie: Konzepte für die Energiewende

Literature on specific topics as required

Storage Technology

Learning objectives
Acquaintance with technologies for storing energy in predominantly renewable energy supply systems. Basic knowledge of dimensioning, evaluation and management of energy storage systems.

Contents
Importance of energy storage in energy supply systems with a high proportion of renewable energy, operation and physical principles of existing storage technologies such as pumped storage, compressed air energy storage, secondary batteries and thermal energy storage, design and characterisation of energy storage

Special methodology
Application tools, planning exercises and planning systematics, handling a project / an issue regarding shallow geothermal energy

Literature
Sterner, Michael: Energiespeicher - Bedarf, Technologien, Integration, 2014, Springer-Verlag GmbH Berlin Heidelberg, 748 S. 513 Abb.

Subject from elective module BS-1 and BS-2

Learning objectives
On the basis of selected subjects from other courses, the understanding and knowledge of other subject areas, beyond their own specialist subjects, shall be expanded, in order to support inter and trans-disciplinary work.

Contents
Dependant on the respective course

Special methodology
Dependant on the respective course

Literature
Dependant on the respective course

Subject/module from course 1 and 2

Learning objectives
On the basis of selected subjects from other courses, the understanding and knowledge of other subject areas, beyond their own specialist subjects, shall be expanded, in order to support inter and trans-disciplinary work.

Contents
Dependant on the respective course

Special methodology
Dependant on the respective course

Literature
Dependant on the respective course

7-1 Laboratory practical training III

Section:	Advanced Course	**Credits:**	4
Offered:	every semester	**Semester:**	7
Prerequisites:	none	**Responsible for the module:**	Head of IGE

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Laboratory training 3.	4	2	L		Stu	30 h	90 h	various

Learning objectives

In the laboratory trainings provided, the practical application and the handling and evaluation of real working and measurement methods is learnt. The quantitative analyses are combined with previously acquired theoretical knowledge and enable students to transfer them to other applications or to develop optimisation and planning processes. Students are able to plan and carry out measurements and to document them in the form of (measurement) records and reports and to present and evaluate them.

Contents

The technical contents of the various laboratory offers are listed in the annex of the module "6-1 Laboratory training II".

Special methodology

Laboratory Practice

Literature

Subject-specific

7-2 In-depth module

Section:	Advanced Course	**Credits:**	5
Offered:	every semester	**Semester:**	7
Prerequisites:	none	**Responsible for the module:**	

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
In-depth hydraulics	3	2	L + E		mPb 15 min	30 h	60 h	Floß
Fire protection and Plant Safety	2	2	L + E			30 h	30 h	LA

Learning objectives
The student knows and understands the essential components of hydraulic systems and is able to dimension components.

Contents
Requirements of thermal energy systems on hydraulics, hydraulic circuits and application examples, distributor, hydraulic separator, pump design and optimised control strategies, valve design (K_{VS} value, valve authority, valve characteristic, heat exchanger characteristic, flow characteristic), faults and problems in hydraulics, creating simple hydraulic concepts.
The lecture gives an introduction into the field of fire protection. As part of the lectures, constructional and technical fire protection in particular, shall be dealt with. Here, the protection objectives of fire protection, the model building ordinance and the regional construction ordinance, the possibilities and limits of the defensive fire protection as well as the fire behaviour of building materials are dealt with. Moreover, the fire resistance of components is discussed. This is done once from the perspective of space sealing in case of fire (doors, flaps and bulkheads) and again with respect to existing electrical installations. In connection with plant-specific fire protection, fire alarm systems, fire extinguishing systems and fire-fighting equipment as well as smoke and heat extraction systems are also discussed.

Special methodology
Exercises and laboratory experiments

Literature
Roos, H.: Hydraulik der Warmwasserheizung, Oldenburg Verlag Munich Wien

Reinhold, C.: Mess-, Steuerungs- und Regelungstechnik, Vogel Buchverlag

7-3 2. Elective module (specialisation Building Systems)

Section:	Advanced Course	**Credits:**	9
Offered:	every semester	**Semester:**	7
Prerequisites:	Foundation course	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Responsible for the submodule
Acoustics / Noise protection	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Interpretation of TGA components	(3)	(2)	L + E		K 60 min	30 h	60 h	Brose
Building Biology I	(3)	(2)	V+Ü+ L		mPb 15 min	30 h	60 h	Haibel
Building Biology II	(3)	(2)	V+Ü+ L		mPb 15 min	30 h	60 h	Haibel
Energy Optimisation still to be finalised	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Structural Engineering theory	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Climate-friendly Construction	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Lighting Technology	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
Sanitary technology	(3)	(2)	L + E		K 60 min	30 h	60 h	Floss
Seminar: Building Systems-1	(3)	(2)	S		Stb	30 h	60 h	Entress
Seminar: Building Systems-2	(3)	(2)	S		Stb	30 h	60 h	Entress
Special section: Refrigeration technology	(3)	(2)	L + E		K 60 min	30 h	60 h	Siegismund
Special section Ventilation and Air-conditioning Systems	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Haibel
Thermo-active Component systems	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Koenigsdorff
Subject from Elective Module ES-1	(3)	(2)				30 h	60 h	
Subject from Elective Module ES-1	(3)	(2)				30 h	60 h	
Subject/module from course 1								
Subject/module from course 2								

Overarching learning objectives

The students should be given the opportunity to be able to individually go into depth in the elective subject. Learning objectives, contents, methods and literature are listed for the above-mentioned sub-modules in 6-4-1.

7-4 2. Elective module (specialisation energy systems)

Section:	Advanced Course	**Credits:**	9
Offered:	every semester	**Semester:**	7
Prerequisites:	Foundation course	**Responsible for the module:**	Entress

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Responsible for the submodule
Energy Data Management	(3)	(2)	L + E		Stb	30 h	60 h	Gerber
History of technology	(3)	(2)	L + E		Stb	30 h	60 h	Haibel
Principles of Geothermal power:	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Koenigsdorff
Industry Lecture-1	(3)	(2)	S		Stb	30 h	60 h	Floss
Industry Lecture-2	(3)	(2)	S		Stb	30 h	60 h	Floss
Pipeline construction and operation	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Koenigsdorff
Seminar: Energy Systems 1 and 2	(3)	(2)	S		Stb	30 h	60 h	Entress
Seminar: Energy Systems 1 and 2	(3)	(2)	S		Stb	30 h	60 h	Entress
Special section: Energy Industry	(3)	(2)	L + E		mPb 15 min	30 h	60 h	Bretzke
Special section: Electr. systems	(3)	(2)	L + E		K 60 min	30 h	60 h	Kasikci
Special section: Thermodynamics	(3)	(2)	L + E		K 60 min	30 h	60 h	Haibel
Special section: Controlled Energy Systems	(3)	(2)	L + E		K 60 min	30 h	60 h	Gerber
Storage Technology	(3)	(2)	L + E		K 60 min	30 h	60 h	Siegismund
Subject/module from course 1								Entress
Subject/module from course 2								Entress

Overarching learning objectives

The students should be given the opportunity to be able to individually go into depth in the elective subject. Learning objectives, contents, methods and literature are listed for the above-mentioned sub-modules in 6-6-1.

7-5 Bachelor thesis

Section:	Advanced Course	**Credits:**	12
Offered:	every semester	**Semester:**	7
Prerequisites:	subject-specific	**Responsible for the module:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Bachelor thesis (with colloquium)	12		S		Stb		360 h	Subject specific

Learning objectives

The students acquire the ability to work independently to formulate, solve, document and present a problem.

Contents

In the colloquium for the undergraduate thesis, students learn by a guided seminar on how they, in the course of their thesis, familiarise themselves with in a topic, create a schedule and project plan, conduct a literature review, propose solutions and evaluate as well as implement or realise solutions and submit and present a scientific paper.

Special methodology

Seminar

Int. Preparation for a stay abroad

Section:	Advanced Course	**Credits:**	6
Offered:	every semester	**Semester:**	3
Prerequisites:	none	**Responsible for the module:**	Floß/Siegismund

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Intercultural Training (General Studies)	2	2	S		Stu	30 h	30 h	Subject specific
Language course (General Studies)	2	2	L + E		Stu	30 h	30 h	Subject specific
English lecture	2	2	V		Stu	30 h	30 h	Subject specific

Learning objectives

- Preparing students interculturally and linguistically for study abroad
- Language repetition and consolidation of basic linguistic skills in an English-language lecture and exercise

Contents

Subject-specific

Special methodology

Seminar, lecture and exercise

Literature

Subject-specific

Int. Studying Abroad

Section:	Advanced Course	**Credits:**	20
Offered:	every semester	**Semester:**	5
Prerequisites:	none	**Responsible for the module:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Lecture by learning agreement	20	*	*	*	*	*	600 h	Subject specific

Learning objectives

- Evidence of ability to study abroad
- Expansion and deepening of subject-specific knowledge
- Acquisition of transversal skills

Contents

- Learning Agreement: Agreement regarding subjects or modules between the students, the Biberach University and the host university, which must be covered during the period of study abroad
- No restriction in the selection of modules or subjects offered by Biberach University
- The coursework required at the host university depends on what is offered

Special methodology

See courses offered by the university abroad

Literature

See courses offered by the university abroad

*according to the learning agreement and module handbook of the university abroad

Int. Follow-up to the stay abroad

Section:	Advanced Course	**Credits:**	4
Offered:	every semester	**Semester:**	7
Prerequisites:	none	**Responsible for the module:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	PVL	PL	KS	ES	Lecturer
Mentoring guest student	2	2	S		Stu	30 h	30 h	Subject specific
Workshop Internationalisation	2	2	L + E		Stu	30 h	30 h	Subject specific

Learning objectives

To summarise skills, competencies and experiences acquired abroad for self-reflection and communication to other students to develop the internationalisation

Contents

- Creating various documentation such as reports, presentations, lectures and information material
- Care of exchange students at the Biberach University
- Assisting in internationally oriented excursions and events

Special methodology

Seminar briefing

Literature