Technische Universität Hamburg-Harburg

Module Manual

Master of Science

Energy and Environmental Engineering

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Program description

Content

Building on the competences acquired during the Bachelor study the TUHH Master study program in Energy and Environmental Engineering prepares the graduates for leading roles in the energy producing and consuming industry, for undertaking environmental protection tasks or for independent research activities. The Master program is characterized by its scientific orientation, focus building and acquisition of effective and structured interdisciplinary work methods. The focal points of the syllabus relate closely with the research subjects of the participating TUHH institutes from the Mechanical Engineering, Process Engineering and Civil Engineering deanships. This reflects the close link between research and teaching and ensures that the contents of the lectures always remain up to date. It also offers possibilities for contributing work to the research of the TUHH, for example within the framework of study projects, seminar themes or the project course.

The Master degree in Energy and Environmental Engineering is based on the fundamental skills acquired in the Bachelor degree with the same name. After a joint familiarization in core competences in energy and environmental engineering, the students have the possibility to specialize by choosing independently lectures from three disciplines: Energy Engineering, Environmental Engineering or Energy and Environmental Engineering.

A further goal of the Master of Energy and Environmental Engineering is to prepare the graduates by also strengthening interpersonal competences through practice in technical communication. The theoretical knowledge is supplemented by practical laboratory courses. In addition, skills are conveyed that allow a subsequent appointment in a responsible position in industry or research.

Career prospects

The operating conditions of the energy market and the environmental protection are subjected to increasingly accelerating changes. To account for this in the degree study, special attention is given to convey future-proof knowledge. This enables the students to be easily adaptable to market changes, so that also in future developments they can react autonomously, adapt successfully to their desired placement targets and extend independently their professional horizons. Towards this aim the Master of Energy and Environmental Engineering covers a wide scientific and methodological advanced curriculum.

After successful graduation the graduates are in a position to interpret in depth methods and techniques from the core disciplines of thermodynamics, fluid mechanics and process engineering. They also possess well-founded knowledge in energy engineering and environmental engineering, encompassing both conventional and renewable energy sources. The theoretical skills are complemented by practical assignments within laboratory courses and seminars. The graduates are in a position to utilize specialist methods and tools, to draw whole process balances and design the corresponding apparatus. They can identify the environmental impact in general and develop specific strategies for mitigating the various environmental pressures emanating from industrial plant. The students become practice in critically studying a problem from their discipline, classifying it within their subject area and orally elaborate suitable solution procedures.

The graduates are in a position to undertake responsibly engineering tasks in various fields of activity within energy and environmental engineering and carry them out competently. They can perform engineering work in industry or embark into a research career.

Continuous interaction with Industry within the framework of joint research or through further contact opportunities enables to closely follow the increasingly accelerating changes in qualification profiling demanded by the market. This facilitates the continuous adjustment of the curricular contents of the Master study in Energy and Environmental Engineering to the prevailing market conditions.

Learning target

The students acquire advanced and comprehensive knowledge in engineering, mathematical and natural sciences that can be used for scientific work in Energy Engineering, Environmental Engineering or neighboring disciplines. The have developed a critical awareness of the most modern developments in their subject area and on the basis of this they can then perform responsibly in professional activities and the society as a whole. The key competences for practical engineering assignments, obtained already in the Bachelor study program, are in the Master study program further strengthened.

Knowledge

Knowledge consists of facts, basic fundamentals and theories, which are conveyed during the Master of Energy and Environmental Engineering in the following manner:

- The graduates obtain the capability to describe at greater depth methods and procedures from the core subjects Thermodynamics, Fluid Mechanics and Process Engineering, as an enabling basis for embarking in more advanced courses in energy and environmental engineering. The latter cover conventional as well as renewable energy.
- The specialist theoretical knowledge of the graduates is strengthened through practical assignments (laboratory practical courses and seminars).
- The graduates can describe the structure, operation and organization of conventional and regenerative energy plants and describe the construction characteristics of their components. They are competent to identify the facets for an energetically and economically optimal operation of energy systems, while also considering the additional criteria for conserving resources and enabling sustainability, environmental compatibility and cost effectiveness.
- The graduates are able to assess the environmental impact and choose suitable means for minimizing environmental risks and achieve resource savings.
- In the framework of a project course the graduates are trained in solving in teamwork complex process engineering assignments.
- Through the non-technical lectures or the Master thesis the graduates are put in a position to expand their knowledge beyond the purely technical level and win a social perspective on the profession.

Skills

The ability to utilize learnt knowledge for solving specific problems is strengthened in the Master of Energy and Environmental Engineering in various ways:

- The graduates are able to tackle the balancing and design configuration of processes and their components, by using appropriate specialized methods and tools.
- The graduates can convert an orally expressed context into an abstract formal description, to break down a general problem description to partial problems within their discipline or adjoining disciplines, in order to then select the most suitable method for solving the problem.
- The graduates are competent to identify the goals of an energy technical project, a plant or the society as a whole, aimed at satisfying the energy demand in a balanced and sustainable manner. They can set responsibly priorities and select the optimal problem solution approaches.
- The graduates have learned to consider critically a problem from their specialization, to categorize it within their discipline and orally explain solution approaches.

Social skills

Social competence includes the individual ability and desire to work together with others in achieving set targets, to consider the interests of others, to express oneself clearly, and ultimately to contribute to the common work and living environments.

- The graduates can find themselves within a disciplinary homogeneous team, work out a solution approach, undertake specific partial tasks and deliver responsibly part results. They can also deliberate on their own contribution.
- The graduates are capable to undertake responsibility within the group, to contribute to the group effort and discuss and present their results.
- The graduates know how to interactively and multidisciplinary discuss the results of their scientific work, to present them to an audience and defend them.
- The graduates are able to communicate with specialists and the public on contents and problems in energy and environmental engineering. They can respond appropriately to questions, additions and comments on it.

Independence

The interpersonal skills encompass, beyond autonomous handling, also the ability to further develop one's own capacity to act. Also included are the capability and preparedness to reflect on the work of others and contribute one's own share in specialized discussions:

- The graduates can investigate independently a narrowly focused part of energy and environmental engineering and summarize in a seminar the results in detail, using current presentation techniques or a written essay observing the fundamental principles of good scientific practice.
- The graduates can work autonomously and deliver results on time.
- The graduates are able to perform responsibly research assignments under time constraints and with limited resources, embodying all knowledge obtained during the study program. They also undertake full responsibility for the deliverables.

Program structure

The curriculum of the Master degree in Energy and Environmental Engineering is split into three parts:

- Teaching of advanced knowledge supplementary to the Bachelor of Energy and Environmental Engineering for deepening the core qualification (36 LP of compulsory lectures, including also the practical course in Energy and Environmental Engineering) and further strengthening of the specialist and interpersonal competences already acquired during the Bachelor.
- Advanced lectures in the framework of three branches of study (elective lectures). The students must choose, depending on their particularly chosen study focus, a total of always 3 Modules à 6 LP from each of the available thematic areas: Energy Systems (a total of 30 LP are available), Environmental Technology (a total of 36 LP are available) and Energy and Environmental Engineering (a total of 78 LP are available). The elective part of the curriculum includes also a total of 10 LP of practical courses.
- The Master thesis (compulsory).

The modules that belong to the Master of Energy and Environmental Engineering are in turn allocated as follows:

• Mathematical, natural scientific and engineering fundamentals and applications (seven modules)

o six Process Engineering modules

o one module on Environmental Protection and Management.

• Engineering applications (20 modules)

o five modules on thermal energy systems

o one module on electrical engineering

o four modules on renewable energies

o four modules on water and wastewater engineering

o four modules on environmental engineering

o two modules on the acquisition of practical skills (Practical Course on Energy and Environmental Engineering, Seminar Energy and Environmental Engineering).

• Interdisciplinary lectures from the non-technical catalogue (two modules)

o Business and Management

o Nontechnical Elective Complementary Courses for Master.

In addition the students have to complete the following modules:

• Process Design Project in the 3th semester

• Master thesis in the 4th semester.

The Master of Energy and Environmental Engineering places the emphasis on advancing the mathematical and natural scientific as well as engineering qualifications of the students and expose them to applications. Particular focus is placed on the advanced study directions of Energy Systems and Environmental Engineering, which can be studied in Module ratios of 3:6, 4:5, 5:4 or 6:3. It is furthermore provided that during the preparation of projects such as the Seminar Energy and Environmental Engineering or the Process Design Project additional “soft skills” are conveyed. At the endof the course the capacity for independent scientific work is attained through the Master thesis.

Core qualification

The Master course in Energy and Environmental Engineering aims at preparing the students for addressing successfully energy and environmental problems. The curriculum combines wide specialised process engineering and mechanical engineering syllabuses with a scientific education specialisation. The degree is focused at the requirements of the ensuing professional praxis, as these emerge from the technical, economic, ecologic and societal developments. In addition, the students must choose compulsory elective lectures within the three specialisation paths available. In this selection you may choose to place the focus either on Environmental Technology, on Renewable Energies or on Conventional Energy Systems without, however, neglecting the other two subject areas.

As basis qualification and on the basis of compulsory lectures become all graduates deep and extensive engineering knowledge in the fundamental subject areas of transport processes and fluid mechanics. The theoretical knowledge is supplemented by a related to real life practical laboratory course. This laboratory course covers subjects from both energy systems and environmental technology.

A further key aspect within the basis qualification for the degree are technical communication skills. These are cultivated within the framework of the Seminar in Energy and Environmental Engineering, a course that strengthens the “soft skills” of the graduates and prepares them for independent working.

The technical content of the basis qualification is complemented by a number of non-technical supplementary courses as well as compulsory elective Business & Management lectures. These widen the horizon and expertise of the graduates with qualifications which are important for a successful subsequent entry into the profession.

Module M0523: Business & Management

Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way around selected special areas of management within the scope of business management. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M0524: Nontechnical Elective Complementary Courses for Master

Module Responsible	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**The Nontechnical Academic Programms (NTA)** imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses. **The Learning Architecture** consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses. The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles". The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies. **Teaching and Learning Arrangements** provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses. **Fields of Teaching** are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way. The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations. **The Competence Level** of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc. This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life. **Specialized Competence (Knowledge)** Students can • explain specialized areas in context of the relevant non-technical disciplines, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, • Can communicate in a foreign language in a manner appropriate to the subject.
Skills	**Professional Competence (Skills)** In selected sub-areas students can • apply basic and specific methods of the said scientific disciplines, • aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.
Personal Competence	

Social Competence	**Personal Competences (Social Skills)** Students will be able • to learn to collaborate in different manner, • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, • to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), • to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	**Personal Competences (Self-reliance)** Students are able in selected areas • to reflect on their own profession and professionalism in the context of real-life fields of application • to organize themselves and their own learning processes • to reflect and decide questions in front of a broad education background • to communicate a nontechnical item in a competent way in writen form or verbaly • to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M0540: Transport Processes

Courses

Title	Typ	Hrs/wk	CP
Multiphase Flows (L0104)	Lecture	2	2
Reactor Design Using Local Transport Processes (L0105)	Problem-based Learning	2	2
Heat & Mass Transfer in Process Engineering (L0103)	Lecture	2	2

Module Responsible	Prof. Michael Schlüter
Admission Requirements	none
Recommended Previous Knowledge	All lectures from the undergraduate studies, especially mathematics, chemistry, thermodynamics, fluid mechanics, heat- and mass transfer.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe transport processes in single- and multiphase flows and they know the analogy between heat- and mass transfer as well as the limits of this analogy. • explain the main transport laws and their application as well as the limits of application. • describe how transport coefficients for heat- and mass transfer can be derived experimentally. • compare different multiphase reactors like trickle bed reactors, pipe reactors, stirring tanks and bubble column reactors. • are known. The Students are able to perform mass and energy balances for different kind of reactors. Further more the industrial application of multiphase reactors for heat- and mass transfer are known.
Skills	The students are able to: • optimize multiphase reactors by using mass- and energy balances, • use transport processes for the design of technical processes, • to choose a multiphase reactor for a specific application.
Personal Competence	
Social Competence	The students are able to discuss in international teams in english and develop an approach under pressure of time.
Autonomy	Students are able to define independently tasks, to solve the problem "design of a multiphase reactor". The knowledge that s necessary is worked out by the students themselves on the basis of the existing knowledge from the lecture. The students are able to decide by themselves what kind of equation and model is applicable to their certain problem. They are able to organize their own team and to define priorities for different tasks.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Colloquium
Examination duration and scale	15 min Presentation + 90 min multiple choice written examen
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L0104: Multiphase Flows	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	WiSe
Content	• Interfaces in MPF (boundary layers, surfactants) • Hydrodynamics & pressure drop in Film Flows • Hydrodynamics & pressure drop in Gas-Liquid Pipe Flows • Hydrodynamics & pressure drop in Bubbly Flows • Mass Transfer in Film Flows • Mass Transfer in Gas-Liquid Pipe Flows • Mass Transfer in Bubbly Flows • Reactive mass Transfer in Multiphase Flows • Film Flow: Application Trickle Bed Reactors • Pipe Flow: Application Turbular Reactors • Bubbly Flow: Application Bubble Column Reactors
Literature	Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. Clift, R.; Grace, J.R.; Weber, M.E.: Bubbles, Drops and Particles, Academic Press, New York, 1978. Fan, L.-S.; Tsuchiya, K.: Bubble Wake Dynamics in Liquids and Liquid-Solid Suspensions, Butterworth-Heinemann Series in Chemical Engineering, Boston, USA, 1990. Hewitt, G.F.; Delhaye, J.M.; Zuber, N. (Ed.): Multiphase Science and Technology. Hemisphere Publishing Corp, Vol. 1/1982 bis Vol. 6/1992. Kolev, N.I.: Multiphase flow dynamics. Springer, Vol. 1 and 2, 2002. Levy, S.: Two-Phase Flow in Complex Systems. Verlag John Wiley & Sons, Inc, 1999. Crowe, C.T.: Multiphase Flows with Droplets and Particles. CRC Press, Boca Raton, Fla, 1998.

Course L0105: Reactor Design Using Local Transport Processes	
Typ	Problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	WiSe
Content	In this Problem-Based Learning unit the students have to design a multiphase reactor for a fast chemical reaction concerning optimal hydrodynamic conditions of the multiphase flow. The four students in each team have to: • collect and discuss material properties and equations for design from the literature, • calculate the optimal hydrodynamic design, • check the plausibility of the results critically, • write an exposé with the results. This exposé will be used as basis for the discussion within the oral group examen of each team.
Literature	see actual literature list in StudIP with recent published papers

Course L0103: Heat & Mass Transfer in Process Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	WiSe
Content	• Introduction - Transport Processes in Chemical Engineering • Molecular Heat- and Mass Transfer: Applications of Fourier's and Fick's Law • Convective Heat and Mass Transfer: Applications in Process Engineering • Unsteady State Transport Processes: Cooling & Drying • Transport at fluidic Interfaces: Two Film, Penetration, Surface Renewal • Transport Laws & Balance Equations with turbulence, sinks and sources • Experimental Determination of Transport Coefficients • Design and Scale Up of Reactors for Heat- and Mass Transfer • Reactive Mass Transfer • Processes with Phase Changes – Evaporization and Condensation • Radiative Heat Transfer - Fundamentals • Radiative Heat Transfer - Solar Energy
Literature	1. Baehr, Stephan: Heat and Mass Transfer, Wiley 2002. 2. Bird, Stewart, Lightfood: Transport Phenomena, Springer, 2000. 3. John H. Lienhard: A Heat Transfer Textbook, Phlogiston Press, Cambridge Massachusetts, 2008. 4. Myers: Analytical Methods in Conduction Heat Transfer, McGraw-Hill, 1971. 5. Incropera, De Witt: Fundamentals of Heat and Mass Transfer, Wiley, 2002. 6. Beek, Muttzall: Transport Phenomena, Wiley, 1983. 7. Crank: The Mathematics of Diffusion, Oxford, 1995. 8. Madhusudana: Thermal Contact Conductance, Springer, 1996. 9. Treybal: Mass-Transfer-Operation, McGraw-Hill, 1987.

Module M0542: Fluid Mechanics in Process Engineering

Courses

Title	Typ	Hrs/wk	CP
Applications of Fluid Mechanics in Process Engineering (L0106)	Recitation Section (large)	2	2
Fluid Mechanics II (L0001)	Lecture	2	4

Module Responsible	Prof. Michael Schlüter
Admission Requirements	none
Recommended Previous Knowledge	• Mathematics I-III • Fundamentals in Fluid Mechanics • Technical Thermodynamics I-II • Heat- and Mass Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe different applications of fluid mechanics in Process Engineering, Bioprocess Engineering, Energy- and Environmental Process Engineering and Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity in an example of free jets, empirical solutions in an example with the Forchheimer equation, numerical methods in an example of Large Eddy Simulation.
Skills	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure.
Personal Competence	
Social Competence	The students are able to discuss a given problem in small groups and to develop an approach.
Autonomy	Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L0106: Applications of Fluid Mechanics in Process Engineering	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	The Exercise-Lecture will bridge the gap between the theoretical content from the lecture and practical calculations. For this aim a special exercise is calculated at the blackboard that shows how the theoretical knowledge from the lecture can be used to solve real problems in Process Engineering.
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006. 7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008. 8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008. 12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. 13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. 14. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011.

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	• Differential equations for momentum-, heat and mass transfer • Examples for simplifications of the Navier-Stokes Equations • Unsteady momentum transfer • Free shear layer, turbulence and free jets • Flow around particles - Solids Process Engineering • Coupling of momentum and heat transfer - Thermal Process Engineering • Rheology – Bioprocess Engineering • Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering • Flow threw porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006. 7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008. 8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008. 12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. 13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

Module M1036: Practical Course on Energy and Environmental Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Practical Course on Energy and Environmental Engineering (L1386)	Laboratory Course	6	6

Module Responsible	Prof. Alfons Kather
Admission Requirements	None
Recommended Previous Knowledge	“Gas and Steam Power Plants“
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The practical course aims at consolidating the knowledge obtained in the Bachelor Energy and Environmental Engineering. Aim is the application of methods and techniques for the analysis and evaluation of test results in the praxis. Special emphasis is given to the quantitative evaluation of the environmental impact from energy and industrial systems. By performing laboratory experiments the students are exposed to taking reliable measurements in real equipment and get training in the reporting and quality assurance of the measurement results. From the parameters being monitored they conclude quantitatively on key performance indices of the test facility. The students formulate subsequently a laboratory report with the conclusions and the critical evaluation of the rig. Within the framework of team work the students learn to analyse and evaluate the plant and the chemical phenomena tested. By means of presentations on the test procedures followed and the results obtained, accompanied by discussion and critical results’ evaluation, the students practice furthermore technical communication and professional argumentation.
Skills	The participants must take within the group responsibility for partial aspects of the practical course, which in case of inadequate fulfilment may have negative consequences for the whole group. In this manner the teamwork and communication abilities of the participants are cultivated and their ability to undertake leadership responsibilities strengthened. In addition, the participants are trained in the compilation of test transcripts and the analysis and critical evaluation of measurements, taken in part at large facilities. In this way they are exposed to plant scales corresponding to the later profession. Out of the requirement to prepare laboratory transcripts on the experiments, the students practice written technical communication skills. In the framework of certain experiments the students must also cultivate presentation skills, to present technical aspects of the tests performed and discuss them technically. In this process it is expected that students exercise an analytic and critical way of thinking.
Personal Competence	
Social Competence	The organising together in a group of the test analysis and the preparation of the transcript for the experiment in direct responsibility strengthen the social competence of the group participants. The definition of the solution methodologies and the splitting to sub-problems takes place in teamwork. For the preparation of the joint transcript and the reaching of the final conclusions over the experiment performed, communication as well as teamworking abilities are essential.
Autonomy	Each student must contribute to the selection of the transcript author(s) and to the planning and timely performance of the analysis and evaluation of the results. The short presentations of the results for certain experiments are, in turn, direct personal contributions of the individual student.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written elaboration
Examination duration and scale	Submission of transcript and debriefing (120 min) incl. questioning of the students
Assignment for the Following Curricula	Energy and Environmental Engineering: Core qualification: Compulsory

Course L1386: Practical Course on Energy and Environmental Engineering

Typ	Laboratory Course
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Alfons Kather, Dozenten des SD V
Language	DE
Cycle	SoSe
Content	In the Practical Course on Energy Systems the following experiments are offered: • Combined heat, power and chill production in the district heating plant of the TUHH • Measurement of the fine particulate emissions from a biomass boiler • Acceptance test of a steam turbine plant • Heat transfer on a flat plate • Energy balance of a condensation boiler • Formation of heavy metal complexes
Literature	Skripte werden für jeden Versuch zur Verfügung gestellt.

Module M1120: Seminar energy and environmental engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Seminar energy and environmental engineering (L1456)	Seminar	6	6

Module Responsible	Prof. Alfons Kather
Admission Requirements	None
Recommended Previous Knowledge	Basic lectures in: Heat Transfer, Gas-Steam Power Plants. The participation in the introductory session is mandatory.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students, based on a literature survey, learn to study in detail a subject theme from the disciplines of Energy and Environmental Engineering and deliver afterwards a summary presentation to a specialised audience. Environmental issues and their multidisciplinary linkages are preferred, when selecting the thematic area of these studies. Through their own written contribution the students communicate an overview over the subject and practice technical writing. With the discussion the students practice scientific debating on a specialised subject matter.
Skills	The students can, when working on a technical topic not familiar to them: • conduct a literature survey • choose the relevant information for their presentation • prepare a written summary • present results in front of peers and staff • correctly cite and reference sources.
Personal Competence	
Social Competence	The students practice a critical assessment of the literature in a predefined specialised theme and learn to give presentations on their own technical sub-topic tailored to their public and discuss with the audience. When attending technical presentations, the students can formulate questions to other speakers and participate in the ensuing discussion. The fulfilment of the tasks combines independent work with group and teamwork.
Autonomy	The students can, guided by instructors, critically reflect on their learning and work status, and write a scientific report.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written elaboration
Examination duration and scale	According to the participation in group discussions and an individual presentation + Written report.
Assignment for the Following Curricula	Energy and Environmental Engineering: Core qualification: Compulsory

Course L1456: Seminar energy and environmental engineering	
Typ	Seminar
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	WiSe
Content	- Introductory lecture with choice of the subject, fixing the dates, etc. - Literature Survey on the subject of the talk - Preparing the presentation with Powerpoint - Submission of an extended summary of between 12 to 20 pages (ca. 18 000 to 25 000 characters excluding spaces), the literature used and the presentation in an electronic version - Oral presentation (15 minutes) and discussion (10 minutes)
Literature	

Specialization Energy and Environmental Engineering

In this specialisation path three Modules must be chosen out of a number of compulsory selective lectures covering a wide spectrum of practically relevant aspects of both Energy Systems and Environmental Technology. With the chosen Modules the student can focus in Energy Systems, Environmental Technology or even a combination of both subject areas.

On the one hand the graduates obtain further extensive knowledge over key aspects of Energy Systems – both conventional as well as renewable. On the other hand, they become in-depth coverage of environmental engineering aspects relating to solid wastes handling and wastewater technology. This includes also the sustainable utilisation of resources, so that an environmentally friendly energy generation can occur.

The curriculum is further complemented by lectures in thematically relevant subjects. These encompass solid particle technology, wastewater analysis and membrane technology, which play a fundamental role in Energy Systems and Environmental Engineering.

The specialisation path is rounded up with participation in a process design project, in which the students learn how to work together for solving a complex process engineering problem and how to use specialised tools for designing processes. They also experience what obstacles may be faced and difficulties tackled, whilst designing a process.

Module M0801: Water Resources and -Supply

Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of water management and the key processes involved in water treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
Skills	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
Personal Competence	
Social Competence	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
Autonomy	Students will be in a position to work on a subject independently and present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	60 min (chemistry) + presentation
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0311: Chemistry of Drinking Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	The topic of this course is water chemistry with respect to drinking water treatment and water distribution Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards). Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework. Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester.
Literature	**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. **Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003.

Course L0312: Chemistry of Drinking Water Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Klaus Johannsen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0402: Water Resource Management	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview: • Current situation of global water resources - User and Stakeholder conflicts - Wasserressourcenmanagement in urbane Gebieten - Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen. - Ökobilanzierung, Benchmarking in der Wasserversorgung
Literature	• Aktuelle UN World Water Development Reports • Branchenbild der deutschen Wasserwirtschaft, VKU (2011) • Aktuelle Artikel wissenschaftlicher Zeitschriften • Ppt der Vorlesung

Course L0403: Water Resource Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mathias Ernst
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1037: Nuclear Power Plants and Steam Turbines

Courses

Title	Typ	Hrs/wk	CP
Steam Turbines in Renewable and Conventional Applications (L1286)	Lecture	2	2
Steam Turbines in Renewable and Conventional Applications (L1287)	Recitation Section (small)	1	1
Basics of Nuclear Power Plants (L1283)	Lecture	2	2
Basics of Nuclear Power Plants (L1285)	Recitation Section (small)	1	1

Module Responsible Prof. Alfons Kather

Admission Requirements None

Recommended Previous Knowledge

For the part "Steam Turbines":

- "Gas and Steam Power Plants"
- "Technical Thermodynamics I & II"

For the part "Basics of Nuclear Power Plants" knowledge of:

- Thermodynamics
- Fluid Mechanics
- Gas-Steam Power Plants

is required

Educational Objectives After taking part successfully, students have reached the following learning results

Professional Competence

Knowledge

After successful completion of the part "Steam Turbines" of the module the students must be in a position to:

- name and identify the various constructive sections and groups of steam turbines
- describe and explain the key operating conditions for the application of steam turbines
- classify different construction types and differentiate among steam turbines according to size and operating ranges
- describe the thermodynamic processes and the constructive and operational repercussions resulting from the latter
- calculate thermodynamically a turbine stage and a stage grouping
- calculate or estimate and evaluate further sections of the turbine
- outline diagramms describing the operating range and the constructive characteristics
- investigate the constructive aspects and develop from the thermodynamic requirements the required construction characteristics
- discuss and argue on the operation characteristics of different turbine types
- evaluate thermodynamically the integration of different turbine designs in heat cycles

In the part of the module "Basics of Nuclear Power Plants" the students gain an overview of the safety requirements for the design, construction and operation of nuclear power plants.

Students of various study programmes, who wish to specialize in the filed of nuclear power engineering in future, are introduced to the special requirements of the nuclear power technology, which are important for the perception of this field.

After successful completion of this part of the module the students acquire the following skills:

- Know the fundamental physical processes for the energetic use of nuclear energy, which extends up to using nuclear fission in a regulated reactor
- Know the physical and technical features of different reactor types
- Know the construction of a nuclear plant for electricity generation
- Understand and elucidate the heat generation in the fuel rods and the heat transfer to the cooling medium of the nuclear reactor (reactor thermodynamics)
- Understand and explain the concepts for regulating water cooled reactors
- Comprehend the concepts behind the safety systems that safeguard the necessary reliability and the fundamental constructive features of existing and new nuclear power plants
- Understand the basic technical safety requirements on component integrity and their verification under long-term operation

Skills

In the part of the module "Steam Turbines" the students learn the fundamental approaches and methods for the design and operational evaluation von komplex plant and gain confidence in seeking optimisations.

In the part of the module "Basics of Nuclear Power Plants" the students:

- obtain the ability to estimate the potential of nuclear power generation from an economical and technical standpoint in comparison to fossil plants
- can evaluate the performance and technical limitations in using nuclear power plants for supplying the electric grid both with base-load electricity and regulating energy
- can judge the hazards from radioactive radiation and the behaviour of radioactive elements based on the tables of nuclides
- can evaluate the effectiveness of safety systems against various failure events being considered
- from knowledge obtained on the impact of power plant operation on compoment integrity can identify the requirements aiming at failure prevention
- can define the fundamental repercussions for design and management of nuclear power plants on the basis of the overlaying requirements of the technical nuclear Regulations

Personal Competence	
Social Competence	In the part of the module "Steam Turbines" the students learn: • to work together with others whilst seeking a solution • to assist each other in problem solving. In the part of the module "Basics of Nuclear Power Plants" the students learn to: • participate in discussions • present results • work together in a team
Autonomy	In the part of the module "Steam Turbines" the students learn the independent working of a complex thema whilst considering various aspects. They also learn how to carry independently single functions in a system combination. In the part of the module "Basics of Nuclear Power Plants" the students become the ability to gain independently knowledge and transfer it also to new problem solving.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1286: Steam Turbines in Renewable and Conventional Applications	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	• Introduction • Construction Aspects of a Steam Turbine • Energy Conversion in a Steam Turbine • Construction Types of Steam Turbines • Behaviour of Steam Turbines • Sealing Systems for Steam Turbines • Axial Thrust • Regulation of Steam Turbines • Stiffness Calculation of the Blades • Blade and Rotor Oscillations • Fundamentals of a Safe Steam Turbine Operation • Application in Conventional and Renewable Power Stations
Literature	• Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) • Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121) • Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109) • Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)

Course L1287: Steam Turbines in Renewable and Conventional Applications	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1283: Basics of Nuclear Power Plants	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Uwe Kleen
Language	DE
Cycle	WiSe
Content	• Fundamentals of nuclear physics: • 1. Radioactive decay, half-life 2. Release of energy from nuclear reactions 3. Nuclear fission 4. Neutron balance 5. Reactor balancing • Types of reactors • Radioactivity and radiation protection • Nuclear fuel cycle and final disposal • Reactor dynamics, regulation behaviour of reactors • Reactor thermodynamics of water cooled reactors • Nuclear technical Regulations, safety technical requirements • Safety technical design, safety systems for water cooled reactors • Component integrity • Operation and maintenance • Novel and future reactor types The lecture is supplemented by solving example exercises and is accompanied by an excursion.
Literature	• Fassbender, Einführung in die Reaktorphysik, Verlag Karl Thiemig, München • Ziegler, Lehrbuch der Reaktortechnik, Springer Verlag Berlin • Lamarsh, Introduction to Nuclear Engineering, Prentice Hall

Course L1285: Basics of Nuclear Power Plants	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Uwe Kleen
Language	DE
Cycle	WiSe
Content	• Fundamentals of nuclear physics: • 1. Radioactive decay, half-life 2. Release of energy from nuclear reactions 3. Nuclear fission 4. Neutron balance 5. Reactor balancing • Types of reactors • Radioactivity and radiation protection • Nuclear fuel cycle and final disposal • Reactor dynamics, regulation behaviour of reactors • Reactor thermodynamics of water cooled reactors • Nuclear technical Regulations, safety technical requirements • Safety technical design, safety systems for water cooled reactors • Component integrity • Operation and maintenance • Novel and future reactor types The lecture is supplemented by solving example exercises and is accompanied by an excursion.
Literature	• Fassbender, Einführung in die Reaktorphysik, Verlag Karl Thiemig, München • Ziegler, Lehrbuch der Reaktortechnik, Springer Verlag Berlin • Lamarsh, Introduction to Nuclear Engineering, Prentice Hall

Module M0949: Rural Development and Sanitation for different Climate Zones

Courses

Title	Typ	Hrs/wk	CP
Rural Development in Different Climates (L0941)	Lecture	2	2
Resources Oriented Sanitation: High and Low-Tech Options (L0942)	Lecture	2	3
Resources Oriented Sanitation: High - and Low - Tech Options (L0504)	Laboratory Course	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners. Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world.
Skills	Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory.
Personal Competence	
Social Competence	
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written elaboration
Examination duration and scale	During the course of the semester, the students work towards five mile stones. The work includes presentations and papers. Detailed information can be found at the beginning of the smester in the StudIP course module handbook.
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0941: Rural Development in Different Climates	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Small Breakout Groups on “Rural Development” and presentation of results • Living Soil – THE key element of Rural Development • Permaculture Principles of Rural Development • Case Studies: Global Ecovillage Network, Complementary Currencies • Going Further: The TUHH Toolbox for Rural Development • Rainwater Harvesting, Participatory planning principles • Participant Workshop: Video contest: Participants groups search, introduce, show and discuss excellent short water videos • EMAS Technologies, Hand-Pump and wells • Practical Pump/Well-Building • Seminar: Participants prepare and give short 5 min presentations “Best Practice cases in Rural Development” • In Depth: Rural Drinking Water Supply (Dr. Bendinger) • cont. Rural Drinking Water Supply (Dr. Bendinger) • cont. Rural Drinking Water Supply (Dr. Bendinger) • Exam
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

Course L0942: Resources Oriented Sanitation: High and Low-Tech Options	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	• Small Breakout Groups on “The horrific global situation in Sanitation ” and presentation of results • Keynote lecture: Resources Oriented Sanitation around the World • Participant Workshop: Video contest: Participants groups search, introduce, show and discuss excellent short water videos • In Depth: Terra Preta Sanitation, an emerging concept based on historic global best practice in the Amazon Region • Seminar: All participants prepare and give 10 min presentations (choice of topics) • cont. • cont. • cont. • Rehearsal and final panel discussion • Exam
Literature	• J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys

Course L0504: Resources Oriented Sanitation: High - and Low - Tech Options	
Typ	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Course work	Practical course: Preparation and execution of four experiments and written report about the experiments.
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	- Construction of urine-diverting toilets - Comparison of stored and fresh urine: ammonia concentration - Comparison of stored and fresh urine: alkalinity
Literature	Skript Steven A. Esrey, Jean Gough, Dave Rapaport, Ron Sawyer, Mayling Simpson-Hébert, Jorge Vargas and Uno Winblad: Ecological Sanitation, SIDA, Stockholm 1998, http://www.ecosanres.org/pdf_files/Ecological_Sanitation.pdf

Module M0512: Use of Solar Energy

Courses

Title	Typ	Hrs/wk	CP
Collector Technology (L0018)	Lecture	2	2
Solar Power Generation (L0015)	Lecture	2	2
Radiation and Optic (L0016)	Lecture	1	1
Radiation and Optic (L0017)	Recitation Section (small)	1	1

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	none
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module, students will be able to deal with technical foundations and current issues and problems in the field of solar energy and explain and evaulate these critically in consideration of the prior curriculum and current subject specific issues. In particular they can professionally describe the processes within a solar cell and explain the specific features of application of solar modules. Furthermore, they can provide an overview of the collector technology in solar thermal systems.
Skills	Students can apply the acquired theoretical foundations of exemplary energy systems using solar radiation. In this context, for example they can assess and evaluate potential and constraints of solar energy systems with respect to different geographical assumptions. They are able to dimension solar energy systems in consideration of technical aspects and given assumptions. Using module-comprehensive knowledge students can evalute the economic and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics.
Personal Competence	
Social Competence	
Autonomy	Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis fo the lectures. Furthermore, with the assistance of lecturers, they can discrete use calculation methods for analysing and dimensioning solar energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

Course L0018: Collector Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Agis Papadopoulos
Language	DE
Cycle	SoSe
Content	• Introduction: Energy demand and application of solar energy. • Heat transfer in the solar thermal energy: conduction, convection, radiation. • Collectors: Types, structure, efficiency, dimensioning, concentrated systems. • Energy storage: Requirements, types. • Passive solar energy: components and systems. • Solar thermal low temperature systems: collector variants, construction, calculation. • Solar thermal high temperature systems: Classification of solar power plants construction. • Solar air conditioning.
Literature	• Vorlesungsskript. • Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013. • Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012. • Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011. • Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009. • de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008. • Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.

Course L0015: Solar Power Generation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dietmar Obst, Martin Schlecht
Language	DE
Cycle	SoSe
Content	1. Introduction 2. Primary energy and consumption, available solar energy 3. Physics of the ideal solar cell 4. Light absorption PN junction characteristic values of the solar cell efficiency 5. Physics of the real solar cell 6. Charge carrier recombination characteristics, junction layer recombination, equivalent circuit 7. Increasing the efficiency 8. Methods for increasing the quantum yield, and reduction of recombination 9. Straight and tandem structures 10. Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell 11. Concentrator 12. Concentrator optics and tracking systems 13. Technology and properties: types of solar cells, manufacture, single crystal silicon and gallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells on carriers (amorphous silicon, CIS, electrochemical cells) 14. Modules 15. Circuits
Literature	• A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995 • A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994 • H.-J. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995 • A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005 • C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983 • H.-G. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttgart, 1994 • R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston, 1986 • B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995 • P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005 • U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001 • V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003 • G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik

Course L0016: Radiation and Optic	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer
Language	DE
Cycle	SoSe

Content	• Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation
	• Structure of the atmosphere
	• Properties and laws of radiation
	  ◦ Polarization
	  ◦ Radiation quantities
	  ◦ Planck's radiation law
	  ◦ Wien's displacement law
	  ◦ Stefan-Boltzmann law
	  ◦ Kirchhoff's law
	  ◦ Brightness temperature
	  ◦ Absorption, reflection, transmission
	• Radiation balance, global radiation, energy balance
	• Atmospheric extinction
	• Mie and Rayleigh scattering
	• Radiative transfer
	• Optical effects in the atmosphere
	• Calculation of the sun and calculate radiation on inclined surfaces

Literature	• Helmut Kraus: Die Atmosphäre der Erde • Hans Häckel: Meteorologie • Grant W. Petty: A First Course in Atmosheric Radiation • Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy • Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung

Course L0017: Radiation and Optic	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Beate Geyer
Language	DE
Cycle	SoSe
Content	Applications of stages of calculation within the radiation gauge. Within the exercise the various tasks are actively discussed and applied to various cases of application.
Literature	siehe Vorlesungsscript

Module M0513: System Aspects of Renewable Energies

Courses

Title	Typ	Hrs/wk	CP
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2
Energy Trading (L0019)	Lecture	1	1
Energy Trading (L0020)	Recitation Section (small)	1	1
Deep Geothermal Energy (L0025)	Lecture	2	2

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	none
Recommended Previous Knowledge	Module: Technical Thermodynamics I Module: Technical Thermodynamics II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy.
Skills	Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode. Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades.
Personal Competence	
Social Competence	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.
Autonomy	Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Renewable Energies: Core qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Fröba
Language	DE
Cycle	SoSe

Content	1. Introduction to electrochemical energy conversion
	2. Function and structure of electrolyte
	3. Low-temperature fuel cell
	  ◦ Types
	  ◦ Thermodynamics of the PEM fuel cell
	  ◦ Cooling and humidification strategy
	4. High-temperature fuel cell
	  ◦ The MCFC
	  ◦ The SOFC
	  ◦ Integration Strategies and partial reforming
	5. Fuels
	  ◦ Supply of fuel
	  ◦ Reforming of natural gas and biogas
	  ◦ Reforming of liquid hydrocarbons
	6. Energetic Integration and control of fuel cell systems

Literature	• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

Course L0019: Energy Trading	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Michael Sagorje
Language	DE
Cycle	SoSe
Content	• Basic concepts and tradable products in energy markets • Primary energy markets • Electricity Markets • European Emissions Trading Scheme • Influence of renewable energy • Real options • Risk management Within the exercise the various tasks are actively discussed and applied to various cases of application.
Literature	

Course L0020: Energy Trading	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Michael Sagorje
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0025: Deep Geothermal Energy	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Ben Norden
Language	DE
Cycle	SoSe
Content	1. Introduction to the deep geothermal use 2. Geological Basics I 3. Geological Basics II 4. Geology and thermal aspects 5. Rock Physical Aspects 6. Geochemical aspects 7. Exploration of deep geothermal reservoirs 8. Drilling technologies, piping and expansion 9. Borehole Geophysics 10. Underground system characterization and reservoir engineering 11. Microbiology and Upper-day system components 12. Adapted investment concepts, cost and environmental aspect
Literature	• Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012) • www.geo-energy.org • Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012. • Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013. • Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001) • Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Auflage (19. April 2010)

Module M0721: Air Conditioning

Courses

Title	Typ	Hrs/wk	CP
Air Conditioning (L0594)	Lecture	3	5
Air Conditioning (L0595)	Recitation Section (large)	1	1

Module Responsible	Prof. Gerhard Schmitz
Admission Requirements	none
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x-diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants.
Skills	Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	1. Overview 1.1 Kinds of air conditioning systems 1.2 Ventilating 1.3 Function of an air condition system 2. Thermodynamic processes 2.1 Psychrometric chart 2.2 Mixer preheater, heater 2.3 Cooler 2.4 Humidifier 2.5 Air conditioning process in a Psychrometric chart 2.6 Desiccant assisted air conditioning 3. Calculation of heating and cooling loads 3.1 Heating loads 3.2 Cooling loads 3.3 Calculation of inner cooling load 3.4 Calculation of outer cooling load 4. Ventilating systems 4.1 Fresh air demand 4.2 Air flow in rooms 4.3 Calculation of duct systems 4.4 Fans 4.5 Filters 5. Refrigeration systems 5.1. compression chillers 5.2Absorption chillers
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0595: Air Conditioning	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0749: Waste Treatment and Solid Matter Process Technology

Courses

Title	Typ	Hrs/wk	CP
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	2
Thermal Waste Treatment (L0320)	Lecture	2	2
Thermal Waste Treatment (L1177)	Recitation Section (large)	1	2

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	none
Recommended Previous Knowledge	Basics of • thermo dynamics • fluid dynamics • chemistry
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can name, describe current issue and problems in the field of thermal waste treatment and particle process engineering and contemplate them in the context of their field. The industrial application of unit operations as part of process engineering is explained by actual examples of waste incineration technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglomeration of renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, electricity , heat and mineral recyclables.
Skills	The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts.
Personal Competence	
Social Competence	Students can • respectfully work together as a team and discuss technical tasks • participate in subject-specific and interdisciplinary discussions, • develop cooperated solutions • promote the scientific development and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Specialisation Bio energies: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0052: Solid Matter Process Technology for Biomass	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	SoSe
Content	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
Literature	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L0320: Thermal Waste Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta, Dr. Joachim Gerth, Dr. Ernst-Ulrich Hartge
Language	EN
Cycle	SoSe
Content	• Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals • basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition • Incineration techniques: grate firing, ash transfer, boiler • Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination • Ash treatment: Mass, quality, treatment concepts, recycling, disposal
Literature	Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013.

Course L1177: Thermal Waste Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Ernst-Ulrich Hartge, Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0906: Molecular Modeling and Computational Fluid Dynamics

Courses

Title	Typ	Hrs/wk	CP
Computational Fluid Dynamics - Exercises in OpenFoam (L1375)	Recitation Section (small)	1	1
Computational Fluid Dynamics in Process Engineering (L1052)	Lecture	2	2
Statistical Thermodynamics and Molecular Modelling (L0099)	Lecture	2	3

Module Responsible	Prof. Michael Schlüter
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I-IV • Basic knowledge in Fluid Mechanics • Basic knowledge in chemical thermodynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module the students are able to • explain the the basic principles of statistical thermodynamics (ensembles, simple systems) • describe the main approaches in classical Molecular Modeling (Monte Carlo, Molecular Dynamics) in various ensembles • discuss examples of computer programs in detail, • evaluate the application of numerical simulations, • list the possible start and boundary conditions for a numerical simulation.
Skills	The students are able to: • set up computer programs for solving simple problems by Monte Carlo or molecular dynamics, • solve problems by molecular modeling, • set up a numerical grid, • perform a simple numerical simulation with OpenFoam, • evaluate the result of a numerical simulation.
Personal Competence	
Social Competence	The students are able to • develop joint solutions in mixed teams and present them in front of the other students, • to collaborate in a team and to reflect their own contribution toward it.
Autonomy	The students are able to: • evaluate their learning progress and to define the following steps of learning on that basis, • evaluate possible consequences for their profession.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Oral exam
Examination duration and scale	1h examen in teams
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L1375: Computational Fluid Dynamics - Exercises in OpenFoam	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	• generation of numerical grids with a common grid generator • selection of models and boundary conditions • basic numerical simulation with OpenFoam within the TUHH CIP-Pool
Literature	OpenFoam Tutorials (StudIP)

Course L1052: Computational Fluid Dynamics in Process Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	• Introduction into partial differential equations • Basic equations • Boundary conditions and grids • Numerical methods • Finite difference method • Finite volume method • Time discretisation and stability • Population balance • Multiphase Systems • Modeling of Turbulent Flows • Exercises: Stability Analysis • Exercises: Example on CFD - analytically/numerically
Literature	Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2. Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868. Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6

Course L0099: Statistical Thermodynamics and Molecular Modelling	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Sven Jakobtorweihen
Language	EN
Cycle	SoSe
Content	• **Some lectures will be carried out as computer exercises** • Introduction to Statistical Mechanics • The ensemble concept • The classical limit • Intermolecular potentials, force fields • Monte Carlo simulations (acceptance rules) (Übungen im Rechnerpool) (exercises in computer pool) • Molecular Dynamics Simulations (integration of equations of motion, calculating transport properties) (exercises in computer pool) • Molecular simulation of Phase equilibria (Gibbs Ensemble) • Methods for the calculation of free energies
Literature	Daan Frenkel, Berend Smit: Understanding Molecular Simulation, Academic Press M. P. Allen, D. J. Tildesley: Computer Simulations of Liquids, Oxford Univ. Press A.R. Leach: Molecular Modelling - Principles and Applications, Prentice Hall, N.Y. D. A. McQuarrie: Statistical Mechanics, University Science Books T. L. Hill: Statistical Mechanics , Dover Publications

Module M0847: Analytical Methods and Treatment Technologies for Wastewaters

Courses

Title	Typ	Hrs/wk	CP
Low-Cost Procedures for Water and Wastewater Analysis (L0505)	Lecture	2	3
Physico-Chemical Water Treatment (L0482)	Lecture	2	3

Module Responsible	NN
Admission Requirements	none
Recommended Previous Knowledge	Fundamental knowledge in chemistry and physics (knowledge acquired at school)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know some non-biological processes for the treatment of water and wastewater as well as the fundamentals of mass transfer which is essential for many treatment processes. They have knowledge about analytical procedures which can be applied even without the availability of a laboratory and which are useful for evaluating the performance of (waste)water treatment processes and the assessment of surface water quality in an economically feasible way.
Skills	The students are able to select suitable processes for the treatment of wastewaters with respect to their characteristics. They can evaluate the efforts and costs for analytical procedures for the characterization of waters/wastewaters and select economically feasible analytical procedures.
Personal Competence	
Social Competence	The students have the competence to plan and to perform wastewater analyses together with colleagues in small groups and to efficiently distribute the respective tasks within the group.
Autonomy	The students are capable to make their own decisions with respect to the selection of suitable water/wastewater treatment processes as well as economically feasible analytical procedures for water/wastewater characterization.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0505: Low-Cost Procedures for Water and Wastewater Analysis	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	1 Introduction 2 Costing of wastewater and water analyses 3 Parameters routinely measured in municipal wastewater effluents 4 Surrogate parameters 5 Field methods 6 Basic laboratory instruments and equipment 6.1 Balances 6.2 Volumetric dosing instruments 6.3 Photometer 6.3.1 General 6.3.2 Principle of photometry 6.3.3 Elements of a photometer 6.4 Deionised water supply 6.5 Safety equipment 7 Inorganic parameters 7.1 Inorganic parameters by probes/electrodes 7.1.1 Dissolved oxygen 7.1.1.1 Polarographic measurement of dissolved oxygen 7.1.1.2 Optical probe for measuring dissolved oxygen utilising luminescence quenching of oxygen 7.1.1.3 Titrimetric determination of dissolved oxygen 7.1.2 pH 7.1.3 Alkalinity 7.1.4 Electric conductivity/salinity 7.2 Nitrogen and phosphorus compounds (nutrients) 7.2.1 Colorimetric methods without expensive instruments 7.2.2 Reflectometric methods 7.2.3 Photometric methods 8 Particles in water and wastewater 9 Organic sum parameters 9.1 Overview 9.2 Chemical Oxygen Demand: Why to avoid COD analyses by the dichromate method? 9.3 TOC cuvette tests 9.4 Absorption of UV light (254 nm) as a surrogate parameter for COD 9.5 Volatile Solids as surrogate for COD 9.6 Biological oxygen demand 10 Microbiological parameters determined in a low-cost way 11 Toxicity toward activated sludge
Literature	Skript auf StudIP

Course L0482: Physico-Chemical Water Treatment	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	- Stripping - Evaporation - Wastewater Incineration - Wet Air Oxidation - Ozonation - Advanced Oxidation Processes
Literature	Physical-Chemical Treatment of Water and Wastewater, A.P. Sincero, G.A. Sincero, CRC Press, Boca Raton 2003; Handbook of Separation Techniques for Chemical Engineers, P.A. Schweitzer, ed., McGraw-Hill, New York 1988 Perry´s Chemical Engineers´ Handbook, R.H. Perry, D.W. Green, J.O. Maloney, eds., McGraw-Hill, New York 1984 Chemical Engineering, Vol. 2, J.M. Coulson, J.F. Richardson, Pergamon Press, Oxford 1991 Ozone in Water Treatment, B. Langlais, D.A. Reckhow, D.R. Brink, eds., Lewis Publishers, Chelsea 1991

Module M0900: Examples in Solid Process Engineering

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Fluidization Technology (L0431)	Lecture	2	2
Practical Course Fluidization Technology (L1369)	Laboratory Course	1	1
Technical Applications of Particle Technology (L0955)	Lecture	2	2
Exercises in Fluidization Technology (L1372)	Recitation Section (small)	1	1

Module Responsible	Prof. Stefan Heinrich
Admission Requirements	None
Recommended Previous Knowledge	Knowledge from the module particle technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After completion of the module the students will be able to describe based on examples the assembly of solids engineering processes consisting of multiple apparatuses and subprocesses. They are able to describe the coaction and interrelation of subprocesses.
Skills	Students are able to analyze tasks in the field of solids process engineering and to combine suitable subprocesses in a process chain.
Personal Competence	
Social Competence	Students are able to discuss technical problems in a scientific manner.
Autonomy	Students are able to acquire scientific knowledge independently and discuss technical problems in a scientific manner.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0431: Fluidization Technology

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Stefan Heinrich
Language	EN
Cycle	WiSe
Content	Introduction: definition, fluidization regimes, comparison with other types of gas/solids reactors Typical fluidized bed applications Fluidmechanical principle Local fluid mechanics of gas/solid fluidization Fast fluidization (circulating fluidized bed) Entrainment Solids mixing in fluidized beds Application of fluidized beds to granulation and drying processes
Literature	Kunii, D.; Levenspiel, O.: Fluidization Engineering. Butterworth Heinemann, Boston, 1991.

Course L1369: Practical Course Fluidization Technology	
Typ	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Heinrich
Language	EN
Cycle	WiSe
Content	Experiments: • Determination of the minimum fluidization velocity • heat transfer • granulation • drying
Literature	Kunii, D.; Levenspiel, O.: Fluidization Engineering. Butterworth Heinemann, Boston, 1991.

Course L0955: Technical Applications of Particle Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Werner Sitzmann
Language	DE
Cycle	WiSe
Content	Unit operations like mixing, separation, agglomeration and size reduction are discussed concerning their technical applicability from the perspective of the practician. Machines and apparatuses are presented, their designs and modes of action are explained and their application in production processes for chemicals, food and feed and in recycling processes are illustrated.
Literature	Stieß M: Mechanische Verfahrenstechnik I und II, Springer - Verlag, 1997

Course L1372: Exercises in Fluidization Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Heinrich
Language	EN
Cycle	WiSe
Content	Exercises and calculation examples for the lecture Fluidization Technology
Literature	Kunii, D.; Levenspiel, O.: Fluidization Engineering. Butterworth Heinemann, Boston, 1991.

Module M0904: Process Design Project

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Process Design Project (L1050)	Projection Course	6	6

Module Responsible	Dozenten des SD V
Admission Requirements	none
Recommended Previous Knowledge	• Particle Technology and Solid Process Engineering • Transport Processes • Process- and Plant Design II • Fluid Mechanics for Process Engineering • Chemical Reaction Engineering • Bioprocess- and Biosystems-Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After the students passed the project course successfully they know: • how a team is working together so solve a complex task in process engineering • what kind of tools are necessary to design a process • what kind of drawbacks and difficulties are coming up by designing a process
Skills	After passing the Module successfully the students are able to: • utilize tools for process design for a specific given process engineering task, • choose and connect apparatusses for a complete process, • collecting all relevant data for an economical and ecological evaluation, • optimization of calculation sequence with respect to flowsheet simulation.
Personal Competence	
Social Competence	The students are able to discuss in international teams in english and develop an approach under pressure of time.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice. They are able to organize their own team and to define priorities.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Project
Examination duration and scale	
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory Chemical and Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L1050: Process Design Project

Typ	Projection Course
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	NN
Language	DE
Cycle	WiSe
Content	In the Process Design Project the students have to design in teams an energy or process engineering plant by calculating and designing single plant components. The calculation of costs as well as the process safety is another important aspect of this course. Furthermore the approval procedures have to be taken into account.
Literature	

Module M0802: Membrane Technology

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Membrane Technology (L0399)	Lecture	2	3
Membrane Technology (L0400)	Recitation Section (small)	1	2
Membrane Technology (L0401)	Laboratory Course	1	1

Module Responsible	Prof. Mathias Ernst
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to rank the technical applications of industrially important membrane processes. They will be able to explain the different driving forces behind existing membrane separation processes. Students will be able to name materials used in membrane filtration and their advantages and disadvantages. Students will be able to explain the key differences in the use of membranes in water, other liquid media, gases and in liquid/gas mixtures.
Skills	Students will be able to prepare mathematical equations for material transport in porous and solution-diffusion membranes and calculate key parameters in the membrane separation process. They will be able to handle technical membrane processes using available boundary data and provide recommendations for the sequence of different treatment processes. Through their own experiments, students will be able to classify the separation efficiency, filtration characteristics and application of different membrane materials. Students will be able to characterise the formation of the fouling layer in different waters and apply technical measures to control this.
Personal Competence	
Social Competence	Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions within their group on laboratory experiments to be undertaken jointly and present these to others.
Autonomy	Students will be in a position to solve homework on the topic of membrane technology independently. They will be capable of finding creative solutions to technical questions.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Environmental Engineering: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0399: Membrane Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well. Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis. The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice.
Literature	• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004. • Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands • Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley & Sons, Ltd., 2004

Course L0400: Membrane Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Course work	Students can voluntarily hand in solutions to exercises. They can gather extra points with the handed-in solutions. The students are given more detailed information at the beginning of the course.
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0401: Membrane Technology	
Typ	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Course work	Compulsory report: Students hand in a report about the carried out experiments.
Lecturer	Prof. Mathias Ernst
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1294: Bioenergy

Courses

Title	Typ	Hrs/wk	CP
Biofuels Process Technology (L0061)	Lecture	1	1
Biofuels Process Technology (L0062)	Recitation Section (small)	1	1
Thermal Utilization of Biomass (L1767)	Lecture	2	2
World Market for Agricultural Commodities (L1769)	Lecture	1	1
Sustainable Mobility (L0010)	Lecture	2	1

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to reproduce an in-depth outline of energy production from biomass, aerobic and anaerobic waste treatment processes, the gained products and the treatment of produced emissions.
Skills	Students can apply the learned theoretical knowledge of biomass-based energy systems to explain relationships for different tasks, like dimesioning and design of biomass power plants. In this context, students are also able to solve computational tasks for combustion, gasification and biogas, biodiesel and bioethanol use.
Personal Competence	
Social Competence	Students can participate in discussions to design and evaluate energy systems using biomass as an energy source.
Autonomy	Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy systems independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow.
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

Course L0061: Biofuels Process Technology	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Oliver Lüdtke
Language	DE
Cycle	WiSe

Content	• General introduction
	• What are biofuels?
	• Markets & trends
	• Legal framework
	• Greenhouse gas savings
	• Generations of biofuels
	    ◦ first-generation bioethanol
	        ▪ raw materials
	        ▪ fermentation distillation
	    ◦ biobutanol / ETBE
	    ◦ second-generation bioethanol
	        ▪ bioethanol from straw
	    ◦ first-generation biodiesel
	        ▪ raw materials
	        ▪ Production Process
	        ▪ Biodiesel & Natural Resources
	    ◦ HVO / HEFA
	    ◦ second-generation biodiesel
	        ▪ Biodiesel from Algae
	• Biogas as fuel
	    ◦ the first biogas generation
	        ▪ raw materials
	        ▪ fermentation
	        ▪ purification to biomethane
	    ◦ Biogas second generation and gasification processes
	• Methanol / DME from wood and Tall oil ©

Literature	• Skriptum zur Vorlesung • Drapcho, Nhuan, Walker; Biofuels Engineering Process Technology • Harwardt; Systematic design of separations for processing of biorenewables • Kaltschmitt; Hartmann; Energie aus Biomasse: Grundlagen, Techniken und Verfahren • Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development • VDI Wärmeatlas

Course L0062: Biofuels Process Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Anne Lamp
Language	DE
Cycle	WiSe

Content	• Life Cycle Assessment
	    ◦ Good example for the evaluation of CO2 savings potential by alternative fuels - Choice of system boundaries and databases
	• Bioethanol production
	    ◦ Application task in the basics of thermal separation processes (rectification, extraction) will be discussed. The focus is on a column design, including heat demand, number of stages, reflux ratio ...
	• Biodiesel production
	    ◦ Procedural options for solid / liquid separation, including basic equations for estimating power, energy demand, selectivity and throughput
	• Biomethane production
	    ◦ Chemical reactions that are relevant in the production of biofuels, including equilibria, activation energies, shift reactions

Literature	Skriptum zur Vorlesung

Course L1767: Thermal Utilization of Biomass	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe

Content	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.
	
	The course is structured as follows:
	
	• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course
	• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste
	• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying
	• Thermo-chemical conversion of solid biofuels
	  ◦ Basics of thermo-chemical conversion
	  ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use
	  ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels
	  ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material
	• Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)
	• Bio-chemical conversion of biomass
	  ◦ Basics of bio-chemical conversion
	  ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry
	  ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage

Literature	**Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage**

Course L1769: World Market for Agricultural Commodities	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Thomas Mielke
Language	EN
Cycle	WiSe
Content	1) Markets for Agricultural Commodities What are the major markets and how are markets functioning Recent trends in world production and consumption. World trade is growing fast. Logistics. Bottlenecks. The major countries with surplus production Growing net import requirements, primarily of China, India and many other countries. Tariff and non-tariff market barriers. Government interferences. 2) Closer Analysis of Individual Markets Thomas Mielke will analyze in more detail the global vegetable oil markets, primarily palm oil, soya oil, rapeseed oil, sunflower oil. Also the raw material (the oilseed) as well as the by-product (oilmeal) will be included. The major producers and consumers. Vegetable oils and oilmeals are extracted from the oilseed. The importance of vegetable oils and animal fats will be highlighted, primarily in the food industry in Europe and worldwide. But in the past 15 years there have also been rapidly rising global requirements of oils & fats for non-food purposes, primarily as a feedstock for biodiesel but also in the chemical industry. Importance of oilmeals as an animal feed for the production of livestock and aquaculture Oilseed area, yields per hectare as well as production of oilseeds. Analysis of the major oilseeds worldwide. The focus will be on soybeans, rapeseed, sunflowerseed, groundnuts and cottonseed. Regional differences in productivity. The winners and losers in global agricultural production. 3) Forecasts: Future Global Demand & Production of Vegetable Oils Big challenges in the years ahead: Lack of arable land for the production of oilseeds, grains and other crops. Competition with livestock. Lack of water. What are possible solutions? Need for better education & management, more mechanization, better seed varieties and better inputs to raise yields. The importance of prices and changes in relative prices to solve market imbalances (shortage situations as well as surplus situations). How does it work? Time lags. Rapidly rising population, primarily the number of people considered “middle class” in the years ahead. Higher disposable income will trigger changing diets in favour of vegetable oils and livestock products. Urbanization. Today, food consumption per caput is partly still very low in many developing countries, primarily in Africa, some regions of Asia and in Central America. What changes are to be expected? The myth and the realities of palm oil in the world of today and tomorrow. Labour issues curb production growth: Some examples: 1) Shortage of labour in oil palm plantations in Malaysia. 2) Structural reforms overdue for the agriculture in India, China and other countries to become more productive and successful, thus improving the standard of living of smallholders.
Literature	Lecture material

Course L0010: Sustainable Mobility	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Karsten Wilbrand
Language	DE
Cycle	WiSe
Content	• Global megatrends and future challenges of energy supply • Energy Scenarios to 2060 and importance for the mobility sector • Sustainable air, sea, rail and road traffic • Developments in vehicle and drive technology • Overview of Today's fuels (production and use) • Biofuels of 1 and 2 Generation (availability, production, compatibility) • Natural gas (GTL, CNG, LNG) • Electromobility based on batteries and hydrogen fuel cell • Well-to-Wheel CO2 analysis of the various options • Legal framework for people and freight
Literature	• Eigene Unterlagen • Veröffentlichungen • Fachliteratur

Specialization Energy Engineering

In this specialisation path three Modules must be chosen out of a number of compulsory selective lectures covering a wide spectrum of aspects of Energy Systems with practical professional relevance. Training in this specialisation path is concentrated mainly on electricity generation from conventional and renewable energy sources, encompassing electricity distribution too.

Module M0742: Thermal Engineering

Courses

Title	Typ	Hrs/wk	CP
Thermal Engineering (L0023)	Lecture	3	5
Thermal Engineering (L0024)	Recitation Section (large)	1	1

Module Responsible	Prof. Gerhard Schmitz
Admission Requirements	none
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students know the different energy conversion stages and the difference between efficiency and annual efficiency. They have increased knowledge in heat and mass transfer, especially in regard to buildings and mobile applications. They are familiar with German energy saving code and other technical relevant rules. They know to differ different heating systems in the domestic and industrial area and how to control such heating systems. They are able to model a furnace and to calculate the transient temperatures in a furnace. They have the basic knowledge of emission formations in the flames of small burners and how to conduct the flue gases into the atmosphere. They are able to model thermodynamic systems with object oriented languages.
Skills	Students are able to calculate the heating demand for different heating systems and to choose the suitable components. They are able to calculate a pipeline network and have the ability to perform simple planning tasks, regarding solar energy. They can write Modelica programs and can transfer research knowledge into practice. They are able to perform scientific work in the field of thermal engineering.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0023: Thermal Engineering	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	WiSe
Content	1. Introduction 2. Fundamentals of Thermal Engineering 2.1 Heat Conduction 2.2 Convection 2.3 Radiation 2.4 Heat transition 2.5 Combustion parameters 2.6 Electrical heating 2.7 Water vapor transport 3. Heating Systems 3.1 Warm water heating systems 3.2 Warm water supply 3.3 piping calculation 3.4 boilers, heat pumps, solar collectors 3.5 Air heating systems 3.6 radiative heating systems 4. Thermal traetment systems 4.1 Industrial furnaces 4.2 Melting furnaces 4.3 Drying plants 4.4 Emission control 4.5 Chimney calculation 4.6 Energy measuring 5. Laws and standards 5.1 Buildings 5.2 Industrial plants
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0024: Thermal Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0511: Electricity Generation from Wind and Hydro Power

Courses

Title	Typ	Hrs/wk	CP
Renewable Energy Projects in Emerged Markets (L0014)	Project Seminar	1	1
Hydro Power Use (L0013)	Lecture	1	1
Wind Turbine Plants (L0011)	Lecture	2	3
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1

Module Responsible	Dr. Joachim Gerth
Admission Requirements	none
Recommended Previous Knowledge	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe. Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.
Personal Competence	
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar.
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0014: Renewable Energy Projects in Emerged Markets	
Typ	Project Seminar
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Andreas Wiese
Language	DE
Cycle	SoSe

Content	1. Introduction
	  ◦ Development of renewable energies worldwide
	    ▪ History
	    ▪ Future markets
	  ◦ Special challenges in new markets - Overview
	2. Sample project wind farm Korea
	  ◦ Survey
	  ◦ Technical Description
	  ◦ Project phases and characteristics
	3. Funding and financing instruments for EE projects in new markets
	  ◦ Overview funding opportunitie
	  ◦ Overview countries with feed-in laws
	  ◦ Major funding programs
	4. CDM projects - why, how , examples
	  ◦ Overview CDM process
	  ◦ Examples
	  ◦ Exercise CDM
	5. Rural electrification and hybrid systems - an important future market for EE
	  ◦ Rural Electrification - Introduction
	  ◦ Types of Elektrizifierungsprojekten
	  ◦ The role of the EEInterpretation of hybrid systems
	  ◦ Project example: hybrid system Galapagos Islands
	6. Tendering process for EE projects - examples
	  ◦ South Africa
	  ◦ Brazil
	7. Selected projects from the perspective of a development bank - Wesley Urena Vargas, KfW Development Bank
	  ◦ Geothermal
	  ◦ Wind or CSP
	
	Within the seminar, the various topics are actively discussed and applied to various cases of application.

Literature	Folien der Vorlesung

Course L0013: Hydro Power Use	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Stephan Heimerl
Language	DE
Cycle	SoSe
Content	• Introduction, importance of water power in the national and global context • Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies • Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems • Construction of hydroelectric power plants: description of the individual components and their technical system interaction • Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. • Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection • Hydropower and the Environment • Examples from practice
Literature	• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage • Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage • Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage • von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage • Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering • Physical fundamentals for utilization of wind energy • Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships • Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures • Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection • Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics • Development and planning of offshore wind farms • Operation and optimization of offshore wind farms • Day excursion
Literature	• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage • Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage • Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage • Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage • Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Module M0641: Steam Generators

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Steam Generators (L0213)	Lecture	3	5
Steam Generators (L0214)	Recitation Section (large)	1	1

Module Responsible	Prof. Alfons Kather
Admission Requirements	None
Recommended Previous Knowledge	• "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics" • "Steam Power Plants"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students outline the steam thermodynamics and the technical types of steam generators. They are in a position to describe the basic principles of steam generators and highlight the combustion and fuel supply aspects of fossil-fuelled power plants. They can perform thermal design calculations and conceive the water-steam side, as well as determine the constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these also in the context of related disciplines.
Skills	The students will be able, using detailed knowledge on the calculation, design and construction of steam generators linked with a wide theoretical and methodical foundation, to understand the main design and construction aspects of steam generators. Through problem definition and formulation, modelling of processes and training in the solution methodology for partial problems they obtain a good overview of this key component of the power plant. Within the framework of the exercise the students obtain the ability to draw the balances and dimension the steam generator and its components. For this purpose small but close to reality tasks are solved, to highlight aspects of the design of steam generators.
Personal Competence	
Social Competence	An excursion within the framework of the lecture is planned for those students that are interested. In this come the students in direct contact with the whole subject field of gas and steam generators. Through discussions with the plant personnel they obtain an overview of the daily operation problems and their solution approach.
Autonomy	The students assisted by the tutors will be able to develop alone basic calculations covering partial aspects of the steam generator. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process schemata and boundary conditions highlighted.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory

Course L0213: Steam Generators	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	• Thermodynamics of steam • Basic principles of steam generators • Types of steam generators • Fuels and combustion systems • Coal pulverizers and coal drying • Modes of operation • Thermal analysis and design • Fluid dynamics in steam generators • Design of the water-steam side • Construction • Stress analysis • Feed water for steam generators • Operating behaviour of steam Generators
Literature	• Dolezal, R.:Dampferzeugung. Springer-Verlag, 1985 • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992 • Kakaç, Sadık: Boilers, Evaporators and Condensers. John Wiley & Sons, New York, 1991 • Stultz, S.C. and Kitto, J.B. (Ed.): Steam - its generation and use. 40th edition, The Babcock & Wilcox Company, Barberton, Ohio, USA, 1992

Course L0214: Steam Generators	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1000: Combined Heat and Power and Combustion Technology

Courses

Title	Typ	Hrs/wk	CP
Combined Heat and Power and Combustion Technology (L0216)	Lecture	3	5
Combined Heat and Power and Combustion Technology (L0220)	Recitation Section (large)	1	1

Module Responsible	Prof. Alfons Kather
Admission Requirements	None
Recommended Previous Knowledge	• "Gas-Steam Power Plants" • "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students outline the thermodynamic and chemical fundamentals of combustion processes. From the knowledge of the characteristics and reaction kinetics of various fuels they can describe the behaviour of premixed flames and non-premixed flames, in order to describe the fundamentals of furnace design in gas-, oil- and coal combustion plant. The students are furthermore able to describe the formation of NO_x and the primary NO_x reduction measures, and evaluate the impact of regulations and allowable limit levels. The students present the layout, design and operation of Combined Heat and Power plants and are in a position to compare with each other district heating plants with back-pressure steam turbine or condensing turbine with pressure-controlled extraction tapping, CHP plants with gas turbine or with combined steam and gas turbine, or even district heating plants with an internal combustion engine. They can explain and analyse aspects of combined heat, power and cooling (CCHP) and describe the layout of the key components needed. Through this specialised knowledge they are able to evaluate the ecological significance of district CHP generation, as well as its economics.
Skills	Using thermodynamic calculations and considering the reaction kinetics the students will be able to determine interdisciplinary correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the combustion of gaseous, liquid and solid fuels and determination of the quantities and concentrations of the exhaust gases. In this module the first step toward the utilisation of an energy source (combustion) to provide usable energy (electricity and heat) is taught. An understanding of both procedures enables the students to holistically consider energy utilisation. Examples taken from the praxis, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction. Within the framework of the exercises the students will first learn to calculate the energetic and mass balances of combustion processes. Moreover, the students will gain a deeper understanding of the combustion processes by the calculation of reaction kinetics and fundamentals of burner design. In order to perform further analyses they will familiarise themselves to the specialised software suite EBSILON Professional^{TM}. With this tool small and close to reality tasks are solved on the PC, to highlight aspects of the design and balancing of heating plant cycles. In addition CHP will also be considered in its economic and social contexts.
Personal Competence	
Social Competence	Especially during the exercises the focus is placed on communication with the tutor. This animates the students to reflect on their existing knowledge and ask specific questions for improving further this knowledge level.
Autonomy	The students assisted by the tutors will be able to perform estimating calculations. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process arrangements and boundary conditions are highlighted.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0216: Combined Heat and Power and Combustion Technology	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	In the subject area of "Combined Heat and Power" covers the following themes: • Layout, design and operation of Combined Heat and Power plants • District heating plants with back-pressure steam turbine and condensing turbine with pressure-controlled extraction tapping • District heating plants with gas turbine • District heating plants with combined steam and gas turbine • District heating plants with motor engine • Geothermal power and heat generation • Combined cooling heat and power (CCHP) • Layout of the key components • Regulatory framework and allowable limits • Economic significance and calculation of the profitability of district CHP plant whereas the subject of Combustion Technology includes: 1. Thermodynamic and chemical fundamentals 2. Fuels 3. Reaction kinetics 4. Premixed flames 5. Non-premixed flames 6. Combustion of gaseous fuels 7. Combustion of liquid fuels 8. Combustion of solid fuels 9. Combustion Chamber design 10. NO_x reduction
Literature	Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung": • W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEW Verlag • Kehlhofer, Kunze, Lehmann, Schüller: Handbuch Energie, Band 7, Technischer Verlag Resch • W. Suttor: Praxis Kraft-Wärme-Kopplung, C.F. Müller Verlag • K. W. Schmitz, G. Koch: Kraft-Wärme-Kopplung, VDI Verlag • K.-H. Suttor, W. Suttor: Die KWK Fibel, Resch Verlag und für die Grundlagen der "Verbrennungstechnik": • Warnatz Jürgen, Maas Ulrich, Dibble Robert W.; Technische Verbrennung: hysikalisch-chemische Grundlagen, Modellbildung, Schadstoffentstehung. Berlin [u. a.] : Springer, 2001

Course L0220: Combined Heat and Power and Combustion Technology	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1235: Electrical Power Systems I

Courses

Title	Typ	Hrs/wk	CP
Electrical Power Systems I (L1670)	Lecture	3	4
Electrical Power Systems I (L1671)	Recitation Section (large)	2	2

Module Responsible	Prof. Christian Becker
Admission Requirements	none
Recommended Previous Knowledge	Fundamentals of Electrical Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration of equipment into electric power systems.
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of electric power systems and to assess the results.
Personal Competence	
Social Competence	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.
Autonomy	Students can independently tap knowledge of the emphasis of the lectures.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	90 - 150 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Electrical Engineering: Core qualification: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory Renewable Energies: Core qualification: Compulsory

Course L1670: Electrical Power Systems I	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• on-board electrical power systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• asymmetric failure calculation
	  ◦ symmetric components
	  ◦ calculation of asymmetric failures
	• control in networks and power stations
	• insulation coordination and protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2014 A. J. Schwab: "Elektroenergiesysteme", Springer, 3. Auflage, 2012 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2005

Course L1671: Electrical Power Systems I	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• on-board electrical power systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• asymmetric failure calculation
	  ◦ symmetric components
	  ◦ calculation of asymmetric failures
	• control in networks and power stations
	• insulation coordination and protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2014 A. J. Schwab: "Elektroenergiesysteme", Springer, 3. Auflage, 2012 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2005

Specialization Environmental Engineering

In this specialisation path three Modules must be chosen out of a number of compulsory selective lectures covering a wide spectrum of aspects of Environmental Engineering with practical professional relevance. Training in this specialisation path is concentrated mainly on the environmental protection of soil, water and air. An extensive overview of the various technical solutions in these areas is offered, to prepare the graduates for a successful subsequent entry into the profession of Environmental Engineer.

Module M0830: Environmental Protection and Management

Courses

Title	Typ	Hrs/wk	CP
Integrated Pollution Control (L0502)	Lecture	2	2
Health, Safety and Environmental Management (L0387)	Lecture	2	3
Health, Safety and Environmental Management (L0388)	Recitation Section (small)	1	1

Module Responsible	NN
Admission Requirements	none
Recommended Previous Knowledge	• Good knowledge in Technologies for Environmental Protection (end-of-pipe, integrated solutions) • Good knowledge of the relevant Environmental Legislation • Basic knowledge of instruments for Environmental Assessment
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the basics of regulations, economic instruments, voluntary initiatives, fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements. They can analyse and discuss industrial processes, substance cycles and approaches from end-of-pipe technology to eco-efficiency and eco-effectiveness, showing their sound knowledge of complex industry related problems. They are able to judge environmental issues and to widely consider, apply or carry out innovative technical solutions, remediation measures and further interventions as well as conceptual problem solving approaches in the full range of problems in different industrial sectors.
Skills	Students are able to assess current problems and situations in the field of environmental protection. They can consider the best available techniques and to plan and suggest concrete actions in a company- or branch-specific context. By this means they can solve problems on a technical, administrative and legislative level.
Personal Competence	
Social Competence	The students can work together in international groups.
Autonomy	Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory Environmental Engineering: Core qualification: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0502: Integrated Pollution Control	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	WiSe
Content	The lecture focusses on: • The Regulatory Framework • Pollution & Impacts, Characteristics of Pollutants • Approaches of Integrated Pollution Control • Sevilla Process, Best Available Technologies & BREF Documents • Case Studies: paper industry, cement industry, automotive industry • Field Trip
Literature	**Förstner**, Ulrich (1998): Integrated Pollution Control, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-80313-0 **Shen**, Thomas T. (1999): Industrial Pollution Prevention, Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-65208-3

Course L0387: Health, Safety and Environmental Management	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Hans-Joachim Nau
Language	EN
Cycle	WiSe
Content	• Objectives of and benefit from HSE management • From dilution and end-of-pipe technology to eco-efficiency and eco-effectiveness Behaviour control: regulations, economic instruments and voluntary initiatives • Fundamentals of HSE legislation ISO 14001, EMAS and Responsible Care ISO 14001 requirements Environmental performance evaluation Risk management: hazard, risk and safety Health and safety at the workplace • Crisis management
Literature	C. Stephan: Industrial Health, Safety and Environmental Management, MV-Verlag, Münster, 2007/2012 (can be found in the library under GTG 315) Exercises can be downloaded from StudIP

Course L0388: Health, Safety and Environmental Management	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Hans-Joachim Nau
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0902: Wastewater Treatment and Air Pollution Abatement

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Biological Wastewater Treatment (L0517)	Lecture	2	3
Air Pollution Abatement (L0203)	Lecture	2	3

Module Responsible	Dr. Ernst-Ulrich Hartge
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of biology and chemistry basic knowledge of solids process engineering and separation technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students are able to • name and explain biological processes for waste water treatment, • characterize waste water and sewage sludge • discuss legal regulations in the area of emissions and air quality • classify off gas tretament processes and to define their area of application
Skills	Students are able to • choose and design processs steps for the biological waste water treatment • combine processes for cleaning of off-gases depending on the pollutants contained in the gases
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory Renewable Energies: Specialisation Bio energies: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0517: Biological Wastewater Treatment

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Course work	No compulsory course work.
Lecturer	Dr. Joachim Behrendt
Language	DE/EN
Cycle	WiSe
Content	Charaterisation of Wastewater Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment
Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen

	ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 TUB_HH_Katalog

Course L0203: Air Pollution Abatement	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Ernst-Ulrich Hartge
Language	EN
Cycle	WiSe
Content	In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators.
Literature	Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff. - Amsterdam [u.a.] : Butterworth-Heinemann, 2002 Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson. - Cambridge [u.a.] : Cambridge Univ. Press, 2002 Air pollution control technology handbook, Karl B. Schnelle. - Boca Raton [u.a.] : CRC Press, c 2002 Air pollution, Jeremy Colls. - 2. ed. - London [u.a.] : Spon, 2002

Module M0874: Wastewater Systems

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Wastewater Systems - Collection, Treatment and Reuse (L0934)	Lecture	2	2
Wastewater Systems - Collection, Treatment and Reuse (L0943)	Recitation Section (large)	1	1
Advanced Wastewater Treatment (L0357)	Lecture	2	2
Advanced Wastewater Treatment (L0358)	Recitation Section (large)	1	1

Module Responsible	Prof. Ralf Otterpohl
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of wastewater management and the key processes involved in wastewater treatment.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors.
Skills	Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants.
Personal Competence	
Social Competence	
Autonomy	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory

Course L0934: Wastewater Systems - Collection, Treatment and Reuse

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	•Understanding the global situation with water and wastewater •Regional planning and decentralised systems •Overview on innovative approaches •In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse •Mathematical Modelling of Nitrogen Removal •Exercises with calculations and design
Literature	Henze, Mogens: Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages George Tchobanoglous, Franklin L. Burton, H. David Stensel: Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy McGraw-Hill, 2004 - 1819 pages

Course L0943: Wastewater Systems - Collection, Treatment and Reuse	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf Otterpohl
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0357: Advanced Wastewater Treatment	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Behrendt
Language	DE
Cycle	SoSe
Content	Survey on advanced wastewater treatment reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Course L0358: Advanced Wastewater Treatment	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Joachim Behrendt
Language	DE
Cycle	SoSe
Content	Aggregate organic compounds (sum parameters) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003

Module M0857: Geochemical Engineering

Courses

Title	Typ	Hrs/wk	CP
Contaminated Sites and Landfilling (L0906)	Lecture	2	2
Contaminated Sites and Landfilling (L0907)	Recitation Section (large)	1	2
Geochemical Engineering (L0904)	Lecture	2	2

Module Responsible	Dr. Joachim Gerth
Admission Requirements	none
Recommended Previous Knowledge	Module: General and Inorganic Chemistry, Module:Organic Chemistry, Biology (Basic Knowledge)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module students acquire profound knowledge of biogeochemical processes, the fate of pollutants in soil and groundwater, and techniques to deposit contaminated waste material. They are able to describe in principle the behaviour of chemicals in the environment. Students can explain and report the approach to remediate contaminated sites.
Skills	With the completion of this module students can apply the acquired theoretical knowledge to model cases of site pollution and critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation strategies and techniques. Model projects can be devised and treated.
Personal Competence	
Social Competence	Students can discuss technical and scientific tasks within a seminar subject specific and interdisciplinary .
Autonomy	Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	2 hours
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory Environmental Engineering: Core qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0906: Contaminated Sites and Landfilling

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth, Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects. The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare.
Literature	1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Natural attenuation of fuels and chlorinated solvents in the subsurface.** Todd H. Wiedemeier(Ed.), ISBN: 0471197491 Lesesaal 2: US - Umweltschutz, Signatur USH-844

Course L0907: Contaminated Sites and Landfilling	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Joachim Gerth, Dr. Marco Ritzkowski
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0904: Geochemical Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth
Language	EN
Cycle	SoSe
Content	As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment.
Literature	**Geochemistry, groundwater and pollution.** C. A. J. Appelo; D. Postma Leiden [u.a.] Balkema 2005 Lehrbuchsammlung der TUB, Signatur GWC-515

Module M0519: Particle Technology and Solid Matter Process Technology

Courses

Title	Typ	Hrs/wk	CP
Advanced Particle Technology II (L0050)	Lecture	2	2
Advanced Particle Technology II (L0051)	Recitation Section (small)	1	1
Experimental Course Particle Technology (L0430)	Laboratory Course	3	3

Module Responsible	Prof. Stefan Heinrich
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of solids processes and particle technology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After completion of the module the students will be able to describe and explain processes for solids processing in detail based on microprocesses on the particle level.
Skills	Students are able to choose process steps and apparatuses for the focused treatment of solids depending on the specific characteristics. They furthermore are able to adapt these processes and to simulate them.
Personal Competence	
Social Competence	Students are able to present results from small teamwork projects in an oral presentation and to discuss their knowledge with scientific researchers.
Autonomy	Students are able to analyze and solve problems regarding solid particles independently or in small groups.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L0050: Advanced Particle Technology II

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Stefan Heinrich
Language	DE
Cycle	WiSe
Content	• Exercise in form of "Project based Learning" • Agglomeration, particle size enlargement • advanced particle size reduction • Advanced theorie of fluid/particle flows • CFD-methods for the simulation of disperse fluid/solid flows, Euler/Euler methids, Descrete Particle Modeling • Treatment of simulation problems with distributed properties, solution of population balances
Literature	Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990. Stieß, M.: Mechanische Verfahrenstechnik I und II. Springer Verlag, Berlin, 1992.

Course L0051: Advanced Particle Technology II

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Course work	A problem-based learning task is set at the beginning over the semester in StudIP. The students can work on the task during the semester under supervision of a tutor. Presenting their results with a poster, they can gain 5-10 extra points for the exam (100 points in total).
Lecturer	Prof. Stefan Heinrich
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0430: Experimental Course Particle Technology	
Typ	Laboratory Course
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Course work	Compulsory report: The students have to write five reports (one report for each experiment) with 5 to 10 pages.
Lecturer	Prof. Stefan Heinrich
Language	DE
Cycle	WiSe
Content	• Fluidization • Agglomeration • Granulation • Drying • Determination of mechanical properties of agglomerats
Literature	Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990. Stieß, M.: Mechanische Verfahrenstechnik I und II. Springer Verlag, Berlin, 1992.

Module M0619: Waste Treatment Technologies

Courses

Title	Typ	Hrs/wk	CP
Waste and Environmental Chemistry (L0328)	Laboratory Course	2	2
Biological Waste Treatment (L0318)	Problem-based Learning	3	4

Module Responsible	Prof. Kerstin Kuchta
Admission Requirements	none
Recommended Previous Knowledge	chemical and biological basics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics.
Skills	The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group.
Personal Competence	
Social Competence	Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism.
Autonomy	Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Project
Examination duration and scale	Elaboration and presentation (15-25 minutes in groups), successful participation at Praktikum
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory Environmental Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Course L0328: Waste and Environmental Chemistry	
Typ	Laboratory Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Kerstin Kuchta
Language	DE/EN
Cycle	WiSe
Content	The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS Chalorific value
Literature	Scripte

Course L0318: Biological Waste Treatment	
Typ	Problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Kerstin Kuchta
Language	EN
Cycle	WiSe
Content	1. Introduction 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 8. Plant design practical phase
Literature	

Thesis

Module M-002: Master Thesis

Courses			
Title	Typ	Hrs/wk	CP

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §24 (1): At least 78 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. • The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them. • The students can place a research task in their subject area in its context and describe and critically assess the state of research.
Skills	The students are able: • To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. • To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way. • To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can • Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. • Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able: • To structure a project of their own in work packages and to work them off accordingly. • To work their way in depth into a largely unknown subject and to access the information required for them to do so. • To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Examination	according to Subject Specific Regulations
Examination duration and scale	see FSPO
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy and Environmental Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computational Science and Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory

	Ship and Offshore Technology: Thesis: Compulsory
	Theoretical Mechanical Engineering: Thesis: Compulsory
	Process Engineering: Thesis: Compulsory
	Water and Environmental Engineering: Thesis: Compulsory