ENTECH (M.Sc.)

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Studienplan der Fakultät Maschinenbau für den Master of Science Studiengang ENTECH (Energy Technologies)

Fassung vom 04.06.2014

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Änderungshistorie	
Redaktionelle Änderungen vom 25.06.2014	Änderungen im Abschnitt 1.2: • in den Schwerpunkten 1 und 2 sind keine schriftlichen Prüfungen vorgesehen. • im Modul „Interdisziplinäres Projekt“ wird die Erfolgskontrolle mit „bestanden“ bzw. „nicht bestanden“ bewertet.

0 Abkürzungsverzeichnis

Fakultäten:	mach	Fakultät für Maschinenbau
	etit	Fakultät für Elektrotechnik und Informationstechnik
	ciw	Fakultät für Chemieingenieurwesen und Verfahrenstechnik
	wiwi	Fakultät für Wirtschaftsingenieurwesen
	baugeo	Fakultät für Bauingenieur-, Geo- und Umweltwissenschaften
	arch	Fakultät für Architektur
Semester:	WS	Wintersemester
	SS	Sommersemester
Leistungen:	LP	Leistungspunkte
	mPr	mündliche Prüfung
	sPr	schriftliche Prüfung
	Gew	Gewichtung einer Prüfungsleistung im Modul bzw. in der Gesamtnote

In diesem Studienplan ist nur die weibliche Sprachform gewählt worden. Alle personenbezogenen Aussagen gelten jedoch stets für Frauen und Männer gleichermaßen.

1 Studienpläne, Module und Prüfungen

Die Angabe der Leistungspunkte (LP) erfolgt gemäß dem „European Credit Transfer and Accumulation System" (ECTS) und basiert auf dem von den Studierenden zu absolvierenden Arbeitspensum.

1.1 Prüfungsmodalitäten

In jedem Semester sind für schriftliche Prüfungen mindestens ein Prüfungstermin und für mündliche Prüfungen mindestens zwei Termine anzubieten. Prüfungstermine sowie Termine, zu denen die Meldung zu den Prüfungen spätestens erfolgen muss, werden von der Prüfungskommission festgelegt. Die Meldung für die Modul- und Modulteilprüfungen erfolgt in der Regel mindestens eine Woche vor der Prüfung. Melde- und Prüfungstermine werden rechtzeitig durch Anschlag bekanntgegeben, bei schriftlichen Prüfungen mindestens 6 Wochen vor der Prüfung.
Über Hilfsmittel, die bei einer Prüfung benutzt werden dürfen, entscheidet die Prüferin. Eine Liste der zugelassenen Hilfsmittel ist gleichzeitig mit der Ankündigung des Prüfungstermins bekanntzugeben.
Für die Erfolgskontrollen in den Schwerpunkt-Modulen gelten folgende Regeln:
Die Modul- und Modulteilprüfungen sind mündlich abzunehmen.
Die Prüfung im Kernbereich eines Schwerpunkts ist an einem einzigen Termin anzulegen. Erfolgskontrollen im Ergänzungsbereich können separat erfolgen. Bei mündlichen Prüfungen in Schwerpunkten bzw. Schwerpunkt-Teilmodulen soll die Prüfungsdauer 5 Minuten pro Leistungspunkt betragen. Erstreckt sich eine mündliche Prüfung über mehr als 12 LP soll die Prüfungsdauer 60 Minuten betragen.

1.2 Masterstudium mit Modulen

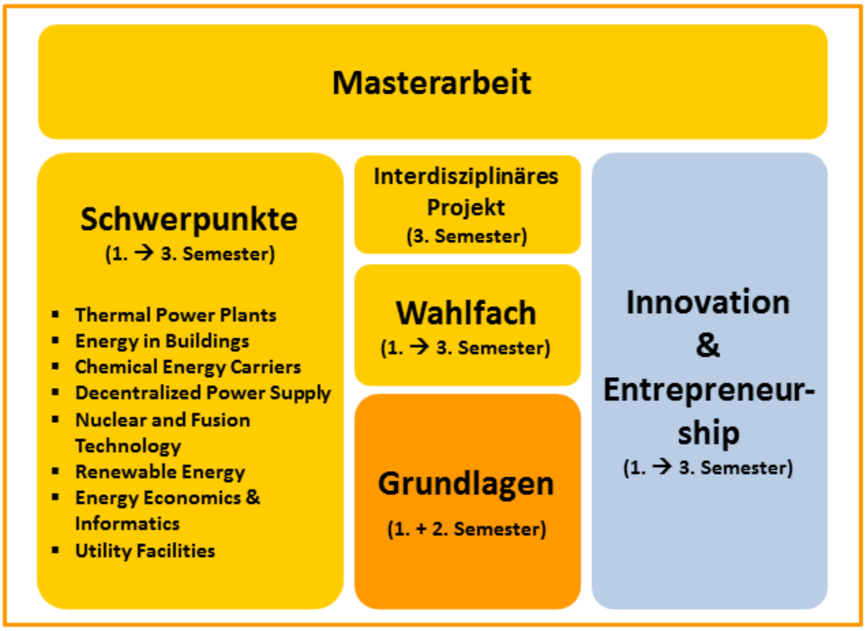
Das Masterstudium kann nur zum Wintersemester aufgenommen werden. Da sich die Wahl der zu belegenden Module bzw. Lehrveranstaltungen nach den individuellen Voraussetzungen richtet, kann kein allgemeingültiger Studienplan angegeben werden. Schriftliche Prüfungen werden als Klausuren mit der angegebenen Prüfungsdauer in Stunden abgenommen. Benotete Erfolgskontrollen gehen mit dem angegebenen Gewicht (Gew) in die Gesamtnote ein.
Folgende Module sind im Masterstudiengang zu belegen:

Module		Veranstaltung	LP	Erfolgs-kontrolle	Gew.
1.	Grundlagen	siehe Kapitel 2.1	17	sPr/mPr	17
2.	Innovation und Entrepreneurship	siehe Kapitel 2.2	20	sPr/mPr	20
3.	Interdisziplinäres Projekt	siehe Kapitel 2.3	6	Schein	6
4.	Schwerpunkt 1	siehe Kapitel 2.5	16	mPr	16
5.	Schwerpunkt 2	siehe Kapitel 2.5	16	mPr	16
6.	Wahlfach	siehe Kapitel 2.4	15	sPr/mPr	15

Im Modul Interdisziplinäres Projekt wird die Erfolgskontrolle anderer Art („Schein“) mit „bestanden“ bzw. „nicht bestanden“ bewertet.

Im Anschluss an die Modulprüfungen ist eine Masterarbeit (30 LP) zu erstellen.

Der Aufbau des Studiengangs ist in folgender Grafik dargestellt.



1.3 Persönlicher Studienplan

Jede Studierende muss bis zum 30. November nach Studienantritt einen Persönlichen Studienplan erarbeiten, diesen mit den verantwortlichen Vertretern abstimmen und von diesen unterzeichnen zu lassen. Die zuständigen Vertreter sind

- für die Grundlagen, das Interdisziplinäre Projekt und das Wahlfach die Vorsitzende des Prüfungsausschusses
- für die Schwerpunkte: Die Schwerpunktverantwortlichen, wie in 2.5. genannt
- für den Bereich Innovation & Entrepreneurship die Modulverantwortliche

Der vollständige Persönliche Studienplan muss von der Studierenden verwahrt werden und ist in Kopie dem Vorsitzenden des Prüfungsausschusses zu übermitteln. Der vollständige Persönliche Studienplan wird durch die Studierende anschließend im Studierendenservice eingereicht. Der Persönliche Studienplan muss von der Studentin zum Universitätswechsel der jeweiligen Partneruniversität zugänglich gemacht werden, ebenso wie ein aktuelles Transcript of Records. Er ist verbindliche Grundlage für das Masterstudium und die Anrechnung der absolvierten Veranstaltungen. Eine Änderung des Persönlichen Studienplans bedarf der Rücksprache mit der verantwortlichen Vertreterin und der schriftlichen Kenntnisgabe an den Studierendenservice.

2 Zugelassene Module und Teilmodule

Jedes Modul bzw. Teilmodul kann nur einmal im Rahmen des konsekutiven Masterstudiengangs ENTECH gewählt werden. Die einzelnen Lehrveranstaltungen sind dem Modulhandbuch zu entnehmen.

2.1 Modul: Grundlagen

Bachelorabsolventinnen des Maschinenbaus, der Elektrotechnik oder des Chemieingenieurwesens müssen auf sie zugeschnittene Lehrveranstaltungen belegen. Für Absolventinnen einer anderen Fachrichtung erfolgt die Belegung nach Absprache und Genehmigung durch den Prüfungsausschuss.

Absolventinnen aus dem Bereich **Chemieingenieurswesen** müssen die Lehrveranstaltungen

- Electric Power Generation and Power Grid (3 LP)
- Power Electronics (3 LP)
- Machines and Processes (7 LP)
- Electrical Machines (4 LP)

verpflichtend belegen.

Absolventinnen aus dem Bereich **Elektrotechnik** müssen die Lehrveranstaltungen

- Engineering Thermodynamics and Heat Transfer I (7 LP)
- Engineering Mechanics I (6 LP)
- Mechanical Design I (4 LP)

verpflichtend belegen.

Absolventinnen aus dem Bereich **Maschinenbau** müssen die Lehrveranstaltungen

- Heat Transfer (3 LP)
- Electric Power Generation and Power Grid (3 LP)
- Power Electronics (3 LP)
- Mass Transfer and reaction kinetics (4 LP)
- Electrical Machines (4 LP)

verpflichtend belegen.

2.2 Modul: Innovation und Entrepreneurship

Aus den Lehrveranstaltungen zum Modul „Innovation und Entrepreneurship“ müssen mindestens 20 LP erbracht werden. Die Vermittlung von Schlüsselqualifikationen im Umfang von 6 LP findet im Rahmen dieser Lehrveranstaltungen statt. Es dürfen in dem Modul maximal 25 LP erworben werden. In jedem Fall werden bei der Festlegung der Modulnote alle Teilmodulnoten gemäß ihrer Leistungspunkte gewichtet. Bei der Bildung der Gesamtnote wird das Modul mit 20 LP gewertet.

2.3 Modul: Interdisziplinäres Projekt

Jede Studierende muss eines der angebotenen Projekte (siehe Modulhandbuch) belegen.

2.4 Modul: Wahlfach

Im Modul Wahlfach sind aus der Gesamtheit der Module „Grundlagen“ und „Schwerpunkte" Lehrveranstaltungen im Umfang von mindestens 15 LP zu belegen (siehe Modulhandbuch).

2.5 Modul: Schwerpunkt 1 und Schwerpunkt 2

Folgende Schwerpunkte sind derzeit vom Fakultätsrat für den Masterstudiengang genehmigt:

	Schwerpunkte	Verantwortlicher/ Fakultät
1	Thermal Power Plants (TPP)	Bauer (mach)
2	Chemical Energy Carriers (CEC)	Kolb (ciw)
3	Decentralized Power Supply and Grid Integration (DPS)	Leibfried (etit)
4	Energy in Buildings (EB)	Wagner (arch)
5	Nuclear and Fusion Technology (NT)	Schulenberg (iket)
6	Energy Economics and Informatics (EEI)	Fichtner (wiwi)
7	Renewable Energy and Energy Storage (RES)	Schilling (baugeo)
8	Utility Facilities (UF)	Zarzalis (ciw)

In jedem Schwerpunkt müssen Erfolgskontrollen mit mindestens 16 LP erfolgreich absolviert werden. Jeder Schwerpunkt besteht aus einem Kern- und Ergänzungsbereich. Aus dem Kernbereich müssen Lehrveranstaltungen im Umfang von mindestens 8 LP gewählt werden. Die übrigen Leistungspunkte können aus dem Ergänzungsbereich kommen. Die Bildung der Schwerpunktnote erfolgt dann anhand der mit einer Benotung abgeschlossenen Teilmodule.
Es dürfen in jedem Schwerpunkt maximal 20 LP erworben werden. In jedem Fall werden bei der Festlegung der Schwerpunktnote alle Teilmodulnoten gemäß ihrer Leistungspunkte gewichtet. Bei der Bildung der Gesamtnote wird jeder Schwerpunkt mit 16 LP gewertet.
Die Beschreibung der Schwerpunkte hinsichtlich der jeweils darin enthaltenen Lehrveranstaltungen, sowie Einteilung in Kern- und Ergänzungsbereich sind dem aktuellen Modulhandbuch des Masterstudiengangs zu entnehmen.

Für die Schwerpunkte werden Vorkenntnisse vorausgesetzt. Hierbei sind die folgenden Teilmodule je nach gewählten Schwerpunkten Pflicht, sofern sie noch nicht als andere Teilmodulprüfungen belegt wurden oder im Rahmen des Bachelorstudiums belegt wurden.

LV	ECTS	TPP	CEC	DPS	EB	NT	EEI	RES	UF
Heat Transfer	**3**	x			x	x		x	
Fluid Dynamics	**3**	x	x	x	x	x	x	x	x
Machines and Processes	**7**	x	x	x	x	x	x	x	x
Mass Transfer and reaction kinetics	**4**		x						x

X = Kurse die für einen Schwerpunkt verpflichtend zu belegen sind.

3 Masterarbeit

Für die Betreuung der Masterarbeit stehen folgende Institute zur Wahl:

Institut	Abk.	Fakultät/Bereich
Institut Entwerfen und Bautechnik (IEB)	IEB	Architektur
Institut für Angewandte Geowissenschaften (AGW)	AGW	Bauingenieur-, Geo- und Umweltwissenschaften
Institut für Technologie und Management im Baubetrieb (TMB)	TMB	Bauingenieur-, Geo- und Umweltwissenschaften
Institut für Kern- und Energietechnik	IKET	Bereich 3
Institut für Neutronenphysik und Reaktortechnik	INR	Bereich 3
Institut für Nukleare Entsorgung	INE	Bereich 3
Institut für Technische Physik	ITEP	Bereich 3
Institut für Katalyseforschung und –Technologie	IKFT	Bereich 4
Institut für Anorganische Chemie	AOC	Chemie und Biowissenschaften
Engler-Bunte-Institut, Bereich Chemische Energieträger- und Brennstofftechnologie	EBI-CEB	Chemieingenieurwesen und Verfahrenstechnik
Engler-Bunte-Institut, Bereich Verbrennungstechnik	EBI-VBT	Chemieingenieurwesen und Verfahrenstechnik
Institut für Elektroenergiesysteme und Hochspannungstechnik	IEH	Elektrotechnik und Informationstechnik
Lichttechnisches Institut	LTI	Elektrotechnik und Informationstechnik
Fachgebiet für Strömungsmaschinen	FSM	Maschinenbau
Institut für Angewandte Informatik / Automatisierungstechnik	AIA	Maschinenbau
Institut für Angewandte Materialien – Werkstoffkunde	IAM-WK	Maschinenbau
Institut für Angewandte Materialien - Zuverlässigkeit von Bauteilen und Systemen	IAM-ZBS	Maschinenbau
Institut für Arbeitswissenschaft und Betriebsorganisation	IFAB	Maschinenbau
Institut für Fahrzeugsystemtechnik	FAST	Maschinenbau
Institut für Fusionstechnologie und Reaktorsicherheit	IFRT	Maschinenbau
Institut für Kolbenmaschinen	IFKM	Maschinenbau
Institut für Mess- und Regelungstechnik	MRT	Maschinenbau
Institut für Mikrostrukturtechnik	IMT	Maschinenbau

Institut	**Abk.**	**Fakultät/Bereich**
Institut für Produktentwicklung	IPEK	Maschinenbau
Institut für Strömungslehre	ISL	Maschinenbau
Institut für Technische Mechanik	ITM	Maschinenbau
Institut für Technische Thermodynamik	ITT	Maschinenbau
Institut für Thermische Strömungsmaschinen	ITS	Maschinenbau
Institut für Angewandte und Numerische Mathematik	IANM	Mathematik
Institut für Angewandte Informatik und formale Beschreibungsverfahren (AIFB)	AIFB	Wirtschaftswissenschaften
Institut für Entrepreneurship, Technologiemanagement und Innovation	EnTechnon	Wirtschaftswissenschaften
Institut für Industriebetriebslehre und Industrielle Produktion	IIP	Wirtschaftswissenschaften

Mit Zustimmung der Schwerpunktsverantwortlichen kann die Prüfungskommission auch Masterarbeiten an anderen Instituten die am Masterstudiengang beteiligt sind genehmigen. Zustimmung und Genehmigung sind vor Beginn der Arbeit einzuholen.

2 Module Handbook - a helpful guide throughout the studies

The programme exists of several **subjects** (e.g. business administration, economics, operations research). Every subject is split into **modules** and every module itself exists of one or more interrelated **courses**. The extent of every module is indicated by credit points (CP), which will be credited after the successful completion of the module. Some of the modules are **obligatory**. According to the interdisciplinary character of the programme, a great variety of **individual specialization and deepening possibilities** exists for a large number of modules. This enables the student to customize content and time schedule of the programme according to personal needs, interest and job perspective. The **module handbook** describes the modules belonging to the programme. It describes:

- the structure of the modules
- the extent (in CP),
- the dependencies of the modules,
- the learning outcomes,
- the assessment and examinations.

The module hanbook serves as a necessary orientation and as a helpful guide throughout the studies. The module handbook does not replace the **course catalogue**, which provides important information concerning each semester and variable course details (e.g. time and location of the course).

Begin and completion of a module

Every module and every course is allowed to be credited only once. The decision whether the course is assigned to one module or the other (e.g. if a course is selectable in two or more modules) is made by the student at the time of signing in for the corresponding exam. The module is **succeeded**, if the general exam of the module and/or if all of its relevant partial exams have been passed (grade min 4.0). In order to that the minimum requirement of credits of this module have been met.

General exams and partial exams

The module exam can be taken in a general exam or several partial exams. If the module exam is offered as a **general exam**, the entire content of the module will be reviewed in a single exam. If the module exam exists of **partial exams**, the content of each course will be reviewed in corresponding partial exams. The registration for the examinations takes place online via the self-service function for students. The following functions can be accessed on https://studium.kit.edu/meinsemester/Seiten/pruefungsanmeldung.aspx:

- Sign in and sign off exams
- Retrieve examination results
- Print transcript of records

For further and more detailed information also see https://zvwgate.zvw.uni-karlsruhe.de/download/leitfaden_studierende.pdf

Repeating exams

Principally, a failed exam can repeated only once. If the **repeat examination** (including an eventually provided verbal repeat examination) will be failed as well, the **examination claim** is lost. Requests for a second repetition of an exam require the approval of the examination committee. A request for a second repetition has to be made without delay after loosing the examination claim. A counseling interview is mandatory. For further information see http://www.wiwi.kit.edu/serviceHinweise.php.

Bonus accomplishments and additional accomplishments

Bonus accomplishments can be achieved on the basis of entire modules or within modules, if there are alternatives at choice. Bonus accomplishments can improve the module grade and overall grade by taking into account only the best possible combination of all courses when calculating the grades. The student has to declare a Bonus accomplishment as such at the time of registration for the exams. Exams, which have been registered as Bonus accomplishments, are subject to examination regulations. Therefore, a failed exam has to be repeated. Failing the repeat examination implies the loss of the examination claim.
Additional accomplishments are voluntarily taken exams, which have no impact on the overall grade of the student and can take place on the level of single courses or on entire modules. It is also mandatory to declare an additional accomplishment as such at the time of registration for an exam. Up to 2 modules with a minimum of 9 CP may appear additionally in the certificate. After the approval of the examination committee, it is also possible to include modules in the certificate, which are not defined in the module handbook. Single additional courses will be recorded in the transcript of records. Courses and modules, which have been declared as bonus accomplishments, can be changed to additional accomplishments.

Further information

More detailed information about the legal and general conditions of the programme can be found in the examination regulation of the programme (in the appendix).

Used abbreviations

LP/CP	Credit Points/ECTS	Leistungspunkte/ECTS
LV	course	Lehrveranstaltung
RÜ	computing lab	Rechnerübung
S	summer term	Sommersemester
Sem.	semester/term	Semester
ER/SPO	examination regulations	Studien- und Prüfungsordnung
KS/SQ	key skills	Schlüsselqualifikationen
SWS	contact hour	Semesterwochenstunde
Ü	excercise course	Übung
V	lecture	Vorlesung
W	winter term	Wintersemester

3 Learning Outcomes

Learning Outcomes (M.Sc., ENTECH, KIT), 10/01/2018

Graduates of the ENTECH master's program at KIT are able to contribute independently to value-creation processes in the field of energy technology. Their research-oriented education qualifies them for positions associated with high levels of responsibility in industry, technical services, as well as in academic environments. Simultaneously they acquire the qualification for participating in a doctorate program.

Graduates gain broad interdisciplinary knowledge in the fields of mechanical, chemical and electrical engineering. This interdisciplinarity is guaranteed through the mandatory modules "basics" ME, CE, and EE, in which students acquire qualifications of the two other engineering fields in addition to the qualifications of their own bachelor's program.

In the module Innovation/Entrepreneurship, the focus of the master's program is put on creativity, problem solving and team building in an international environment. Within this module, students experience the innovation process through practical examples in collaboration with a variety of industry partners - from start-up companies to global players, along with fellow students. These exercises enable them to seize business opportunities either within a company or by starting-up their own business. Students are qualified to make well-grounded decisions considering social, economic and ethic conditions.

Within the Innovative Project students work on a specific task to practice the acquired multidisciplinary qualifications as a whole. The project is defined by an industry partner or a central organizational unit with respect to competitive, economical and technical aspects.

In the specialization field, which consists of two major fields and associated elective courses, graduates gain the necessary knowledge to transfer the general basic knowledge to specific problems of energy technologies. The major fields include: Thermal Power Plants, Chemical Energy Carriers, Decentralized Power Supply and Grid Integration, Energy in Buildings, Nuclear and Fusion Technology, Energy Economics and Informatics, Renewable Energy and Energy Storage as well as Utility Facilities. They are able to deal with the current state of research and to develop further methods. They can design, evaluate and interpret comprehensive and, if necessary, interdisciplinary simulation studies. They are able to develop energy technology products from their understanding of market requirements and value-added processes. To optimize their own approaches, the graduates have learned to reconsider the methods they use and the actions they undertake and adapt them to changing conditions.

The master's program ENTECH is a double degree program in cooperation with the partner universities IST Lisbon, Uppsala University and INP Grenoble. The course language is English. The subjects of the first study year, which is completed either at KIT or IST Lisbon, are mainly basic subjects as well as the module Innovation/Entrepreneurship. The second study year of the master's program is focused on the technical major fields and their application. These studies take place at a second of the four mentioned partner universities. As a double master's degree students complete a minimum of 60 ECTS at each of the two partner universities and get certificates of the master's degree of the participating partner universities. At KIT the M.Sc. Energy Technologies (ENTECH) is awarded. A unique addition is the Open Space Studio Journey (OSS) for ENTECH, a 24month personal development program in cooperation with InnoEnergy. The program has an additional international orientation by bringing together students of all current intakes of the partner universities in the form of common events of the Innoenergy Masterschool and the OSS. This systematically fosters an early establishment of a personal network. As a unique characteristic, the program ENTECH is interdisciplinary by combining expertise in Mechanical Engineering, Chemical Engineering and Electrical Engineering.

4 Actual Changes

Important changes are pointed out in this section in order to provide a better orientation. Although this process was done with great care, other/minor changes may exist.

2581998 - Basics of Liberalised Energy Markets (S. 43)

Anmerkungen

The course "Basics of Liberalised Energy Markets" [2581998] will be reduced to 3 credits in winter term 2015/2016 and the tutorial [2581999] is no longer offered.

22601 - Chemical Technology of Water (S. 50)

Anmerkungen

The course will not be offered any more from winter term 2014/2015 on. The examination will be offered latest until summer term 2017 (repeaters only).

5 Modules

5.1 All modules

Module: BASICS CE [CE]

Coordination: A. Class
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
17	Every term	2

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
23399	Electric Power Generation and Power Grid (p. 56)	2	W	3	B. Hoferer
23385	Power Electronics (p. 90)	2	W	3	T. Leibfried, A. Kloenne
3134140	Machines and Processes (p. 76)	4	S	7	H. Kubach, H. Bauer, U. Maas, B. Pritz
2306315	Electrical Machines (p. 58)	2	S	4	M. Doppelbauer

Learning Control / Examinations
oral or written exam, graded, duration depends on the lecture

Conditions
For students with a Bachelor‘s degree in Chemical Engineering the courses listed above are obligatory.

Qualification Goals
After completing the module the students are able to:

- understand the basic processes of mechanical and electrical energy conversion
- understand the basic processes of the generation of rotating magnetic fields
- describe the operating principles and characteristics of asynchronous and synchronous electrical machines
- name and describe basic energy conversion processes and energy converting machines
- understand the mechanisms of losses and energy efficiency of electric machines
- explain the application of these energy conversion processes in various machines
- analyze and evaluate the processes and machines in terms of functionality and efficiency
- solve basic technical problems in terms of operating the machines
- know the physical basics of electrical engineering (electrical field, magnetic field, resistor, capacitor, inductor).

Furthermore these basic courses enable the students to speak a common language, which is an important prerequisite in the field of energy technologies, which has a pronounced interdisciplinary character.

Content
The basic courses will form the foundation for a solid knowledge required for the main subjects and specializations in ENTECH. The harmonization of the students' knowledge in the different fundamentals of energy engineering is important. This is done by a modular structure of classes. Bachelors with a background in mechanical engineering will deepen their knowledge in subjects like electrical machines or power electronics, electrical engineers will attend courses in thermodynamics or fluid mechanics, and chemical engineers will attend lectures like "Power Electronics" or "Machines and Processes".
These basic courses will assure, that independent of the prior knowledge acquired during the BSc studies, all graduates of the Master programme will have acquired a fundamental knowledge in mechanical design, thermodynamics, electric power generation, electrical machines, thermal engines, power electronics, heat transfer and fluid mechanics, which constitute the fundamentals for energy engineering.

Module: BASICS EE [EE]

Coordination: A. Class
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
17	Every term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
3165014	Technical Thermodynamics and Heat Transfer I (p. 103)	3	W	7	U. Maas, R. Schießl
3161010	Engineering Mechanics I (p. 102)	5	W	6	T. Langhoff, T. Böhlke
2145186	Mechanical Design I (p. 79)	4	W	4	A. Albers, N. Burkardt

Learning Control / Examinations
oral or written exam, graded, duration depends on the lecture

Conditions
For students with a Bachelor's degree in Electrical Engineering the courses listed above are obligatory.

Qualification Goals
The students are able to:

- analyze the function of unknown machine elements
- use the interpretation and dimensioning guidelines according the common standardization regulations
- identify technical problems and to work out and evaluate systematic solutions
- illustrate problem solving's in technical drawings and cad models according to the common standardization regulations
- synthesize the design steps of product engineering by means of a complex technical system
- solve basic problems in statics indipendently
- understand the basic elements of statics
- acquire the competency to master the fundamentals of thermodynamics and the ability to apply the knowledge and problem-solving in various branches of mechanical engineering and especially in the Energy Technology sector.

Furthermore these basic courses enable the students to speak a common language, which is an important prerequisite in the field of energy technologies, which has a pronounced interdisciplinary character.

Content
The basic courses will form the foundation for a solid knowledge required for the main subjects and specializations in ENTECH. The harmonization of the students' knowledge in the different fundamentals of energy engineering is important. This is done by a modular structure of classes. Bachelors with a background in mechanical engineering will deepen their knowledge in subjects like electrical machines or power electronics, electrical engineers will attend courses in thermodynamics or fluid mechanics, and chemical engineers will attend lectures like "Power Electronics" or "Machines and Processes".
These basic courses will assure, that independent of the prior knowledge acquired during the BSc studies, all graduates of the Master programme will have acquired a fundamental knowledge in mechanical design, thermodynamics, electric power generation, electrical machines, thermal engines, power electronics, heat transfer and fluid mechanics, which constitute the fundamentals for energy engineering.

Module: BASICS ME [ME]

Coordination: A. Class
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
17	Every term	2

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22568	Heat Transfer (p. 69)	2	S	3	N. Zarzalis
23399	Electric Power Generation and Power Grid (p. 56)	2	W	3	B. Hoferer
23385	Power Electronics (p. 90)	2	W	3	T. Leibfried, A. Kloenne
22534	Mass Transfer and Reaction Kinetics (p. 81)	2	S	4	N. Zarzalis
2306315	Electrical Machines (p. 58)	2	S	4	M. Doppelbauer

Learning Control / Examinations
oral or written exam, graded, duration depends on the lecture

Conditions
For students with a Bachelor‘s degree in Mechanical Engineering the courses listed above are obligatory.

Qualification Goals
Alfter completing the module, the students have theoretical fundamentals and solid understanding of electrical power engineering. Furthermore they understand and master the analogy between momentum and energy transport. The students can analyse new problems with the aid of the acquired methods.
Furthermore these basic courses enable the students to speak a common language, which is an important prerequisite in the field of energy technologies, which has a pronounced interdisciplinary character.

Content
The basic courses will form the foundation for a solid knowledge required for the main subjects and specializations in ENTECH. The harmonization of the students’ knowledge in the different fundamentals of energy engineering is important. This is done by a modular structure of classes. Bachelors with a background in mechanical engineering will deepen their knowledge in subjects like electrical machines or power electronics, electrical engineers will attend courses in thermodynamics or fluid mechanics, and chemical engineers will attend lectures like “Power Electronics” or “Machines and Processes”.
These basic courses will assure, that independent of the prior knowledge acquired during the BSc studies, all graduates of the Master programme will have acquired a fundamental knowledge in mechanical design, thermodynamics, electric power generation, electrical machines, thermal engines, power electronics, heat transfer and fluid mechanics, which constitute the fundamentals for energy engineering.

Module: Innovation/Entrepreneurship [INNO]

Coordination: O. Terzidis
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
20		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2581012	Renewable Energy – Resources, Technology and Economics (p. 96)	2/0	W	4	R. McKenna
2545001	Entrepreneurship (p. 63)	2	W/S	3	O. Terzidis
23684	Project Management for Engineers (p. 92)	2	S	3	M. Noe
2540464	eEnergy: Markets, Services, Systems (p. 54)	2/1	S	4	C. Weinhardt
2545011	Design Thinking (p. 53)	2	W	3	O. Terzidis, Dr. Kneisel, Dr. H. Haller, P. Nitschke
2500006	Business Planning for Founders (p. 45)	2	W/S	3	O. Terzidis

Learning Control / Examinations
oral or written exam, graded, duration depends on the lecture

Conditions
None.

Qualification Goals
After completion of the module students
- know the principles of innovation and entrepreneurship
- can initiate patent research
- can name, compare and use the central methods and process models of product development within moderate complex technical systems.

Content
The module introduces the basic concepts of entrepreneurship and illustrates the different stages of the dynamic development of the company. The topics include: introduction to methods for generating innovative business ideas, translating patents into business concepts, general principles of financial planning, the design and implementation of service-oriented information systems for Entrepreneurs, Technology Management and Business Model Generation and "Lean Startup" methods for the implementation of business ideas by the way of controlled experiments in the market and basics of product development.

Module: Interdisciplinary Project [IP]

Coordination: H. Bauer, M. Gabi
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
6		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22527	Design of a jet engine combustion chamber (p. 42)	2	W	6	N. Zarzalis
	Energy Supply of the KIT (p. 61)		W	6	Leibfried

Learning Control / Examinations
certificate

Conditions
None.

Qualification Goals
The students methodically develop, deliberate, evaluate and formulate systems and processes in an independent and sustainable manner in consideration of technical, social, economic and ethic conditions.

Content

Module: Elective Course [EC]

Coordination: H. Bauer, M. Gabi
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
15		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22568	Heat Transfer (p. 69)	2	S	3	N. Zarzalis
3134140	Machines and Processes (p. 76)	4	S	7	H. Kubach, H. Bauer, U. Maas, B. Pritz
22569	Fluid Dynamics (p. 64)	2	W	3	N. Zarzalis
2306315	Electrical Machines (p. 58)	2	S	4	M. Doppelbauer
23399	Electric Power Generation and Power Grid (p. 56)	2	W	3	B. Hoferer
3161010	Engineering Mechanics I (p. 102)	5	W	6	T. Langhoff, T. Böhlke
22534	Mass Transfer and Reaction Kinetics (p. 81)	2	S	4	N. Zarzalis
23385	Power Electronics (p. 90)	2	W	3	T. Leibfried, A. Kloenne
3165014	Technical Thermodynamics and Heat Transfer I (p. 103)	3	W	7	U. Maas, R. Schießl
22528	Applied Combustion Technology (p. 40)	2	S	4	N. Zarzalis
22605	Water Treatment with Membrane Technology (p. 41)	2	W	4	H. Horn, F. Saravia
2581998	Basics of Liberalised Energy Markets (p. 43)	2/1	W	3	W. Fichtner
5072	Batteries and Fuel Cells (p. 44)	2	W	4	H. Ehrenberg, F. Scheiba
9093	Carbon Capture and Storage (p. 46)	2	W	4	F. Schilling
2130910	CFD for Power Engineering (p. 48)	2	S	4	I. Otic
22331	Chemical Fuels (p. 49)	2	S	4	S. Bajohr, G. Schaub
22601	Chemical Technology of Water (p. 50)	2/0	W	4	H. Horn
2590458	Computational Economics (p. 52)	3	W	5	P. Shukla, S. Caton
2581006	Efficient Energy Systems and Electric Mobility (p. 55)	2/0	S	3,5	R. McKenna, P. Jochem
23376	Electric Power Transmission & Grid Control (p. 57)	3	W	6	T. Leibfried
1720997	Energy and Indoor Climate Concepts for High Performance Buildings (p. 59)	2	S	2	A. Wagner, Prof. Andreas Wagner, Dr. Ferdinand Schmidt
22325	Energy from Biomass (p. 60)	2	W	3	N. Dahmen, S. Bajohr
2581002	Energy Systems Analysis (p. 62)	2	W	3	V. Bertsch
3165016	Fundamentals of Combustion I (p. 68)	2	W	4	U. Maas, J. Sommerer
3166550	Fundamentals of Combustion II (p. 65)	2	S	4	U. Maas, J. Sommerer
2170490	Combined Cycle Power Plants (p. 66)	2	S	4	T. Schulenberg
6339091	Geothermal Energy I (p. 38)	2	W	4	T. Kohl
10425	Geothermal Energy II (p. 39)	5	S	4	T. Kohl
1720998	Integrated design of low energy buildings – Architecture, structure, materials and building physics (p. 70)	4	W	4	A. Wagner, Prof. Ludwig Wappner, Prof. Matthias Pfeifer, Dr. Michael Haist, Prof. Andreas Wagner
2170460	Nuclear Power Plant Technology (p. 71)	2	S	4	T. Schulenberg, K. Litfin
2169461	Coal Fired Power Plant Technology (p. 51)	2	W	4	T. Schulenberg
22531	Laboratory Work in Combustion Technology (p. 73)	2	S	4	N. Zarzalis
2171487	Laboratory Exercise in Energy Technology (p. 74)	3	W/S	4	H. Bauer, U. Maas, H. Wirbser
2161224	Machine Dynamics (p. 77)	3	S	5	C. Proppe

2162220	Machine Dynamics II (p. 78)	2	W	4	C. Proppe
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
23388	Modern Software Tools in Power Engineering (p. 84)	3	S	6	T. Leibfried
2511106	Nature-inspired Optimisation Methods (p. 85)	3	S	5	P. Shukla
2189920	Nuclear Fusion Technology (p. 86)	2	W	4	A. Badea
2189921	Nuclear Power and Reactor Technology (p. 87)	3	W	6	A. Badea
2511104	Organic Computing (p. 88)	2/1	S	4,5	H. Schmeck
2189465	Reactor Safety I: Fundamentals (p. 95)	2	S	4	V. Sánchez-Espinoza
2511108	Smart Energy Distribution (p. 98)	2	S	4	H. Schmeck
23745	Solar Energy (p. 99)	4	W	6	B. Richards
23271	Radiation Protection I: Ionising Radiation (p. 100)	2	W	3	B. Breustedt, M. Urban
23682	Superconducting Materials for Energy Applications (p. 101)	2	S	3	F. Grilli
2189904	Ten lectures on turbulence (p. 104)	2	W	4	I. Otic
22516	Thermal Waste Treatment (p. 105)	2	W	3	T. Kolb
2170476	Thermal Turbomachines II (p. 108)	3	S	6	H. Bauer
22332	Transport and Storage of Chemical Energy Carriers (p. 109)	2	S	4	T. Kolb
1731099	Urban planning and energy infrastructure (p. 110)	4	W	4	M. Neppl, Prof. Markus Neppl, Dipl.-Ing. Markus Peter
3190923	Fundamentals of Energy Technology (p. 67)	5	S	8	A. Badea
2189907	Heat Transfer in Nuclear Reactors (p. 111)	2	W	4	X. Cheng
2169553	Thermal Turbomachines I (in English) (p. 107)	3	W	6	H. Bauer
2170491	Simulator Exercises Combined Cycle Power Plants (p. 97)	2	S	2	T. Schulenberg
2171488	Workshop on computer-based flow measurement techniques (p. 91)	3	W/S	4	H. Bauer

Learning Control / Examinations
written or oral exam, graded, depends on the lecture

Conditions
For the module “Elective Course” courses of at least 15 ECTS must be chosen from the modules “Basics” and “Major Fields”. For students with a Bachelor‘s degree in Electrical Engineering the courses “Fluid Dynamics” and “Machines and Processes” are obligatory.

Qualification Goals
The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of Energy Technologies. The students learn to deal with the state of the art and to further develop existing methods.
The specific learning outcomes are defined by the respective coordinator of the course.

Content

Module: Thermal Power Plants [MF1]

Coordination: H. Bauer
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2161224	Machine Dynamics (p. 77)	3	S	5	C. Proppe
2171487	Laboratory Exercise in Energy Technology (p. 74)	3	W/S	4	H. Bauer, U. Maas, H. Wirbser
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
2169461	Coal Fired Power Plant Technology (p. 51)	2	W	4	T. Schulenberg
2169453	Thermal Turbomachines I (p. 106)	5	W	6	H. Bauer
22528	Applied Combustion Technology (p. 40)	2	S	4	N. Zarzalis
2162220	Machine Dynamics II (p. 78)	2	W	4	C. Proppe
2170490	Combined Cycle Power Plants (p. 66)	2	S	4	T. Schulenberg
22531	Laboratory Work in Combustion Technology (p. 73)	2	S	4	N. Zarzalis
2170476	Thermal Turbomachines II (p. 108)	3	S	6	H. Bauer
9093	Carbon Capture and Storage (p. 46)	2	W	4	F. Schilling
2189921	Nuclear Power and Reactor Technology (p. 87)	3	W	6	A. Badea
2170491	Simulator Exercises Combined Cycle Power Plants (p. 97)	2	S	2	T. Schulenberg
2171488	Workshop on computer-based flow measurement techniques (p. 91)	3	W/S	4	H. Bauer

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area:

- Thermal Turbomachines I
- Thermal Turbomachines II
- Applied Combustion Technology
- Nuclear Power and Reactor Technology

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF TPP the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Heat Transfer
- Fluid Dynamics
- Machines and Processes

Qualification Goals
The students will understand the basic operation of thermal power plants, their performance and environmental aspects. Based on their knowledge of the fundamentals in thermodynamics, fluid mechanics and technical mechanics they will be able to lay out, design and calculate power plants and their major components. They will understand the needs of future energy system with an increased contribution of intermittent renewable energies with respect to flexibility and alternative fuels.

Content

On a global scale, thermal power plants generate more than 90% of the electricity fed into the public grid and hence are the backbone of the electric energy supply of modern industrial societies. The specialization describes the design of different thermal power plants such as coal fired power plants, nuclear power plants, gas turbines and combined cycle power plants and their major components. Amongst those special emphasis is directed towards thermal turbo machines and the principles of applied combustion. The specialization is complemented by fundamental lectures on rotor dynamics as well as practical exercises in the framework of thermal power plants.

Module: Chemical Energy Carriers [MF2]

Coordination: T. Kolb
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
3165016	Fundamentals of Combustion I (p. 68)	2	W	4	U. Maas, J. Sommerer
2171487	Laboratory Exercise in Energy Technology (p. 74)	3	W/S	4	H. Bauer, U. Maas, H. Wirbser
22325	Energy from Biomass (p. 60)	2	W	3	N. Dahmen, S. Bajohr
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
3166550	Fundamentals of Combustion II (p. 65)	2	S	4	U. Maas, J. Sommerer
22331	Chemical Fuels (p. 49)	2	S	4	S. Bajohr, G. Schaub
22531	Laboratory Work in Combustion Technology (p. 73)	2	S	4	N. Zarzalis
22516	Thermal Waste Treatment (p. 105)	2	W	3	T. Kolb
22332	Transport and Storage of Chemical Energy Carriers (p. 109)	2	S	4	T. Kolb

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area:

- Fundamentals of Combustion I
- Chemical Fuels
- Fuel Lab

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF CEC the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Fluid Dynamics
- Machines and Processes
- Mass Transfer and Reaction Kinetics

Qualification Goals
The lectures in the module "Chemical Energy Carriers" are focused on the characterization of Chemical Energy Carriers and the processes for production and use of Chemical Energy Carriers.
An Introduction to global reserves and production, environmental aspects, photosynthesis, fossil fuel formation will be given. Characteristic properties of raw materials and fuels, process overview of fuel upgrading, conversion and cleaning will be discussed. Examples like chemical upgrading processes in petroleum refining, non-conventional liquid fuels from fossil and biomass feedstock will be given.
Different lab-modules are focused on instrumental methods of analysing the essential properties of Chemical Energy Carriers. The students will have the opportunity to perform measurements on the institute's test facilities.
The major outcome of the lectures will be the understanding of principles of production and upgrading of fuels, of fuel conversion processes (mechanical, thermal, chemical, biological, thermo-chemical and electro-chemical) and of criteria for assessing different fuels and fuel conversion processes.

Content
Chemical Energy Carriers are high quality fuels and chemicals designed for energy applications. Chemical Energy Carriers can be solids, liquids and gases. They are produced from fossil or biogenic energy resources (e.g. coal, mineral oil or wood) as well

as from chemical substances as CO_2 and H_2. They are designed to be used in highly efficient energy conversion processes for supply of final energy (heat, power and mobility). Due to their typically high energy density they are well suited for storage and transportation over long distances. Chemical Energy Carriers will therefore play a major role in all future energy scenarios.

Module: Decentralized Power Supply and Grid Integration [MF3]

Coordination: T. Leibfried
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
23395	Pulsed Power Technology and Applications (p. 93)	6	W	8	G. Müller
2581006	Efficient Energy Systems and Electric Mobility (p. 55)	2/0	S	3,5	R. McKenna, P. Jochem
23376	Electric Power Transmission & Grid Control (p. 57)	3	W	6	T. Leibfried
3190923	Fundamentals of Energy Technology (p. 67)	5	S	8	A. Badea
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
23388	Modern Software Tools in Power Engineering (p. 84)	3	S	6	T. Leibfried
2511104	Organic Computing (p. 88)	2/1	S	4,5	H. Schmeck
2511108	Smart Energy Distribution (p. 98)	2	S	4	H. Schmeck
23682	Superconducting Materials for Energy Applications (p. 101)	2	S	3	F. Grilli

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
The course 23395 Pulsed Power Technology and Applications is compulsory for the module.
Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF DPS the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Fluid Dynamics
- Machines and Processes

Qualification Goals
Students know the physical basics of power transmission by the three-phase power system. They are able to do the basic electrical design of the major components of an HVDC transmission system. Students further know the most important designs of FACTS (Flexible AC Transmission Systems) and their fields of application. They have knowledge about the grid control system and its functionality. Students further know strategies for operating an intelligent (smart) power grid. They further get knowledge about superconducting power grid equipment, their chances and the technological challenges to bring them into operation.

Content
The topic „decentralized power supply and grid integration" deals with technologies, methods and algorithms required for establishing a modern and flexible power supply system with a high amount of decentralized power supply generated by renewables. Current challenges of the European power supply system are the fluctuation of power generation especially by renewables and power consumption, voltage gradients by PV and electric mobiles in the distribution grid and voltage gradients in the EHV grid by the high amount of wind power in the northern part of Europe together with a regional lacks of power generation. This requires electric power transportation over long distances. The lecture "Electrical Power Consumption and Grid Control" provides basic knowledge about the physics of power transmission in the three-phase power system, technologies like HVDC (High Voltage DC transmission) and FACTS (Flexible AC transmission systems) as well as the basics of grid control such as primary and secondary grid control. The lecture "Superconductivity in Smart Grid Power Applications" provides knowledge about new grid equipment such as superconducting current limiters which allow fundamentally new grid architectures or superconducting cables and power transformers. Superconducting power transformers offer new ways of grid design and operation by the combination of the functionalities of a transformer with extremely low losses and a current limiter. Electric mobility leads to new challenges such as local peak power demands in the distribution grid but offers also new chances due to

the storage capacity of their batteries. This capacity can be used e.g. for a local harmonization of the power demand of a smart home. The lecture “Efficient Energy Systems and Electric Mobility” illuminates these aspects having some impact on the future power grid architecture. New methods and algorithms are required for an active management of the distribution grid, basics are provided in the lecture “Smart Energy Distribution”. The topic „decentralized power supply and grid integration“ provides the tools to major contribute to the development of the future power supply system.

Module: Energy in Buildings [MF4]

Coordination: A. Wagner
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
1720998	Integrated design of low energy buildings – Architecture, structure, materials and building physics (p. 70)	4	W	4	A. Wagner, Prof. Ludwig Wappner, Prof. Matthias Pfeifer, Dr. Michael Haist, Prof. Andreas Wagner
1731099	Urban planning and energy infrastructure (p. 110)	4	W	4	M. Neppl, Prof. Markus Neppl, Dipl.-Ing. Markus Peter
1720997	Energy and Indoor Climate Concepts for High Performance Buildings (p. 59)	2	S	2	A. Wagner, Prof. Andreas Wagner, Dr. Ferdinand Schmidt
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
2171488	Workshop on computer-based flow measurement techniques (p. 91)	3	W/S	4	H. Bauer

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area:

- Integrated design of low energy buildings – Architecture, structure, materials and building physics
- Urban planning and energy infrastructure
- Energy and indoor climate concepts for high performance buildings

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF EB the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Heat Transfer
- Fluid Dynamics
- Machines and Processes

Qualification Goals
One learning outcome is to get basic knowledge of architectural design principles, building construction, building materials properties and technical building systems in order to better understand their interdependencies in terms of building energy performance. On the urban level, the understanding of urban structures including energy supply concepts on different scales as well as urban planning processes is in focus. Further, the capability to evaluate different design concepts and planning strategies in terms of technical system integration, energy efficiency and sustainability is trained. Finally, the knowledge of different modelling techniques and the capability to apply the offered software packages for simulating the building performance in terms of energy and indoor comfort is fostered.

Content
This course introduces into design concepts as well as innovative technologies for high energy efficiency and renewable energy use in buildings. Emphasis is put on integrated solutions showing the interaction between space concept, construction principle, materiality, technical equipment and building energy performance. Besides the view on single buildings, aspects of urban planning with regard to energy infrastructure and sustainable development of urban quarters will be tackled, seeking possible answers on the question about the role of buildings and cities in tomorrow's overall energy system on different scales.
Two introductory lectures – 'Design, Construction and Technical Systems of Buildings' and 'Urban Planning and Energy Infrastructure' – provide necessary fundamentals for students without architectural background. This is followed by a lecture on

'Energy Concepts and Technologies for High Performance Buildings' which focuses exclusively on energy optimized building. It shows how the design strategy and the choice of appropriate technical systems can open the way towards net zero energy buildings. The seminar on 'Building Simulation' enables to experience the influence of different building and system parameters on the overall building energy performance, practicing with different simulation platforms.

Module: Nuclear and Fusion Technology [MF5]

Coordination: T. Schulenberg
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2170460	Nuclear Power Plant Technology (p. 71)	2	S	4	T. Schulenberg, K. Litfin
23271	Radiation Protection I: Ionising Radiation (p. 100)	2	W	3	B. Breustedt, M. Urban
2189465	Reactor Safety I: Fundamentals (p. 95)	2	S	4	V. Sánchez-Espinoza
2130910	CFD for Power Engineering (p. 48)	2	S	4	I. Otic
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
2189904	Ten lectures on turbulence (p. 104)	2	W	4	I. Otic
2189921	Nuclear Power and Reactor Technology (p. 87)	3	W	6	A. Badea
2189920	Nuclear Fusion Technology (p. 86)	2	W	4	A. Badea
2189907	Heat Transfer in Nuclear Reactors (p. 111)	2	W	4	X. Cheng

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area:

- Nuclear Power Plant Technology
- Radiation Protection I: Ionising Radiation
- Nuclear Thermal-Hydraulics
- Reactor Safety I: Fundamentals
- Nuclear Safety II: Safety Assessment of Nuclear Power Plants
- Nuclear Power and Reactor Technology

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF NT the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Heat Transfer
- Fluid Dynamics
- Machines and Processes

Qualification Goals
The students will learn to understand and apply the basic principles of nuclear reactor design, including the key technologies of core design and design of nuclear safety systems, and will be introduced to a number of additional technologies needed to convert nuclear power to electricity. Among these are the production and recycling of nuclear fuel, the handling of radioactive material, the design of nuclear power plants as well as an outlook to the alternative technology of nuclear fusion. The courses are mainly application oriented, corresponding with the needs of the nuclear industry, which are vendors, suppliers and utilities operating nuclear power plants.

Content
Nuclear power plants are contributing around 14% of the world-wide electricity production at competitive costs without emissions of greenhouse gases. More than 60 nuclear power plants are currently under construction and more than 150 ones are planned to be built. The courses on nuclear power will cover a wide range of technologies needed to design and operate such nuclear

power plants.
The first semester will start with an introduction to the technologies of pressurized water reactors and boiling water reactors as well as to the physics of radioactive decay and nuclear fission. These courses will be accompanied by courses on mathematical modeling, on thermal-hydraulics and nuclear safety, as well as on the chemistry of the nuclear fuel cycle, which in total provide a solid basis for the specialized courses on nuclear technologies offered in the second semester.
These latter courses will go deeper into the reactor core design, including the neutron physics which are responsible for the fission chain reaction, the heat removal from the fuel rods by the coolant flow and the assessment methods for the safety performance of these challenging power plants. Moreover, nuclear power is not only available from natural uranium. The spent fuel can be recycled through the conversion of uranium to plutonium, for which we need fast reactors and a closed nuclear fuel cycle, which is subject of two further courses in the second semester.
Last not least, there are complementary but still important courses offered on radiation protection and on the decommissioning and dismantling of nuclear facilities, as well as on computational fluid dynamics, which are not based on the learning outcome of other courses. Moreover, a lecture on nuclear fusion technology will introduce to a new and most innovative domain of nuclear power technologies.

Module: Energy Economics and Informatics [MF6]

Coordination: W. Fichtner
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2511106	Nature-inspired Optimisation Methods (p. 85)	3	S	5	P. Shukla
2581002	Energy Systems Analysis (p. 62)	2	W	3	V. Bertsch
2590458	Computational Economics (p. 52)	3	W	5	P. Shukla, S. Caton
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
23388	Modern Software Tools in Power Engineering (p. 84)	3	S	6	T. Leibfried
2581006	Efficient Energy Systems and Electric Mobility (p. 55)	2/0	S	3,5	R. McKenna, P. Jochem
2581998	Basics of Liberalised Energy Markets (p. 43)	2/1	W	3	W. Fichtner
3190923	Fundamentals of Energy Technology (p. 67)	5	S	8	A. Badea

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area.

- Nature-inspired Optimisation Methods
- Energy Systems Analysis

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF EEI the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Fluid Dynamics
- Machines and Processes

Qualification Goals
The courses provide students with a basic comprehension of the different approaches of informatics, especially used in energy economics. Furthermore, the students will obtain an overview of the current trends in the fields of energy technology and liberalized energy markets.

Content
Within this specialization, two disciplines converge by the use of computer based simulation models to analyze complex energy systems. To realize this, the lectures will focus on the one hand on optimization problems which are solved to optimality or approximately by using heuristics. On the other hand, the lectures provide an overview of the most central topics in the field of energy economics at present, namely energy efficiency and electric mobility, energy markets, energy resources and technologies as well as political framework conditions.

Module: Renewable Energy and Energy Storage [MF7]

Coordination: F. Schilling
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
5072	Batteries and Fuel Cells (p. 44)	2	W	4	H. Ehrenberg, F. Scheiba
6339091	Geothermal Energy I (p. 38)	2	W	4	T. Kohl
23745	Solar Energy (p. 99)	4	W	6	B. Richards
2161224	Machine Dynamics (p. 77)	3	S	5	C. Proppe
22325	Energy from Biomass (p. 60)	2	W	3	N. Dahmen, S. Bajohr
0109400	Mathematical Modelling and Simulation (p. 82)	2	W	4	G. Thäter, V. Heuveline
10425	Geothermal Energy II (p. 39)	5	S	4	T. Kohl
2162220	Machine Dynamics II (p. 78)	2	W	4	C. Proppe
2142897	Microenergy Technologies (p. 83)	2	S	4	M. Kohl

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area:

- Batteries and Fuel Cells
- Geothermal Energy I
- Windpower
- Wind and Hydropower
- Solar Energy

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF RES the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Heat Transfer
- Fluid Dynamics
- Machines and Processes

Qualification Goals
The courses provide students with a basic comprehension of the different approaches of "Renewable Energies" and "Energy Storage Technologies".

- The underlying physical, geological, physico-chemical and technological concepts for wind, solar, geothermal, hydro- and biomass power plants and energy conversion and energy storage ranging from hydro-power-plants and batteries to power to gas and other unconventional energy storage technologies
- "Green footprint" of the technologies
- Risk and Risk Reduction strategies

A profound knowledge of different technologies in a holistic view is the main outcome of the courses. This includes the quantitative understanding of underlying processes and mechanisms as well as the ability to implement state of the art technologies.

Content
The growing population on our planet as well as the successful development of economies leads to a fast rising energy demand and need of reducing environmental impact of power systems. So called "Renewable Energies" such as wind power, solar power, geothermal energy, hydropower or bio-energy have the potential to deliver sustainable Energy on windy and sunny days or as

base-load energy, respectively. Without storage of energy, a transformation to energy system with low environmental impact seems rather complicated. With this in mind, the courses are designed for a deeper understanding of the underlying concepts and processes of different “Renewable Technologies” and “Energy Storage Concepts”. Physical, geological, physico-chemical and technological aspects as well as simulation strategies for the different technologies aretherefore in the focus of the lectures.

Module: Utility Facilities [MF8]

Coordination: N. Zarzalis
Degree programme: ENTECH (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22601	Chemical Technology of Water (p. 50)	2/0	W	4	H. Horn
22516	Thermal Waste Treatment (p. 105)	2	W	3	T. Kolb
22331	Chemical Fuels (p. 49)	2	S	4	S. Bajohr, G. Schaub
22332	Transport and Storage of Chemical Energy Carriers (p. 109)	2	S	4	T. Kolb
22531	Laboratory Work in Combustion Technology (p. 73)	2	S	4	N. Zarzalis
22605	Water Treatment with Membrane Technology (p. 41)	2	W	4	H. Horn, F. Saravia

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Each Major Field contains core subjects and supplementary subjects. Courses of at least 8 ECTS have to be chosen from the core area:

- Chemical Fuels
- Transport and Storage of Chemical Energy Carriers
- Membrane Separation in Water Treatment

Dependinig on the chosen Major Field, students need to have previous knowledge. For the MF UF the following courses are obligatory, if they have not already been chosen within another module or been taken during the Bachelor's programme:

- Fluid Dynamics
- Machines and Processes
- Mass Transfer and Reaction Kinetics

Qualification Goals

- To enable the students to operate public utilities for gas and water supply, waste treatment and disposal
- To provide a multidisciplinary approach to the planning, process engineering and management aspects of such utilities
- To enable the students to integrate regional requirements, while taking into account the long-range preservation of the environment

Content
The main subject "Utility Facilities" is a multidisciplinary approach to the planning and management, as well as to the process engineering aspects, of public utilities for gas, water and waste treatment and disposal. The courses have components in natural sciences, advanced and appropriate technology, socio-economics and management.
Courses dealing with the application of basic principles of engineering, in special problems of a **municipal utility company**, will be offered. Because this municipal companies concern the utilisation of water or fuels, special courses in **drinking water preparation** (water treatment as separation, oxidation, biodegradation,disinfection and membrane technology) and transport and storage of chemical energy carriers (e.g. gas grid, transportation and storage of gaseous fuels), will also be offered.
In order to cover municipal companies for thermal waste treatment, special courses in **technical systems for thermal waste treatment** (i.e. grate furnace, rotary kiln, fluidized bed, pyrolysis / gasification technology) and the technology of **high temperature process engineering**, dealing with the generation of high temperatures and the heat transfer mechanisms at high temperatures, will be offered, too.

6 Courses

6.1 All Courses

Course: Geothermal Energy I [6339091]

Coordinators: T. Kohl
Part of the modules: Elective Course (p. 22)[EC], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
Elective course: written exam (Multiple Choice and 2 -3 questions with active answers)

Conditions
basic physics and thermodynamics

Learning Outcomes
critical reflection of physical processes involved in Geothermal Energy conversion
ability to understand and determine the evolution of heat flow density within the Geosphere
capability to schematically layout simple low enthalpy geothermal systems

Content
- Introduction and overview of geothermal systems
- Heat transport processes in rocks
- Basic physics of porous media
- Application to steady state and transient heat conduction (i.e. temperature field of the Earth, transport in continental and oceanic crust, influence of topography and paleoclimatic temperature signals, radiogenic heat generation, energy conservation)
- heat advection and Darcy flow regime
- Introduction into geothermal methods:
Thermal and petrophysical rock properties, Bullard Plot Interpretation, BHT temperature correction, temperature Logging techniques
- Introduction into Drilling and Logging Technologies

• Basics of petrophysics and wireline loogging
• Passive/Active electric measurement
• Sonic Log, Nuclear methods
• Televiewer methods

- Introduction and statistics of Geothermal production
- High temperature systems (Conventional high enthalpy utilization, EGS Systems / Hydraulic Fields in Reservoirs, Associated physical processes in fractured media, Induced Seismicity)
- Low enthalpy utilization (Heat pump, Dimensioning and Installation of Ground Coupled Heat Pump Systems, Current Problems in GCHP Installation)

Course: Geothermal Energy II [10425]

Coordinators: T. Kohl
Part of the modules: Elective Course (p. 22)[EC], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
4	5	Summer term	en

Learning Control / Examinations
Elective course: written exam (Multiple Choice and 2 -3 questions with active answers)

Conditions
basic physics, mathematics and thermodynamics

Learning Outcomes
• critical reflection of physical processes involved in Geothermal Energy conversion
• capability to schematically layout simple deep geothermal systems
• basic understanding of the underlying processes in Enhanced Geothermal Systems

Content
- Applied Geothermics: Usage of deep geothermal systems
- High Enthalpie Reservoirs
- Hydrothermal systems
- Enhanced Geothermal Systems
- Different concepts for using geothermal potentials

  • Porous and Nonporous geothermal reservoirs
  • High temperature systems Low enthalpy utilization

- Exploration

  • Geophysical Exploration
  • Geological Exploration

- Exploitation

  • Different concepts for using geothermal Energy in different geological enviroments

- Stimulation

  • Chemical stimulation
  • Hydraulic stimulation

- Drilling Technologies

  • History
  • Preparing thedrillsite
  • Drilling technologies
  • Well completion

Course: Applied Combustion Technology [22528]

Coordinators: N. Zarzalis
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
fluid mechanics, heat and mass transfer

Learning Outcomes
Students learn to design burners for gaseous and liquid fuels. Furthermore, they know about the design parameters which influence the flame geometry and they can apply this knowledge in order to engineer the flame shape.

Content

- Combustion and Thermo Chemistry
- Fuels
- Laminar flames
- Turbulent flames
- Flame stabilisation
- Burner design and scaling
- Droplet evaporation and combustion
- Combustion of solid fuels

Course: Water Treatment with Membrane Technology [22605]

Coordinators: H. Horn, F. Saravia
Part of the modules: Utility Facilities (p. 37)[MF8], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
The examination results from the chosen module.
Elective course: oral exam, graded

Conditions
None.

Learning Outcomes
The student

- has knowledge about the main processes in membrane filtration,
- knows about operation and function of membrane plants used in water treatment.

Content
1. Principles of membrane separation
2. Membrane manufacturing and membrane characteristics
3. Membrane configuration and membrane modules
4. Membrane plants in practice
5. Latest developments and trends

Literature
Elective literature:

- Baker, R. W.: Membrane Technology and Applications. 2nd ed. Wiley & Sons, 2004.
- Crittenden, J. [Ed.]: Water Treatment. Principles and Design. 2nd ed. Wiley & Sons, 2005.
- Melin, T., Rautenbach, R.: Membranverfahren. Grundlagen der Modul- und Anlagenauslegung. 3., aktualis. u. erw. Aufl. Springer, 2007.
- Ohlrogge, K., Ebert, K. [Hrsg.]: Membranen. Grundlagen, Verfahren und industrielle Anwendungen. Wiley-VCH, 2006.

Course: Design of a jet engine combustion chamber [22527]

Coordinators: N. Zarzalis
Part of the modules: Interdisciplinary Project (p. 21)[IP]

ECTS Credits	Hours per week	Term	Instruction language
6	2	Winter term	en

Learning Control / Examinations
Certificate

Conditions
Engineering Thermodynamics, Fluid Mechanics, Heat and Mass Transfer, Construction

Recommendations
None.

Learning Outcomes

- The students master the important parameters of a combustion chamber and are able to design one.
- The students can evaluate different concepts for combustion chamber concerning diverse criteria (safety, ecological relevance, . .). Furthermore the students learn how to use the acquired knowledge. They realize that every problem can be solved by reading literature and using the knowledge of the basic subjects.
- The students learn how to work in a team. They create a realistic schedule and fulfill it. Furthermore they know how to present their results due to the numerous presentations already performed.

Content
The combustion chamber is designed for the geometric boundary conditions and the performance data of a jet engine. An industrial partner can define the task, i.e. geometry and performance data.
Strategy:
The theory (description and functionality of a jet engine with emphasis in the combustion chamber) is explained in four lessons. After that the group will be organized to solve the following tasks:
- construction
- aerodynamic
- wall cooling / material
- temperature distribution within the combustor, emissions

The project leader is selected after a discussion about the strategy and the definition of the interfaces. His first task is to create a time schedule, which is discussed by the team. The time schedule contains meetings in which the members present their work progress to the team. The responsibility of the professor is to participate in these meetings, to evaluate the work progress and to propose modifications/corrections of the prospected project work. The project ends with a presentation of the performed work by all participants. The aim of the following questioning is to check the knowledge of every student and of the group. The performance influences the mark. The group performance weights 70 % of the total and the performance of every student carries 30%.
If an industry partner is involved, the students will visit them at the end of the project and present them their results.

Remarks
None.

Course: Basics of Liberalised Energy Markets [2581998]

Coordinators: W. Fichtner
Part of the modules: Energy Economics and Informatics (p. 34)[MF6], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
3	2/1	Winter term	en

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Students have to be familiar with economic theory and principles

Learning Outcomes
The student has detailed knowledge concerning the new challenges of liberalised energy markets. He has the ability to:

- Understand the new economic reality of liberalised energy markets
- Obtain a deeper understanding of the different submarkets of the power market
- Identify problems of the liberalised energy markets

Content
1. The European liberalisation process
1.1 The concept of a competitive market
1.2 The regulated market
1.3 Deregulation in Europe
2. Pricing and investments in a liberalised power market
2.1 Merit order
2.2 Prices and investments
2.3 Market flaws and market failure
2.4 Regulation in liberalised markets
2.5 Additional regulation mechanisms
3. The power market and the corresponding submarkets
3.1 List of submarkets
3.2 Types of submarkets
3.3 Market rules
4. Risk management
4.1 Uncertainties in a liberalised market
4.2 Investment decisions under uncertainty
4.3 Estimating future electricity prices
4.4 Portfolio management
5. Market power
5.1 Defining market power
5.2 Indicators of market power
5.3 Reducing market power
6. Market structures in the value chain of the power sector

Media
Media will likely be provided on the e-learning platform ILIAS.

Literature
Elective literature:
Power System Economics; Steven Stoft, IEEE Press/Wiley-Interscience Press, 0-471-15040-1

Remarks
The course “Basics of Liberalised Energy Markets” [2581998] will be reduced to 3 credits in winter term 2015/2016 and the tutorial [2581999] is no longer offered.

Course: Batteries and Fuel Cells [5072]

Coordinators: H. Ehrenberg, F. Scheiba
Part of the modules: Elective Course (p. 22)[EC], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
none

Learning Outcomes
The participants will become familiar with the basic concepts of electrochemical energy storage and conversion. They will study different designs of efficiently working batteries and fuel cells. With this background they should be able to evaluate materials for specific battery and fuel cell applications and to select appropriate battery and fuel cell components for energy storage and conversion. The students will furthermore obtain a profound knowledge of characterization methods for the determination of performance parameters (reaction), fatigue and ageing mechanisms in batteries and fuel cells.

Content
The basic principles of electrochemistry will be recapitulated and then applied with respect to electrochemical energy storage and conversion. Different concepts for storage systems are compared with a focus on the materials demands. The specific characteristics are discussed and the strengths and weaknesses of the different battery concepts are compared in the light of the specific requirements for mobile and stationary applications, respectively. The following battery systems will be considered: (1) Pb-based batteries, (2) NiCd and NiMH batteries, (3) Sodium-beta alumina batteries (SBB), (4) flow redox batteries (FRB) and the all vanadium redox battery (VRB), (5) Lithium-ion batteries. Fuel cell technology will be explained in general (high-T and low-T systems) and then highlighted with specific examples for automotive applications: (1) H2/O2 polymer-electrolyte membrane fuel cell, (2) direct methanol fuel cell, (3) intermediate-T PBI polymer-electrolyte fuel cell. One focus will be on the materials side, another on the detailed investigation of reaction mechanisms and degradation phenomena in the catalysts and complete electrodes. Sophisticated characterization tools will be discussed, which allow to follow these processes during operation.

Course: Business Planning for Founders [2500006]

Coordinators: O. Terzidis
Part of the modules: Innovation/Entrepreneurship (p. 20)[INNO]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter / Summer Term	en

Learning Control / Examinations
Presentation, Business Plan

Conditions
none

Recommendations
Participation in Entrepreneurship Lecture is desirable

Learning Outcomes
After completing the seminar students know methods to develop business ideas based on patents and to formulate a business plan.

Content
This seminar introduces basic concepts of business planning for entrepreneurs to the participants. It focusses on practical concepts and hands-on-methods on how to turn business ideas into solid businesses (e.g. Business Modelling, Market Potential, Planning of Resources, and further more) and on the creation of a realistic and viable Business Plan (with or without Venture Capital).

Media
Presentations, creativity techniques, Business Model Canvas, Value Proposition Designer, Customer Value Lifecycle

Literature
Osterwalder, Alexander and Pigneur, Yves (2010): Business Model Generation
McKinsey & Company (2010): Planen, gründen, wachsen.
- Ries, Eric (2011): The Lean StartUp – How Constant Innovation Creates Radically Successful Businesses. London, UK, Penguin Books
- Dorf, Richard C., Byers, Thomas. H. and Nelson, Andrew J. (2010): Technology Ventures – From Idea to Enterprise.
- Harvard Business School Publishing (2007): Creating a Business Plan – Expert Solutions to Everyday Challenges.

Remarks
winter term + summer term

Course: Carbon Capture and Storage [9093]

Coordinators: F. Schilling
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
Elective course: The form of the examination is decided together with the students. Either a written exam, an extended protocol, a seminar lecture or an oral exam.

Conditions
Basic physics and thermodynamics

Learning Outcomes
critical reflection of chances and risks of CCS
ability to apply strategies of risk assessment and risk reduction in CCS
capability to discuss CCS on a profound basis

Content
- Why Carbon Capture and Storage?
  - Global CO_2 Cycle, Anthropogenic CO_2 Emissions and Impact to Global and Regional Climate
- CO_2 Capture Technologies
  - Prae-Combustion
  - Post-Combustion
  - Oxyfuel
  - Chemical Looping
  - Emerging Capture Technologies
  - Further CO_2 Reduction Technologies
- CO_2 Transport
  - CO_2 purity and Material Properties
  - Pipeline
  - Ships
  - Train
  - Trucks
- CO_2 Storage
  - Geological Storage Potentials
    - Saline Aquifers
    - Enhanced Oil recovery
    - Enhanced Gas Recovery
    - Coal Bed Methane
  - Trapping Mechanisms
    - Structural Trapping
    - Chemical Trapping
    - Physical Trapping
    - Solubility Trapping
  - Exploration & Site Characterisation
    - Geology, Geophysics, Geochemical, and Geomechanical
    - Social Aspects
  - Site Development

  - Drilling
  - Monitoring
  - Erection of Injection Facility
- Monitoring – During Injection
  - Physical
  - Chemical
  - Biological
- Site Abandonment
- Long Term Monitoring
  - Physical
  - Chemical
  - Biological
- Risk Assessment – Risk Management

Course: CFD for Power Engineering [2130910]

Coordinators: I. Otic
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral exam, length: 30 minutes

Conditions
None.

Learning Outcomes
After completing the course students are able:

- to understand the fundamentals of computational fluid dynamics (CFD)
- to simulate turbulent flow with heat transfer using CFD
- to present, analyse and evaluate the simulation results.

Content
Basic equations
Statistical description and turbulence modelling
Numerical Solution of Partial Differential Equations (Basics)
Finite volume method
As part of the course an application-oriented project will be carried out independently or in a team.

Media
Blackboard and Powerpoint presentation

Course: Chemical Fuels [22331]

Coordinators: S. Bajohr, G. Schaub
Part of the modules: Utility Facilities (p. 37)[MF8], Elective Course (p. 22)[EC], Chemical Energy Carriers (p. 26)[MF2]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral examination
Duration: 30 min

Conditions
None

Recommendations
None

Learning Outcomes
After completing the course students can:

- Understand and describe the principles of production and upgrading of liquid fuels and their properties
- Understand fuel conversion processes (raw materials to products)
- Apply chemical equilibrium and reaction engineering fundamentals

Content
A. General aspects of chemical fuels
1. Introduction
2. Characteristic properties of raw materials and fuel products
3. Upgrading, conversion – process overview
B. Petroleum and petroleum refining (example)
4. Properties of petroleum and petroleum products
5. Refinery structures
6. Separation processes in petroleum refining
7. Chemical upgrading processes in petroleum refining
8. Energy efficiency and pollution control
C. Non-petroleum liquid fuels (example)
9. Liquid fuels from gaseous or solid feedstock
10. Liquid fuels from biomass feedstock
D. Gaseous and solid fuels
11. Example: fuel gas from coal and biomass

Media
Blackboard and slides/power point presentation

Literature
1) Course note package
2) Elvers B. (Ed.), Handbook of Fuels, Energy Sources for Transportation,
Wiley VCH, Weinheim 2008
3) Jess A., Wasserscheid P., Chemical Technology, An Integral Textbook,
Wiley VCH, Weinheim 2013

Course: Chemical Technology of Water [22601]

Coordinators: H. Horn
Part of the modules: Utility Facilities (p. 37)[MF8], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2/0	Winter term	de

Learning Control / Examinations
The examination results from the chosen module.
Elective course: oral exam, graded

Conditions
See corresponding module information.

Learning Outcomes
The student has a basic knowledge of water chemistry and knows the most important methods for the treatment of different raw waters for drinking and process water purposes.

Content
Water: hydrological cycle, physical and chemical characteristics, water as solvent, water hardness, Calcium-carbonate system, water treatment - part I (sieving, sedimentation, flotation, filtration, flocculation), water treatment - part II (adsorption, ion exchange, gas transfer, deacidification, softening, oxidation, disinfection), calulations.

Literature
Elective literature:

- Crittenden, J. [Ed.]: Water Treatment. Principles and Design. 2nd ed. Wiley & Sons, 2005.
- DVGW: Wasseraufbereitung - Grundlagen und Verfahren. In: Lehr- und Handbuch Wasserversor-gung Bd.6. Oldenbourg Industrie-Verlag, 2004.
- Frimmel, F. H.: Wasser und Gewässer. Ein Hand-buch. Spektrum Verlag, 1999.
- Grohmann, A., Hässelbarth, U., Schwerdtfeger, W.(Hrsg.): Die Trinkwasserverordnung. 4. Auflage, E. Schmid, Berlin, 2002.
- Sigg,L., Stumm, W.: Aquatische Chemie. Eine Einführung in die Chemie wässriger Lösungen und natürlicher Gewässer. Verlag der Fachvereine Zürich, 1994.
- Stumm, W., Morgan, J. J.: Aquatic Chemistry. Chemical Equilibria and Rates in Natural Waters. 3rd ed. Wiley & Sons, 1996.

Remarks
The course will not be offered any more from winter term 2014/2015 on. The examination will be offered latest until summer term 2017 (repeaters only).

Course: Coal Fired Power Plant Technology [2169461]

Coordinators: T. Schulenberg
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. The participants can name the most important components of coal fired power plants and describe their function. They can design or modify coal fired power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of combustion systems, of boiler design and of flue gas cleaning systems. On this basis, they can describe and analyze the specific behavior of the power plant components as well as the entire power plant in the grid. Participants in the lecture have a trained analytical thinking and judgment in power plant design.

Content
The lecture presents the technology of coal fired power plants, which are conventional steam turbine plants as well as advanced combined cycle power plants with integrated coal gasification. It includes combustion systems, steam generators, a short overview over steam turbine technologies, the cooling system and the water supply system as well as the off gas treatment. Coal gasification will be explained with fixed bed, fluidized bed and entrained flow gasifiers. The integrated coal gasification combined cycle includes also the raw gas purification system. In addition, a visit to a coal fired power plant will be offered.

Media
power point presentation for download from the ILIAS server

Literature
Lecture notes (Vorlesungsskript) for download from the ILIAS Server
Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers, Steam Plant Operation, 9th Edition, McGraw Hill, New York 2012

Course: Computational Economics [2590458]

Coordinators: P. Shukla, S. Caton
Part of the modules: Energy Economics and Informatics (p. 34)[MF6], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Winter term	en

Learning Control / Examinations
The examination results from the chosen module.
Elective course: written exam; if less than 6 participiants: oral exam

Conditions
basic knowledge of informatics and some programming experience

Learning Outcomes
The students will get to know methods and concepts of Computational Economics and to apply them in innovative ways.
The objectives of this course are to teach fundamentals of Computational Economics in the context of their application in practice. Based on a fundamental understanding of the essential concepts they will be able to apply them reasonably in appropriate situations in their professional life, to adjust them whenever necessary and to explain their appropriate use.

Content
Examining complex economic problems with classic analytical methods usually requires making numerous simplifying assumptions, for example that agents behave rationally or homogeneously. Recently, widespread availability of computing power gave rise to a new field in economic research that allows the modeling of heterogeneity and forms of bounded rationality: Computational Economics. Within this new discipline, computer based simulation models are used for analyzing complex economic systems. In short, an artificial world is created which captures all relevant aspects of the problem under consideration. Given all exogenous and endogenous factors, the modelled economy evolves over time and different scenarios can be analyzed. Thus, the model can serve as a virtual testbed for hypothesis verification and falsification.

Media

- PowerPoint

Literature

- R. Axelrod: “Advancing the art of simulation in social sciences”. R. Conte u.a., Simulating Social Phenomena, Springer, S. 21-40, 1997.
- R. Axtel: “Why agents? On the varied motivations for agent computing in the social sciences”. CSED Working Paper No. 17, The Brookings Institution, 2000.
- K. Judd: “Numerical Methods in Economics”. MIT Press, 1998, Kapitel 6-7.
- A. M. Law and W. D. Kelton: “Simulation Modeling and Analysis”, McGraw-Hill, 2000.
- R. Sargent: “Simulation model verification and validation”. Winter Simulation Conference, 1991.
- L. Tesfation: “Notes on Learning”, Technical Report, 2004.
- L. Tesfatsion: “Agent-based computational economics”. ISU Technical Report, 2003.

Elective literature:

- Amman, H., Kendrick, D., Rust, J.: “Handbook of Computational Economics”. Volume 1, Elsevier North-Holland, 1996.
- Tesfatsion, L., Judd, K.L.: “Handbook of Computational Economics”. Volume 2: Agent-Based Computational Economics, Elsevier North-Holland, 2006.
- Marimon, R., Scott, A.: “Computational Methods for the Study of Dynamic Economies”. Oxford University Press, 1999.
- Gilbert, N., Troitzsch, K.: “Simulation for the Social Scientist”. Open University Press, 1999.

Remarks
Lecture number for the tutorial of this class is 2590459

Course: Design Thinking [2545011]

Coordinators: O. Terzidis, Dr. Kneisel, Dr. H. Haller, P. Nitschke
Part of the modules: Innovation/Entrepreneurship (p. 20)[INNO]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
Project presentation & active participation

Conditions
none

Recommendations
Participation in Entrepreneurship Lecture is desirable

Learning Outcomes
After this seminar, students know basic approaches to achieve innovation; that is specific techniques and methods that focus on the actual end-users or current "non-users" of certain products and services. The seminar cultivates a PROBLEM ORIENTED approach with clear CUSTOMER FOCUS. After attending the seminar, students will understand the need for a precise observation of end-user needs as the basis for market-driven innovation.

Content
Qualitative methods of collecting primary market data (Contextual Inquiry: Observation and interviews), processing unstructured data sets to derive user needs, formulation and validation of concrete problems, idea generation in innovation teams, idea Darwinism: selection, combination and prioritization, prototyping, user testing, Pitch .
The seminar is based on practical challenges; ideally industrial partners define the tasks inspired by real life requirements.
Attendance is compulsory at the seminar days - the learning elements and experience of the seminar days cannot be replaced by literature studies. Please note the days of the seminar sometimes include Fridays and Saturdays.

Media
Presentations, creativity techniques, prototyping

Literature
Overview articles:
- BROWN, T. 2008. Design Thinking. Harvard Business Review (Jun) 84-92.

Books:
Design Thinking & Creativity
- KELLEY, T. & LITTMAN, J. 2002. The Art of Innovation – Success Through Innovation the IDEO Way. London, UK, Profile Books
- KELLEY, T. & LITTMAN, J. 2006. The Ten Faces of Innovation – Strategies for Heightning Creativity. London, UK, Profile Books.

Design Thinking at large
- MARTIN, R. 2009. The Design of Business – Why Design Thinking is the Next Competitive Advantage. Boston, MA, U.S., Harvard Business Press
- BROWN, T. & KATZ, B. 2009. Change by Design – How Design Thinking Transforms Organizations and Inspires Innovation. New York, U.S., Harper Collins Books

Innovation Management
- CHRISTENSEN, C.M. et al. 2004. Seeing What´s Next. – Using the Theories of Innovation to Predict Industry Change. Boston, MA U.S., HBS Press
- ANDREW, J.P. & SIRKIN, H.L. 2006. Payback – Reaping the Rewards of Innovation. Boston, MA U.S., HBS Press
- RIES, E. 2011. The Lean StartUp – How Constant Innovation Creates Radically Successful Businesses. London, UK, Penguin Books

Remarks
winter term + summer term

Course: eEnergy: Markets, Services, Systems [2540464]

Coordinators: C. Weinhardt
Part of the modules: Innovation/Entrepreneurship (p. 20)[INNO]

ECTS Credits	Hours per week	Term	Instruction language
4	2/1	Summer term	en

Learning Control / Examinations
The assessment consists of a written exam (60 min) (according to §4(2), 1 of the examination regulation). By successful completion of the exercises (according to §4(2), 3 of the examination regulation) a bonus can be obtained. If the grade of the written exam is at least 4.0 and at most 1.3, the bonus will improve it by one grade level (i.e. by 0.3 or 0.4). The bonus only applies to the first and second exam of the semester in which it was obtained.

Conditions
None.

Learning Outcomes
The student

- understands the tasks and basic structure of the energy economy, in particular concerning electricity markets,
- understands the change in the energy economy and the necessity for the development of a Smart Grid,
- knows the market mechanisms in the energy market and their role in coordination and allocation of electric energy,
- is able to describe the relation between OTC, spot and balancing energy markets,
- knows the regulation specifications for energy markets and can reflect them critically,
- is able to model smart grid mechanisms and to evaluate them by simulation based methods.

Content
Scope of the lecture *eEnergy: Markets, Services, Systems* is economics and information management in energy markets. Integration of the growing number of renewable energy sources imposes new challenges on energy markets and the power system. To improve coordination between supply and demand it is necessary to interlink centralized and decentralized generators as well as consumers by means of ICT. Current electricity networks are extended by intelligent IT components thus incorporating the "Smart Grid". Existing market structures for electricity have to be adjusted for a successful implementation of demand side management and integration of an increasing number of renewable energy producers as well as electric vehicles. Apart from regulatory and economic concepts, methods for modeling and analysis of energy markets are introduced and explained during the course.
The lecture is structured as follows:

1. **Electricity Markets**
   Market Models, EEX (spot and futures market), OTC Trading, Market Coupling
2. **Regulation**
   Charges and Incentives, Network Congestion (Management)
3. **Demand Side Management**
   Smart Meters, Tariffs, Price Elasticity, Storage Systems, Electric Mobility
4. **Modeling and Analysis of Energy Markets**

Media

- PowerPoint
- E-learning platform ILIAS

Literature

- Erdmann G, Zweifel P. *Energieökonomik, Theorie und Anwendungen*. Berlin Heidelberg: Springer; 2007.
- Grimm V, Ockenfels A, Zoettl G. Strommarktdesign: Zur Ausgestaltung der Auktionsregeln an der EEX *. *Zeitschrift für Energiewirtschaft*. 2008:147-161.
- Stoft S. *Power System Economics: Designing Markets for Electricity*. IEEE; 2002.,
- Ströbele W, Pfaffenberger W, Heuterkes M. *Energiewirtschaft: Einführung in Theorie und Politik*. 2nd ed. München: Oldenbourg Verlag; 2010:349.

Remarks
The lecture has also been added in the IIP Module *Basics of Liberalised Energy Markets*.

Course: Efficient Energy Systems and Electric Mobility [2581006]

Coordinators: R. McKenna, P. Jochem
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC], Energy Economics and Informatics (p. 34)[MF6]

ECTS Credits	Hours per week	Term	Instruction language
3,5	2/0	Summer term	en

Learning Control / Examinations
The examination results from the chosen module.
Elective course: written exam, 60 min

Conditions
none

Learning Outcomes
After completing the course the students:

- Understand the concept of energy efficiency as applied to specific systems
- Obtain an overview of the current trends in energy efficiency
- Are able to determine and evaluate alternative methods of energy efficiency improvement
- Have an overview of technical and economical stylized facts on electric mobility
- Can judge economical, ecological and social impacts through electric mobility

Content
Efficient Energy Systems

- Introduction to energy efficiency: definition, measurement and potentials
- Energy efficiency perspectives from neoclassical and ecological economics
- Political frameworks and barriers, including the “rebound” effect
- Cross-cutting approaches to energy efficiency, e.g. CHP
- Examples of energy efficiency potentials and strategies in the industrial and domestic sectors Electric Mobility
- Energy efficiency in the transport sector
- Battery technology
- Energy economic impacts from electric mobility on the power plant portfolio and the grid
- Environmental impacts
- Acceptance of new technologies (in particular electric mobility)

Media
Media will likely be provided on the e-learning platform ILIAS.

Literature
Will be anounced in the lecture.

Course: Electric Power Generation and Power Grid [23399]

Coordinators: B. Hoferer
Part of the modules: Elective Course (p. 22)[EC], BASICS ME (p. 19)[ME], BASICS CE (p. 17)[CE]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
oral examination

Conditions
none

Recommendations
none

Learning Outcomes
Alfter completing the course, the students have theoretical fundamentals and solid understanding of electrical power engineering. The students are able to analyse problems in the field of power generation and power grid and to develop approaches to these problems.

Content
Power generation fundamental lecture. The lecture covers the entire topic of power generation from conversion of primary energy resources in coal fired power plants and nuclear power plants to utilisation of renewable energy. The lecture gives a review of the physical fundamentals, technical-economical aspects and potential for development of power generation both conventional generation and renewable generation. The lecture covers basics in power grids.

Literature
Material is available at the beginning of the lecture. Literature: Schwab; Elektroenergiesysteme.

Course: Electric Power Transmission & Grid Control [23376]

Coordinators: T. Leibfried
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Power Point Presentation worked out and presented by the student about special topics presented in the lecture, each student will get his own topic for presentation
Duration: 15-20 minutes plus discussion

Conditions
none

Recommendations
none

Learning Outcomes
After completing the course students

- can design an AC transmission system and describe its limitations
- can do the basic design an HVDC power transmission system and are able to describe the functional components, their necessity and working principle.
- can design an appropriate FACTS system and are able to describe different alternatives and know their working principle

They understand the basic working principle oft he power grid control system.

Content
Characteristic and limitations of the AC power transmission in the HV and MV grid. HVDC transmission system using LCC technology, FACTS (Flexible AC transmission Systems), Grid control principle and system.

Media
Blackboard and Powerpoint presentation

Literature
Course note packet
P. Kundur
“Power System Stability and Control“
McGraw-Hill Inc., 1994, ISBN 0-07-035958-X
N. G. Hingorani, L. I. Gyugyi
“Understanding FACTS“
Institute of Electrical and Electronics Engineers Inc., 2000, ISBN 0-7803-3455-8

Course: Electrical Machines [2306315]

Coordinators: M. Doppelbauer
Part of the modules: Elective Course (p. 22)[EC], BASICS ME (p. 19)[ME], BASICS CE (p. 17)[CE]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
oral examination;
duration: 20-30 minutes

Conditions
S. module

Recommendations
Candidates should have attended lectures and exercises.

Learning Outcomes
After completing the course the students are able to:

- understand the basic processes of mechanical and electrical energy conversion,
- specify and calculate electrical transformers,
- understand the basic processes of the generation of rotating magnetic fields,
- describe the operating principles and characteristics of asynchronous and synchronous electrical machines,
- identify the sources of torque and noise related problems of electric machines,
- understand the behavior of mechanical transmission elements and typical machines loads like fans, compressors and conveyors and specify a suitable electric machines accordingly,
- understand the mechanisms of losses and energy efficiency of electric machines.

Content

- Electrical machine basics
- Magnetic circuit basics
- Permanent magnets
- Rotating field windings
- DC (commutator) machines
- Synchronous machines
- Asynchronous machines

Media
Blackboard and powerpoint presentation. Practical examples as needed.

Literature
Course note packet

- H. A. Toliyat, G. B. Kliman: **Handbook of Electric Motors,** CRC Press, Taylor&Francis Group, 2004
- T. Wildi: **Electrical Machines, Drives and Power Systems,** Prentice Hall, 2005
- J.R. Hendershot, T. Miller: **Design of Brushless Permanent-Magnet Motors,** Magna Physics Publishing and Oxford University Press, 1994
- P.L. Alger: **The Nature of Polyphase Induction Machines,** John Wiley&Sons, Inc. and Chapmann&Hall, Ltd., 1951
- Rolf Fischer: **Elektrische Maschinen** (German language only), Carl Hanser Verlag, 2009

Course: Energy and Indoor Climate Concepts for High Performance Buildings [1720997]

Coordinators: A. Wagner, Prof. Andreas Wagner, Dr. Ferdinand Schmidt
Part of the modules: Elective Course (p. 22)[EC], Energy in Buildings (p. 30)[MF4]

ECTS Credits	Hours per week	Term	Instruction language
2	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Energy concepts, 100%, oral exam with grading, 30 min.

Conditions
Design, Construction and Technical Systems of Low Energy Buildings (course 1 of this main subject) or
Engineering Thermodynamics and Heat Transfer I (basic course of EnTech) and Thermal Energy Systems (basic knowledge from Bachelor Studies)
This lecture can not be combined with the lectures [2157200], [2158201] and [2157202]

Recommendations
Urban planning and energy infrastructure

Learning Outcomes
After completing the course the students have:

- Basic understanding of energy performance of buildings
- Knowledge of new building technologies for low energy buildings with high indoor environmental quality
- Capability to realize the potential of different active and passive components due to climate and building use
- Capability to judge between different system approaches for integrated solutions towards net zero buildings and smart grid integration

Content
Energy standards and demand structure of different building types, heat conservation strategies, advanced insulation materials and systems, smart windows for heat and solar protection, ventilation strategies (with heat recovery), passive cooling concepts, effective shading systems, thermal mass activation, building integrated PCM, energy efficient lighting (OLED), heating & cooling with natural sources and sinks, heat pump technologies for heating, cooling and air-conditioning, solar assisted heating and cooling, combined heat (and cold) and power generation, net zero buildings, buildings as active components in energy distribution systems / smart grids, performance assessment and optimization, certification.

Literature
lecture slides as pdf, recommendations for further reading

Course: Energy from Biomass [22325]

Coordinators: N. Dahmen, S. Bajohr
Part of the modules: Chemical Energy Carriers (p. 26)[MF2], Elective Course (p. 22)[EC], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
Elective course: written exam; if less than 10 participiants: oral exam possible

Conditions
None.

Learning Outcomes
The course mediates fundamentals and process engineering aspects of technically relevant biomass conversion and conditioning processes. On this basis, the students learn to understand and to evaluate processes for biomass utilisation by balancing mass and energy streams. If necessary, basics of chemistry, thermodynamic equilibrium and/or of reaction kinetic calculations are introduced. By also looking at the regional and global feedstock potentials the students are sensitized for balancing out the most value added use of biomass with its sustainable production as part of the global solution for the worlds energy demand.

Content
All fossil energy carriers are finite. Moreover, their conversion into energy leads to an increase of the CO2-concentration in the atmosphere awaiting drastic consequences on climate. The course emphasizes on biomass as the only renewable carbon resource. Along with relevant fundamentals on biomass production pathways to produce energy carriers like substitute natural gas (SNG), bio diesel or other fuels from biomass are shown. All relevant technologies involved in biomass conversion processes are introduced, also evaluating their state of development and application potential.
The course will focus on:
Production, properties, and characterisation of biomass; types of biomass, feedstock potential, energy density and energy content, characterisation methods. **Potential and sustainability**; energy demand and supply, potentials today and in the future, CO2.emissions and reduction potential. Chemical conversion - energy carriers from oil seeds. **Biochemical conversion**; fermentation to liquid products (ethanol. . .), fermentation to biogas, biogas upgrading, algae, microbiological syntheses. Thermochemical conversion – carbonization, pyrolysis and gasification; feedstock pre-treatment, principles and engineering basics of conversion technologies; **Chemical synthesis and product refining**; primary synthesis with synthesis gas (Fischer-Tropsch-, H2, CH4-, methanol-, DME-synthesis), secondary synthesis (MTO, MTP etc.).
The course is an oral lecture with MS-Powerpoint slides and black board writings.
Literature references are given during the lectures; handouts of the slides are provided; the students are encouraged to use modern media like internet for their own research.

Course: Energy Supply of the KIT []

Coordinators: Leibfried
Part of the modules: Interdisciplinary Project (p. 21)[IP]

ECTS Credits	Hours per week	Term	Instruction language
6		Winter term	en

Learning Control / Examinations

Conditions
None.

Learning Outcomes
The energy supply of the KIT is comparable to the supply of a small city with electrical as well as thermal energy. In order to understand such a system many different aspects and process steps need to be considered. This begins with the generation with conventional or renewable power plants and includes the distribution as well as the consumption of the produced electrical or thermal energy.
In order to teach a basic understanding and create awareness for links between different areas of energy production, the student teams will learn to analyze the corresponding power system of the KIT and incorporate additional renewable as well as conventional power plants. This will clarify the needs and difficulties when establishing such a complex autarkic energy supply scheme at the KIT campus.

Content
Construction and simulation of the current energy supply at the KIT. This includes the simulation of the specific power plants with the software Thermoflex.
- Development of a schematic scheme of the power plants
- Incorporation of the individual components in Thermoflex.
- Simulation of the thermodynamic cycles.
- Evaluation of the energy output of these power plants.
- Evaluation of the fuel consumption and the efficiency of the power plants.
- Development of further strategies for the optimization of the power plants/ the energy supply strategy.

In addition, a link to power system design and planning with the software DIgSILENT PowerFactory and Matlab has to be established:
- Incorporation of the thermal power plants into an available medium voltage power grid.
- Estimation of renewable in feed potential @ the KIT-Campus (focus on solar)
- Basic understanding of storage system dimensioning and positioning

Course: Energy Systems Analysis [2581002]

Coordinators: V. Bertsch
Part of the modules: Energy Economics and Informatics (p. 34)[MF6], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module.
Elective course: winter term: written exam, summer term: oral exam

Conditions
None.

Learning Outcomes
The student
- has the ability to understand and critically reflect the methods of energy system analysis, the possibilities of its application in the energy industry and the limits and weaknesses of this approach
- can use select methods of the energy system analysis by her-/himself

Content
1. Overview and classification of energy systems modelling approaches
2. Usage of scenario techniques for energy systems analysis
3. Unit commitment of power plants
4. Interdependencies in energy economics
5. Scenario-based decision making in the energy sector
6. Visualisation and GIS techniques for decision support in the energy sector

Media
Media will likely be provided on the e-learning platform ILIAS.

Remarks
Since 2011 the lecture is offered in winter term. Exams can still be taken in summer term.

Course: Entrepreneurship [2545001]

Coordinators: O. Terzidis
Part of the modules: Innovation/Entrepreneurship (p. 20)[INNO]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter / Summer Term	en

Learning Control / Examinations
The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation).

Conditions
None.

Learning Outcomes
Students are generally introduced to the topic of entrepreneurship. After successful completion of the lecture they should have an overview of the sub-areas of entrepreneurship and have to be able to understand basic concepts of entrepreneurship.

Content
This lecture, as an obligatory part of the module "Entrepreneurship", introduces basic concepts of entrepreneurship. It approaches the individual steps of dynamic corporate development. The focus here is the introduction to methods for generating innovative business ideas, the translation of patents into business concepts and general principles of financial planning.
Other topics are the design and use of service-oriented information systems for founders, technology management, business model generation and lean startup methods for the implementation of business ideas in the way of controlled experiments in the market.

In addition to the lectures the KIT Entrepreneurship Talks, where successful entrepreneurs share their experiences from the early stages of their companies, will be given. Dates and times will be announced in time on the EnTechnon website.

More details: http://etm.entechnon.kit.edu/211.php

Course: Fluid Dynamics [22569]

Coordinators: N. Zarzalis
Part of the modules: Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
oral/written examination

Conditions
Mathematics I, II and III

Learning Outcomes
The students understand and master the analogy between momentum and energy transport. In case of the momentum transport the students can use the principle of momentum balance in order to calculate hydrodynamic forces. Furthermore they know how to calculate the pressure drop and the flow resistance.

Content

- viscosity and the mechanisms of momentum transport
- balance equations for mass (continuity) and momentum
- frictionless flows – Bernoulli equation
- viscous flows
  - velocity distribution in laminar flows
  - velocity distribution in turbulent flows
  - compressible flows – sound velocity

Course: Fundamentals of Combustion II [3166550]

Coordinators: U. Maas, J. Sommerer
Part of the modules: Chemical Energy Carriers (p. 26)[MF2], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
None

Recommendations
Attendance of the tutorial (3166551 - Fundamentals of Combustion II)

Learning Outcomes
After completing the course attendents are able to:

- explain the processes involved in ignition (auto-ignition and induced ignition).
- describe the governing mechanisms in combustion of liquid and solid fuels.
- understand the mechanisms governing pollutant formation.
- describe turbulent reacting flows by means of simple models.
- explain the occurence of engine knock.
- outline the basic numerical schemes applied in the simulation of reacting flows.

Content

- Three dimensional Navier-Stokes equations for reacting flows
- Tubulent reactive flows
- Turbulent non-premixed flames
- Turbulent premixed flames
- Combustion of liquid and solid fuels
- Engine knock
- Thermodynamics of combustion processes
- Transport phenomena

Literature
Lecture notes;
Combustion - Physical and Chemical Fundamentals, Modeling and Simulation,Experiments, Pollutant Formation; Authors: U. Maas, J. Warnatz, R.W. Dibble, Springer; Heidelberg, Karlsruhe, Berkley 2006

Course: Combined Cycle Power Plants [2170490]

Coordinators: T. Schulenberg
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral Examination 30 min

Conditions
None.

Recommendations
Knowlegde in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.
We recommend to combine the lecture with the Simulator Exercises for Combined Cycle Power Plants (2170491)

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. The participants can name the most important components of the combined cycle power plant and describe their function. They can design or modify combined cycle power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of gas turbine design, steam turbine design and boiler design. On this basis, they can describe and analyze the specific behavior of the power plant components as well as the entire power plant in the grid. Participants in the lecture have a trained analytical thinking and judgment in power plant design.

Content
Layout of a combined cycle power plant, design and operation of gas turbines, of the heat recovery steam generator, of the feedwater system and cooling systems. Design and operation of steam turbines, of the generator and its electrical systems. System response to challinging grids, protection systems, water make-up and water chemistry. Design concepts of different power plant manufacturers, innovative power plant concepts.

Media
Lecture with English Power Point Presentation

Literature
Power point slides, lecture notes and other lecture material will be provided.
Recommended additional literature:
C. Lechner, J. Seume, Stationäre Gasturbinen, Springer Verlag, 2. Auflage 2010

Course: Fundamentals of Energy Technology [3190923]

Coordinators: A. Badea
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC], Energy Economics and Informatics (p. 34)[MF6]

ECTS Credits	Hours per week	Term	Instruction language
8	5	Summer term	en

Learning Control / Examinations
Examination: written; orally only for students of Mechanical Engineering
Duration: written 90 minutes; orally 45 minutes

Conditions
Can not be combined with lecture 'Fundamentals of Energy Technology' [2130927].

Learning Outcomes
The students will receive state of the art knowledge about the very challenging field of energy industry and the permanent competition between the economical profitability and the long-term sustainability.

Content
The following relevant fields of the energy industry are covered:
- Energy forms
- Thermodynamics relevant to energy industry
- Energy sources: fossil fuels, nuclear energy, renewable sources
- Energy industry in Germany, Europe and worldwide
- Power generation and environment
- Evaluation of energy conversion processes
- Thermal/electrical power plants and processes
- Transport of energy / energy carriers
- Energy storage
- Systems utilizing renewable energy sources
- Basics of economic efficiency and calculus / Optimisation
- Future of the energy industry

Course: Fundamentals of Combustion I [3165016]

Coordinators: U. Maas, J. Sommerer
Part of the modules: Chemical Energy Carriers (p. 26)[MF2], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Written exam

Conditions
Can not be combined with lecture 'Fundamentals of Combustion I' [2165515].

Recommendations
Attendance of the tutorial (3165017 - Fundamentals of Combustion I)

Learning Outcomes
After completing this course students are able to:

- explain the chemical and physical processes gorverning combustion.
- discuss diagnostic methods applied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).
- understand the mechanisms governing pollutant formation

Content

- Ignition processes
- Fundamental concepts ans phenomena
- Experimental analysis of flames
- Conservation equations for laminar flat flames
- Chemical reactions
- Chemical kinetics mechanisms
- Laminar premixed flames
- Laminar diffusion flames
- Pollutant formation

Media
Blackboard and Powerpoint presentation

Literature
Lecture notes,
Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, authors: U. Maas, J. Warnatz, R.W. Dibble, Springer-Lehrbuch, Heidelberg 1996

Remarks
Lecture number of the tutorial for this class is 3165017

Course: Heat Transfer [22568]

Coordinators: N. Zarzalis
Part of the modules: BASICS ME (p. 19)[ME], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
oral/written examination

Conditions
Mathematics I, II and III

Learning Outcomes
The students understand and master the analogy between momentum and energy transport. In case of the energy transport the students master the calculation of the heat transfer coefficient for different flow- and thermodynamic conditions by the use of Nu-number.
The students can analyse new problems with the aid of the acquired methods. The lack of knowledge to solve the problems is closed by a literature study.

Content

- Introduction to conduction
- Introduction to convection
  - The convection boundary layers
  - Laminar and turbulent flow
  - Boundary layers Similarity
  - The effects of turbulence
- External flow
- Internal flow
- Free convection

Course: Integrated design of low energy buildings – Architecture, structure, materials and building physics [1720998]

Coordinators: A. Wagner, Prof. Ludwig Wappner, Prof. Matthias Pfeifer, Dr. Michael Haist, Prof. Andreas Wagner
Part of the modules: Energy in Buildings (p. 30)[MF4], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	4	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Integrated design, 100%, oral exam with grading, 30 min.

Conditions
Engineering Mechanics

Recommendations
Heat Transfer

Learning Outcomes
Basic knowledge of architectural design principles, building construction andmaterials properties, building physics and technical services systems

Content
Fundamentals of building construction, sustainable building and structural design methodology, construction typologies and building structure, materials and constructions in the climatic context, supporting structures, basic sizing of structural systems, heat and moisture transfer and storage in building envelopes, thermal comfort, steady state / dynamic heat balance, heating and ventilation, passive cooling

Literature
lecture slides as pdf, recommendations for further reading

Course: Nuclear Power Plant Technology [2170460]

Coordinators: T. Schulenberg, K. Litfin
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral
Duration: approximately 30 minutes
no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Knowledge of thermodynamics are a mandatory requirement for this course.
Basic knowledge of the physics of nuclear fission wiill be helpful.
Simulator exercises with a simplified pressurized water reactor and a simplified boiling water reactor are offered to ease understanding of thermodynamics and neutron physics.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in nuclear power plant engineering. The participants can describe the most important components of nuclear power plants and their function. You can design or modify nuclear power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of core design, design of primary and secondary systems, and of nuclear safety technologies. Based on the acquired knowledge in thermodynamics and neutron physics, they can describe and analyze the specific behavior of the nuclear power plant components and assess risks. Participants of the lecture have a trained analytical thinking and judgment in the design of nuclear power plants.

Content
Power plants with pressurized water reactors:
Design of the pressurized water reactor

- Fuel assemblies
- Control rods and drives
- Core instrumentation
- Reactor pressure vessel and its internals

Components of the primary system

- Primary coolant pumps
- Pressurizer
- Steam generator
- Water make-up system

Secondary system:

- Turbines
- Reheater
- Feedwater system
- Cooling systems

Containment

- Containment design
- Components of safety systems
- Components of residual heat removal systems

Control of a nuclear power plant with PWR
Power plants with boiling water reactors:
Design of the boiling water reactor

- Fuel assemblies
- Control elements and drives
- Reactor pressure vessel and its internals

Containment and components of safety systems
Control of a nuclear power plant with boiling water reactors

Media
Powerpoint presentations
PWR simulator
BWR simulator

Literature
lecture notes

Course: Laboratory Work in Combustion Technology [22531]

Coordinators: N. Zarzalis
Part of the modules: Utility Facilities (p. 37)[MF8], Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1], Chemical Energy Carriers (p. 26)[MF2]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral examination (not graded)

Conditions
Fluid dynamic, heat transfer

Recommendations
The “laboratory work in combustion technology” is a very good completion to the lesson “applied combustion technology”

Learning Outcomes
After completing the course students can:

- Measure the temperature inside the flame by means of thermocouples
- Perform an exhaust gas analysis
- Determine the degree of burn out from the exhaust analysis data
- Determine the efficiency of a furnace
- Determine the stability range of a burner
- Determine the laminar flame velocity according the bomb method

Content
The LAB-CT consists of 4 experiments dealing with:

- Energy conversion
- Unsteady flame propagation in a pressure vessel
- Swirl-stabilized flames
- Combustion in porous inert media

Course: Laboratory Exercise in Energy Technology [2171487]

Coordinators: H. Bauer, U. Maas, H. Wirbser
Part of the modules: Chemical Energy Carriers (p. 26)[MF2], Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter / Summer Term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
1 report, approx. 12 pages
Discussion of the documented results with the assistents

Duration: 30 minutes

no tools or reference materials may be used

Conditions
none

Recommendations
none

Learning Outcomes
Attending this course enables the students to:

- accomplish design related, experimental, numerical, analytical or theoretical tasks with a scientific background
- perform a correct evaluation of the obtained results
- adequately document and present their results in a scientific framework

Content
ITS topics
At ITS students will work on tasks, which will be defined each semester by the research asisstants, similar to topics of Bachelor- and Master-Theses. The following tasks are therefore just exemplary:

- concept for accurate repeated positioning of a camera of a robot arm
- Advanced image processing using Python
- Investigation of fuel atomization using novel mathemtical methods with MATLAB®
- Development of a post-processing routine for the determination of wetted surface area from SPH particle data
- Modelling and calculation of heat transfer and temperature profiles of test rig components applying Finite-Element-Methods
- Extension of a simulation modell to investigate spray evaporation using OpenFOAM®
- Control of the settings of an acoustic levitator using LabVIEW®

ITT topics
At the ITT students can choose between eight topics and elaborate them in groups of two.

1. Investigation of the operating behavior of a heat pump (cold steam machine) by determining the coefficient of performance (CoP) of the system as a function of the temperature level.
2. Implementing and testing of an experimental cooling tower: investigation of the mixing of cold and warm air.
3. Determination of the ignition delay of alternative fuel mixtures (bio-ethanol, methanol, diesel) with a rapid compression machine.
4. Development of alternative burner systems for cooking with alternative fuels (replacement of wood, kerosene, gases and coal).
5. Experimental investigation of burner systems to reduce pollutant emissions and increase efficiency.
6. Design of novel heat storage systems for residential heating systems / heat pumps.
7. Development of absorption refrigeration systems from the waste heat of passenger cars.
8. Influence of thermal disturbances on a laminar flow.

Remarks

The time to process the topic is 120 hours, corresponding to 4 ETCS Credits. The students have to process the topic successfully till the beginning of the following semester. Otherwise, the Laboratory Exercise is not passed and the student has to process another topic in the following semester. The processing time in the semester is flexible and shall be arranged between the supervisor and the student by mutual agreement.

The registration and the allocation of the topics takes place within the first two weeks of the lecture period on ILIAS: https://ilias.studium.kit.edu

Course: Machines and Processes [3134140]

Coordinators: H. Kubach, H. Bauer, U. Maas, B. Pritz
Part of the modules: BASICS CE (p. 17)[CE], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
7	4	Summer term	en

Learning Control / Examinations
successful lab course and written exam (2 h)
Taking part at the exam is possible only when lab course has been successfully completed

Conditions
Successful lab course is a precondition to take part at the exam.

Learning Outcomes
The students can name and describe basic energy conversion processes and energy converting machines. They can explain the application of these energy conversion processes in various machines. They can analyze and evaluate the processes and machines in terms of functionality and efficiency and they are able to solve basic technical problems in terms of operating the machines.

Content
basics of thermodynamics and combustion
thermal fluid machines

- steam turbunes
- gas turbines
- combined-cycle plants
- turbines and compressors
- aircraft engines

hydraulic fluid machines

- oerating performance
- characterization
- control
- cavitation
- wind turbines, propellers

internal combustion engines

- characteristic parameters
- engine parts
- kinematics
- engine processes
- emissions

Media
slides to download
Documentation of the labcourse

Remarks
The number of credit points depends whether the lab course is successfully attended (7 CP) or not (5 CP).
Lab course and lecture take place in summer and winter semester.
In the SS the lecture is held in English. The lab course is always bilingual.

Course: Machine Dynamics [2161224]

Coordinators: C. Proppe
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Summer term	en

Learning Control / Examinations
written

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to apply engineering-oriented calculation methods in order to model and to understand dynamic effects in rotating machinery. This includes the investigation of runup, stationary operation of rigid rotors including balancing, transient and stationary behavior of flexible rotors, critical speeds, dynamics of slider-crank mechanisms, torsional oscillations.

Content
1. Introduction
2. Machine as mechatronic system
3. Rigid rotors: equations of motion, transient and stationary motion, balancing
4. Flexible rotors: Laval rotor (equations of motion, transient and stationary behavior, critical speed, secondary effects), refined models)
5. Slider-crank mechanisms: kinematics, equations of motion, mass and power balancing

Literature
Biezeno, Grammel: Technische Dynamik, 2. Edition, 1953

Holzweißig, Dresig: Lehrbuch der Maschinendynamik, 1979

Dresig, Vulfson: Dynamik der Mechanismen, 1989

Remarks
Lecture number for the tutorial of this class is 2161225

Course: Machine Dynamics II [2162220]

Coordinators: C. Proppe
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
oral exam, no auxiliary means allowed

Conditions
none

Recommendations
Machine Dynamics

Learning Outcomes
Students are able to develop and analyze detailed models in machine dynamics that encompass continuum models, fluid structure interaction, and stability analyses.

Content
- hydrodynamic bearings
- rotating shafts in hydrodynamic bearings
- belt drives
- virbation of turbine blades

Literature
R. Gasch, R. Nordmann, H. Pfützner: Rotordynamik, Springer, 2006

Course: Mechanical Design I [2145186]

Coordinators: A. Albers, N. Burkardt
Part of the modules: BASICS EE (p. 18)[EE]

ECTS Credits	Hours per week	Term	Instruction language
4	4	Winter term	en

Learning Control / Examinations
Concomitant to the lecture, a workshop with 3 workshop sessions takes place over the semester. During the workshop the students are divided into groups and their mechanical design knowledge will be tested during a colloquium at the beginning of every single workshop session. The attendance is mandatory and will be controlled. The pass of the colloquia and the process of the workshop task are required for the successful participation.
Furthermore an online test is carried out.
Further information will be announced in Ilias and at the beginning of the lecture mechanical design I.

Conditions
none

Learning Outcomes
The students are able to ...

- describe complex systems using the system technique.
- identify and formulate functional connections of a technical system.
- use the contact and channel approach (C&C²-A).
- choose a spring and calculate it.
- identify different bearings and bearing arrangements and to select a suitable one for the particular situation.
- dimension bearing arrangements for different load cases.
- use the basic rules and principals of visualization and create a technical drawing.
- describe the functional connections of a technical system using the C&C²-A approach and sytem theory.

Furthermore the students can describe as a team technical solutions with a gear and draw chosen components in different technical expositions.

Content
Introduction in product development
Tools for visualization (technical drawing)
Product generation as a problem solving process
Technical systems for Product generation

- systems theory
- Elementary model C&CM

Basics of selected technical components

- springs
- bearings

Concomitant to the lectures, tutorials take place with the following contents:
Gear workshop
Tutorial "tools of visualization (technical drawing)"
Tutorial "technical systems product development, sytem theory, element model C&CM"
Tutorial "springs"
Tutorial "bearing and bearing arrangements"

Media
Beamer
Visualizer
Mechanical components

Literature
Lecture note:
The lecture notes can be downloaded via the eLearning platform Ilias.
Literature:

Konstruktionselemente des Maschinenbaus - 1 und 2
Grundlagen der Berechnung und Gestaltung von Maschinenelementen;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-22033-X
or per full text access provided by university library
Grundlagen von Maschinenelementen für Antriebsaufgaben;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-29629-8

Remarks
Lecture notes:
All lecture slides and additional information will be provided in ILIAS. All lecture notes and additional slides will be provided in Ilias.

Course: Mass Transfer and Reaction Kinetics [22534]

Coordinators: N. Zarzalis
Part of the modules: BASICS ME (p. 19)[ME], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
oral/written examination

Conditions
Mathematics I, II and III

Learning Outcomes
The students understand and master the analogy between momentum, energy and mass transport.
They can calculate the mass flows for different fluid and thermodynamics conditions with the aid of the analogy of heat and mass transfer (Nu- and Sh-number). Furthermore, the students can apply the basic chemical kinetic concepts in order to calculate the rates of species. The students can analyse new problems with the aid of the acquired methods. The lack of knowledge to solve the problems is closed by a literature study.

Content
Mass Transfer

- Ficks's law of diffusion
  - Equimolar diffusion
  - One way diffusion
- Liquid-vapor interfaces
- Analogy between heat and mass transfer – Sherwood and Nusselt number

Reaction Kinetics

- Elementary reaction rates – Bimolecular reaction and collision theory
- Rate of reaction for multistep mechanisms
- Net production rates
- Rate coefficients and equilibrium constants
- Steady-state approximation
- Chemical time scales

Partial equilibrium

Course: Mathematical Modelling and Simulation [0109400]

Coordinators: G. Thäter, V. Heuveline

Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Renewable Energy and Energy Storage (p. 35)[MF7], Decentralized Power Supply and Grid Integration (p. 28)[MF3], Thermal Power Plants (p. 24)[MF1], Chemical Energy Carriers (p. 26)[MF2], Energy Economics and Informatics (p. 34)[MF6], Energy in Buildings (p. 30)[MF4], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral examination

Conditions
none

Learning Outcomes
1) Broad horizon of modelling tools
2) (Un)stability and (un)reliability of models
3) Adequate accuracy and verification

Content
Mathematics as way of thinking (via modelling) and as technique (i.e. providing tools) meets problems arising in everyday life. The problems themselves are easy to understand and the lecture will not rely on too much previous knowledge. Basic understanding of probability and Ordinary Differential equations will be enough. But you should bring along some enthusiasm to use computers. Themes will comprise
1) Difference equations
2) Population models
3) Traffic modelling
4) Game theory
5) Chaos
6) Problems in mechanics and fluid dynamics
This course is well-suited for the first term.

Course: Microenergy Technologies [2142897]

Coordinators: M. Kohl
Part of the modules: Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
as elective subject in major field or as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, energy technologies, mechatronics and information technology. A comprehensive introduction is given in the basics and current developments in this new and very dynamically evolving field.
The lecture is (supplementary/compulsory) in the master course of „Micro Energy Technologies“ and supplementary in the major of „Mechatronics and Microsystems Technology“ in Mechanical Engineering.
Mechanical Engineering: Major M&M
Energy Technologies: NN
Energietechnik: NN

Learning Outcomes
- Knowledge of the principles of energy conversion
- Knowledge of the underlying concepts of thermodynamics and materials science
- Explanation of layout, fabrication and function of the treated devices
- Calculation of important properties (time constants, forces, displacements, power, degree of efficiency, etc.)
- Development of a layout based on specifications

Content
- Basic physical principles of energy conversion
- Layout and design optimization
- Technologies
- Selected devices
- Applications

The lecture includes amongst others the following topics:
Micro energy harvesting of vibrations
Thermal micro energy harvesting
Microtechnical applications of energy harvesting
Heat pumps in micro technology
Micro cooling

Literature
- Lecture notes (overhead transparencies) „Micro Energy Technologies“
- Stephen Beeby, Neil White, Energy Harvesting for Autonomous Systems, Artech House, 2010
- Shashank Priya, Daniel J. Inman, Energy Harvesting Technologies, Springer, 2009

Course: Modern Software Tools in Power Engineering [23388]

Coordinators: T. Leibfried
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC], Energy Economics and Informatics (p. 34)[MF6]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral test at the beginning of the internship
Duration: 15-20 minutes plus discussion
Written report about the results of the experiments performed during the internship

Conditions
none

Recommendations
none

Learning Outcomes
After completing the course students can:

- apply commercial software for calculating magnetic and electric field.
- apply commercial software for power grid calculations.

Content
During this practical course students will be able to work with three power engineering software tools. Participants should individually solve three typical engineering tasks:

- · **Modelling a high voltage bushing using finite element software "Maxwell".**
  In this module students will design a high voltage transformer bushing which resists high electric field stress. Using a finite element software it is possible to determine critical values already during the design phase, before producing costly models or prototypes.
- · **Development and Validation of an elevator control system based on a Siemens Simatic S7 PLC**

The PLC software Simatic S7 is a standard system for all kinds of industrial automation and control tasks. It consists of several programs which can be individually configured. During this course module students will be able to develop a control system which can be tested on a physical elevator model.
· **Load Flow Calculation of an industrial distribution grid using grid simulation software „DIgSILENT Powerfactory"**
The intention of this network analysis module is to understand the theory of load flow and short circuit calculation and to get familiar with its usage in practice. Further, an insight in real network calculation software shall be imparted.

Media
Blackboard and Powerpoint presentation

Literature
Course note packet
P. Kundur
"Power System Stability and Control"
McGraw-Hill Inc., 1994, ISBN 0-07-035958-X
N. G. Hingorani, L. I. Gyugyi
"Understanding FACTS"
Institute of Electrical and Electronics Engineers Inc., 2000, ISBN 0-7803-3455-8

Course: Nature-inspired Optimisation Methods [2511106]

Coordinators: P. Shukla
Part of the modules: Energy Economics and Informatics (p. 34)[MF6], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Summer term	en

Learning Control / Examinations
The examination results from the chosen module.
Elective course: written exam; if less than 6 participants: oral exam

Conditions
None.

Learning Outcomes
After completing the course the students know:

- Different nature-inspired methods: local search, simulated annealing, tabu search, evolutionary algorithms, ant colony optimization, particle swarm optimization
- Different aspects and limitation of the methods
- Applications of such methods
- Multi-objective optimization methods
- Constraint handling methods
- Different aspects in parallelization and computing platforms

Content
Many optimization problems are too complex to be solved to optimality. A promising alternative is to use stochastic heuristics, based on some fundamental principles observed in nature. Examples include evolutionary algorithms, ant algorithms, or simulated annealing. These methods are widely applicable and have proven very powerful in practice. During the course, such optimization methods based on natural principles are presented, analyzed and compared. Since the algorithms are usually quite computational intensive, possibilities for parallelization are also investigated.

Media
Powerpoint slides with annotations on graphics screen, access to Internet resources, recorded lectures

Literature
F. Glover and M. Laguna. „Tabu Search” In: Handbook of Applied Optimization, P. M. Pardalos and M. G. C. Resende (Eds.), Oxford University Press, pp. 194-208, 2002. G. Raidl and J. Gottlieb: Empirical Analysis of Locality, Heritability and Heuristic Bias in Evolutionary Algorithms: A Case Study for the Multidimensional Knapsack Problem. Evolutionary Computation, MIT Press, 13(4), pp. 441-475, 2005.
Weiterführende Literatur:
E. L. Aarts and J. K. Lenstra: „Local Search in Combinatorial Optimization”. Wiley, 1997. D. Corne and M. Dorigo and F. Glover: „New Ideas in Optimization”. McGraw-Hill, 1999. C. Reeves: „Modern Heuristic Techniques for Combinatorial Optimization”. McGraw-Hill, 1995. Z. Michalewicz, D. B. Fogel: „How to solve it: Modern Heuristics”. Springer, 1999. E. Bonabeau, M. Dorigo, G. Theraulaz: „Swarm Intelligence”. Oxford University Press, 1999. A. E. Eiben and J. E. Smith: „Introduction to Evolutionary Computing”. Springer, 2003. K. Weicker: „Evolutionäre Algorithmen”. Teubner, 2002. M. Dorigo, T. Stützle: „Ant Colony Optimization”. MIT Press, 2004. K. Deb: „Multi-objective Optimization using Evolutionary Algorithms”, Wiley, 2003.

Remarks
Lecture number for the tutorial of this class is 2511107

Course: Nuclear Fusion Technology [2189920]

Coordinators: A. Badea
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
written exam, graded, 60 min

Conditions
None.

Recommendations
good level of knowledge in physics and mathematics

Learning Outcomes
This lecture is dedicated to Master students of mechanical engineering and other engineering studies. Goal of the lecture is the understanding of the physics of fusion, the components of a fusion reactor and their functions. The technological requirements for using fusion technology for future commercial production of electricity and the related environmental impact are also addressed. The students are capable of giving technical assessment of the usage of the fusion energy with respect to its safety and sustainability.

Content
nuclear fission & fusion
neutronics for fusion
fuel cycles, cross sections
gravitational, magnetic and inertial confinement
fusion experimental devices
energy balance for fusion systems; Lawson criterion and Q-factor
materials for fusion reactors
plasma physics, confinement
plasma heating
timeline of the fusion technology
ITER, DEMO
safety and waste management

Course: Nuclear Power and Reactor Technology [2189921]

Coordinators: A. Badea
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter term	en

Learning Control / Examinations
written exam, graded, 80 min

Conditions
None.

Recommendations
numerical methods, partial differential equations, special functions, orthogonal polynomials

Learning Outcomes
This lecture is dedicated to Master students of mechanical engineering and other engineering studies. Goal of the lecture is the understanding of reactor technology and of the major physical processes in converting nuclear power into electrical energy. Present and future nuclear systems (including reactors of the generation IV) are addressed. The students are capable of understanding the advantages and disadvantages of different reactor technologies by using the delivered knowledge on reactor physics, thermal-hydraulics, reactor design, control, safety and requirements of the front-end and back-end of the fuel cycle.

Content
nuclear fission & fusion,
chain reactions,
moderation,
light-water reactors,
transport- and diffusion-equation,
power distributions in reactor,
reactor safety,
reactor dynamics,
design of nuclear reactors,
breeding processes,
nuclear power systems of generation IV

Course: Organic Computing [2511104]

Coordinators: H. Schmeck
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4,5	2/1	Summer term	en

Learning Control / Examinations
The examination will be offered latest until summer term 2017 (repeaters only).
The examination results from the chosen module.
Elective course: written exam; if less than 10 participiants: oral exam possible

Conditions
The students need basic knowledge of informatics, they should have some programming experience.

Learning Outcomes
The students will get to know methods and concepts of Organic Computing and to apply them in innovative ways.
The objectives of this course are to teach fundamentals of Organic Computing in the context of their application in practice. Based on a fundamental understanding of the essential concepts they will be able to apply them reasonably in appropriate situations in their professional life, to adjust them whenever necessary and to explain their appropriate use.

Content
The mission of Organic Computing is to tame complexity in technical systems by providing appropriate degrees of freedom for self-organized behaviour adapting to changing requirements of the execution environment, in particular with respect to human needs. According to this vision an organic computer system should be aware of its own capabilities, the requirements of the environment, and it should be equipped with a number of "self-x" properties allowing for the anticipated adaptiveness and for a reduction in the complexity of system management. These self-x properties include self-organisation, self-configuration, self-optimization, self-healing, self-protection and self-explanation. In spite of these self-x properties, an organic system should be open to external control actions which might be necessary to prevent undesired behaviour. The course addresses major concepts and methods of Organic Computing and highlights the impact and potential of Organic Computing with respect to real-world applications, specifically in traffic and energy scenarios.

Media
powerpoint slides with annotations, access to applets and Internet ressources, lecture recording (camtasia).

Literature

- Autonomic Computing: Concepts, Infrastructure and Applications. M. Parashar and S. Hariri (Ed.), CRC Press. December 2006.
- Self-Organization in Biological Systems. S. Camazine, J. Deneubourg, N. R. Franks, J. Sneyd, G. Theraulaz and E. Bonabeau. Princeton University Press, 2003.
- Complex Adaptive Systems: An Introduction. H. G. Schuster, Scator Verlag, 2001.
- Introduction to Evolutionary Computing. A. E. Eiben and J. E. Smith. Natural Computing Series, Springer Verlag, 2003. Swarm Intelligence: From Natural to Artificial Systems.Eric Bonabeau, Marco Dorigo and Guy Theraulaz. Oxford University Press, 1999.
- Control of Complex Systems. K. Astrom, P. Albertos, M. Blanke, A. Isidori and W. Schaufelberger. Springer Verlag, 2001.
- Organic Computing - A Paradigm Shift for Complex Systems. C. Müller-Schloer, H. Schmeck, T. Ungerer (eds): Springer, Autonomic Systems, Basel, 627 p., 2011

Elective literature:

- **Adaptive and Self-organising Systems,** Christian Müller-Schloer, Moez Mnif, Emre Cakar, Hartmut Schmeck, Urban Richter,
  June 2007. Preprint.Submitted to ACM Transactions on Autonomous and Adaptive Systems (TAAS)
- **Organic Computing - Addressing Complexity by Controlled Self-organization,** Jürgen Branke, Moez Mnif, Christian Müller-Schloer, Holger Prothmann, Urban Richter, Fabian Rochner, Hartmut Schmeck, In Tiziana Margaria, Anna Philippou, and Bernhard Steffen, *Proceedings of ISoLA 2006*, pp. 200-206. Paphos, Cyprus, November 2006.
- Evolutionary Optimization in Dynamic Environments. J. Branke. Kluwer Academic Publishers, 2002.
- Self-star Properties in Complex Information Systems: Conceptual and Practical Foundations (Lecture Notes in Computer Science. O. Babaoglu, M. Jelasity, A. Montresor, C. Fetzer, S. Leonardi, A. van Moorsel and M. van Steen. Springer Verlag, 2005.
- Design and Control of Self-organizing Systems. C. Gershenson. PhD thesis, Vrije Universiteit Brussel, Brussels, Belgium, 2007.

- VDE / ITG / GI - Positionspapier: Organic Computing - Computer- und Systemarchitektur im Jahr 2010. Juli 2003. it - Information Technology, Themenheft Organic Computing, Oldenbourg Verlag. Volume: 47, Issue: 4/2005.

further references will be announced in class

Remarks
Currently, it is not clear whether this course will be offered after SS 2017.

Course: Power Electronics [23385]

Coordinators: T. Leibfried, A. Kloenne
Part of the modules: BASICS CE (p. 17)[CE], Elective Course (p. 22)[EC], BASICS ME (p. 19)[ME]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
written examination

Conditions
Fundamentals of Electrical Engineering,
Fundamentals of Electronics

Learning Outcomes
The students

- have profound knowledge about power electronic switches, their application and protection
- possess key skills in of generic power electronic circuits
- are able to analyse and calculate fundamental switched-power supplies
- understand Line-Frequency Phase Controlled Rectifiers and Inverters
- are endued with practical converter design considerations
- are able to implement the basic control strategies in power electronic systems

Content
- Introduction to Power Electronics
- Overview of Power Semiconductor Switches (Diodes, Thyristors, GTO, BJT, Mosfet)
- Drive and Snubber Circuits
- Structure of Power Module Packages
- Heat Transfer of Power Semiconductors
- DC-DC Switch-Mode Converters (Step-Down Converter, Step-Up Converter, Buck-Boost Converter, Flyback Converter)
- Line-Frequency Phase-Controlled Rectifiers and Inverters (Single-Phase, Three-Phase)
- High Voltage DC Transmission
- Switch-Mode Inverters (Single Phase, Three Phase)
- Concepts of Current Control in Swicht-Mode Inverters
- Variable Freqency Inverters

Literature
Prof. Kloenne, Lecture Notes, Summer Semester 2013
Mohan, N.; Undeland, T.M.; Robbins, W.P.: Power Electronics, Converters, Applications and Design; Wiley, 1989

Course: Workshop on computer-based flow measurement techniques [2171488]

Coordinators: H. Bauer
Part of the modules: Energy in Buildings (p. 30)[MF4], Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter / Summer Term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Group colloquia for each topic

Duration: approximately 10 minutes

no tools or reference materials may be used

Conditions
none

Learning Outcomes
The students are able to:

- theoretically describe and explain the fundamentals of computer aided measurements and and adopt them practically
- apply the basics learned during the lecture to a practical problem in the form of a PC excercise

Content
The laboratory course offers an introduction into the acquisition of basic test data in fluid mechanics applications as well as a basic hands-on training for the application of modern PC based data acquisition methods. The combination of lectures about measurement techniques, sensors, signal converters, I/O systems, bus systems, data acquisition, handling and control routines and tutorials for typical fluid mechanics applications allows the participant to get a comprehensive insight and a sound knowledge in this field. The graphical programming environment LabVIEW from National Instruments is used in this course as it is one of the standard software tools for data acquisition worldwide.
Basic design of measurements systems

- Logging devices and sensors
- Analog to digital conversion
- Program design and programming methods using LabView
- Data handling
- Bus systems
- Design of a computer aided data acquisition system for pressure, temperature and derived parameters
- frequency analysis

Literature
Germer, H.; Wefers, N.: Meßelektronik, Bd. 1, 1985
LabView User Manual
Hoffmann, Jörg: Taschenbuch der Messtechnik, 6., aktualisierte. Aufl. , 2011

Course: Project Management for Engineers [23684]

Coordinators: M. Noe
Part of the modules: Innovation/Entrepreneurship (p. 20)[INNO]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students understand and apply safely the basics and tools of project management. The main issues of project communication can be described and applied. The work steps from specification to submission of work are clear and can be applied for different practical situations. The safe application of project changes and claims is a common task. The students can analyse real scenarios in project management and apply the methods learned in this seminar.

Content
This seminar belongs to the key qualifications within the master study and is a non-technical course within the diploma study of electrical engineering and information technology. Each part is structured in a short introduction followed by group exercises. Practical examples are given in this group exercise.

Remarks
The course takes place on 5 afternoons. Current information can be found on the IMS (www.ims.kit.edu) webpage.

Course: Pulsed Power Technology and Applications [23395]

Coordinators: G. Müller
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Winter term	en

Learning Control / Examinations
oral exam (20 min) and written report about the results of the experiments conducted (one report per group)

Conditions
none

Learning Outcomes
The students know the common methods of high-power pulse generation including voltage multiplication by stacking, pulsed generators based on transmission lines, different methods of pulse forming and the related measurement technique. Furthermore, students are familiar with actual scientific and industrial applications of pulsed power.
After completing the course students have theoretical and practical experience on the performance of different types of pulse generators and components (e.g. switches), according measurement techniques and data acquisition using oscilloscopes. Students will know the basics of electroporation process and analytical methods for material characterization (SEM, EDX, XRD).

Content
Pulsed power is generated by means of discharging stored energy as electrical energy into a load in a single short pulse or with a controllable repetitive rate of short pulses. Corresponding voltage and current amplitudes are between several kV and some 10 MV and between 1 kA and several 10 MA respectively. Electrical power of such pulses ranges from Megawatts to few 100 Terawatts with a variety of applications in different research and industrial fields (e.g. energy, material processing, and medicine). The lecture will address the following topics:
Basics:
• Electrical strength of dielectrics
• Energy storage (capacitive, inductive)
• Switches (opening and closing switches)
Systems:
• pulse forming and transmission lines
• voltage and power amplification
• high-power generators
• metrology in pulsed technique
Applications:
• surface treatment by charged particle beams (electrons, ions)
• electrodynamic fragmentation
• electroporation and bioelectrics
• inertial confinement fusion
An excursion will be offered to the Institute for Pulsed Power and Microwave Technology (IHM) at Campus North. Different pulsed power facilities and their specific applications will be presented.
The laboratory course gives an overview of the features and phenomena of pulse power engineering and emerging applications. Modern applications of pulsed power technologies cover a wide range of topics, ranging from applications in the field of renewable energies as a pretreatment method for biomass conversion, material processing for high temperature applications (e.g. concentrated solar power), inertial confinement fusion to medical applications like the electro chemo therapy for cancer treatment. Beside the electrical engineering aspect, one goal of this course is to provide basic knowledge in bioelectric (interaction of pulsed electric field with biological cells) and in analytical methods for material characterization. Following topics will be addressed:
• Transmission line based generators
• Marx- generator
• Magnetic switches
• Gas filled spark gap
• Impedance measurement on biological tissue
• Inactivation of biological cells and electro-orientation
• Surface modification by pulsed electron beams
• Material characterization by SEM, EDX, XRD
In total 8-9 experiments will be conducted. The tests are carried out in groups of two or three students. Since working with high voltages (up to 120 kV) particular emphasis is put on safety. Therefore, part of the internship is an obligatory safety briefing conducted at the beginning of the course.

Remarks

Practical course will be conducted in the laboratories of the Institute for Pulsed Power and Microwave Technologies (IHM) at Campus North. To reach Campus North participants are recommended to use the free KIT-shuttle.

Course: Reactor Safety I: Fundamentals [2189465]

Coordinators: V. Sánchez-Espinoza
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral examination duration: 20-30 minutes

Conditions
Nuclear power plant technology, Nuclear thermal hydraulics

Learning Outcomes
After completing the course students

- are familiar with the general reactor safety principles and requirements and well as with nuclear regulation
- know the main safety features of different nuclear power plant types (Gen-II, Gen-II and Gen-IV)
- understand the methodologies for accident analysis and event classifications
- are familiar with the main mechanism of design basis and beyond design basis accidents including role of preventive and mitigative accident management measures
- are familiar with the principles of risk assessment for nuclear reactor
- know about the past major accidents in nuclear power plants and their radiological consequences

Content
Potential risk of nuclear power plants, Safety philosophy, safety requirements and general design criteria, Nuclear regulation and licensing, Safety features of reactors of the Gen-II, -III and IV, Internal events in nuclear power plants, External events in nuclear power plants, Design basis accidents, Severe accidents, Radiological consequences of accidents, Accidents in nuclear power plants, Risk assessment

Media
Blackboard and Powerpoint presentation

Literature

- Course note packet
- B. R. Sehgal; Nuclear Safety in LWR: Severe Accident Phenomenology. Academic Press Elsevier. 2012.
- John C. Lee and Norman J. McCormick.July; Risk and Safety Analysis of Nuclear Systems. 2011
- G. Petrangeli; Nuclear Safety. Elsevier Butterworth-Heinemann. 2006
- W. M. Stacey; Nuclear Reactor Physics, John Wiley & Sons, 2001
- J. N. Lillington; Light Water Reactor Safety: The Development of Advanced Models and Codes for Light Water Reactor Safety Analysis. ELSEVIER. 1995.

Course: Renewable Energy – Resources, Technology and Economics [2581012]

Coordinators: R. McKenna
Part of the modules: Innovation/Entrepreneurship (p. 20)[INNO]

ECTS Credits	Hours per week	Term	Instruction language
4	2/0	Winter term	en

Learning Control / Examinations
The assessment consists of a written exam according to Section 4(2), 1 of the examination regulation.

Conditions
None.

Learning Outcomes
The student:

- understands the motivation and the global context of renewable energy resources.
- gains detailed knowledge about the different renewable resources and technologies as well as their potentials.
- understands the systemic context and interactions resulting from the increased share of renewable power generation.
- understands the important economic aspects of renewable energies, including electricity generation costs, political promotion and marketing of renewable electricity.
- is able to characterize and where required calculate these technologies.

Content
1. General introduction: Motivation, Global situation
2. Basics of renewable energies: Energy balance of the earth, potential definition
3. Hydro
4. Wind
5. Solar
6. Biomass
7. Geothermal
8. Other renewable energies
9. Promotion of renewable energies
10. Interactions in systemic context
11. Excursion to the “Energieberg” in Mühlburg

Media
Media will be provided on the e-learning platform ILIAS.

Literature
Elective literature:

- Kaltschmitt, M., 2006, Erneuerbare Energien : Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, aktualisierte, korrigierte und ergänzte Auflage Berlin, Heidelberg : Springer-Verlag Berlin Heidelberg.
- Kaltschmitt, M., Streicher, W., Wiese, A. (eds.), 2007, Renewable Energy: Technology, Economics and Environment, Springer, Heidelberg.
- Quaschning, V., 2010, Erneuerbare Energien und Klimaschutz : Hintergründe - Techniken - Anlagenplanung – Wirtschaftlichkeit München : Hanser, Ill.2., aktualis. Aufl.
- Harvey, D., 2010, Energy and the New Reality 2: Carbon-Free Energy Supply, Eathscan, London/Washington.
- Boyle, G. (ed.), 2004, Renewable Energy: Power for a Sustainable Future, 2nd Edition, Open University Press, Oxford.

Course: Simulator Exercises Combined Cycle Power Plants [2170491]

Coordinators: T. Schulenberg
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
2	2	Summer term	en

Learning Control / Examinations
Oral examination (ca. 15 min)

Conditions
None.

Recommendations
Participation at the lecture Combined Cycle Power Plants (2170490) is recommended.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. On the basis of the learned fundamentals in thermodynamics, in instrumentation and control engineering, as well as on the basis of the acquired knowledge of design of combined cycle plants, the participants can operate a real combined cycle power plant. This application creates a deeper understanding of the dynamic processes of the power plant, the specific importance of the plant components and the limits of the load capacity of the components. Participants can optimize normal operation and analyze incidents. They can work self-organized and reflexive. They have communicative and organizational skills in teamwork, even under major technical challenges.

Content
Start-up of the power plant from scratch; load changes and shut down; dynamic response of the power plant in case of malfuctions and of sudden load changes; manual operation of selected components.

Media
The power plant simulator is based on the control system of a real SIEMENS power plant. The English user surface is based on US standard.

Literature
Slides and other documents of the lecture Combined Cycle Power Plants.

Course: Smart Energy Distribution [2511108]

Coordinators: H. Schmeck
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
The examination will be offered latest until summer term 2017 (repeaters only).
Written exam, unless the number of registered students is too small.

Conditions
The students should have an understanding of informatics, they would benefit from some previous knowledge of self-organisation and methods for optimisation, but this is not mandatory

Learning Outcomes
The students will develop an understanding for the major challenges of the Energiewende and for the necessity and potential of information and communication technology for addressing basic problems that arise from decentralisation and an increased share of renewables in the power mix, They will know how to deal with these problems by using concepts like virtualisation and self-organisation in intelligent energy management systems. They will know how to design and apply adequate methods for smart energy distribution in various related problem settings and they will be capable to explain the appropriate use of these methods. In this way the students will get to know the scope of topics in the emerging discipline of Energy Informatics and its relevance for the design of tomorrow's energy system..

Content
The course addresses the challenges of the Energiewende with respect to the role of information and communication technologies for shaping tomorrow's engery systems. The increasing share of power generation from renewable sources and the decentralisation of power generation lead to an increasing need for local balancing of power supply and demand. While traditional power management was based on the assumption that power consumption is not controllable and that electric power cannot be stored effectively, future power management will depend significantly on much more flexibility in demand and in innovative ways of storing energy.
The course will present concepts for smart energy management that have been developed in projects on "e-energy" and "ICT for Electric Mobility", like virtual power plants, local agent-based power management, concepts of load shifting, autonomic and organic approaches to power management in smart homes, utilization of mobile and stationary batteries for stabilization of the power grid. Furthermore, it addresses aspects of security and privacy due to the pervasive use of ICT in energy systems.
The concepts presented in this course are essential topics of the emerging discipline of Energy Informatics.

Media
slides, on screen annotations , lecture recording using camtasia

Remarks
This course is offered to students of the (KIC) MSc program EnTech but may also be taken by students of the Master programs Industrial Engineering, Economics Engineering, Information Engineering and Management, and Mathematics in Economics.

Course: Solar Energy [23745]

Coordinators: B. Richards
Part of the modules: Elective Course (p. 22)[EC], Renewable Energy and Energy Storage (p. 35)[MF7]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Winter term	en

Learning Control / Examinations
Elective course: written exam

Conditions
Semiconductor fundamentals

Learning Outcomes
Students will be provided a comprehensive and detailed knowledge about solar energy conversion and related applications and technology. A profound knowledge of the technology will allow the students to carry out their own research on solar energy conversion. The lecture includes exercises on selected topics to deepen insight into the field.

Content
This course addresses different technical and scientific aspects of photovoltaic light conversion such as silicon 3rd generation, thin film and organic photovoltaics, tandem and concentrator solar cells and measurement techniques. Installation requirements and financial considerations for small and large size photovoltaic power plants for on-grid and off-grid solutions will be discussed. An introduction into solar thermal power plants and the respective technology will be given. Both solar energy harvesting technologies will be discussed as part of a greater concept for a reliable future energy supply.

Remarks
The lecture number for the tutorial of this class is 23750

Course: Radiation Protection I: Ionising Radiation [23271]

Coordinators: B. Breustedt, M. Urban
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

Conditions
None.

Learning Outcomes
The students know about the basics of radiation protection concerning ionizing radiation.

Content
The lecture shows the basics of radiation protection concerning ionizing radiation.

Course: Superconducting Materials for Energy Applications [23682]

Coordinators: F. Grilli
Part of the modules: Decentralized Power Supply and Grid Integration (p. 28)[MF3], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral exam, about 25 min.

Conditions
None.

Learning Outcomes
After attending this course, the students will have

- Received an introduction to superconductivity, with an overview of its main features and of the theories developed to explain it;
- Learned about superconducting materials and their properties, especially those currently employed in energy applications (niobium-based superconductors, cuprates, MgB2) and promising recently discovered ones (pnictides);
- Familiarized with the wide range of superconducting energy applications (magnets, cables, fault current limiters, motors, transformers, etc.), and learned about the advantages they offer with respect to their conventional counterparts.

Content

- Introduction of the course
- Basics of superconductivity
- Materials I (low-T_c superconductors)
- Materials II (high-T_c superconductors)
- Stability
- AC losses
- Simulation and modeling
- Cables
- Fault current limiters
- Magnets, motors, transformers
- Smart-grids
- Lab tour

Media
Blackboard, PowerPoint slides, script written by the teacher (100+ pages)

Literature
Various. It will be provided on a lecture-by-lecture basis.

Remarks
Current information can be found on the IMS (www.ims.kit.edu) webpage. At the end of the course an excursion is planned to KIT Campus North (ITEP).

Course: Engineering Mechanics I [3161010]

Coordinators: T. Langhoff, T. Böhlke
Part of the modules: BASICS EE (p. 18)[EE], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
6	5	Winter term	en

Learning Control / Examinations
written, 90 min. Additives as announced

Conditions
none

Recommendations
None.

Learning Outcomes
The students can

- analyse different equilibrium systems based on the notion of forces and moments, e.g. plane and spatial force systems on a rigid body
- compute internal forces and moments for linear structures and as a result analyse and evaluate the internal load
- compute systems under the influence of friction
- determine the center of lines, areas, masses and volumes
- apply the principal of virtual displacements
- evaluate the stability of equilibrium positions
- compute and evaluate the load of straight bars in the framework of thermoelasticity
- solve worksheet problems about topics of the lecture using the computer algebra system MAPLE

Content

- basics of vector calculus
- force systems
- statics of rigid bodies
- internal forces and moments in bars and beams
- friction
- centre of gravity, centre of mass
- work, energy, principle of virtual work
- statics of inextensible ropes
- elastostatics of tension-compression-bars

Literature
lecture notes
Hibbeler, R.C: Technische Mechanik 1 - Statik. Prentice Hall. Pearson Studium 2005.
Gross, D. et al.: Technische Mechanik 1 - Statik. Springer 2006.
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Parkus, H.: Mechanik der festen Körper. Springer 1988.

Course: Technical Thermodynamics and Heat Transfer I [3165014]

Coordinators: U. Maas, R. Schießl
Part of the modules: BASICS EE (p. 18)[EE], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
7	3	Winter term	en

Learning Control / Examinations
Final exam: 3 h

Conditions
Prerequisite: attestation each semester by homework assignments

Recommendations
Attendance of the tutorial (3165015 - Technical Thermodynamics and Heat Transfer I)

Learning Outcomes
After completing the course students can:

- describe the correlations between the chemical and thermodynamic properties of pure substances.
- setup the balance equations for mass and energy for different processes.
- determine the direction of a process.
- understand the fundamental processes in phase transitions.
- explain the basics of ideal thermodynamic cycles.

Content
System, properties of state
Chemical and thermodynamic properties of pure components
Absolute temperature, model systems
1st law of thermodynamics for resting and moved systems
Entropy and 2nd law of thermodynamics
Behavior of real substances described by tables, diagrams and equations of state
Machine processes

Media
Blackboard and Powerpoint presentation

Literature
Lecture notes
Additional Books (some examples):
Schaum's outlines: Thermodynamics for Engineers
M.C. Potter, C. W. Sommerton
McGraw-Hil, 1st edition (1994)
ISBN 0070507074
Y. A. Cengel, M. A. Boles: Thermodynamics, An Engineering Approach McGraw-Hill, (e.g: 3rd Ed. (1998))
ISBN 0-07-913238-3
Michael J. Moran, Howard N. Shapiro, Fundamentals of
Engineering Thermodynamics
Wiley (e.g: 3rded., 1998), ISBN 0 471 97960 0

Course: Ten lectures on turbulence [2189904]

Coordinators: I. Otic
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral examination; duration: 20 minutes

Conditions
None.

Recommendations

- Undergraduate statistics and probability theory. Graduate-level fluid mechanics.

Learning Outcomes
At the completion of this course, students
- are able to understand fundamentals of statistical fluid mechanics, turbulence theory and turbulence modelling
- are able to derive RANS and LES transport equations
- get working knowledge of modelling techniques that can be used for solving engineering heat and mass transfer problems.

Content
The course is aimed of giving the fundamentals of turbelence theory, modelling and simulation. Governing equations and statistical description of turbulence are introduced. Reynolds equations, Kolmogorov's theory and scales of turbulent ows are discussed. Homogeneous and isotropic turbulence. Turbulent free-shear ows and wall-bounded turbulent ows are discussed. Turbulence modelling approaches and simulation methods are introduced.

Literature
Reference texts:
- Lecture Notes
- Presentation slides
Recommended Books:
- Pope, S. B.: Turbulent Flows. Cambridge University Press , 2003.
- Hinze J. O.: Turbulence. McGraw-Hill, 1975.

Course: Thermal Waste Treatment [22516]

Coordinators: T. Kolb
Part of the modules: Utility Facilities (p. 37)[MF8], Elective Course (p. 22)[EC], Chemical Energy Carriers (p. 26)[MF2]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter term	en

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
Bachelor in mechanical or chemical engineering or similar
Basics in thermodynamics, chemistry, process design, fuels, combustion

Learning Outcomes
The course introduces waste as a chemical energy carrier, its specification and availability.
Students know process principles and can evaluate thermal waste treatment processes for different waste specifications. Basic legal aspects of waste management are addressed.

Content

- waste as chemical energy carrier
- technical systems for thermal waste treatment
- legal aspects of waste management
- economical and ecological process evaluation
- process design principles
- municipal solid waste, MSW
- hazardous waste
- sewage sludge
- process principles - combustion, gasification pyrolysis
- technical systems - grate furnace, rotary kiln, fluidized bed

Course: Thermal Turbomachines I [2169453]

Coordinators: H. Bauer
Part of the modules: Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
6	5	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral
Duration: approximately 30 min

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines II'.

Learning Outcomes
The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to to describe and analyse not only the individual components but also entire assemblies. The students can asses and evaluate the effects of physical, economical and ecological boundary conditions.

Content
Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

Literature
Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

Remarks
Lecture number for the tutorial of this class is 2169454

Course: Thermal Turbomachines I (in English) [2169553]

Coordinators: H. Bauer
Part of the modules: Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter term	en

Learning Control / Examinations
oral
Duration: approximately 30 min

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines II'.

Learning Outcomes
The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to to describe and analyse not only the individual components but also entire assemblies. The students can asses and evaluate the effects of physical, economical and ecological boundary conditions.

Content
Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

Literature
Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

Course: Thermal Turbomachines II [2170476]

Coordinators: H. Bauer
Part of the modules: Elective Course (p. 22)[EC], Thermal Power Plants (p. 24)[MF1]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral (can only be taken in conjunction with 'Thermal Turbomachines I')
Duration: approx. 30 minutes (–> 1 hour including Thermal Turbomachines I)

Auxiliary:no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines I'.

Learning Outcomes
Based on the fundamental skills learned in 'Thermal Turbomachines I' the students have the ability to design turbines and compressors and to analyse the operational behavior of these machines.

Content
General overview, trends in design and development

Comparison turbine - compressor

Integrating resume of losses

Principal equations and correlations in turbine and compressor design, stage performance

Off-design performance of multi-stage turbomachines

Control system considerations for steam and gas turbines

Components of turbomachines

Critical components

Materials for turbine blades

Cooling methods for turbine blades (steam and air cooling methods)

Short overview of power plant operation

Combustion chamber and environmental issues

Literature
Lecture notes (Available via internet)
Bohl, W.: Strömungsmaschinen, Bd. I,II, Vogel Verlag 1990, 1991
Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993
Traupel, W.: Thermische Turbomaschinen, Bd. I,II, Springer-Verlag, 1977, 1982

Course: Transport and Storage of Chemical Energy Carriers [22332]

Coordinators: T. Kolb
Part of the modules: Utility Facilities (p. 37)[MF8], Elective Course (p. 22)[EC], Chemical Energy Carriers (p. 26)[MF2]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
oral exam, graded, duration depends on the lecture

Conditions
basics in chemistry, heat and mass transfer

Learning Outcomes
Application of basic principles of engineering on the special problems of a municipal utility company

Content

- Basics of conversion and production of chemical energy carriers
- Gas grid, transportation and storage of gaseous fuels
- The role of fuel gas in sustainable energy systems
- Management systems and economics for utility companies.

Course: Urban planning and energy infrastructure [1731099]

Coordinators: M. Neppl, Prof. Markus Neppl, Dipl.-Ing. Markus Peter
Part of the modules: Elective Course (p. 22)[EC], Energy in Buildings (p. 30)[MF4]

ECTS Credits	Hours per week	Term	Instruction language
4	4	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Urban planning, 60 %, oral exam with grading, 30 min., 40% project work in exercises with grading

Conditions
None.

Learning Outcomes
Understanding of urban structures including energy supply concepts on different scales as well as urban planning processes

Content
Basics of urban form and urban development, decision and operation levels in urban planning, fundamentals of sustainable urban development, urban planning and energy concepts, urban (energy) infrastructure, energy supply for settlements/quarters/neighbourhoods, climate protection and adaptation concepts, exploitation of relevant data for systematic urban planning, modeling of urban energy flows, urban load management/smart cities

Literature
lecture slides as pdf, recommendations for further reading

Course: Heat Transfer in Nuclear Reactors [2189907]

Coordinators: X. Cheng
Part of the modules: Nuclear and Fusion Technology (p. 32)[MF5], Elective Course (p. 22)[EC]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral examination; duration: 30 minutes

Conditions
None.

Learning Outcomes
This lecture is focused on students of mechanical engineering and chemical engineering in bachelor or master degree courses. The students learn some important processes and analysis methods of flow and heat transfer in nuclear reactors. After the lecture the students are capable of carrying out thermal-hydraulic analysis and making suggestions to improve the heat removal from the reactor core. Through the exercises with a specific numerical simulation programs the students will master the engineering procedure to perform thermal-hydraulic analysis of nuclear reactors.

Content

1. Overview of nuclear systems
2. Design tasks and design criteria of nuclear thermal-hydraulics
3. Heat release and distribution in nuclear reactors
4. Heat transfer process in nuclear reactors
5. Temperature distribution in coolant and structural materials
6. Pressure drops in nuclear systems
7. Flow stability of nuclear systems
8. Critical flow under accident conditions
9. Natural circulation and passive safety systems
10. Methodologies of thermal-hydraulic design

Literature

1. W. Oldekop, Einführung in die Kernreaktor und Kernkraftwerkstechnik, Verlag Karl Thiemig, München, 1975
2. L.S. Tong, J. Weisman, Thermal-hydraulics of pressurized water reactors, American Nuclear Society, La Grande Park, Illinois, USA
3. R.T. Lahey, F.J. Moody, The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, 2nd edition, ANS, La Grande Park, Illinois, USA, 1993

Remarks
The lecture number for the tutorial of this class is 2189909

Study and Examination Regulations of Karlsruhe Institute of Technology (KIT) about the Master's Program Energy Technologies (ENTECH)

dated July 24, 2012

Pursuant to Article 10, par. 2, clause 5 and Article 20 of the Act on Karlsruhe Institute of Technology (KIT Act – KITG) of July 14, 2009 (bulletin, p. 317 f.), last amended by Article 32 of the Act on Reform of Public Service Legislation (Service Legislation Reform Act – DRG) of November 9, 2010 (bulletin, pp. 793, 967) and Article 8, par. 5 and Article 34, par. 1 of the Law of Baden-Württemberg on Universities and Colleges (Landeshochschulgesetz - LHG) of January 01, 2005 (bulletin, p. 1 f.), last amended by Article 5 of the Act on the Abolition and Compensation of Tuition Fees and on the Amendment of Other Laws (Tuition Fee Abolition Act – StuGebAbschG) of December 21, 2011 (bulletin, p. 565 f.), the Senate of Karlsruhe Institute of Technology (KIT) adopted the following Study and Examination Regulations about the Master's Program Energy Technologies (ENTECH) on February 27, 2012.

The Presidents expressed their approval on July 24, 2012.

Contents

Within the framework of the implementation of the Bologna process for the establishment of a European higher education area, it is the defined objective of Karlsruhe Institute of Technology (KIT) that higher education of students at KIT is to be completed by the master's degree. KIT therefore understands the consecutive bachelor's and master's programs offered by KIT as an integrated concept with a consecutive curriculum.

Only the feminine gender was chosen in the wording. However, all information pertaining to persons shall apply equally to women and men.

I. General Provisions

Article 1 - Scope, Objectives

(1) The present master's examination regulations shall apply to the course of studies, examinations, and graduation in the master's program of Energy Technologies (hereinafter referred to as ENTECH) that is held in the English language at the Department of Mechanical Engineering and organized jointly by the Departments of Mechanical Engineering, Chemical Engineering, and Electrical Engineering and Information Technology.

(2) During the master's program, scientific qualifications acquired under the bachelor's program shall be further enhanced or complemented. The student shall be able to independently apply scientific findings and methods and to evaluate their significance and applicability to the solution of complex scientific and social problems.

Article 2 - Academic Degree

Upon successful completion of the master's examination, the academic degree of "Master of Science" (abbreviated by "M.Sc.") shall be conferred.

Article 3 - Regular Period of Studies, Organization of Studies, Credits

(1) The regular period of studies shall be four semesters. It includes the courses of studies, examinations, and the master's thesis.

(2) The contents to be covered by the studies are divided into modules that consist of one or several courses of studies that are related in terms of contents and time. The type, scope, and allocation of modules to a subject as well as possibilities of combining modules are outlined in the studies plan. The modules and their scopes are defined in Article 16.

(3) The work expenditure envisaged for passing studies courses and modules is expressed in credits. The criteria for assigning credits correspond to the ECTS (European Credit Transfer System). One credit corresponds to a work expenditure of about 30 hours.

(4) The scope of study achievements required for the successful completion of the studies is measured in credits and amounts to a total of 120 credits.

(5) As a rule, the credits shall be distributed equally over the semesters in the studies plan.

(6) The program language shall be English. The study and examination achievements shall be made in the English language.

Article 4 - Organization of Examinations

(1) The master's examination shall consist of a master's thesis and module examinations, with each module examination comprising one or several module part examinations. A module part examination shall consist of at least one control of success.

(2) Controls of success are:
1. Written examinations,

2. Oral examinations, or
3. Controls of success of another type.

Controls of success of another type are e.g. presentations, market studies, projects, case studies, experiments, written papers, reports, seminar theses, and short examinations in writing during the studies, provided that they are not marked as written or oral examinations in the description of modules or courses in the studies plan.

(3) As a rule, at least 50% of a module examination shall be passed in the form of written or oral examinations (par. 2, Nos. 1 and 2). The remaining examinations shall be made by controls of success of another type (par. 2, No. 3).

Article 5 - Registration for and Admission to Examinations

(1) To participate in module examinations or module part examinations, the student shall register online on the students portal or in writing with the Study Office. Registration for the master's thesis shall be made with the Study Office.

(2) For admission to written and/or oral examinations (Art. 4, par. 2, Nos. 1 and 2) in a certain module, the student shall make online on the students portal or with the Study Office a binding declaration on the selection of the respective module or courses, if applicable, prior to the first written or oral examination in this module. Registration for the first written or oral examination and the first control of success of another type in a module shall be considered a binding selection of this module.

(3) Admission may only be refused, if

1. the student has ultimately failed in an intermediate diploma examination, bachelor's or master's examination of a program comparable or related to ENTECH, if the student is presently passing an examination procedure, or if the student has lost her right to pass examinations in such a program or if
2. the student is not able to furnish evidence of the study achievements required for the respective module examination according to the studies plan.

In cases of doubt, the examination committee shall decide. If a study achievement was made under the bachelor program already and if this achievement was included in the grade, the examination committee may refuse admission. In case of mandatory courses, the examination committee may assign another mandatory course.

Article 6 - Execution of Examinations and Controls of Success

(1) Controls of success shall be performed parallel to the studies, usually during teaching of the syllabus of the individual modules or shortly afterwards.

(2) The type of control of success (Art. 4, par. 2, Nos. 1 - 3) in the individual studies courses shall be specified by the examiner of the respective course depending on the contents of the course and teaching objectives of the module. The examiner, type of the controls of success, their frequency, sequence, and weighing, and the determination of the course grade shall be announced at least six weeks prior to the start of the semester. The examiner and student may agree on a later change of the type of control of success taking into account Art. 4, par. 3.

(3) A written examination may also be passed orally and an oral examination may also be passed in writing. This modification shall be announced at least six weeks prior to the examination.

(4) A student suffering from a chronic or permanent physical disability that prevents partial or complete execution of the controls of success in the form envisaged may apply for this type of examination be changed, provided that appropriate evidence is furnished. The responsible examination committee and, in urgent cases that cannot be postponed until the next meeting of the committee, its chairperson shall permit another type of control of success.

(5) Written examinations (Art. 4, par. 2, No. 1) shall usually be evaluated by an examiner according to Art. 14, par. 2 or Art. 14, par. 3. The grade shall be the arithmetic mean of the individual grades, if the evaluation is made by several examiners. If the arithmetic mean does not correspond to any of the grade levels defined in Art. 7, par. 2, clause 2, the grade shall be rounded to the next grade level. In case of equal distance to the next higher and lower levels, the grade shall be rounded to the next higher grade level. The evaluation procedure shall not exceed six

weeks. Individual written examinations shall last at least 60 and not more than 240 minutes.

(6) Oral examinations (Art. 4, par. 2, No. 2) shall be performed as individual or group examinations by several examiners (examining board) or by one examiner in the presence of an associate. Prior to determining the grade, the examiner shall consult the other examiners of the examining board. Oral examinations shall usually last at least 15 minutes and not more than 60 minutes per student.

(7) Major details and results of the oral examination in the individual subjects shall be recorded in the minutes. The result of the examination shall be announced to the student directly after the oral examination.

(8) Students who intend to take the same examination at a later point of time shall be admitted to oral examinations as an audience depending on the space available. They shall not be admitted to the consultation of the examining board and announcement of the examination results. For major reasons or at the request of the student to be examined, admission of an audience may be refused.

(9) For controls of success of another type, appropriate deadlines and submission dates shall be specified. It is to be ensured by the way of formulating the task and by adequate documentation that the achievements made can be credited to the student. Major details and results of such a control of success shall be recorded in the minutes.

(10) Theses or papers to be written within the framework of a control of success of another type shall be provided with the following declaration: “Ich versichere wahrheitsgemäß, die Arbeit selbstständig angefertigt, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde.” (I herewith declare that the present thesis/paper is original work written by me alone and that I have indicated completely and precisely all aids used as well as all citations, whether changed or unchanged, of other theses and publications). If the

thesis/paper does not contain this declaration, it will not be accepted. Major details and results of such a control of success shall be recorded in the minutes.

(11) During oral controls of success of another type, an associate shall be present in addition to the examiner, who shall also sign the minutes together with the examiner.

Article 7 - Evaluation of Examinations and Controls of Success

(1) The result of a control of success shall be specified by the examiners in the form of a grade.

(2) The following grades only may be used in the master's certificate:

1 = "sehr gut" (very good)	for an outstanding performance;
2 = "gut" (good)	for a performance that is far above the average;
3 = "befriedigend" (satisfactory)	for a performance meeting average requirements;
4 = "ausreichend" (sufficient)	for a performance that is still acceptable in spite of its deficiencies;
5 = "nicht ausreichend" (failed)	for a performance that is no longer acceptable due to major deficiencies.

For the differentiated evaluation of the master's thesis and module part examinations, the following grades may be applied exclusively:

1	1.0, 1.3	sehr gut (very good),
2	1.7, 2.0, 2.3	gut (good),
3	2.7, 3.0, 3.3	befriedigend (satisfactory),
4	3.7, 4.0	ausreichend (sufficient), and
5	4.7, 5.0	nicht ausreichend (failed).

These grades shall be applied in the minutes, transcript of records, and diploma supplement.

(3) For controls of success of another type, the studies plan may envisage the grade "bestanden" (passed) or "nicht bestanden" (failed).

(4) When determining the weighed means of module grades and the total grade, only the first decimal place shall be considered. All following decimal places shall be deleted without rounding.

(5) Every module, course, and control of success may only be credited once in the same course of studies. Modules, studies courses or controls of success that have already been credited under a bachelor's program, on the basis of which the present consecutive master's program has been conceived, shall not be credited again.

(6) Controls of success of another type shall only be considered by module part or module examinations, if grading was not accomplished in accordance with par. 3. The controls of success to be documented and the associated conditions shall be outlined in the studies plan.

(7) A module part examination is passed, if the grade is at least "ausreichend" (4.0, sufficient).

(8) A module examination is passed, if the module grade is at least "ausreichend" (4.0, sufficient). If the module examination consists of several module part examinations, the module is passed, if all module part examinations required have been passed. The module examination or module part examination and determination of the module grade shall be outlined in the studies plan. The differentiated course grades (par. 2) shall be used for calculating the module grades. If it is not defined by the studies plan when a module examination is passed, this module examination is not passed, if an examination in a module part allocated to this module has not been passed.

(9) The results of the master's thesis, the module and module part examinations, and of the controls of success of another type as well as the credits acquired shall be documented by the Study Office of KIT.

(10) The grades of the partial modules of a module shall be considered proportionally to the credits assigned to the modules when calculating the module grade.

(11) The total grade of the master’s examination, the module grades, and the partial module grades are:

Down to 1.5	“sehr gut” (very good),
from 1.6 to 2.5	“gut” (good),
from 2.6 to 3.5	“befriedigend” (satisfactory),
from 3.6 to 4.0	“ausreichend” (sufficient).

Article 8 - Expiry of the Right to Take an Examination, Repetition of Examinations and Controls of Success

(1) Students may repeat once a written examination that has not been passed (Art. 4, par. 2, No. 1). In case a repeated written examination is evaluated with the grade of “nicht ausreichend” (failed), an oral reexamination shall take place soon after the date of the failed examination. In this case, the grade of this examination may not be better than “ausreichend” (sufficient).

(2) Students may repeat once an oral examination that has not been passed (Art. 4, par. 2, No. 2).

(3) Repeated examinations according to paragraphs 1 and 2 shall correspond to the first examination in terms of contents, scope, and type (oral or written). At request, exceptions may be approved of by the responsible examination committee. Failed attempts at other universities shall be considered.

(4) Repetition of a control of success of another type (Art. 4, par. 2, No. 3) is described in the studies plan.

(5) A second repetition of the same written or oral examination shall be possible in exceptional cases only. The application for a second repetition shall be submitted to the examination committee by the student in writing. The examination committee shall decide on the first application of the student for a second repetition, if the application is approved of. If the examination committee dismisses the application, the president shall decide. Upon comment of the examination committee, the

president shall decide on further applications for a second repetition. Paragraph 1, cl. 2 and 3 shall apply accordingly.

(6) A module shall not be passed, if the module examination or a module part examination has not been passed.

(7) Repetition of a passed control of success shall not be permitted.

(8) In case a master's thesis has been granted the grade "nicht ausreichend" (failed), it can be repeated once. A second repetition of the master's thesis shall be excluded.

Article 9 – Absence, Withdrawal, Deception, Breach of Regulations

(1) The student can withdraw from written module examinations or module part examinations until the start of the examination without having to indicate any reasons. In case of oral module examinations or module part examinations, withdrawal shall be declared three working days prior to the date of examination at the latest (deregistration). Withdrawal from an oral examination less than three working days prior to the date of examination shall be possible only under the conditions of par. 3. Deregistration shall be made by a written notice to the examiner or by online deregistration on the students portal or, if this is impossible, with the Study Office. Withdrawal from an examination by revocation shall be deemed no registration for the examination. In principle, withdrawal from oral reexaminations in the sense of Art. 8, par. 2, shall be possible only under the conditions of par. 3.

(2) A module examination or a module part examination shall be deemed to have been "nicht ausreichend" (failed) (5.0), if the student fails to be present at the examination without a good reason or if she withdraws from the examination after its start without a good reason. The same shall apply, if the master's thesis has not been submitted within the period envisaged, unless the student is not responsible for having exceeded the deadline.

(3) The reason given for withdrawal after the start of the examination or absence shall be notified immediately, credibly, and in writing to the examination committee. In

case of sickness of the student or of a child maintained by the student alone or of a relative in need of care, submission of a medical certificate and, in cases of doubt, of a certificate issued by a public health officer may be required. Acceptance of the withdrawal shall be excluded, if parts of the examination have already been taken before the start of the impediment and if the examination has not been passed due to the results of these examination parts. In case the reason is accepted, a new date shall be fixed for the examination. Already available examination results shall be taken into account. In case of module examinations, consisting of several examinations, the results of examinations passed until the accepted withdrawal or the accepted absence shall be credited.

(4) In case the student tries to influence the result of her module examination or module part examination by deception or the use of impermissible aids, this module examination or module part examination shall be deemed to have been "nicht ausreichend" (failed, 5.0).

(5) A student disturbing the proper execution of the examination may be excluded from the continuation of the module examination or module part examination by the examiner or the supervisor. In this case, the examination shall be deemed to have been "nicht ausreichend" (failed, 5.0). In serious cases, the examination committee may exclude the student from further examinations.

(6) Within a period of one month, the student may ask for decisions made according to paragraphs 4 and 5 being revised by the examination committee. The student shall be informed immediately in writing about incriminating decisions by the examination committee. The reasons of these decisions shall be indicated and the student shall be informed about the legal remedies available. Prior to a decision, the student shall be given the opportunity to comment.

(7) Details relating to honesty during examinations and traineeships ('rules of conduct') are outlined in the General Statutes of KIT, as amended.

Article 10 - Maternity Protection, Parental Leave, Assumption of Family Obligations

(1) At the student's request, the maternity protection periods as defined by the Act on the Protection of the Working Mother (MuSchG), as amended, shall be considered accordingly. The required evidence shall be enclosed with this request. The maternity protection periods suspend any deadline according to the present examination regulations. The duration of maternity protection shall not be included in the deadline given.

(2) At request, the deadlines of parental leave shall be considered according to the valid legislation (BErzGG). Four weeks prior to the desired start of the parental leave period at the latest, the student shall inform the examination committee in writing about the time when she wishes to be on parental leave. The required evidence shall be enclosed. The examination committee shall then check whether the legal prerequisites would justify an employee's claim for parental leave and inform the student immediately of the result and the new times of examination. The period of work on the master's thesis may not be interrupted by parental leave. In this case, the thesis shall be deemed to have not been assigned. Upon expiry of the parental leave period, the student shall receive a new subject.

(3) At request, the examination committee shall decide on the flexible handling of examination deadlines according to the provisions of the Law of Baden-Württemberg on Universities and Colleges, if students have to assume family obligations. The period of work on a master's thesis may not be interrupted or extended by the assumption of family obligations. In this case, the thesis shall be deemed to have not been assigned. The student shall be given a new subject that is to be covered within the time specified in Article 11.

Article 11 - Master's Thesis Module

(1) For admission to the master's thesis, the number of module part examinations that remain to be passed by the student under the master's program must not exceed three. The application for admission to the master's thesis shall be submitted three

months after the last module examination. In case the student fails to observe this deadline without good reasons, the master's thesis shall be deemed to have been "nicht ausreichend" (failed, 5.0) in the first attempt. As for the rest, Article 15 shall apply accordingly. At the student's request, the chairperson of the examination committee, by way of exception, shall take care of the student receiving a subject for the master's thesis by a supervisor within four weeks upon application. In this case, the subject is issued by the chairperson of the examination committee.

(2) The subject, task, and scope of the master's thesis shall be limited by the supervisor such that the master's thesis can be handled with the expenditure outlined in par. 3.

(3) The master's thesis shall demonstrate that the student is able to deal with a problem of her subject area in an independent manner and within the given period of time using scientific methods that correspond to the state of the art. The master's thesis shall be assigned 30 credits. The duration of work on the thesis shall amount to six months. Following the master's thesis, four weeks upon submission at the latest, a colloquium of about 30 minutes' duration on the subject of the master's thesis and its results shall take place at the institute of the examiner.

(4) The master's thesis can be assigned by every examiner according to Art. 14, par. 2. The examination committee shall decide on exceptions. The student shall be given the possibility of proposing the subject. The master's thesis may also be accepted in the form of a group work, if the contribution of the individual student that is to be evaluated in the examination can be distinguished clearly based on objective criteria and if the requirement outlined in par. 1 is fulfilled.

(5) When submitting the master's thesis, the student shall assure in writing that the thesis is original work by her alone and that she has used no sources and aids other than indicated, marked all citations in word and content, and observed the statutes of KIT for upholding good scientific practice, as amended. If the thesis does not contain this declaration, it shall not be accepted. The declaration may be of the following type: "Ich versichere wahrheitsgemäß, die Arbeit selbstständig verfasst, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht

zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde sowie die Satzung des KIT zur Sicherung guter wissenschaftlicher Praxis in der jeweils gültigen Fassung beachtet zu haben.“ (I herewith declare that the present thesis is a original work written by me alone and that I have indicated completely and precisely all aids used as well as all citations, whether changed or unchanged, of other theses, and that I have observed the statutes of KIT for upholding good scientific practice as amended). If an untrue declaration is made, the master’s thesis shall be evaluated “nicht ausreichend” (5.0, failed).

(6) The time of assignment of the subject of the master’s thesis and the time of submission of the master’s thesis shall be recorded in the files. The student shall be allowed to return the subject of the master’s thesis once only within the first two months of the period of work on the thesis. At the justified request of the student, the examination committee may extend this time of work on the thesis according to par. 3 by three months at the maximum. If the master’s thesis is not submitted in time, it shall be deemed to have been “nicht ausreichend” (failed, 5.0), unless the student is not responsible for this failure. Article 8 shall apply accordingly.

(7) The master’s thesis shall be assessed and evaluated by a supervisor and, as a rule, by another examiner from the Departments involved in the master’s program. One of them shall be university teacher. In case of deviating evaluations of both examiners, the examination committee shall fix the grade of the master’s thesis within the limits of the evaluations of both examiners. The evaluation period shall not exceed eight weeks.

Article 12 - Additional Achievements, Additional Modules

(1) Further credits (additional achievements) in the amount of 20 per course of studies at the maximum may be acquired. Articles 3 and 4 of the examination regulations shall remain unaffected.

(2) At the student’s request, the results of a maximum of two modules shall be included as additional modules in the master’s certificate and marked accordingly.

Additional modules shall not be included when calculating the total grade. All additional modules and additional achievements shall be included automatically in the transcript of records and marked as additional modules or additional achievements. Additional modules shall be listed with the grades according to Article 7.

(3) The student shall declare a module examination an additional achievement when registrating for this examination already.

Article 13 - Examination Committee

(1) For the ENTECH master's program, an examination committee shall be formed. It shall consist of five members entitled to vote: Three professors, junior professors, university lecturers or assistant professors, two representatives of the group of academic staff members according to Art. 10, par. 1, cl. 2, No. 2, LHG, and one representative of the group of students with an advisory vote. The term of office of the non-student members shall be two years, the term of office of the student member shall be one year.

(2) The chairperson, her deputy, the other members of the examination committee, and their deputies shall be appointed by the department councils of the Departments of Mechanical Engineering, of Chemical Engineering, and of Electrical Engineering and Information Technology, the members of the group of academic staff according to Art. 10, par. 1, cl. 2, No. 2, LHG and the representative of the group of students shall be proposed by the members of the respective group. Reappointment shall be possible. The chairperson and her deputy shall be university teachers. The chairperson of the examination committee shall be responsible for current transactions and supported by the respective examination secretary's office.

(3) The examination committee shall be responsible for the organization of module examinations and the execution of the tasks assigned to it according to the present study and examination regulations. It shall take care of the provisions of the present study and examination regulations being observed and decide on examination matters. It shall decide on the recognition of study periods, study achievements, and

module examinations and confirm equivalence. It shall regularly report to the respective departments about the development of examination and study periods as well as about the times of work on the master's theses and the distribution of module and total grades. It shall make suggestions for reforms of the study and examination regulations and module descriptions.

(4) The examination committee may transfer the execution of its tasks for all standard cases to the chairperson of the examination committee.

(5) The members of the examination committee shall have the right to participate in examinations. The members of the examination committee, the examiners, and the associates shall be under the obligation of discretion. If they do not work in the public service sector, they shall be obliged to secrecy by the chairperson of the committee.

(6) In matters of the examination committee, which are related to an examination to be passed at another department, a competent professor, junior professor, university lecturer or assistant professor to be appointed by the respective department shall be consulted at the request of a member of the examination committee. This person shall have voting right for this particular matter.

(7) The student shall be informed in writing about incriminating decisions by the examination committee. These decisions shall be justified and provided with an information on legal remedies available. Objections against decisions made by the examination committee shall be addressed to the Presidential Committee of KIT in writing or for record within one month upon receipt of the decision.

Article 14 - Examiners and Associates

(1) The examination committee shall appoint the examiners and associates. It may transfer this task to its chairperson.

(2) Examiners shall be university teachers and members of the departments involved in the master's program, who have a post-doctoral lecture qualification, as well as scientists working at the departments, who have been authorized to examine

students. For appointment as examiner and associate, persons shall have the scientific qualification corresponding to the examination subject at least. When evaluating the master's thesis, one examiner shall be university teacher.

(3) If courses are performed by persons other than those mentioned under par. 2, these shall be appointed examiners, if the respective department has granted them the authorization to examine.

(4) Persons having an academic degree in an engineering program or an equivalent academic degree only may be appointed associate.

Article 15 - Recognition of Study Periods, Study Achievements, and Module Examinations

(1) Study periods and study achievements in the same or other courses of studies at KIT or other universities shall be recognized, if equivalence is confirmed. Clause 1 shall apply to both passed and failed examinations. Equivalence shall be confirmed, if achievements largely correspond to those of the respective studies course in terms of contents, scope, and requirements. The decision shall not be based on a schematic comparison, but on an overall evaluation and analysis. The scope of recognition of study achievements and module examinations shall be based on the principles of the ECTS. Equivalence in terms of contents shall be confirmed based on qualification objectives of the module.

(2) If achievements are recognized, the grades – provided that the grade systems are comparable - shall be taken over and considered when calculating the module grades and total grade. If no grades have been granted, the achievement does not have to be recognized. The student shall be obliged to submit the documents required for recognition.

(3) When recognizing study periods, study achievements, and module examinations passed or made outside of the Federal Republic of Germany, the equivalence agreements adopted by the Conference of Ministers of Education and the German

Rectors Conference as well as agreements concluded within the framework of university partnerships shall be considered.

(4) Paragraph 1 shall apply accordingly to study periods and study achievements passed or made at state-approved remote studies and other education institutions and in particular at state-owned or state-approved cooperative universities.

(5) Recognition of parts of the master's examination may be refused, if more than half of all controls of success and/or more than half of the credits required in the studies course and/or the master's thesis module is/are to be recognized. This shall apply in particular to a change of studies courses or a change of the place of studies.

(6) Examination achievements that were part of the underlying bachelor's program cannot be recognized. The same shall apply to all studies courses that served as a basis of admission to the master's program.

(7) The examination committee shall be responsible for recognitions. Prior to confirming equivalence, the competent representatives of the subject shall be heard. The examination committee shall decide on enrollment in a higher semester depending on the type and scope of study and examination achievements to be recognized.

II. Master's Examination

Article 16 - Scope and Type of the Master's Examination

(1) The master's examination shall consist of the module examinations according to par. 2 and the master's thesis (Art. 11).

(2) In the first two years, students shall pass module or module part examinations in the following modules:

1. Fundamentals: In the amount of at least 17 credits; details are outlined in the studies plan,
2. innovation/entrepreneurship: In the amount of at least 20 credits,
3. interdisciplinary project: In the amount of six credits,
4. focus: Two focuses in the amount of at least 16 credits each; details are outlined in the studies plan,
5. modules according to Nos. 1 and 4 in the amount of 15 credits depending on the individual studies plan.

Conveying of key qualifications in the amount of six credits takes place within the framework of the scientific exercises and projects in the innovation/entrepreneurship module (No. 2).

(3) The eligible courses and credits assigned to the modules, the controls of success and study achievements, as well as the partial modules to be selected as focuses are outlined in the studies plan. Only students fulfilling the requirements according to Article 5 will be admitted to the corresponding module part examinations.

(4) In the fourth semester, a master's thesis shall be written as another examination part according to Art. 11.

Article 17 - Passing of the Master's Examination, Calculation of the Total Grade

(1) The master's examination shall be passed, if all examination achievements mentioned in Art. 16 were evaluated with the grade "ausreichend" (sufficient) at least.

(2) The total grade of the master's examination shall be the mean value weighed with credits. All examination achievements shall be weighed with their credits according to Art. 16.

(3) In case of outstanding achievements with a total grade of 1.1 or better, the predicate of "mit Auszeichnung" (with distinction) shall be granted.

Article 18 – Master's Transcript, Master's Certificate, Diploma Supplement, and Transcript of Records

(1) Upon evaluation of the last examination, a master's certificate and a transcript shall be issued about the master's examination. The master's certificate and transcript shall be issued not later than six weeks upon the evaluation of the last examination. The master's certificate and transcript shall be issued in the German and English languages. The master's certificate and transcript shall bear the date of the successful passing of the last examination. They shall be handed over to the student simultaneously. The master's certificate shall document the conferral of the academic degree of master. The master's certificate shall be signed by the president and the dean of the Department of Mechanical Engineering and provided with the seal of the university.

(2) The transcript shall list the grades reached in the module examinations and the master's thesis, the assigned credits, and the total grade. The transcript shall be signed by the dean of the Department of Mechanical Engineering and the chairperson of the examination committee.

(3) In addition, the student shall be given a diploma supplement in the German and English languages, which corresponds to the requirements of the applicable ECTS user's guide. The diploma supplement shall contain a transcript of the student's records.

(4) The transcript of records shall list all examination achievements of the student in a structured form. This shall include all modules and module grades and the assigned

credits as well as studies courses assigned to the modules together with the grades and assigned credits. The transcript of records shall clearly reflect the assignment of courses of studies to the individual modules. Recognized study achievements shall be included in the transcript of records. All additional achievements shall be listed in the transcript of the records.

(5) The master's certificate, master's transcript, and the diploma supplement, including the transcript of records, shall be issued by the Study Office of KIT.

III. Final Provisions

Article 19 - Notification of Failure, Certificate of Examination Achievements

(1) The notice about the ultimate failure in the master's examination shall be given to the student by the examination committee in writing. This notice shall include an information on the legal remedies available.

(2) In case the student has ultimately failed in the master's examination, she shall be given at request and against submission of the exmatriculation certificate a written certificate about the examination achievements made, the respective grades as well as the examinations that are still lacking and the confirmation that the examination has not been passed. The same shall apply when the entitlement to an examination has expired.

Article 20 - Invalidity of the Master's Examination, Deprivation of the Master's Degree

(1) If the student has been guilty of deception during an examination and if this fact becomes known upon the hand-over of the certificate only, the grades of the module examinations, during which the student was guilty of deception can be corrected. If applicable, this module examination may be declared to have been "nicht ausreichend" (5.0, failed) and the master's examination may be declared to have been "nicht bestanden" (failed).

(2) If the conditions for admission to an examination were not fulfilled without the student wanting to deceive and if this fact becomes known upon the hand-over of the certificate only, this default shall be remedied by the passing of the examination. If the student intentionally and wrongly obtained admission to the examination, the module examination may be declared to have been "nicht ausreichend" (5.0, failed) and the master's examination may be declared to have been "nicht bestanden" (failed).

(3) Prior to a decision of the examination committee, the student shall be given the opportunity to comment.

(4) The incorrect certificate shall be confiscated and, if applicable, a new certificate shall be issued. Together with the incorrect certificate, the master's certificate shall also be confiscated, if the master's examination was declared to have been "nicht bestanden" (failed) due to a deception.

(5) A decision pursuant to par. 1 and par. 2, cl. 2 shall be excluded after a period of five years upon the date of issue of the certificate.

(6) Deprivation of the academic degree shall be subject to the legal provisions.

Article 21 - Inspection of Examination Files

(1) Upon completion of the master's examination, the student shall be granted the right to inspect her master's thesis, the related opinions, and minutes of the examination within one year at request.

(2) For inspection of the written module examinations, written module part examinations, and examination minutes, a period of one month after announcement of the examination result shall apply.

(3) The examiner shall determine the place and time of inspection.

(4) Examination documents shall be kept for at least five years.

Article 22 - Entry into Force

The present study and examination regulations shall enter into force on the day of their publication in the Official Announcements of KIT.

Karlsruhe, July 24, 2012

Professor Dr. sc. tech. Dr. h.c. Horst Hippler
(President)

Professor Dr. Eberhard Umbach
(President)

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