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UNIVERSITY
OF APPLIED SCIENCES

Module Handbook

Master of Energy and Building Systems

Version: 17.12.2014

Contents

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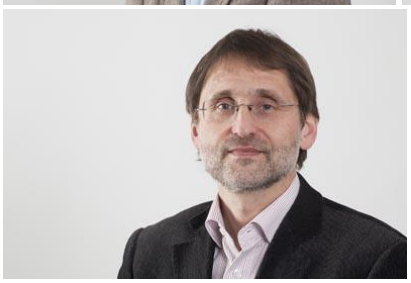

Prof. Dr.-Ing. Volker Siegismund

Prof. Dr.-Ing. Michael Haibel

Prof. Dr.-Ing. Ismail Kasikci

Overview of the modules (according to study and examination regulations) with module & subject responsible person and workload

Range of courses with study and examination requirements										
Masters degree										
Nc.	**Module**		Semester/SWS				Workload (hours)			
	Course	Type	1	2	3	Exam type	Course (hours)	Self-study (hours)	Credit points	Person repsonsibile for the module/subject
1.	**Compulsory modules**								**22**	Dean of the Faculty
1.	1. Basic module					K			7	Dean of the Faculty
	1. Seminar: Energy and Building Systems	S	2			Stb	30	90	4	Dean of the Faculty
	2. Engineering Mathematics	L + E	3				45	45	3	Prof. Dr.rer.nat.Stefan Hofmann
1.	2. Business management	L+S	(4)	(4)		M	60	90	5	Prof. Dr.-Ing. Helmut Ast
1.	3. Modelling and systems theory	L + E	4			K	60	90	5	Prof. Dr.-Ing. Martin Becker
1.	4. Module from other courses	L+S			4		60	90	5	Dean of the Faculty
2.	**Elective module**								**32**	Dean of the Faculty
2.	1. Management and Processes								8	Prof. Dr.-Ing. Helmut Ast
	1. Cost and process optimisation	L+S	(4)	(4)		M	60	60	4	Prof. Dr.-Ing. Helmut Ast
	2. Quality Management	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.-Ing. Helmut Ast
	3. Facility management	L+S	(4)	(4)		Stb	60	60	4	Prof. Dr.-Ing. Helmut Ast
	4. Teaching Assistant	S	1	1		Stu	15	105	4	Dean of the Faculty
2.	2. Energy and building technology								8	Dean of the Faculty
	1. Cooling technology	L+S	(4)	(4)		K	60	60	4	Prof. Dr.-Ing. Volker Siegismund
	2. Data and information technology	L+S	(3)	(3)		Stb	45	75	4	Prof. Dipl.-Phys. Ancreas Gerber
	3. Thermal energy simulation	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.-Ing. Roland Koenigsdorff
	4. Fluid dynamics	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.-Ing. Roland Koenigsdorff
	5. Automation technology	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.-Ing. Martin Becker
	6. Hydraulics	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.-Ing. Alexander Floß
	7. Special topics engineering mathematics	L+S	(3)	(3)		Stu	45	75	4	Prof. Dr.rer.nat.Stefan Hofmann
2.	3. Building Systems								8	Dean of the Faculty
	1. Integral planning and building operation	L+S	(3)	(3)		Stb	45	75	4	Prof. Dipl.-Ing. Gernot Brose
	2. Climate-friendly Construction & Building Physics	L+S	(3)	(3)		Stb	45	75	4	Prof. Dipl.-Phys. Ancreas Gerber
	3. Ventilation and air conditioning systems	L+S	(3)	(3)		M	45	75	4	Prof. Dr.-Ing. Michael Haibel
	4. Lighting design	L+S	(3)	(3)		Stb	45	75	4	Prof. Dipl.-Phys. Ancreas Gerber
	5. Electrical systems	L+S	(3)	(3)		K	45	75	4	Prof. Dr.-Ing. Ismail Kasikci
2.	4. Energy Systems								8	Dean of the Faculty
	1. Geothermal Systems	L+S	(3)	(3)		K	45	75	4	Prof. Dr.-Ing. Roland Koenigsdorff
	2. Renewable and decentralised energy systems	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.rer.nat. Jörg Entress
	3. Smart Grid and Smart Buildings	L+S	(3)	(3)		Stb	45	75	4	Prof. Dr.-Ing. Martin Becker
	4. Electrical/thermal energy systems	L+S	(3)	(3)		K	45	75	4	Prof. Dr.-Ing. Ismail Kasikci
	5. Thermodynamic systems	L+S	(3)	(3)		K	45	75	4	Prof. Dr.-Ing. Michael Haibel
3.	**Research project (FOPR0)**						15	315	**11**	Dean of the Faculty
	1. Individual topic with colloquium			1		Stb + M				
4.	**Master Thesis**						15	735	**25**	Dean of the Faculty
	1. Individual topic with colloquium				1	Stb + M				
	Total						90 x 30 = 2700		**90**	

Legend:

PL:	examination
LP:	credits
K:	written exam
M:	oral exam
Stu:	ungraded research project (homework, laboratory or practical training report, technical drawing, computer program, etc. etc., if necessary with an oral interview)
Stb:	graded research project (homework , laboratory or practical training report, technical drawing, computer program, etc. etc., if necessary with an oral interview)
SWS:	semester week hours
( )	may be taken depending on the offer in 1st, 2nd or 3rd semesters
V:	lecture
Ü:	exercise
S:	seminar

* Subject from other degree programs: max. 4 LP per block and a total of max. 12 LP possible - examination subject specific
Approval to study one subject from other degree programs must be submitted to the examination committee.

1 Compulsory modules

The compulsory modules of the Master's degree programme with their submodules serve to impart the basic skills that are essential for further studies and the acquisition of a Master's degree for all students.

1-1 Basic module

Brief description	P-BaMd	**Credits:**	7
Courses:	EGS	**Semester:**	1
Offered:	every semester	**Module examination:**	see submodules
Prerequisites:	none	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Seminar: Energy and Building Systems	4	2	S	St graded	30 h	90 h	Prof. Dr.-Ing. Alexander Floß and various professors alternating
Engineering Mathematics	3	3	L + E	K 90 Min	45 h	45 h	Prof. Dr.rer.nat. Stefan Hofmann

Overall learning objectives

- The provision, in the context of a seminar, of an independently-acquired, specialist-subject-content orientation, as a starting point and "guide" for an independent Master's degree programme
- To acquire basic knowledge and basic skills to perceive, classify, analyse and overcome problems and challenges that arise within the context of activities with respect to a leadership task.
- To acquire knowledge to independently and systematically investigate and to be able to handle a specialist topic scientifically and methodologically
- To acquire more in-depth knowledge of mathematical engineering for the areas covered in the course of technical and scientific subjects.

Seminar: Energy and Building Systems

Learning objectives

- In-depth knowledge in the field of information and media competence
- To compile and evaluate a sustainability assessment
- As part of the seminar paper, a research topic will be presented. Here, in addition to the economic importance, the state of the art, a specific assignment has to be presented in detail and a sustainability assessment performed.

Contents

Every Masters course starts with a seminar about energy and building systems, in which the students work on individual topics within the framework of a research project based on an overall theme. At the end of the semester they present it to the entire Masters course participants. In parallel, the seminar offers the possibility for the students to already concretise their individual project topics and possible subjects of the final Master's thesis, which are usually carried out within the context of a current research project. The objective of the seminar is therefore to identify the priorities and specific topics for subsequent parts of the course. At the same time, methodological and scientific work should be practiced in this seminar. At the end of the course, students should:

- provide each other with an overview of the presented, current project topics,
- know their own aptitudes and abilities for processing the project subjects,
- have mastered methodological and scientific standards necessary for the processing of master theses and projects and, in a separate investigation (pre-project) demonstrated existing knowledge gaps and filled them independently in the project work in the context of a exemplarily chosen theme, be familiar with and prepare the knowledge regarding the investigated subject so that the actual project work can be begun by the students themselves or another person.

Methodology

Seminar with various lectures by external speakers

Literature

[1] Franke, F.; Klein, A.; Schüller-Zwierlein, A.: Schlüsselkompetenzen –Literatur recherchieren in Bibliotheken und Internet
[2] Stoetzer, M.-W.: Erfolgreich recherchieren
[3] Esselborn-Krumbiegel, H.: Von der Idee zum Text –Eine Anleitung zum wissenschaftlichen Schreiben
[4] Esseborn-Krumbiegel, H.: Richtig wissenschaftlich schreiben
[5] Theisen, M. R.: Wissenschaftliches Arbeiten
[6] Preißner, A.: Wissenschaftliches Arbeiten – Internet nutzen, Text erstellen, Überblick behalten
[1] Thomas Joos: Planungsbuch für Microsoft-Netzwerke, Addison-Wesley (2006)
[2] Peter Georg Stützle: Von der Immobiliendatenbank zum intelligenten Immobiliennetzwerk, Grin Verlag (2013)
[3] Leibniz Universität Hannover/Wilhelm Noack: Word 2007 Wissenschaftliche Arbeiten , Herdt Verlag (2008)
[4] Leibniz Universität Hannover/Wilhelm Noack: Excel 2013 Fortgeschrittene Techniken , Herdt Verlag (2013)
[5] Detlef Ridder: Google SketchUp 8 Praxiseinstieg, mitp Verlag (2011)
[6] Ralf Damaschke: GIMP automatisieren, freies Magazin (2010)

Engineering Mathematics

Learning objectives
Students learn scientific and precise argumentation and reasoning, based on the basic theories of linear algebra and are able to recognise and apply the numerous applications of linear algebra.

Contents
The students know the most important concepts and elements of linear algebra: vector space, basis, scalar product, linear mappings, matrices determinants, eigenvalues and eigenvectors.

Methodology
Lecture, seminar

Literature
[1] Burg/Haf/Wille: Höhere Mathematik für Ingenieure Vol. 1-5, Springer (1993)
[2] Schwarz, Hans: Numerische Mathematik, Teubner (1993)
[3] Törnig, Willi: Numerische Mathematik für Ingenieure und Physiker, Springer (1990)
[4] Munz/Westermann: Numerische Behandlung gewöhnlicher und partieller Differentialgleichungen, Springer (2012)
[5] Lothar Papula: Mathematik für Ingenieure Vol. 1-3, Vieweg
[6] Lothar Papula: Mathematik für Ingenieure und Naturwissenschaftler: Übungen, Vieweg
[7] Fetzer/Fränkel: Mathematik Vol. 1-3, VDI

1-2 Business Management

Brief description	P-Unfg	**Credits:**	5
Courses:	EGS	**Semester:**	1/2
Offered:	every semester	**Module examination:**	orally 30 minutes
Prerequisites:	none	**Coordinator:**	Prof. Dr.-Ing. Helmut Ast

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Business management	5	4	L+S	M 30 Min	60 h	90 h	Prof. Dr.-Ing. Helmut Ast

Learning objectives

To get to know, understand and be able to judge the challenges of corporate management from the point of view of the employees on the one hand and the management on the other hand.
The students should be taught the key points and methods of corporate management for a managerial position (e.g. team leader, department head, manager) in a company. They also receive the tools for starting a business.
Through the insight into the work of personnel departments as well as personnel management by responsible managers, they are prepared for future leadership activities.

Contents

Lecture:
Experience reports from responsible people (management and project or team leader) from planning, construction and operation of buildings and facilities. Examples include:

- The establishment and management of an engineering company
- Leadership of a department of a exporting company
- Leadership of a department of an FM provider
- Management of a project team
- Management of a branch office

The following is included:

- The establishment and management of an engineering company
- Leadership of a department of a exporting company
- Leadership of a department of an FM provider
- Selected business aspects, such as costing of projects, forms of financing, controlling in the company, marketing and acquisition, etc.
- Selected legal aspects, such as labour law, tax law, legal forms of planning and construction and the FM provision.
- Selected organisational aspects, such as the supporting and challenging of staff, dealing with superiors and management,
- Corporate management in national and international environment

The lecturers are at your disposal for further, more in-depth questions.
Seminar part: (moderated by a personnel consultant)
Examples and role playing for typical issues and situations, such as:

- Conducting of a recruitment interview
- Conducting an employee appraisal
- Communicating a promotion or also a warning

- Presenting a restructuring measure, etc.

In the process, both the employee and the supervisor role will be taken on by the students. In groups, selected topics will be worked on: e.g. leading with target agreement, problem-solving approach according to PULS, etc.

Methodology

Lecture and Seminar

Literature

[1] Bullinger, Hans-Jörg / Spath, Dieter / Warnecke, Hans-Jürgen / Westkämper, Engelbert (ed.): Handbuch der Unternehmensorganisation, 3rd edition, Berlin Heidelberg: Springer-Verlag, 2009

[2] DIV Deutscher Ingenieur Verlag: Das Deutsche Ingenieur-Handbuch, Bonn: Verlag für die Deutsche Wirtschaft AG, 2004

[3] Haberkorn, Kurt: Praxis der Mitarbeiterführung, 6th edition, Renningen: expert verlag, 1988

[4] Juca, Rocco: Der GmbH-Geschäftsführer, Berlin Heidelberg: Springer-Verlag, 2006

[5] Kotter, John / Rathgeber, Holger: Das Pinguin-Prinzip, Special edition, Munich: Droemer Verlag, 2009

[6] Rödel, Stefan / Wittemer, Bernhard / Gesmann, Klaus: Existenzgründung, 2nd edition, Landsberg a. L.: mvg-verlag, 1998

[7] Ryborz, Heinz: Mitarbeiter motivieren – aber richtig, Zürich: Oesch Verlag AG, 1992

[8] Stein, Anette / Nanska, Miriam: Ich mache mich selbstständig!, Munich: Markt+Technik Verlag, 2001

[9] Steinmann, Horst / Schreyögg, Georg: Management, 6th edition, Wiesbaden: Betriebswirtschaftlicher Verlag Dr. TH. Gabler/GWV Fachverlage GmbH, 2005

[10] Warnecke, Hans-Jürgen: Die Fraktale Fabrik, 2nd edition, Hamburg: Rowohlt Taschenbuch Verlag GmbH, 1996

[11] Wöhe, Günter: Einführung in die Allgemeine Betriebswirtschaftslehre, 23rd edition, Munich: Verlag Franz Vahlen GmbH, 2008

1-3 Modelling and System Theory

Brief description	P-MbSt	**Credits:**	5
Courses:	EGS	**Semester:**	1
Offered:	every semester	**Module examination:**	Exam, 120 minutes
Prerequisites:	None	**Coordinator:**	Prof. Dr.-Ing. Martin Becker

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Modelling and systems theory	5	4	L + E	K 120 Min	60 h	90 h	Prof. Dr.-Ing. Martin Becker, Prof. Dr.-Ing. Roland Koenigsdorff (alternating)

Learning objectives
In the lecture modelling and systems theory, students should know, understand and learn to apply the methods of modelling (theoretical, experimental) and system theory. For this purpose, the module consists of lectures and practical training.

Contents
The lecture part comprises:

- Introduction to Systems Theory
- Examples of systemic approach in economy, society, science and technology
- Qualitative description of cause-effect-correlations
- System properties (linear, nonlinear, stability, causality, static, dynamic view)
- Systems with/without feedback, with/without storage
- System theory and automatic control
- Fundamentals and applications of modelling
- Terms for system, process, model, balance limit
- Purpose and scope of modelling
- Ways of modelling (theoretical, experimental, black/white-box models)
- Methods of modelling: inductive, deductive, similarity theory, balance and transport equations, development steps from the process via replacement models and phenomenological physical considerations to the model
- Creating mathematical models, structures and consistency of models, linearisation, model reduction, modelling depth
- Analysis and creating experimental models, identification method
- Analytical and numerical solution methods

In the practical training part, the following topics are covered:

- Creation of simulation models with software tools (e.g. B. Matlab/Simulink, ...) or their own programming
- Editing of exercises and application examples (Focus: space/building, facility and controller models) with the help of software tools (e.g. Matlab/Simulink, ...) or their own programming

Methodology
Lecture and practical training

Literature

[1] Dörner, D.: Die Logik des Misslingens, Strategisches Denken in komplexen Situationen,, rororo science, 8.A, 2009
[2] Ossimitz, G; Lapp, C.: Das Metanoia Prinzip- Eine Einführung in systemgerechtes Denken und Handeln, Franzbecker, 2006
[3] Kahlert, J.: Simulation technischer Systeme, Vieweg Verlag, June 2004
[4] Scherf, H.. Modellbildung und Simulation dynamischer Systeme, Oldenbourg Verlag, 2010

1-4 Module from other courses

Brief description	P-MdStg	**Credits:**	5
Courses:	EGS	**Semester:**	3
Offered:	every semester	**Module examination:**	Exam, 120 minutes
Prerequisites:	None	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Module from other courses	5	4	L + E	subject specific	60 h	90 h	Dean of the Faculty

Objective

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

2 Elective module

The elective modules of the master's degree programme with their submodules serve to impart individual specialist topics that are essential in further studies for a sound handling of the research project and the master thesis and the acquisition of a Master's degree

2-1 Management and Processes

Brief description	W-MaPo	**Credits:**	8
Courses:	EGS	**Semester:**	1/2
Offered:	every semester	**Module examination:**	see submodule
Prerequisites:	none	**Coordinator:**	Prof. Dr.-Ing. Helmut Ast

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Cost and process optimisation	4	4	L+S	M 30 Min	60 h	60 h	Prof. Dr.-Ing. Helmut Ast + Lecturers
Quality Management	4	3	L+S	St graded	45 h	75 h	Prof. Dr.-Ing. Helmut Ast
Facility management	4	4	L+S	St graded	60 h	60 h	Prof. Dr.-Ing. Helmut Ast
Teaching Assistant	2	1	S	St un-graded	15 h	105 h	Dean of the Faculty

Overall learning objectives

- To facilitate individual specialisation of subject content in the fields of management and processes
- To acquire the ability to study in-depth and apply selected subject areas in the field of management and processes
- Furthermore, the students should, as part of the elective subject teaching assistant, be given the opportunity to gain experience and knowledge in the field of knowledge processing and knowledge transfer.

Cost and process optimisation

Learning objectives

- Knowledge and understanding of the tasks and requirements of cost and process optimisation (lecture)
- Ability to develop selected aspects of cost and process optimisation and give examples of their use (seminar and research project)

Contents

The students should know and understand the tasks and requirements of cost and process optimisation. In addition, the capability to develop and give examples of selected aspects of cost and process optimisation, shall be expanded, in the form of a seminar and a research project. The course content includes:

Lecture part:

- Basic concepts of management (organisational forms, organisational and operational structure, operations, change management)
- Introduction to organisational structures in the project business with typical process cycles
- Work out the differences in the structures and processes in object-oriented and process-oriented forms of organisation based on the example of an engineering company
- Basic concepts of accounting (bookkeeping, cost accounting, statistics, budgeting)
- Cost centre accounting (cost centre list, cost centre types, calculations)
- Representation of the distribution of costs over the life cycle of buildings
- Presentation of optimisation methods (value analysis, Kaizen, Kanban) and application examples

Seminar part:

- Here, optimisation examples (suggestions from the students are welcome) are worked out concretely. Projects concerning process and cost management of buildings, from planning to disposal with the development of process structures and the related cost centres as well as the recognition and realisation of optimisation potentials, are used as templates.

Methodology

Lecture, seminar

Literature

[1] Becker, Jörg / Kugeler, Martin / Rosemann, Michael (ed.): Prozessmanagement, 2nd edition, Berlin Heidelberg: Springer-Verlag, 2000

[2] Hirzel, Matthias / Kühn, Frank / Gaida, Ingo (ed.): Prozessmanagement in der Praxis, 2nd edition, Wiesbaden: Betriebswirtschaftlicher Verlag Dr. Th. Gabler | GWV Fachverlage GmbH, 2008

[3] HOAI: Honorartabellenbuch mit RifT-Werten, Cologne, Werner Verlag, 2013

[4] Metzner, Steffen / Erndt, Antje: Moderne Instrumente des Immobiliencontrollings, 2nd edition, Sternenfels: Verlag Wissenschaft & Praxis, 2006

[5] Nida-Rümelin, Julian: Die Optimierungsfalle, Munich: Irisiana Verlag, 2011

[6] Pfnür, Andreas: Betriebliche Immobilienökonomie, Heidelberg: Physica-Verlag, 2002

[7] Tissberger, Tobias: Von der Prozeßkostenrechnung zum Prozeßmanagement, Saarbrücken: VDM Verlag Dr. Müller e.K. und Lizenzgeber, 2007

[8] Wagner, Karl W. / Patzak, Gerold: Performance Excellence, Munich: Carl Hanser Verlag, 2007

[9] Willann, Thorben: Konzeptionelle Weiterentwicklung eines Prozessmanagementsystems, Bremen/Hamburg: CT Salzwasser-Verlag GmbH & Ko. KG, 2007

[10] Winkler, Walter / Fröhlich, Peter J.: Hochbaukosten – Flächen – Rauminhalte, 10th edition, Braunschweig/Wiesbaden: Friedr. Vieweg & Sohn Verlagsgesellschaft mbH, 1998

Quality Management

Learning objectives

- Knowledge and understanding of the tasks and requirements of quality management from different perspectives (lecture)
- Ability to methodologically develop and exemplarily apply selected aspects of QM

Contents

The students should learn the tasks and requirements of quality management from different perspectives. In addition, in the form of a seminar and a research project, the ability to methodologically develop and exemplarily apply selected aspects of quality management, will be expanded. The course content includes:

Lecture part:

- Basic concepts of quality management
- DIN EN ISO 9000 ff
- Basic applications for the design, construction and operation of buildings and properties. Examples are:
- Planning phase: on the basis of a specific quality manual of a full service design company, the measures for architects, structural engineers and TGA engineers which are necessary and sensible in order to maintain and increase the quality of planning, are demonstrated. The interactions between the parties are increased.
- Execution phase: using examples it will be shown what measures (interface minimisation, plan testing, quality assurance on site, documentation, acceptance, commissioning) facilitate construction and increase its quality.
- Operating phase: using examples to show what measures are taken regarding quality assurance and enhancing the operation of buildings. These range from training staff to controlling locally.

In addition, external lecturers report on the implementation of the above topics in companies such as:

- Planning office
- Project managers
- Plant engineers
- Component manufacturer
- Facility management provider
- General contractor
- External certification company

Seminar part:

- Current examples (suggestions of students are also welcome) are worked out concretely.

Methodology

Lecture, seminar

Literature:

[1] Ebert, Thilo / Eßig, Natalie / Hausser, Gerd: Zertifizierungssysteme für Gebäude, Munich, Institut für internationale Architektur-Dokumentation GmbH & Co. KG, 2010

[2] Elsner, Willi: Qualitätsmanagement für Baubetriebe, Wiesbaden: Springer Fachmedien Wiesbaden GmbH, 1997

[3] Evangelischer Bundesverband für Immobilienwesen in Wissenschaft und Praxis: Qualitätssicherung am Bau, Munich: Verlag C.H. Beck oHG, 2012

[4] Göbel, Günter / Marhold, Knut / Wenig, E. Rüdiger: QM Fibel, Würzburg: IWW-Institut für Wirtschaftspublizistik GmbH & Co. KG, 2012

[5] Heinrich, Sven: Qualitätsmanagement bei Facility Management Komplettanbietern, Saarbrücken: VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG, 2009

[6] Schmitt, Robert / Pfeifer, Thilo: Qualitätsmanagement, 4th edition, Munich Wien: Carl Hanser Verlag, 2010

[7] Warmuth, Lukas: Qualitätssicherung von ÖBA-Leistungen gemäß ISO 9001, Saarbrücken: AV Akademiker Verlag GmbH & Co. KG, 2012

Facility management

Learning objectives

- Knowledge and understanding of the tasks and requirements of facility management of properties using the example of an industrial site (lecture and field trip)
- The ability to methodically develop and exemplarily apply selected aspects of FM (seminar and research project)

Contents

The students should know and understand the tasks and requirements of the facility management of real estate. This is done using the example of an industrial site to which there is also an excursion. In addition, in the form of a seminar and a research project, the ability to methodically develop and exemplarily apply selected aspects of facility management, will be expanded. The course content includes:

- Organisation of the ownership functions (Industrial Portfolio)
- Area planning of a property
- Cost planning (economic planning, budgeting and project planning, controlling)
- IT systems (SAP, CAD, CAFM, GA)
- Interaction between production and building technology and maintenance planning
- Excursion to semiconductor location in Reutlingen
- Legal aspects of FM (selected laws, standards and guidelines such as operational responsibility)
- Insourcing and outsourcing of FM services
- Tendering and allocation of FM services
- Cost of FM services

Methodology

Lecture, seminar, field trip

Literature

[1] Arbeitsgemeinschaft Industriebau e.V. (ed.): Grundlagen der Standortentwicklung im Industriebau, Munich: Verlag Georg D.W. Callwey GmbH & Co. KG, 2004
[2] Barrett, Peter / Baldry, David: Facilities Management, 2nd edition, Oxford: Science Ltd, 2006
[3] Braun, Hans-Peter / Oesterle, Eberhard / Haller, Peter: Facility Management, 4th edition, Berlin-Heidelberg-New York: Springer-Verlag, 2004
[4] Chanter, Barrie / Swallow, Peter: Building Maintenance Management, Oxford: Blackwell Publishing Ltd, 2005
[5] Gintschel, Manuela: Implementierung eines Facility-Management-Systems, Saarbrücken: VDM Verlag Dr. Müller e.K., 2008
[6] Gondring, Hanspeter / Wagner, Thomas: Facility Management, 2nd edition, Munich; Verlag Franz Vahlen GmbH, 2012
[7] Heinz, John A. / Casault, Richard B.: The Building Comissioning Handbook, 2nd edition, Virgina and Washington: Appa: The Association of Higher Education Facilities Officers and Building Comissioning Association, 2004
[8] Kogler, Josef: Facility Management in einem Industrieunternehmen, Saarbrücken: VDM Verlag Dr. Müller, 2008
[9] Krämer, Stefanie: Total Cost of Ownership, Saarbrücken: VDM Verlag Dr. Müller e.K., 2007
[10] Lutz, Ulrich / Galenza, Kerstin (ed.): Industrielles Facility Management, Berlin-Heidelberg-New York: Springer-Verlag, 2004
[11] May, Michael: IT im Facility Management erfolgreich einsetzen, Berlin-Heidelberg-New York: Springer-Verlag, 2004
[12] Nävy, Jens: Facility Management, 4th edition, Berlin-Heidelberg-New York: Springer-Verlag, 2006

Teaching Assistant

Through their involvement in teaching, such as by the taking on of supervision, support and assistance tasks, the students will be introduced to management and leadership tasks. In addition to team expertise, also communication and presentation techniques are practiced. Through intensive study of specialist topics, these will be further developed.

2-2 Energy and building technology

Brief description	W-EgGt	**Credits:**	8
Courses:	EGS	**Semester:**	1/2
Offered:	every semester	**Module examination:**	see submodule
Prerequisites:	none	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Cooling technology	4	4	L+S	K 90 Min	60 h	60 h	Prof. Dr.-Ing. Volker Siegismund Prof. Dr.-Ing. Alexander Floß
Data and information technology	4	3	L+S	St graded	45 h	75 h	Prof. Dipl.-Phys. Andreas Gerber
Thermal energy simulation	4	3	L+S	St graded	45 h	75 h	Prof. Dr.-Ing. Roland Koenigsdorff
Fluid dynamics	4	3	L+S	St graded	45 h	75 h	Prof. Dr.-Ing. Roland Koenigsdorff
Automation technology	4	3	L+S	St graded	45 h	75 h	Prof. Dr.-Ing. Martin Becker
Hydraulics	4	3	L+S	St graded	45 h	75 h	Prof. Dr.-Ing. Alexander Floß
Special topics engineering mathematics	2	2	L+S	St un-graded	45 h	75 h	Prof. Dr.rer.nat. Stefan Hofmann

Overall learning objectives

- To enable individual in-depth study of specialist content from the wide range of energy and building technology, based on selected specialised topics
- To extend the ability to study and apply selected specialist topics of building and energy technologies and to assess them within the overall context of the fields of energy and building.

Cooling technology

Learning objectives

- Students know different methods of cooling and apply them application-oriented and on the basis of project-based boundary conditions. Students plan and calculate these cooling system concepts with the help of interpretation programs, and evaluate the results, among other things, in terms of economy and energy efficiency.
- Students choose appropriate control strategies for cooling systems. For this they also select suitable storage methods.
- Students gain insight into the current state of research in selected areas, such as cooling methods and control of cooling units and cooling systems

Contents

- A study of various methods of cold generation.
- A study of the theory of mechanically and thermally driven cooling units.
- Refrigeration system concepts
- Selection of cooling units for systems with different boundary conditions.

Methodology

Seminar, exercises

Literature

[1] Pohlmann, W.: Taschenbuch der Kältetechnik: Grundlagen, Anwendungen, Arbeitstabellen und Vorschriften,Berlin, 2013, VDE-Verlag, 21., revised and expanded edition.,ISBN 978-3-8007-3393-4
[2] Cube, H.L.: Lehrbuch der Kältetechnik. Vol. 1., Karlsruhe, 1997, C. F. Mueller-Verlag, 4., fully revised edition, ISBN 978-3-7880-7509-5
[3] Breidenbach, K.: Der Kälteanklagenbauer, Vol. 1: Grundkenntnisse, Berlin, 2012, VDE-Verl.,6 th, revised and expanded edition, ISBN 978-3-8007-3394-1
[4] Breidenbach, K.: Der Kälteanlagenbauer, Vol. 2 :Grundlagen der Kälteanwendung, Berlin, 2010, VDE-Verl., 5th, new and expanded edition, ISBN 978-3-8007-3243-2

Data and information technology

Learning objectives
For the optimisation of systems and the increase in energy efficiency, continuous monitoring has become increasingly important. This places high demands on data management and analysis. This elective provides an overview and theoretical foundations and practical examples.

Contents
- Data acquisition and data management
- Methods for time series analysis
- Statistical and model-based analysis
- Methods of compression and visualisation

Methodology
Lecture, seminar

Literature
[1] H.P. Langtangen, A Primer on Scientific Programming with Python, Springer 2011

Thermal energy simulation

Learning objectives
In this seminar the participant learns the most important physical phenomena of (hot water) storage. Furthermore, he can model the phenomena and knows its specific characteristics. He is able to create simple models on a computer or to use professional software. He can classify, interpret and evaluate simulation results.
For systemic consideration of storage he gets an initial insight into the latest research results.

Contents
- Introduction and overview into thermal energy simulation based on the example of thermal energy building simulation and thermal energy plant simulation
- Activation of the mathematical and physical foundations of thermal energy simulation
- In-depth consideration of the modelling and system equations of thermal energy simulation based on a selected task or a special theme to be examined in-depth
- Presentation of simulation methods and simulation environments /simulation programs for the selected task
- Simulation examples and exercises incl. testing and evaluation of simulation models and simulation results
- Processing of a project / an issue of thermal energy simulation

Methodology
Seminar

Literature
[1] Khartchenko, N.V.: Thermische Solaranlagen, Springer (1995)
[2] Duffie / Beckman: Solar engineering for thermal processes, Wiley (2006)
[3] Urbaneck, Thorsten: Kältespeicher, Oldenbourg (2012)
[4] Klein/Hughes/Kuhn: Mathematical Reference (TRNSYS 17, Vol 4), Solar Energy Laboratory, Wisc. USA

Fluid Dynamics (CFD)

Learning objectives

- Learning the mathematical-physical, IT and application-related basics of fluid dynamics (CFD) in the energy and building technology as well as climate building technology
- Based on the examples taught in the course and practiced on the computer, the practical application goal is the independent, successful handling of their first own CFD project.

Contents

- Introduction to the methods and tools of Computational Fluid Dynamics (CFD) and their areas of application in science and technology
- Activation of mathematical and fluid mechanical basics
- Balance equations of CFD: Navier-Stokes equations and conservation equations for mass and energy in multi-dimensional, transient form
- Additional models & system equations: turbulence models, heat and radiation exchange, natural convection, boundary conditions, etc.
- Solution of system equations in CFD: finite element and finite volume method, numerical solution (iteration, relaxation, convergence, stability)
- Basic simulation examples: Explanation and demonstration of a program system, introductory exercises, tests, evaluation and control, and comparison with known solutions and experiments
- Application: handling a CFD project

Methodology

Lecture, exercise, seminar

Literature

[1] Suhas V. Patankar: Numerical Heat Transfer and Fluid Flow. Hemisphere Publishing Corporation, 1980 (& 1991).
[2] H. Schlichting, K. Gersten: Grenzschicht-Theorie. 9th edition; Springer-Verlag, Berlin, Heidelberg, 1997.
[3] H. K. Versteeg, W. Malalasekera: An introduction to computational fluid dynamics : the finite volume method.
[4] Pearson Education Limited / Longman Group Ltd, 2002.
[5] Herbert Oertel jr., Martin Böhle, Thomas Reviol: Strömungsmechanik. 6th edition; Vieweg+Teubner / Springer Fachmedien, Wiesbaden, 2011.
[6] Eckart Laurien, Herbert Oertel jr: Numerische Strömungsmechanik. 4th edition; Vieweg+Teubner / Springer Fachmedien, Wiesbaden, 2011.
[7] Herbert Oertel jr., Martin Böhle, Thomas Reviol: Übungsbuch Strömungsmechanik. 8th edition; Vieweg+Teubner / Springer Fachmedien, Wiesbaden, 2012.
[8] Stefan Lecheler: Numerische Strömungsberechnung. 2nd edition; Vieweg+Teubner / Springer Fachmedien, Wiesbaden, 2011.

Automation technology

Learning objectives

- To know and understand the importance of building automation for reliable and efficient building operation.
- To further understand conventional regulatory procedure (two-point, PID controller).
- To learn and be able to apply modern methods of control engineering (computational intelligence, advanced process control).
- To learn and understand hardware-in-the-loop method for testing automation devices.
- To learn and understand the possibilities of automation of conventional and renewable energy systems.

Contents

The students should, building on the foundations of measurement, control and regulation technology, know, understand and partially be able to apply higher quality methods of control technology. Furthermore, students should learn and understand the systematic procedure in controller design and controller testing using system engineering methods, rapid prototyping and the hardware-in-the loop (HIL) method.

To be able to better understand and apply the lectures, the module has, in addition to the lecture part, a practical training part in which the students work on given tasks individually in the context of a student research project.

The lecture part covers the following contents:

- Conventional and modern methods of control engineering in the building climate
- Overview of soft computing (knowledge and learning based control strategies, fuzzy control, neural networks, evolutionary strategies, model predictive control (MPC), ...)
- Exemplary in-depth study of selected methods (e.g. fuzzy control, MPC, ...)
- Fundamentals of systems engineering
- Introduction to methods of rapid prototyping and hardware in the loop methodology
- More current subjects concerning control and automation technology (e.g. room automation, façade automation, energy efficiency through building automation ...)

Practical training part:

- Practical training in the laboratory for building automation on selected higher quality control engineering methods (e.g. adaptive control, fuzzy control, MPC, ...)
- Practical training in the laboratory for building automation on hardware in the loop procedure

Methodology

Lecture, practical training

Literature

[1] Nise, N.: Control System Engineering, John Wiley & Sons, 6. Ed. 2010

[2] Kramer, O.: Computational Intelligence: Eine Einführung, 2009

[3] Burns, R: Advanced Control Engineering, Butterworth-Heinemann, 2001

[4] Dittmar, R; Pfeiffer M.B.: Modellprädiktive Regelung, Oldenbourg Verlag, 2004

Hydraulics

Learning objectives

The objective of the course is the expanding and consolidation of the basic knowledge of hydraulics by repeating numerous examples.
In addition, the Master students should be able to develop hydraulic concepts for the various applications in the field of heating and cooling distribution independently and to evaluate them in terms of hydraulic and thermal efficiency.

Contents

- Repetition:
    - Requirement of various components of hydraulics
    - Basic hydraulic circuits
- Energy-saving operation of hydraulic systems
- Extension:
    - Application of hydraulic circuits
    - Integration thermal storage
    - Optimizing the thermal storage capacity
    - Valve authority, depending on the pump control
    - Choke authority

Methodology

Lecture, seminar

Literature

[1] VDI report 1549: „Hydraulik in der Heiz- und Raumlufttechnik“, VDI Verlag Düsseldorf, 2000

Special topics engineering mathematics

Learning objectives
The mathematical principles for the basis of the lecture "Fluid Dynamics" will be conveyed. How numerical approximation methods can be developed based on the underlying physical model equations will be worked out. Problems and hazards of numerical simulations are presented.

Contents
Special topics of engineering mathematics are offered in turn, such as:

- Numerics of partial differential equations (FV method)
- Inferential statistics (estimation theory, hypothesis theory)
- Analytical solution method of the heat transfer equation
- Linear control theory
- Graph theory

Methodology
Tuition in seminars

Literature
[1] Patankar, Suhas V.: Numerical Heat Transfer and Fluid Flow, Routledge (1980)
[2] Ferziger, Joel H.: Computational methods for fluid dynamics, Springer (2002)
[3] Versteeg, H.K.: An introduction to computational fluid dynamics: the finite volume method, Longman (2002)

2-3 Building Systems

Brief description	W-GeSt	**Credits:**	8
Courses:	EGS	**Semester:**	1/2
Offered:	every semester	**Module examination:**	see submodule
Prerequisites:	none	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Integral planning and building operation	4	3	L+S	St graded	45 h	75 h	Prof. Dipl.-Ing. Gernot Brose
Climate-friendly Construction & Building Physics	4	3	L+S	St graded	45 h	75 h	Prof. Dipl.-Phys. Andreas Gerber
Ventilation and air conditioning systems	4	3	L+S	M 30 Min	45 h	75 h	Prof. Dr.-Ing. Michael Haibel
Lighting design	4	3	L+S	St graded	45 h	75 h	Prof. Dipl.-Phys. Andreas Gerber
Electrical systems	4	3	L+S	K 90 Min	45 h	75 h	Prof. Dr.-Ing. Ismail Kasikci

Overall learning objectives

- To allow individual in-depth study of technical content relating to building technology to be selected based on specialised topics
- To extend the ability to study and apply selected specialist topics of building technologies and to assess them within the overall context of the evaluation of a building system

Integral planning and building operation

Learning objectives

- In-depth knowledge of important planning contents and planning processes of technical building services /energy design / building operation, and understanding of the mutual relationships of the various aspects
- Ability to define essential objectives and implement them in concrete planning steps
- Knowledge of and practice in essential planning tools of building services/ energy design/building operation, in particular with a view to minimizing energy consumption
- Team and goal-oriented work in the sense of integral planning

Contents

Based on a model building, the integrated planning ability shall be extended and the methodology practised. The lecture part contains an introduction to the topic of integral planning and building as well as the presentation of the model object. In the seminar part the practical implementation is done in group work. Each team works on its own tasks and, in cooperation with other teams, combines them to form a complete solution. Interim results are regularly presented and discussed in plenary. An optional excursion allows the comparison of one's own approaches to the model building with a functional solution.

Important content and learning objectives are:

- Development and coordination of the mandatory "contractual project specifications" within the meaning of integral planning with regard to building physics / technical, social, ecological and economic aspects
- Ability to define essential objectives and implement them in concrete planning steps
- In-depth knowledge of important planning contents and planning processes of technical building services /energy design / building operation, and understanding of the mutual relationships of the various aspects
- Knowledge of and training in essential planning tools of building services / energy design / building operation, in particular with a view to minimizing energy consumption
- Team and goal-oriented work in the sense of integral planning
- Organisation and scheduling, logging
- Knowledge and evaluation of essential audit documents of the technical building equipment as a basis for trouble-free operation of the building
- Identifying essential operational data to assess the operation of technical building equipment

Methodology

Lecture, project work

Literature

[1] Ackerschott H., Fröhlich U., Mühlenkamp C., Techn. Gebäudeausrüstung, Kommentar zur VOB Teil C ATV DIN 18379, 18380, 18381, Beuth Verlag, Berlin, 2008
[2] Architektenkammer Baden-Württemberg, Nachhaltiges Bauen, was steckt dahinter, Stuttgart, 2013
[3] Bauch U., Helbig W., Baustellenorganisation Vol. 3, R. Müller Verlag, Cologne 2004
[4] DGNB System, Kriterien, DGNB, Stuttgart, 2014
[5] Langen W., Schiffers K.-H., Bauplanung und Bauausführung, Werner Verlag, Munich, 2005
[6] Locher U und H., Koeble W., Frick W., Kommentar zur HOAI, Werner Verlag, Munich 20010
[7] SIA Schweiz, Ingenieur- und Architektenverein Zürich, Teamorientiertes Planen, EDMZ, Bern, 1996
[8] VOB, HOAI, Beck-Texte im dtv, Munich, 2013
[9] Ebert, Thilo et.al., Zertifizierungssysteme für Gebäude, Institut für internationale Architektur-Dokumentation, Munich, 2011

Climate-friendly Construction & Building Physics

Learning objectives

- To learn and understand the relationships between the building envelope and building technology under different climatic conditions.
- To gain a better understanding of the components of the building envelope, such as windows and solar protection
- To create and apply steady-state and transient energy balance of buildings
- Thermally-dynamic properties of components and buildings
- Introduction to the simulation of the thermal behaviour of buildings

Contents

Methodically oriented in-depth scientific study of building physics and climate-friendly construction. The learning objective is an in-depth understanding of building physics relationships based on analytical calculation procedures and simulation models.
Selection of key topics:

- Modelling of transient heat transfer through opaque components
- Requirements and optimisation of buildings in different climatic regions
- Dynamic building and room models
- Coupled heat and moisture transport
- Modelling of glazing and solar protection systems

Methodology

Lecture, seminar

Literature

[1] P. Troege, Climate:Design: Design and Planning for the Age of Climate Change, 2010
[2] P. Häupl, Bauphysik, Ernst und Sohn 2008
[3] Ch. Zürcher, Th. Frank, Bauphysik, Bau und Energie, vdf Hochschulvlg, 2010
[4] S.M. Winchip, Fundamentals of Lighting, 2010
[5] R.H. Simons, A. R. Bean, Lighting Engeneering, Architectual Press, 2001

Ventilation and air conditioning systems

Learning objectives
Several issues of ventilation and air-technical systems are highlighted. In doing so, among other things, the new cooling load calculation according to VDI 2078 is closely considered and its depiction in a small program tool is attempted. In addition, in some applications, an attempt is made to experimentally detect the formation of air currents.

Contents
- Holistic representation of the thermodynamic and fluid dynamic relationships in ventilation and air-conditioning systems
- modelling and validation of the time-discrete states in an air-handling unit (basics, examples, comparison with laboratory experiments)
- Modelling and validation of the steady-state and transient room flow conditions (basics, examples, comparison with laboratory experiments)
- modelling and validation of building aerodynamic conditions in the vicinity of façade openings (basics, examples)

Methodology
Lecture, exercises

Literature
[1] Kober, Müller (Hsg); Luft- und Raumklimatechnik ganzheitlich geplant , CCI-promotor-Verlag, 2013
[2] Recknagel et.al.; Taschenbuch für Heizung + Klimatechnik, Oldenbourg Industrie Verlag, 2013
[3] Reinmuth; Raumlufttechnik, Vogel Verlag, 1996

Lighting design

Learning objectives
On the basis of a project explicitly selected for each group the following tools will be taught:
- Basic handling of Relux and Radiance
- Insight into DIN V 18599-4 - "Useful and final energy demand for lighting"
- The different perspectives of clients, planners and architects
- Design and technical expertise in the field of façade and artificial lighting design

Contents
Advanced topics in lighting design with the aspects:
- Light generation, light output,
- Daylight, Daylight planning,
- Glare rating,
- Simulation of daylight and artificial light,
- Visual comfort,
- Coupling of thermal and light simulation

Moreover, methodically modern simulation and analysis tools are introduced.

Methodology
Lecture, project work

Literature

[1] Kasikci, Projektierung von Niederspannungsanlagen, 3rd edition, Hüthig&Pflaum-Verlag , 2010, ISBN 978-3-8101-0274-4
[2] Kasikci, Projektierungshilfe elektrischer Anlagen in Gebäuden, 7th edition, VDE-Verlag Schriftenreihe 148, 2012
[3] Kasikci, Elektrotechnik für Architekten, Bauingenieure und Gebäudetechniker, Springer-Vieweg ISBN 978-3-8348-0853-0, 2013
[4] DIN 5035 bis 2003: Beleuchtung mit künstlichem Licht
[5] DIN EN 12464-1: March 2003: (Teilweiser Ersatz für DIN 5035-1-7): Teil 1 Beleuchtung von Arbeitsstätten in Innenräumen
[6] DIN EN 12665: September 2002
[7] Basic terms and criteria for specifying lighting requirements
[8] DIN 5035-7 (2004): Lighting of workplaces with visual display workplaces
[9] AMEV / 3.30: Advice for inner artificial lighting in public buildings
[10] International: ISO 8995 / CIE S 008 (similar to DIN EN 12464-1)

Electrical systems

Learning objectives
The student acquires the skills to be able to understand and evaluate electrical networks and systems in the building using project examples. Moreover, he knows the basic concepts for planning and configuration of electrical installations as well as calculation methods of supply facilities and installations.

Contents
The lecture deals with the energy supply systems in buildings The planning, sizing and calculation of electrical systems are the main focus.

- Structure of energy supply, operating variables and terms
- Energy conversion and load characteristics
- Construction of electrical networks, three-phase systems
- Transformers, planning concepts
- Small machine drives in the building
- Switching stations and distribution
- Protective measures and protection technology in NS networks
- Network calculations with the help of CAD programs
- Interfaces for building automation and station control technology
- Supply security, reliability and availability

Methodology
Lectures, seminars, exercises

Literature

[1] Kasikci, I.: Kurzschlussberechnung in elektrischen Anlagen, 3rd edition, Expert-Verlag, 2011
[2] Kasikci, I.: Projektierung von Niederspannungsanlagen, 3rd edition, Hüthig - Verlag, 2010
[3] Kasikci, I.: Projektierungshilfe elektrischer Anlagen in Gebäuden, 7th edition, Schriftenreihe 148, VDE-Verlag 2012
[4] Asea Brown Boveri Taschenbuch: Schaltanlagen, 12th edition, Cornelsen Verlag Düsseldorf, 2011
[5] Oeding, Oswald , Elektrische Kraftwerke und Netze, 6th edition, June 2004
[6] B. Oswald: Netzberechnung, VDE-Verlag, Berlin Offenbach, 1992
[7] 7. Balzer, G. / Nelles, D. / Tuttas, C.: Kurzschlussstromberechnung nach VDE 0102, 3rd edition VDE-Schriftenreihe Vol. 77, 2010

2-4 Energy Systems

Brief description	W-EnSt	**Credits:**	8
Courses:	EGS	**Semester:**	1/2
Offered:	every semester	**Module examination:**	see submodule
Prerequisites:	none	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Geothermal Systems	4	3	L+S	K 120 Min	45 h	75 h	Prof. Dr.-Ing. Roland Koenigsdorff
Renewable and decentralised energy systems	4	3	L+S	St graded	45 h	75 h	Prof. Dr.rer.nat. Jörg Entress
Smart Grid and Smart Buildings	4	3	L+S	St graded	45 h	75 h	Prof. Dr.-Ing. Martin Becker
Electrical/thermal energy systems	4	3	L+S	K 90 Min	45 h	75 h	Prof. Dr.-Ing. Ismail Kasikci
Thermodynamic systems	4	3	L+S	K 90 Min	45 h	75 h	Prof. Dr.-Ing. Michael Haibel

Overall learning objectives

- To allow individual in-depth study of technical content from the field of energy technology to be selected based on specialised topics
- To extend the ability to study and apply selected specialist subjects of energy technology and assess them the within the overall context of the consideration of an energy system

Geothermal Systems

Learning objectives

- To know the basics and mastering the main system techniques and planning methods of near-surface geothermal energy systems in conjunction with buildings, commercial and industrial consumers and power supply systems
- In-depth knowledge and skills in the theory and application of design and simulation methods for near-surface geothermal source systems in the context of the surrounding ground

Contents

- Introduction to and terms of geothermal energy: potential, deep and near-surface geothermal energy, systems and applications, perspectives
- Geological basics: structure and heat balance of the Earth and the near-surface ground, differentiation of geothermally relevant parameters of the subsurface, significant hydrogeological parameters
- Systems for the use of near-surface geothermal energy: springs, air-ground heat exchanger, horizontal collectors, geothermal probes
- Dynamic heat balance of the ground: dynamic single and multi-dimensional heat conduction, groundwater flow, mathematical calculation method
- Calculation methods: short methods, simulation with analytical approximations, FEM, FVM and FDM methods, conductive and convective conditions (thermal conduction and groundwater)
- Application tools: calculation and simulation programs
- Planning systematics, planning & interpretation/simulation exercises
- Processing of a project / an issue of near-surface geothermal energy

Methodology

Lecture, exercise, seminar work

Literature

[1] R. Koenigsdorff: Oberflächennahe Geothermie für Gebäude. Fraunhofer IRB Verlag, Stuttgart, 2011.

[2] Dissertation: Eskilson, Per: Thermal Analysis of Heat Extraction Boreholes.Department of Mathematical Physics, Lund Institute of Technology, Lund, Sweden, 1987

[3] Guidelines:
VDI 4640 - Thermische Nutzung des Untergrunds
sheet 1: Grundlagen, Genehmigungen, Umweltaspekte (2010-06)
sheet 2: Erdgekoppelte Wärmepumpenanlagen (2001-09)
sheet 3: Unterirdische Thermische Energiespeicher (2001-06)
sheet 4: Direkte Nutzungen (2004-09).
Beuth-Verlag, Berlin, 2001-2010.
Verband Beratender Ingenieure VBI (verantw. Hrsg.: Höllen, Arne):
VBI-Leitfaden Oberflächennahe Geothermie.
Vol. 18 der VBI-Schriftenreihe. 3rd edition. Berlin: VBI, 2012

Renewable and decentralised energy systems

Learning objectives
Renewable and decentralised energy systems are gone into in-depth. The increasing complexity of multivalent supply structures is gone into, and the potential of renewable and decentralised energy systems from a technical and energy-sector point of view in combination with the existing supply structures is considered.
Students will be able to look at and evaluate renewable and decentralised energy systems holistically.

Contents
special sections from the following themes are covered:

- The role of renewable energy sources in the future power supply and the integration of increasing shares of renewable energy:
    - Current status and expansion targets in Germany, requirements and solutions
- Solar energy use: among others
    - (Solar thermal systems)
    - Decentralised supply concepts with photovoltaics
    - Solar-thermal power plant concepts
- Wind energy:
    - Development of wind, location influences, types and components of wind turbines, potential, location and plant selection, planning steps, licensing procedures
- Use of biomass as an energy source:
    - Potential and competing uses, growing and harvesting of biomass, plant engineering
- Geothermal power:
    - Technology, potential, location requirements, CHP utilisation concepts
    - Distributed cogeneration and renewable systems as virtual power plants

Methodology
Tuition in seminars

Literature
[1] BMU Schlussbericht FKZ 03MAP146: Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global, 2012
[2] Dena: dena-Studie Systemdienstleistungen 2030, Berlin 2014
[3] BET: Studie „Möglichkeiten zum Ausgleich fluktuierender Einspeisungen aus Erneuerbaren Energien“, Aachen, April 2013
[4] AGORA Energiewende: Studie „Kostenoptimaler Ausbau der Erneuerbaren Energien in Deutschland“, Berlin, may 2013
[5] EWI, Prognos AG: Energiereport IV - Die Entwicklung der Energiemärkte bis zum Jahr 2030, Energiewirtschaftliche Referenzprognose, Cologne, Basel, April 2005

Smart Grid and Smart Buildings

Learning objectives

- To learn and understand future challenges in the planning, execution and operation of buildings in the context of the energy revolution and future network structures .
- To understand the complex interplay of power generation, distribution and use of energy
- To learn and understand the importance of the future role of buildings as virtual power plants and energy storage (elec./thermal)
- To learn and understand possibilities and limits of the integration of conventional and renewable energy systems on and in buildings into the smart grid.
- To be able to develop and use different solution variants based on predefined scenarios of energy production.
- Independent implementation and testing of models in practical training environments (Laboratory of Automation, Smart Grid Laboratory)

Contents

- Challenges of the energy revolution related to the building, industry, transport segments
- Future role of buildings in the context of smart grids
- Buildings as virtual power plants
- Buildings as prosumers
- Buildings and building / energy-related facilities as storage (elec./thermal)
- New challenges and tasks for load, energy and network management
- Requirements for plant and energy monitoring of buildings for appropriate integration into smart grids
- Selected examples in the field of energy generation, energy distribution and energy use
- Impact on future planning, execution and operation of buildings and their systems
- Independent development of solutions in the context of practical training in laboratory automation technology and in the laboratory smart grid

Methodology

Lecture, exercise, seminar work

Literature

[1] B. M.Buchholz, Smart Grids, Grundlagen und Technologien der elektrischen Netze der Zukunft VDE-Verlag, ISBN 978-3-8007-3562-4, 2014

[2] Buchholz, Styczynski: Smart Grids: Grundlagen und Technologien der elektrischen Netze der Zukunft, VDE-Verlag, 2014

[3] Köhler-Schute: Smart Grids: Die Energieinfrastruktur im Umbruch, KS Energy-Verlag, 2012

[4] Servatus, Schneidewind, Rohlfing: Smart Energy – Wandel zu einem nachhaltigen Energiesystem, Springer-Verlag, 2012

[5] Smart Meter Rollout: Praxisleitfaden zur Ausbringung intelligenter Zähler, Springer-Verlag, 2013

[6] Pehnt (ed.): Energieeffizienz, Ein Lehr- und Handbuch, Springer-Verlag, 2010

[7] Wosnitza, Hilger: Energieeffizienz und Energiemanagement, Springer Spektrum, 2012

Electrical/thermal energy systems

Learning objectives
The student acquires the skills to be able to understand and evaluate electrical power systems in low and high-voltage systems using project examples. Moreover, he knows the basic concepts for the energy supply of electrical equipment and calculation methods of supply facilities and installations.

Contents
The student gets an overview of energy conversion systems, their connection to the power grids, planning and calculations. The lecture deals with power generation plants and consumers in low and high-voltage systems. The planning, dimensioning, calculation and simulation of electric power systems are the main focus.

After completing this course, students can
- understand mathematical principles for the calculation of electrical networks
- interpret, plan and simulate generation systems
- understand connection conditions of generator plants
- perform short circuit and load flow calculations
- explain the function and structure of switching devices and switchgear

The following topics represent the content of the lecture:
- Calculation of electrical networks
- Alternative energy plants
- Load Management
- Electrical Power Systems
- Short circuit and load flow calculation
- Electrical equipment and switchgear
- Neutral point treatment and protection technology
- Simulation of networks

Examples of Electrical Systems:
- Structure of energy supply, operating variables and terms
- Energy conversion and load characteristics
- Construction of electrical networks, three-phase systems
- Transformers, planning concepts
- Small machine drives in the building
- Switching stations and distribution
- Protective measures and protection technology in NS networks
- Network calculations with the help of CAD programs
- Interfaces for building automation and station control technology
- Supply security, reliability and availability

Examples of thermal systems:
- Structure of heating and cooling networks
- Construction and structures of hydraulic systems
- Aspects of planning, implementation and operation of thermal networks
- Selected components and their importance for the overall system
- Examples of installed systems
- Importance of inspection, plant monitoring and process optimisation

Methodology
Lecture, exercise, seminar work

Literature:

[1] Kasikci: Projektierung von NS-Anlagen, Hüthig-Verlag, Heidelberg, 3rd edition, 2010
[2] Kasikci, Kurzschlussstromberechnung in elektrischen Anlagen, DIN EN 60909-0 (VDE 0102), 3rd edition, 2011, Expert-Verlag
[3] V. Crasten, Elektrische Energieversorgung 1 and 2 Springer
[4] K. Heuck, K. Dettmann, D. Schulz, Elektrische Energieversorgung, Vieweg
[5] Dietrich Oeding, Bernd R. Oswald: Elektrische Kraftwerke und Netze. Springer-Verlag, 2004
[6] Fachkunde Elektrotechnik, Verlag Europa Lehrmittel

Thermodynamic systems

Learning objectives
It covers two topics:

1. Fundamentals of combustion: What occurs during the formation of flames and in the combustion of technically useful fuels is shown, and how they can be calculated from a thermodynamic perspective
2. Expertise in the field of heat transfer: steady-state/transient heat transfer, processes during evaporation/liquefaction, interpretation of heat transfer, thermal radiation

Contents

- Holistic presentation of the theory of heat transfer and analogies of mass transfer
- Theoretical and experimental methods for determining transient one and multi-dimensional heat conduction processes
- Determination of transient heat conduction with phase change solid/liquid
- Determining the heat transfer coefficient of boiling and condensing
- Calculation of the diffusive mass transfer of water vapour between solids and air
- Calculation of the convective mass transfer of water vapour between solids and air
- Thermodynamic and chemical fundamentals of combustion
- Consideration of the structures and phenomena of flames
- Deflagrative and detonative combustion processes
- Fundamentals of the combustion calculation of solid, liquid and gaseous fuels
- Determining the air demand and the exhaust-gas composition
- Determination of pyrotechnical efficiency

Methodology
Lecture, seminar

Literature
[1] Cerbe, G., Wilhelms, G.: Technische Thermodynamik, 16th edition, Hanser Verlag, 2012
[2] Marek, R., Nitsche, K.: Praxis der Wärmeübertragung, 3rd edition, Hanser Verlag,2013

3 Research project

Brief description	Fopro	**Credits:**	11
Courses:	EGS	**Semester:**	2
Offered:	every semester	**Module examination:**	see submodule
Prerequisites:	none	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Individual topic with colloquium	11	1		St graded + M 45 min	15 h	315 h	

Learning objectives
Acquisition of scientific methodological skills and training of analytical skills through the structuring, processing and documentation of an individual project work.

The students learn to independently, systematically and responsibly analyse, process, and develop innovative solutions for a theoretical/scientific topic in the field of energy and building technology. Presentation of the work carried out and the results obtained in a clearly understandable written thesis and oral presentation. Coherent and structured presentation. Convincing defence of the work.

Contents
- Individual theme with predetermined task
- Creating a schedule and project plan
- Conducting literature reviews, theoretical or experimental work
- Methodical and systematic tracking of a problem and working out an approach usually as a basis for a more advanced master thesis
- Drafting a student research project
- Preparing and giving a presentation

Methodology
Independent scientific work

Literature
Topic-specific

4 Master Thesis

Brief description	MaAb	**Credits:**	26
Courses:	EGS	**Semester:**	-
Offered:	every semester	**Module examination:**	see submodule
Prerequisites:	none	**Coordinator:**	Dean of the Faculty

Structure

Submodule	LP	SWS	Type	Exam	Contact hours	Self-study	Lecturer (s)
Individual topic with colloquium	25	1		St graded + M 45 min	15 h	735 h	

Learning objectives
Students can independently, systematically and responsibly handle a theoretical / scientific issue from the broad field of energy and building technology analysis and develop innovative solutions and possibly implement them theoretically or experimentally. They can display the work carried out and the results obtained in a clearly understandable final written work and oral presentations and they are also able to hold a coherent and structured presentation of their results and defend their work convincingly.

Contents
- Individual theme with partially self-defined task
- Creating a schedule and project plan
- Conducting a thorough literature review
- Development of a solutions concept or solution approaches
- Scientific evaluation of proposed solutions
- Methodical and systematic tracking and implementation of a solution
- Writing a thesis
- Preparing and giving a presentation

Methodology
Independent scientific and individual work

Literature
Topic-specific