Karlsruhe Institute of Technology

Energy Engineering (M.Sc.)

Summer Term 2013
Long version
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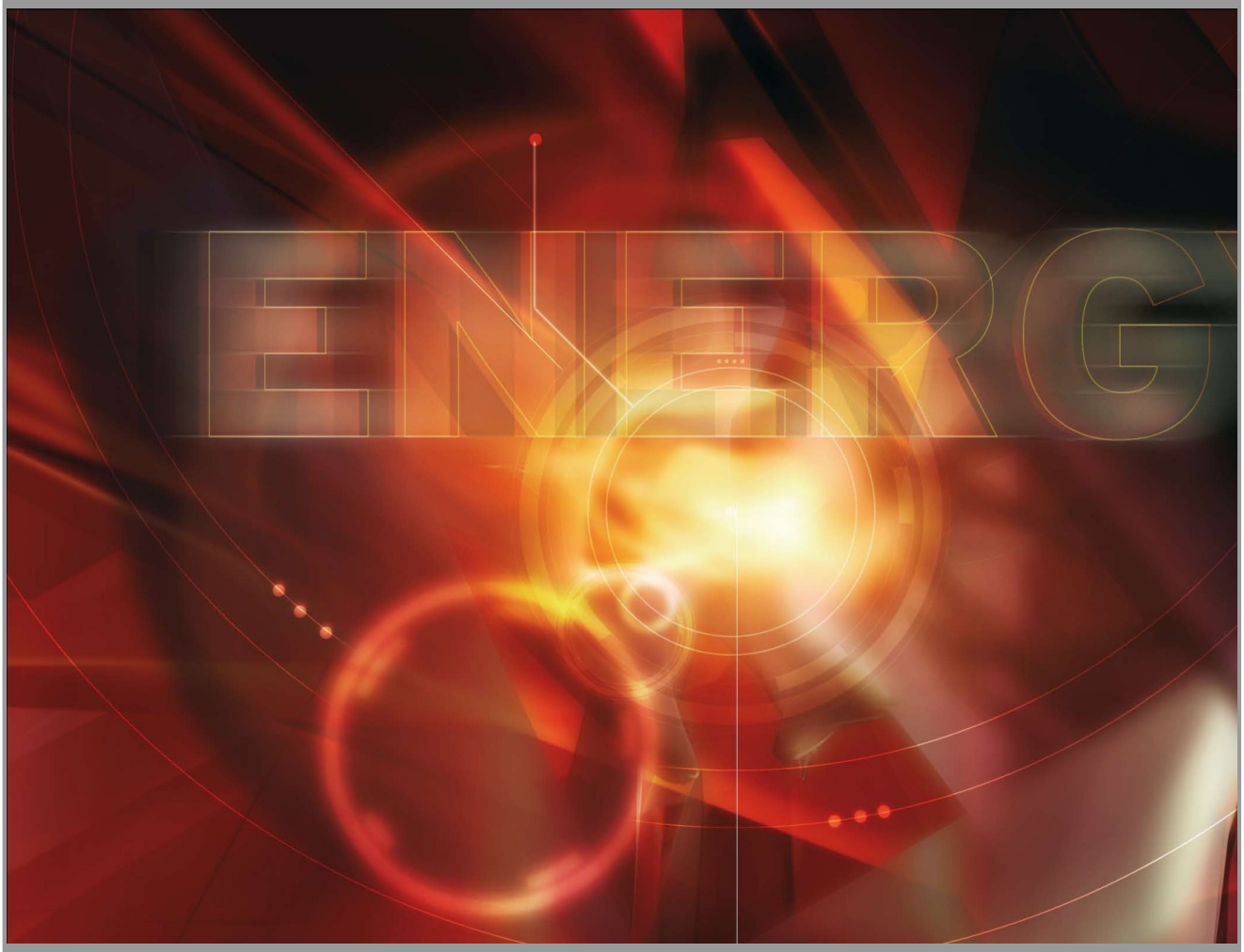
KIT School of Energy



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Publisher:

KIT School of Energy
Karlsruhe Institute of Technology (KIT)
76128 Karlsruhe
www.kit.edu

Contact: Julia.Johnsen@kit edu

Contents

1 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.

23371/23373 - Power Network Analysis (S. 30)

Bedingungen

See German version.

2 Modules

2.1 All modules

Module: [ENERGY4BASIC]

Coordination: Prof. U Maas
Degree programme: Energietechnik (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
17+		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2165501	Engineering Thermodynamics and Heat Transfer I (p. 111)	3	W	6,5	U. Maas
2166526	Technical Thermodynamics and Heat Transfer II (p. 112)	3	S	6,5	U. Maas
2161245	Engineering Mechanics I (p. 109)	5	W	6	T. Böhlke
2162250	Engineering Mechanics II (p. 110)	4	S	5	T. Böhlke
2145178	Mechanical Design I (p. 75)	2	W	2	A. Albers, Burkardt
2146178	Mechanical Design II (p. 77)	2	S	2	A. Albers, Burkardt
2185000	Machinery and Processes (p. 72)	4	W	7	H. Kubach, M. Gabi, H. Bauer, U. Maas, Maas, Gabi, Bauer, Spicher, Kubach
2199104	Electrical Machines (p. 45)		S	4,5	M. Doppelbauer
2300002	Electric Power Generation and Power Grid (p. 44)	2	W	3	B. Hoferer
23320	(p. 69)	2V + 1 Ü	S	4,5	Braun
22534	Mass Transfer and Reaction Kinetics (p. 79)		S	4	N. Zarzalis
22568	Heat Transfer (p. 61)	2	W	3	N. Zarzalis
22569	Fluid Dynamics (p. 52)	2	W	3	N. Zarzalis

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Module: Thermal Power Plants [ENERGY4TPPD]

Coordination: Prof. H.-J. Bauer
Degree programme: Energietechnik (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2181745	Design of highly stresses components (p. 27)	2	W	4	J. Aktaa
2169458	Numerical simulation of reacting two phase flows (p. 89)	2	W	4	R. Koch
2117061	Safety engineering (p. 101)	2	W	4	H. Kany
2169462	Turbine and compressor Design (p. 119)	2	W	4	H. Bauer, A. Schulz
2169459	CFD-Lab using Open Foam (p. 35)	3	W	4	R. Koch
2147161	Intellectual Property Rights and Strategies in Industrial Companies (p. 94)	2	W/S	4	F. Zacharias
2171487	Laboratory Exercise in Energy Technology (p. 68)	4	W/S	4	H. Bauer, U. Maas, H. Wirbser
2169453	Thermal Turbomachines I (p. 116)	3	W	6	H. Bauer
2170476	Thermal Turbomachines II (p. 117)	3	S	6	H. Bauer
22528	Applied Combustion Technology (p. 25)		S	4	N. Zarzalis
22531	Laboratory Work in Combustion Technology (p. 67)		S	4	N. Zarzalis
2161224	Machine Dynamics (p. 73)	3	W	5	C. Proppe
2162220	Machine Dynamics II (p. 74)	2	S	4	C. Proppe
2161217	Mechatronic Softwaretools (p. 104)	2	W	4	C. Proppe
2171486	Integrated measurement systems for fluid mechanics applications (p. 64)	5	W/S	4	H. Bauer, Mitarbeiter
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2199108	Software-Lab Fluid Mechanics (p. 103)		S	2	V. Heuveline
2199109	Optimization and Optimal Control (p. 24)		S	4	V. Heuveline
2169461	Coal fired power plants (p. 66)	2	W	4	P. Fritz, T. Schulenberg
2170490	Combined Cycle Power Plants (p. 54)	2	S	4	T. Schulenberg
9093	Carbon Capture and Storage (p. 32)	2	W	4	F. Schilling
2130921	Nuclear Power Technology (p. 86)		W	6	F. Badea

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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 [ENERGY4CECD]

Coordination: Prof. Kolb
Degree programme: Energietechnik (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22008	Chemische Thermodynamik (p. 38)	3	W	5	Schaber
22824	Thermische Transportprozesse (p. 115)	5	W	7	Kind
22325	Energy from Biomass (p. 49)	2	W	3	N. Dahmen
22516	Thermal Waste Treatment (p. 114)	2	W	3	T. Kolb
2199125	Chemical Energy Storage (p. 36)		W	3	T. Kolb
22332	Transport and Storage of Chemical Energy Carriers (p. 118)		S	4	T. Kolb
2199115	Chemical Fuels (p. 37)	2	S	4	G. Schaub
2199116	Fuel Lab (p. 53)		W	4	S. Bajohr
22533	High Temperature Process Engineering (p. 62)		S	4	N. Zarzalis
2165515	Fundmentals of Combustion I (p. 59)	2	W	4	U. Maas
2166538	Fundamentals of combustion II (p. 60)	2	S	4	U. Maas
22531	Laboratory Work in Combustion Technology (p. 67)		S	4	N. Zarzalis
2171487	Laboratory Exercise in Energy Technology (p. 68)	4	W/S	4	H. Bauer, U. Maas, H. Wirbser
22528	Applied Combustion Technology (p. 25)		S	4	N. Zarzalis
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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: [ENERGY4DPSD]

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

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
23395	Power System Analysis (p. 96)	2	W	3	Weber
23371/23373	Power Network Analysis (p. 30)	2/2	W	6	T. Leibfried
23180	Optimization of Dynamic Systems (p. 91)	2/1	W	4,5	S. Hohmann
2161217	Mechatronic Softwaretools (p. 104)	2	W	4	C. Proppe
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2199117	Superconductivity in Smart Grid Power Applications (p. 108)	2	S	3	M. Noe
2199118	Smart Energy Distribution (p. 102)		S	3	H. Schmeck
2130927	Fundamentals of Energy Technology (p. 58)	4	S	8	F. Badea, D. Cacuci
2199119	Modern Software Tools in Power Engineering (p. 83)	4	S	6	T. Leibfried
2199120	Electrical Power Transmission and Grid Control (p. 46)	2	W	6	T. Leibfried
2511104	Organic Computing (p. 92)	2/1	S	5	H. Schmeck, S. Mostaghim
2581006	Efficient Energy Systems and Electric Mobility (p. 42)	2/0	S	3,5	R. McKenna, P. Jochem

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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 [ENERGY4EIBD]

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

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
1720971	Building Analysis I (p. 55)	2	W	2	A. Wagner, wissenschaftl. Mitarbeiter
2161217	Mechatronic Softwaretools (p. 104)	2	W	4	C. Proppe
2171486	Integrated measurement systems for fluid mechanics applications (p. 64)	5	W/S	4	H. Bauer, Mitarbeiter
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2199108	Software-Lab Fluid Mechanics (p. 103)		S	2	V. Heuveline
2199109	Optimization and Optimal Control (p. 24)		S	4	V. Heuveline
2199121	Energy and Indoor Climate Concepts for High Performance Buildings (p. 48)		S	4	
2199122	Design, Construction, and Technical Systems of Low Energy Buildings (p. 41)	4	W	4	Wappner, Pfeifer, Müller
1731099	Energy on the Urban Scale (p. 50)	2	W	4	Neppl
2199124	Building Simulation (p. 31)		W	5	

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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 modeling 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 [ENERGY4NFTD]

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

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2181745	Design of highly stresses components (p. 27)	2	W	4	J. Aktaa
2189473	Neutron physics of fusion reactors (p. 85)	2	W	4	U. Fischer
2189465	Reactor Safety I: Fundamentals (p. 98)	2	W	4	V. Sánchez-Espinoza
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2199108	Software-Lab Fluid Mechanics (p. 103)		S	2	V. Heuveline
2130921	Nuclear Power Technology (p. 86)		W	6	F. Badea
2170460	Nuclear Power Plant Technology (p. 65)	2	S	4	T. Schulenberg
19435	Decommissioning of Nuclear Facilities I (p. 100)	2	W	4	S. Gentes
2130910	CFD for Power Engineering (p. 34)	2	S	4	I. Otic
2190464	Assessement of Nuclear Power Plants (p. 87)		S	4	
2189910	(p. 107)	2	W	4	X. Cheng
2189904	Ten lectures on turbulence (p. 113)	2	W	4	I. Otic
2189908	Nuclear Thermal-Hydraulics (p. 88)	2	W	4	X. Cheng

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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 [ENERGY4EEID]

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

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2581958	Strategical Aspects of Energy Economy (p. 106)	2/0	W	3,5	A. Ardone
2581010	Introduction to Energy Economics (p. 43)	2/2	S	5,5	W. Fichtner
2581959	Energy Policy (p. 47)	2/0	S	3,5	M. Wietschel
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2199109	Optimization and Optimal Control (p. 24)		S	4	V. Heuveline
2130927	Fundamentals of Energy Technology (p. 58)	4	S	8	F. Badea, D. Cacuci
2199119	Modern Software Tools in Power Engineering (p. 83)	4	S	6	T. Leibfried
2590458	Computational Economics (p. 39)	2/1	W	4,5	P. Shukla, S. Caton
2511106	Nature-inspired Optimisation Methods (p. 84)	2/1	W	5	S. Mostaghim, P. Shukla
2581006	Efficient Energy Systems and Electric Mobility (p. 42)	2/0	S	3,5	R. McKenna, P. Jochem
2581002	Energy Systems Analysis (p. 51)	2/0	W	3	V. Bertsch
2581998	Basics of Liberalised Energy Markets (p. 28)	2/1	W	3,5	W. Fichtner

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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 [ENERGY4RESD]

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

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
23737	Photovoltaics (p. 95)	3	S	6	M. Powalla
2157450	Wind- and Waterpower (p. 121)	2	W	4	M. Gabi, N. Lewald
2161224	Machine Dynamics (p. 73)	3	W	5	C. Proppe
2162220	Machine Dynamics II (p. 74)	2	S	4	C. Proppe
2161217	Mechatronic Softwaretools (p. 104)	2	W	4	C. Proppe
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2199108	Software-Lab Fluid Mechanics (p. 103)		S	2	V. Heuveline
2199109	Optimization and Optimal Control (p. 24)		S	4	V. Heuveline
9093	Carbon Capture and Storage (p. 32)	2	W	4	F. Schilling
2199125	Chemical Energy Storage (p. 36)		W	3	T. Kolb
22325	Energy from Biomass (p. 49)	2	W	3	N. Dahmen
9091	Geothermal Energy I (p. 56)	2	W	4	F. Schilling
2199130	Geothermal Energy II (p. 57)		S	4	T. Kohl
5072	Batteries and Fuel Cells (p. 29)	2	W	3	H. Ehrenberg
23745	Solar Energy (p. 105)	4	W	6	A. Colsmann

Learning Control / Examinations

Conditions
None.

Learning Outcomes
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 [ENERGY4UFD]

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

ECTS Credits	Cycle	Duration
16+	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22008	Chemische Thermodynamik (p. 38)	3	W	5	Schaber
22824	Thermische Transportprozesse (p. 115)	5	W	7	Kind
22531	Laboratory Work in Combustion Technology (p. 67)		S	4	N. Zarzalis
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
22533	High Temperature Process Engineering (p. 62)		S	4	N. Zarzalis
22516	Thermal Waste Treatment (p. 114)	2	W	3	T. Kolb
2199115	Chemical Fuels (p. 37)	2	S	4	G. Schaub
22332	Transport and Storage of Chemical Energy Carriers (p. 118)		S	4	T. Kolb

Learning Control / Examinations

Conditions
None.

Learning Outcomes

- 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.

Module: Modelling and Simulation [ENERGY4MOSI]

Coordination: Prof. U. Maas
Degree programme: Energietechnik (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
7	Every 2nd term, Winter Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
0109500	Mathematical Modelling (p. 80)	2	W	4	V. Heuveline
2169458	Numerical simulation of reacting two phase flows (p. 89)	2	W	4	R. Koch
2185227	Modelling and Simulation (p. 82)	4	W	7	C. Proppe, K. Furmans, C. Stiller, B. Pritz

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Module: Innovation and Entrepreneurship [ENTECH4INNO]

Coordination:
Degree programme: Energietechnik (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
20		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2146202	Methods of Product Development (p. 81)	2	S	6	N. Burkardt
2146203	Innovation Management (p. 63)		S	4	N. Burkardt
2145200	Management Training (p. 71)		W	3	N. Burkardt
2145201	One Week Innovation Target (p. 90)		W	3	N. Burkardt
2581012	Renewable Energy - Resources, Technologies and Economics (p. 99)	2	W	3,5	R. McKenna
2545001	Lecture „Entrepreneurship“ (p. 120)	2/1	W/S	4,5	O. Terzidis, A. Presse

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Module: Interdisciplinary Project [ENTECH4IP]

Coordination:
Degree programme: Energietechnik (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
6		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
22509	Design of combustion chamber in gas turbines (Project) (p. 26)	2	S	4	N. Zarzalis
2146440	Range Extender (p. 97)	2	W	6	H. Bauer
	Local Cogeneration of Heat and Power (p. 70)		W	6	

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

3 Courses

3.1 All Courses

Course: Optimization and Optimal Control [2199109]

Coordinators: V. Heuveline
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID], Thermal Power Plants (p. 7)[ENERGY4TPPD], Renewable Energy (p. 18)[ENERGY4RESD], Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
oral/written examination

Conditions
none

Learning Outcomes
1) Overview in optimization and optimal control
2) Idea about numerical difficulties and strategies
3) Adjoint problems

Content
We treat nonlinear optimisation as well as optimal control with partial differential equations. The lecture is driven by questions coming from applications and covers a non-standard curriculum:
1) Typical strategies for optimization
2) Evolutionary methods and discrete mathematics
3) Mathematical frame for optimal control (well-posedness etc.)
4) Numerical schemes for optimal control

Course: Applied Combustion Technology [22528]

Coordinators: N. Zarzalis
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral/written examination

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: Design of combustion chamber in gas turbines (Project) [22509]

Coordinators: N. Zarzalis
Part of the modules: Interdisciplinary Project (p. 23)[ENTECH4IP]

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

Learning Control / Examinations

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

Recommendations
None.

Learning Outcomes

Content

Remarks
None.

Course: Design of highly stresses components [2181745]

Coordinators: J. Aktaa
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral exam: 30 minutes

Conditions
material science
solid mechanics II

Learning Outcomes
The students know the rules of established design codes for the assessment of components which under operation are subjected to high thermo-mechanical and/or irradiation loadings. They know which constitutive equations are used according to state-of-the-art of technology and research to estimate deformation and damage appearing under these loadings and to predict expected lifetime. They gained insight into the application of these generally non-linear constitutive equations in finite element codes and know the major issues which shall be thereby taken into account.

Content
Contents of the lecture:

- rules of common design codes
- classical models for elasto-plasticity and creep
- lifetime rules for creep, fatigue and creep-fatigue interaction
- unified constitutive models for thermo-elasto-viscoplasticity
- continuum mechanical models for damage at high temperatures
- application of advanced material models in FE-codes

Literature

- R. Viswanathan, Damage Mechanisms and Life Assessment of High-Temperature Components, ASM International, 1989.
- Lemaitre, J.; Chaboche J.L.: Mechanics of Solid Materials, Cambridge University Press, Cambridge, 1990.

Course: Basics of Liberalised Energy Markets [2581998]

Coordinators: W. Fichtner
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

ECTS Credits	Hours per week	Term	Instruction language
3,5	2/1	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

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

Course: Batteries and Fuel Cells [5072]

Coordinators: H. Ehrenberg
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
oral/written examination

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: Power Network Analysis [23371/23373]

Coordinators: T. Leibfried
Part of the modules: (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations
The assessment consists of a written exam (120 min) taking place at the beginn of the recess period (according to Section 4 (2), 1 of the examination regulation). The exam takes place in every winter semester. Re-examinations are offered at every ordinary examination date.

Conditions
See German version.

Learning Outcomes
The goal is to relay theoretical fundamentals in the field of electric power technology and power transmission.
In the first part the lecture deals with the basics of High-Voltage technology. Then the basics of transmission and distribution of electric energy is presented as well as the load flow calculation and the short-circuit calculation methods.
Supporting the lecture, assignments to the curriculum are distributed. Their solution is presented and discussed during
lecture hall exercises.

Content
In its first part, this lecture introduces the High-Voltage technology and its basics. Especially, the reasons for the necessity for the power transmission with high voltages are given. Basic electrical configurations and stresses occurring at multi dielectric systems are presented. Finally the first chapter deals with discharge phenomena.
The second chapter deals with the three phase system. Especially, the mathematical treatment of three phase systems
and the introduction of component systems are contained in this chapter.
The third and very comprehensive chapter deals with the transmission and distribution of electric energy. Firstly, the laws of power transmission via transmission lines are presented. Then, the stability of electric power systems and possibilities to increase the power transmission capacity are discussed. Finally, the physics of energy distribution in the medium and low voltage grid is shown.
The fourth chapter deals with the Calculation of electric power networks and systems. Firstly, the preparatory steps for the calculation of the power network are shown. After discussing the basic network analysis methods, the load flow
calculation are shown. Especially, the method of current iteration and the Newton Raphson method are presented and
the algorithms of the individual methods are shown using an example.
The fifth chapter deals with methods for the calculation of the 3 phase short circuit. Thereby, it is distinguished between the short circuit nearby the generator and far from the generator.
In the sixth chapter the unsymmetrical faults in power networks and their calculation are discussed. Therefore, the symmetrical components are introduced as a first step. Then, the circuits in symmetrical components of all important power network equipment are presented. The chapter closes with the mathematical treatment of unsymmetrical short circuits using the symmetrical component method.
To accompany the lecture, a collection of problems can be downloaded. During lecture hall exercises their solutions will
be discussed.

Media
Online material is available on: www.ieh.uni-karlsruhe.de and can be downloaded using a password.

Literature
Elective literature:
Will be announced in the lecture notes.

Course: Building Simulation [2199124]

Coordinators:
Part of the modules: Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
oral/written examination

Conditions
Energy and Indoor Climate Concepts for High Performance Buildings

Learning Outcomes

- Understanding of modeling buildings in various complexity
- Knowledge of different modeling techniques
- Capability to set up a representative building model for thermal simulation
- Basic capability to simulate and evaluate the building performance in terms of energy and indoor comfort with one of the offered software packages

Content
Basics of building simulation, thermal modelling of buildings (electrical analogy), steady state /dynamic models (response function, numerical), simple / multi-nodal models, modelling rooms / buildings / technical systems / controls, model simplifications and abstraction, relevance of scale, parameter variations / coupling with optimization routines, validation. Introduction into different modelling platforms (Modelica, MathLab/Simulink) and simulation programs DesignBuilder/EnergyPlus, TRNSYS.

Course: Carbon Capture and Storage [9093]

Coordinators: F. Schilling
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral/written examination

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. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
Oral exam, length: 30 minutes

Conditions
None.

Learning Outcomes

- theory and application of computational fluid dynamics (CFD)

Content
This course is specified for both Bachelor and Master students, Power and Nuclear Engineering.
The course is aimed of giving the fundamental of Computational Fluid Dynamics (CFD) for energy technologies. Starting from the basic physical phenomena equations an overview on computational methods and turbulence modeling is given.

Course: CFD-Lab using Open Foam [2169459]

Coordinators: R. Koch
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter term	de

Learning Control / Examinations

- Successful solution of problems

Conditions

- Fluid Dynamics
- Course on numerical fluid mechanics

Recommendations

- Basic knowledge in LINUX

Learning Outcomes

- Application of Open Foam modules
- Grid generation
- Proper definition of boundary conditions
- Numerical errors

Content

- Introduction to using Open Foam
- Grid generation
- Discretization schemes
- Turbulence models
- Two phase flow - spray
- Two Phase flow - Volume of Fluid method

Media

- A CD containing the course material will be handed out to the students

Literature

- Documentation of Open Foam
- www.open foam.com/docs

Remarks

- Number of participants is limited
- Priority for students of the lecture “Numerische Simulation reagierender Zweiphasenströmungen” (Vorl.-Nr. 2169458)

Course: Chemical Energy Storage [2199125]

Coordinators: T. Kolb
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
oral/written examination

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

Learning Outcomes
The students will understand the principles of production and storage of chemical energy carriers based on RES, biomass and fossil fuels. They will be able to evaluate the potential of chemical energy carriers as energy storage for RES surplus energy (SNG) and as liquid designer fuels for e.g. transportation.

Content
Production of Chemical Energy Carriers for Storage
SNG Substitute Natural Gas
SNG from fossil sources (gasification processes)
SNG from biomass
SNG from renewable energy sources RES
Chemical synthesis for liquid energy carriers
Storage of Chemical Energy Carriers
Gas specification
Gas grid
Chemical energy carriers to bridge the production / demand gap from RES
Challenges / potential

Course: Chemical Fuels [2199115]

Coordinators: G. Schaub
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Utility Facilities (p. 20)[ENERGY4UFD]

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

Learning Control / Examinations
oral/written examination

Conditions
basics in chemistry, reaction kinetics, chemical thermodynamics

Learning Outcomes
Understanding of (i) principles of production and upgrading of fuels, (ii) fuel conversion processes, (iii) criteria for assessing different fuels and fuel conversion processes.

Content
Introduction to global reserves and production, environmental aspects, photosynthesis, fossil fuel formation; characteristic properties of raw materials and fuels; process overview of fuel upgrading, conversion, cleaning; examples liquid fuels: liquid fuels from petroleum and biomass, chemical upgrading processes in petroleum refining, non-conventional liquid fuels from fossil feedstocks and biomass feedstocks, fuel gas from coal and biomass.

Course: Chemische Thermodynamik [22008]

Coordinators: Schaber
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Utility Facilities (p. 20)[ENERGY4UFD]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Course: Computational Economics [2590458]

Coordinators: P. Shukla, S. Caton
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

ECTS Credits	Hours per week	Term	Instruction language
4,5	2/1	Winter 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 methods of Computational Economics and applies them on practical issues,
- evaluates agent models considering bounded rational behaviour and learning algorithms,
- analyses agent models based on mathematical basics,
- knows the benefits and disadvantages of the different models and how to use them,
- examines and argues the results of a simulation with adequate statistical methods,
- is able to support the chosen solutions with arguments and can explain them.

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
This course is offered in cooperation with the Institute of Applied Informatics and Formal Description Models (AIFB).

Course: Design, Construction, and Technical Systems of Low Energy Buildings [2199122]

Coordinators: Wappner, Pfeifer, Müller
Part of the modules: Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
oral/written examination

Conditions
Basics in Technical Mechanics, Material Science, Thermal Energy Systems, Heat and Mass Transfer (basic knowledge from Bachelor Studies)

Learning Outcomes

- Basic understanding of building construction, structural systems and technical building services
- Knowledge of thermal and hydric properties of building materials and elements as well as dynamic thermal behaviour of construction systems
- Capability to realize the interdependencies between space concept, construction principle, materiality, thermal building properties and technical equipment
- Capability to evaluate different design strategies in terms of integration, energy efficiency and sustainability

Content
Fundamentals of building construction, sustainable building and structural design methodology, structural design and space impression, construction typologies and building structure, materials and constructions in the climatic and energetic context, supporting structures, basic sizing of structural systems, structural systems and embedded energy, building elements and connection aspects, interface between construction and technical building services, heat and moisture transfer and storage in building envelopes, thermal comfort, steady state / dynamic heat balance, systems for heating/ventilation/cooling/air-conditioning (HVAC).

Course: Efficient Energy Systems and Electric Mobility [2581006]

Coordinators: R. McKenna, P. Jochem
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID], (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes

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

Content
This lecture series combines two of the most central topics in the field of energy economics at present, namely energy efficiency and electric mobility. The objective of the lecture is to provide an introduction and overview to these two subject areas, including theoretical as well as practical aspects, such as the technologies, political framework conditions and broader implications of these for national and international energy systems.
The energy efficiency part of the lecture provides an introduction to the concept of energy efficiency, the means of affecting it and the relevant framework conditions. Further insights into economy-wide measurements of energy efficiency, and associated difficulties, are given with recourse to several practical examples. The problems associated with market failures in this area are also highlighted, including the Rebound Effect. Finally and by way of an outlook, perspectives for energy efficiency in diverse economic sectors are examined.
The electric mobility part of the lecture examines all relevant issues associated with an increased penetration of electric vehicles including their technology, their impact on the electricity system (power plants and grid), their environmental impact as well as their optimal integration in the future private electricity demand (i.e. smart grids and V2G). Besides technical aspects the user acceptance and behavioral aspects are also discussed.

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

Literature
Will be anounced in the lecture.

Course: Introduction to Energy Economics [2581010]

Coordinators: W. Fichtner
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

ECTS Credits	Hours per week	Term	Instruction language
5,5	2/2	Summer term	de

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

Conditions
None.

Learning Outcomes

Content

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

Course: Electric Power Generation and Power Grid [2300002]

Coordinators: B. Hoferer
Part of the modules: (p. 6)[ENERGY4BASIC]

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

Learning Control / Examinations
oral/written examination

Conditions
none

Recommendations
none

Learning Outcomes

- solid understanding of electrical power engineering
- basic and advanced knowledge of electrical power generation and transmission
- capability to analyse and to develop electrical power engineering systems

Content

- Energy resources
- Energy consumption
- Types and use of power plants
- Thermal power plants
- Nuclear power plants
- Hydroelectric power plants
- Wind turbines
- Solar energy plants
- Synchronous generators
- Transmission lines
- Compensation
- Power system analysis

Literature
D.Fink, W. Beaty
Standard Handbook for Electrical Engineers
McGraw-Hill
A .Guile, W. Paterson
Electrical Power Systems
Pergamon Press
J. Weisman, L. Eckart
Modern Power Plant Engineering
Prentice-Hall

Course: Electrical Machines [2199104]

Coordinators: M. Doppelbauer
Part of the modules: (p. 6)[ENERGY4BASIC]

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

Learning Control / Examinations
oral/written examination

Conditions
Basic knowledge of the principles of electromagnetic fields.

Learning Outcomes
Solid understanding of energy conversion and the principals of the most commonly used electrical machines, including permanent magnet and field winding synchronous and asynchronous machines.

Content

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

Course: Electrical Power Transmission and Grid Control [2199120]

Coordinators: T. Leibfried
Part of the modules: (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations
oral/written examination

Conditions
lectures “Electric Power Generation and Power Grid” and (&) “Electrical Machines” or “Power Electronics”

Learning Outcomes
The goal is to relay further and deeper theoretical fundamentals in the field of electric power technology and power transmission.

Content
In the first part the lecture deals with the characteristic of AC power transmission, its limitations and the meaning of active and reactive power for the grid. The second main chapter deals with HVDC, a technology for the transmission of a high amount of electric energy. Subsequently, FACTS are presented which help to increase the flexibility of power transmission systems. Finally, the dynamic behaviour and control of power stations and the entire power grid will be discussed.

Course: Energy Policy [2581959]

Coordinators: M. Wietschel
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content
The course deals with material and energy policy of policy makers and includes the effects of such policies on the economy as well as the involvement of industrial and other stakeholders in the policy design. At the beginning the neoclassical environment policy is discussed. Afterwards the Sustainable Development concept is presented and strategies how to translate the concept in policy decision follows. In the next part of the course an overview about the different environmental instruments classes, evaluation criteria for these instruments and examples of environmental instruments like taxes or certificates will be discussed. The final part deals with implementation strategies of material and energy policy.

Literature
Will be anounced in the lecture.

Course: Energy and Indoor Climate Concepts for High Performance Buildings [2199121]

Coordinators:
Part of the modules: Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
oral/written examination

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)

Learning Outcomes

- 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.

Course: Energy from Biomass [22325]

Coordinators: N. Dahmen
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
oral/written examination

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 on the Urban Scale [1731099]

Coordinators: Neppl
Part of the modules: Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
oral/written examination

Conditions
Thermal Energy Systems, Electrical Grids (basic knowledge from Bachelor Studies)

Learning Outcomes

- Basic understanding of urban structures and urban planning processes
- Knowledge of different energy supply concepts on different scales
- Knowledge of relevant urban data bases as well as tools for modelling and simulatingcities/settlements/quarters/neighbou
- Capability to develop energy-related topics in larger urban contexts

Content
Basics of urban form and urban development, decision and operation levels in urban planning, models of urban building stock, fundamentals of sustainable urban development (new buildings and retrofit), urban planning and energy concepts, urban (energy) infrastructure, urban quarter as reference unit, certification of quarters, energy supply for settlements/quarters/neighbourhoods, climate protection and adaptation concepts on the urban level, examples for energy and supply concepts in different planning stages, exploitation of relevant data for systematic urban planning (short introduction into GIS), simulation of urban energy flows, urban load management/smart cities.

Course: Energy Systems Analysis [2581002]

Coordinators: V. Bertsch
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

ECTS Credits	Hours per week	Term	Instruction language
3	2/0	Winter term	de

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

Conditions
None.

Learning Outcomes

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: Fluid Dynamics [22569]

Coordinators: N. Zarzalis
Part of the modules: (p. 6)[ENERGY4BASIC]

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: Fuel Lab [2199116]

Coordinators: S. Bajohr
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD]

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

Learning Control / Examinations
oral/written examination

Conditions
Basic course “Chemical Fuels”, basics in chemistry and thermodynamics

Learning Outcomes
The students develop a comprehensive understanding of the nature of different fuel types.

Content
Laboratory work on fuel characterization
Analytics of gaseous, liquid and solid fuels

Course: Combined Cycle Power Plants [2170490]

Coordinators: T. Schulenberg
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
Oral Examination 30 min

Conditions
Knowlegde in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

Recommendations
We recommend to combine the lecture with the Simulator Exercises for Combined Cycle Power Plants (2710491)

Learning Outcomes
Design and operation principles of major components of advanced combined cycle power plants including their control. Dynamic response of combined cycle power plants to grid requirements.

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

Course: Building Analysis I [1720971]

Coordinators: A. Wagner, wissenschaftl. Mitarbeiter
Part of the modules: Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
Forming of the grades: 2/3 assignments, 1/3 presentation
Proof of performance and examination: assignments with simulation programs including presentations
Form of examination: written, oral

Conditions
None.

Learning Outcomes
The objective of the seminar is that students learn to identify qualities of a building in terms of energy and indoor climate with different tools. With building inspections, different measurements and the use of computer-based tools they should achieve the ability to realize important parameters and to quantify them as far as possible in order to give an overall evaluation with regard to indoor cliamte and energy consumption.

Content
In the seminar procedures to audit the energy consumption of buildings and to evaluate the energy quality of building parts as well as technical services systems are introduced. Measurements are taken to analyze the indoor climate. Additionally, different computer-based tools in the context of building energy and indoor climate are used.

Literature
Seminar documents as pdf, recommendations for further reading, calculation and simulation programs for climate analysis, comfort evaluation, energy performance.

Course: Geothermal Energy I [9091]

Coordinators: F. Schilling
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
oral/written examination

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 [2199130]

Coordinators: T. Kohl
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
oral/written examination

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: Fundamentals of Energy Technology [2130927]

Coordinators: F. Badea, D. Cacuci
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID], (p. 11)[ENERGY4DPSD]

ECTS Credits	Hours per week	Term	Instruction language
8	4	Summer term	de

Learning Control / Examinations

Conditions
none

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: Fundmentals of Combustion I [2165515]

Coordinators: U. Maas
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD]

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

Learning Control / Examinations
Compulsory elective subject: Written exam.
In SP 45: oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
After completing this course students are able to:

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

Content
Fundamental concepts ans phenomena
Experimental analysis of flames
Conservation equations for laminar flat flames
Thermodynamics of combustion processes
Transport phenomena
Chemical reactions
Chemical kinetics mechanisms
Laminar premixed flames
Laminar diffusion flames

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
Compulsory elective subject: 2+1 SWS and 5 LP.

Course: Fundamentals of combustion II [2166538]

Coordinators: U. Maas
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

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
Ignition processes
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
NOx formation
Formation of hydrocarbons and soot

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; Heidelberg, Karlsruhe, Berkley 2006

Course: Heat Transfer [22568]

Coordinators: N. Zarzalis
Part of the modules: (p. 6)[ENERGY4BASIC]

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 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: High Temperature Process Engineering [22533]

Coordinators: N. Zarzalis
Part of the modules: Utility Facilities (p. 20)[ENERGY4UFD], Chemical Energy Carriers (p. 9)[ENERGY4CECD]

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

Learning Control / Examinations
oral/written examination

Conditions
fluid mechanics, heat and mass transfer

Learning Outcomes
The students can calculate the heat transfer by radiation which is the main heat transport mechanism at high temperatures. This competence together with the knowledge about high temperature resistance materials enables the students to work in the area of design of high temperature process plants.

Content

- High temperature (HT) processes and plants,
- Principles and technologies for HT generation,
- Calculation of heat transfer in plants by flames and hot gas streams,
- Heat transfer models for combustion chambers and furnaces,
- High temperature metallic and ceramic materials
- Examples of HT plants

Course: Innovation Management [2146203]

Coordinators: N. Burkardt
Part of the modules: Innovation and Entrepreneurship (p. 22)[ENTECH4INNO]

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

Learning Control / Examinations
oral/written examination

Conditions
None.

Learning Outcomes
Fully awareness of innovation processes and the ability to integrate these processes into those of product development in their own companies

Content
Basics of Innovation Management
Success factors in innovation competition
Strategic analysis of branches, companies an markets
Innovation traps
Informationmanagement
Pre-studies and feasibility studies
Risk analysis

Course: Integrated measurement systems for fluid mechanics applications [2171486]

Coordinators: H. Bauer, Mitarbeiter
Part of the modules: Energy in Buildings (p. 13)[ENERGY4EIBD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

ECTS Credits	Hours per week	Term	Instruction language
4	5	Winter / Summer Term	de

Learning Control / Examinations
Group colloquia for each topic

Duration: approximentely 10 minutes

no tools or reference materials may be used

Conditions
none

Learning Outcomes
This course provides the opportunity to gain both a theoretical and practical understanding of the fundamentals of computer aided measurements. Each section includes a PC exercise.

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

Remarks
Registration during the lecture period via the website.

Course: Nuclear Power Plant Technology [2170460]

Coordinators: T. Schulenberg
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
This lecture is addressed to students of mechanical engineering. It is complementary to other lectures about power plant technologies as well as steam and gas turbines. The objective is to introduce into design and analysis of pressurized water reactors and boiling water reactors. Included are excercises and a visit of a nuclear power plant.

Content
Physics of nueclear fission and radioactive decay

Basics of the neutron physics for nuclear reactor design

Thermal-hydraulic analysis of pressurized water reactors and boiling water reactors

Design of main components of the power plant

Dynamics of nuclear power plants

Safety systems

Literature
lecture notes

Course: Coal fired power plants [2169461]

Coordinators: P. Fritz, T. Schulenberg
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
None.

Learning Outcomes
The lecture presents the technology of coal fired power plants, which are conventional steam trubine plants as well as advanced combined cycle power plants with integrated coal gaification. It includes combustion systems, steam generators, a short overview over steam turbine technologies, the cooling sytem 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 purificaiton system. In addition, a visit to a coal fired power plant will be offered.

Content
Steam turbine plants

Integrated gasification combined cycle power plants

Literature
Strauß, K.: Kraftkwerkstechnik, Springer Verlag 1998

Course: Laboratory Work in Combustion Technology [22531]

Coordinators: N. Zarzalis
Part of the modules: Utility Facilities (p. 20)[ENERGY4UFD], Thermal Power Plants (p. 7)[ENERGY4TPPD], Chemical Energy Carriers (p. 9)[ENERGY4CECD]

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

Learning Control / Examinations
oral/written examination

Conditions
Fluid dynamic, heat transfer

Learning Outcomes
LAB-CT is focussing to instrumental methods of analysing the essential properties of a combustion process. The students are given the opportunity to perform measurements on the institute's test facilities

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. 9)[ENERGY4CECD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
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 experimental and design related as well as theoretical tasks in a scientific background.
- perform a correct evaluation of the obtained results.
- adequately document and present their results in a scientific framework.

Content

- Micro gas turbine
- Several test rigs for the investigation of heat transfer at thermally high loaded components
- Optimization of components of the internal air and oil system
- Characterization of spray diffusors
- Investigation of pollutant and noise emission as well as reliability and material deterioration
- Exhaust gas treatment
- Exhaust gas turbocharger

Remarks
Online registration within the first two weeks of the lecture periode at: http://www.its.kit.edu

Course: [23320]

Coordinators: Braun
Part of the modules: (p. 6)[ENERGY4BASIC]

ECTS Credits	Hours per week	Term	Instruction language
4,5	2V + 1 Ü	Summer term	de

Learning Control / Examinations
written exacmination

Conditions
None.

Learning Outcomes

Content

Course: Local Cogeneration of Heat and Power []

Coordinators:
Part of the modules: Interdisciplinary Project (p. 23)[ENTECH4IP]

ECTS Credits	Hours per week	Term	Instruction language
6		Winter term	

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Course: Management Training [2145200]

Coordinators: N. Burkardt
Part of the modules: Innovation and Entrepreneurship (p. 22)[ENTECH4INNO]

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

Learning Control / Examinations
oral/written examination

Conditions
None.

Learning Outcomes

Content
A computer based simulation allow participants to exercise their skills and judge their impact over time and on multiple decisions.
Topics:

- focusing upon various company objectives and strategies
- product life cycles, including product launch, entry into a new market and relaunch. The fundamental management techniques of competition analysis, portfolio analysis, marketing mix and pricing of special com-mercial operations are acquired in order to ensure product success. Participants will also become acquainted with and make use of break-even analysis and market re-search reports as a way of making marketing decisions.
- Research and development is another key area in which participants will expand their knowledge; this includes value analysis and the research and development into technological and environmental issues. In addition, participants learn about supply and stock keeping, particularly covering optimal order quantities. With regard to the important theme of production, participants will be taught about investment, disin-vestments, utilization planning, ecological production and rationalization and learn-ing curves, as well as the important decision of whether in-house production or third party supply would be most beneficial.
- Finance and accounting also plays a vital role in the education of future managers, therefore a great deal of attention is paid to this subject. Participants are taught about income and financial statements, cash flow, share prices and shareholder value. Furthermore, they benefit from learning the important skills of cost element, cost center and product cost accounting, progressive break-even analysis and financial budgeting.
- Participants are also trained in the field of staff management. The crucial topics of personnel planning, qualifications, productivity as well as employee turnover and absences are particularly dealt with, as knowledge of these aspects is key for future managers.

Course: Machinery and Processes [2185000]

Coordinators: H. Kubach, M. Gabi, H. Bauer, U. Maas, Maas, Gabi, Bauer, Spicher, Kubach
Part of the modules: (p. 6)[ENERGY4BASIC]

ECTS Credits	Hours per week	Term	Instruction language
7	4	Winter term	de

Learning Control / Examinations
successful lab course and written exam (2 h)

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

Learning Outcomes
After the course students can:

- explain the thermodynamic fundamentals of energy conversion.
- describe the working principle and the configuration of thermal fluid engines.
- describe the working principle and the configuration of hydraulic fluid engines.
- describe the working principle and the configuration of combustion engines.

Content
basics of thermodynamics, 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
- fuels
- emissions
- alternative drive trains

Media
slides and lecture notes to download

Remarks
Every student attends one lab course. Passing the lab course is required to write the exam.

Course: Machine Dynamics [2161224]

Coordinators: C. Proppe
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
Written examination (compulsory subject), auxiliary means: own manuscripts
Oral examination (optional subject) , no auxiliary means allowed

Conditions
none

Recommendations
none

Learning Outcomes
Application of engineering-oriented calculation methods in order to model and to understand dynamic effects in rotating machinery, e.g., 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

Course: Machine Dynamics II [2162220]

Coordinators: C. Proppe
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral exam, no auxiliary means allowed

Conditions
none

Recommendations
Machine Dynamics

Learning Outcomes
Ability to build detailed models in the machine dynamcs: Continuum models, fluid structure interaction, 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 [2145178]

Coordinators: A. Albers, Burkardt
Part of the modules: (p. 6)[ENERGY4BASIC]

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

Learning Control / Examinations
The exam in the discipline of mechanical engineering is composed of the topics from MD I to MD IV.
The complete MD-exam consists of the theoretical and constructive part.
Exam duration:
- 2 h theoretical part
- 3 h constructive part
Both parts of the exam must be passed to pass the complete MD-exam.

Conditions
Obligatory requirements: no

Recommendations
Attendance at MKL I to MKL IV lectures.

Learning Outcomes
Aims of the course

- Implementation of exemplary design process steps of product development with the help of **complex Systems,**
- Procuration of conforming to standards **interpretative rules and dimensioning rules** for part assemblies,
- Adduction to **complex** mechanical common used **machine parts** by fundamental considerations,
- Promotion of the **capacity for teamwork** as well as the **elaboration ability and assertiveness** during activity-related and supervised workshops

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

Media

- Beamer
- Visualizer
- Mechanical components

Literature
Lecture notes:
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:
The Productdevelopment knowledge base PKB will be provided in digital form for registered students. All lecture notes and additional slides will be provided in Ilias.

Course: Mechanical Design II [2146178]

Coordinators: A. Albers, Burkardt
Part of the modules: (p. 6)[ENERGY4BASIC]

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

Learning Control / Examinations
The knowledge will be proofed in a complete exam after MD IV (MACH/ID).

Conditions
Obligatory requirements: no

Recommendations
Attendance Mechanical Design I

Learning Outcomes
The lecture hat the goal

-
- to permute the complex steps of product engineering at the example of complex assemblies,
- to convey the normal application of depiction and drawing techniques, but also design and dimensioning instructions,
- to extend the view on machine elements, but also showing some parallels using the C&CM (Contact & Channel Model),

Content
Following contents will be teached:Grundlagen Lagerung

-
- Bearings
- Selaings
- Design
- Tolerances and fittings
- Shaft-hub connections

Media

-
- Beamer
- Visualizer
- Mechanical components

Literature
Konstruktionselemente des Maschinenbaus - 1 und 2
Grundlagen der Berechnung und Gestaltung von Maschinenelementen;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-22033-X,
also available as electronic paper at the KIT catalogue.
Grundlagen von Maschinenelementen für Antriebsaufgaben;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-29629-8)

Remarks
Lecture notes:
The Productdevelopment knowledge base PKB will be provided in digital form for registered students. 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: (p. 6)[ENERGY4BASIC]

ECTS Credits	Hours per week	Term	Instruction language
4		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 [0109500]

Coordinators: V. Heuveline
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD], Utility Facilities (p. 20)[ENERGY4UFD], Modelling and Simulation (p. 21)[ENERGY4MOSI], Renewable Energy (p. 18)[ENERGY4RESD], Energy Economics and Informatics (p. 17)[ENERGY4EEID], (p. 11)[ENERGY4DPSD], Chemical Energy Carriers (p. 9)[ENERGY4CECD], Energy in Buildings (p. 13)[ENERGY4EIBD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral/written 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: Methods of Product Development [2146202]

Coordinators: N. Burkardt
Part of the modules: Innovation and Entrepreneurship (p. 22)[ENTECH4INNO]

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

Learning Control / Examinations
oral/written examination

Conditions
None.

Learning Outcomes

Content
The lecture mediates fundamental knowledge of systematic product development. It is the prime goal of the lecture to make all activities within the process chain transparent. This ranges from finding a concept all the way to the final product. Thus efficient applicable methods are discussed in the lecture for the support of solving these tasks. On the basis of practical examples creativity methods for finding a concept and a solution, concrete design guidelines for the draft and along with this applicable methods of quality assurance, are introduced. Questions of generation of costs and responsibility for costs are discussed within the design process.

Course: Modelling and Simulation [2185227]

Coordinators: C. Proppe, K. Furmans, C. Stiller, B. Pritz
Part of the modules: Modelling and Simulation (p. 21)[ENERGY4MOSI]

ECTS Credits	Hours per week	Term	Instruction language
7	4	Winter term	de

Learning Control / Examinations
Master students: written exam
Seminar note by colloquium with presentation

Conditions
none

Recommendations
none

Learning Outcomes
The student:

- has an overview of modelling and simulation techniques typical in mechanical engineering ,
- obtains the ability to carry out simulation studies starting from the formulation of problems by concepts, implementation, verification and validation,
- exercises complex simulation studies.

Content
Introduction: Overview, concept formation, simulation studies, time/event-discrete models, event-oriented/process orientated/transaction-oriented view, typical model classes (operation/maintenance, storekeeping, loss-susceptible systems)
Time-continuous models with concentrated parameters, model characteristics and model analysis Numerical treatment of ordinary differential equations and differential-algebraic sets of equations coupled simulations with concentrated parameters
Time-continuous models with distributed parameters, description of systems by means of partial differential equations, model reduction, numerical solution procedures for partial differential equations

Media
presentations

Literature
None.

Remarks
none

Course: Modern Software Tools in Power Engineering [2199119]

Coordinators: T. Leibfried
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID], (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations
oral/written examination

Conditions
The theoretical background of this course is comprised in lectures “Hochspannungstechnik”, “Berechnung elektrischer Energienetze” and “ Electrical Power Transmission and Grid Control “. It is not necessary to attend to those lectures in advance. Basic computer skills are required.

Learning Outcomes
In this course participants will get into touch with commonly used power engineering software tools. Students will have to cope several typical engineering problems by studying the related technical theory and applying that knowledge to find a working solution. This course is an efficient engineering-skill training for students.

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.

Course: Nature-inspired Optimisation Methods [2511106]

Coordinators: S. Mostaghim, P. Shukla
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

ECTS Credits	Hours per week	Term	Instruction language
5	2/1	Winter term	en

Learning Control / Examinations
The assessment consists of a written exam (60 min) (according to Section 4(2), 1 of the examination regulation) and an additional written examination called “bonus exam”, 60 min (according Section 4(2), 3 of the examination regulation) or a selection of exersices . The bonus exam may be split into several shorter written tests.
The grade of this course is the achieved grade in the written examination. If this grade is at least 4.0 and at most 1.3, a passed bonus exam will improve it by one grade level (i.e. by 0.3 or 0.4).

Conditions
None.

Learning Outcomes
To learn:

1. Different nature-inspired methods: local search, simulated annealing, tabu search, evolutionary algorithms, ant colony optimization, particle swarm optimization
2. Different aspects and limitation of the methods
3. Applications of such methods
4. Multi-objective optimization methods
5. Constraint handling methods
6. 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.

Course: Neutron physics of fusion reactors [2189473]

Coordinators: U. Fischer
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The aim of this lecture is to provide the neutron physics principles required for analysis of nuclear fission and fusion reactors. First of all, the basic nuclear interaction processes are presented which are important for the physical behaviour of the reactors. Next the neutron transport phenomenon in matter is described by means of the Boltzmann transport equation. Suitable mathematical solution methods are presented such as the diffusion approximation for nuclear fission reactors and the Monte Carlo method for fusion reactors. The knowledge acquired will eventually be used to solve neutron physics problems related to the design and optimization of the reactors.

Content
Nuclear interaction processes and
energy release

Chain reaction and criticality

Neutron transport, Boltzmann
equation

Diffusion approximation, Monte Carlo
method

Neutronic reactor design

Literature
K. H. Beckurts, K. Wirtz, Neutron Physics, Springer Verlag, Berlin, Germany (1964)

W. M. Stacey, Nuclear Reactor Physics, John Wiley & Sons, Wiley-VCH, Berlin(2007)

J. Raeder (Ed.), Kontrollierte Kernfusion. Grundlagen ihrer Nutzung zur Energieversorgung, Teubner, Stuttgart (1981)

Course: Nuclear Power Technology [2130921]

Coordinators: F. Badea
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral/written examination

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

Learning Outcomes
The students will learn fundamental reactor physics, thermal-hydraulics, control, and safety.
They will also learn about future reactor systems and technological 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: Assessement of Nuclear Power Plants [2190464]

Coordinators:
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
oral/written examination

Conditions
Nuclear power plant technology, Nuclear thermal hydraulics, Nuclear Safety I

Learning Outcomes

- Get familiar with the scope and main elements of the safety analysis in the frame of a licensing process as well as the available methodologies
- Understand the neutron physical and thermal hydraulic behaviour or nuclear power plants under off normal conditions
- Understand key physical processes in a nuclear system and their importance for the plant safety
- Get familiar with advanced numerical simulation tools for safety assessment and their modelling capabilities
- Learn how to evaluate the behaviour of a nuclear power plant under different transient and accidental conditions (TUSA, RIA, LOCA) using numerical codes
- Understand the importance of the quantification of the code's uncertainty and the role of validation for nuclear safety

Content
Fundamentals of safety analysis, Safety assessment methodologies, Fundamentals of reactor dynamics, Control systems of LWR (PWR, BWR), Accident analysis of light water reactors (LWR)
Safety-relevant physical phenomena in LWR and derived safety criteria, Best-estimate numerical tools for the safety assessment of nuclear power plants, Analysis of a reactivity initiated transient in a PWR, Analysis of loss-of-coolant accidents in a PWR, Analysis of a turbine trip transient in a BWR, Quantification of the code's uncertainty and sensitivity, Validation of best-estimate numerical simulation codes

Course: Nuclear Thermal-Hydraulics [2189908]

Coordinators: X. Cheng
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
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. It gives a further insight of fundamentals in nuclear engineering. Goal of the lecture is to understand important processes and methods of the thermal hydraulic design in nuclear systems.

Content

1. criteria and tasks in thermal hydraulic design
2. heat release and heat transfer in nuclear facilities
3. heat transfer in nuclear systems
4. fluid dynamics in nuclear systems
5. thermal hydraulic core design
6. nuclear hydraulic savety aspects

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

Course: Numerical simulation of reacting two phase flows [2169458]

Coordinators: R. Koch
Part of the modules: Modelling and Simulation (p. 21)[ENERGY4MOSI], Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
Oral exam
Duration: approximately 30 minutes

no tools or reference materials are allowed

Conditions
None.

Recommendations
None.

Learning Outcomes
The course is devoted to diploma/master students and doctoral candidates of mechanical and chemical engineering. It gives an overview of the numerical methods used for CFD of single and two phase flows. The course introduces methods for reacting single and two phase flows, as they are typically found in gas turbines and piston engines operated by liquid fuel.

Content
1. Single phase flow: Basic equations of fluid dynamics, Turbulence: DNS, LES, RANS; Finite volume methods, Numerical solvers.

2. Two phase flows: Basics of atomisation, Characterisation of sprays, Numerical prediction of droplet movement, Numerical methods for predicitng of liquid disintegration (VoF, SPH), Numerical methods for secondary atomisation; Droplet evaporation

3. Reacting flows: Combustion models; Single droplet combustion, Spray combustion.

Literature
Lecture notes

Course: One Week Innovation Target [2145201]

Coordinators: N. Burkardt
Part of the modules: Innovation and Entrepreneurship (p. 22)[ENTECH4INNO]

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

Learning Control / Examinations
oral/written examination

Conditions
None.

Learning Outcomes

Content
Starting with the identification of product profiles development teams founded by the participating students are developing marked oriented concepts of innovative products. Solution finding and decision making are trained in a realistic environment using methods and tools learned in the basic modules and coached by members of the responsible IPEK-education team. The results are shown in a final presentation.

Course: Optimization of Dynamic Systems [23180]

Coordinators: S. Hohmann
Part of the modules: (p. 11)[ENERGY4DPSD]

ECTS Credits	Hours per week	Term	Instruction language
4,5	2/1	Winter term	de

Learning Control / Examinations
The assessment consists of a written exam (120 min) taking place at the beginn of the recess period (according to §4 (2), 1 of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

Conditions
None.

Learning Outcomes
Have still to be defined.

Content
Subjects are not available yet.

Remarks
The lecture will be offered the first time in winter term 2011/12.

Course: Organic Computing [2511104]

Coordinators: H. Schmeck, S. Mostaghim
Part of the modules: (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations
The assessment of this course consists of a written examination (60 min) (following §4(2), 1 SPO) and of submitting written exercises that recapitulate the content of the course. The exercises include theoretical questions as well as practical programming. For providing a successful solution to all exercises, a bonus will be granted, improving the grade of a passed exam by one grade-step (0.3 or 0.4, respectively, following §4(2), 3 SPO). The course will be offered every second semester (summer term) and exams may be repeated at every ordinary exam date.

Conditions
None.

Learning Outcomes
The student acquires the ability to master methods and concepts of Organic Computing and to demonstrate innovation skills regarding the used methods.
Therefore the course aims at the teaching of fundamentals and methods of Organic Computing within the context of its applicability in practice. On the basis of a fundamental understanding of the taught concepts and methods the students should be able to choose the adequate methods and concepts, if necessary further develop them according to the situation and use them properly when facing related problems in their later job. The students should be capable of finding arguments for the chosen solutions and express them to others.

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 are 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.

Media
powerpoint slides with annotations using a tablet pc 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.

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

Course: Intellectual Property Rights and Strategies in Industrial Companies [2147161]

Coordinators: F. Zacharias
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
Oral Examen

Conditions
Compulsory preconditions: none

Learning Outcomes
The aim of this lecture is to outline the fundamental principles of intellectual property and the strategic intellectual property work that can be carried out by innovative companies.

Content
The lecture will describe the requirements to be fulfilled and how protection is obtained for patents, design rights and trademarks, with a particular focus on Germany, Europe and the EU. Active, project-integrated intellectual property management and the use of strategic patenting by technologically oriented companies will also be discussed. Furthermore, the significance of innovations and intellectual property for both business and industry will be demonstrated using practical examples, before going on to consider the international challenges posed by intellectual property and current trends in the sector.
Within the context of licensing and infringement, insight will be provided as to the relevance of communication, professional negotiations and dispute resolution procedures, such as mediation for example. The final item on the agenda will cover those aspects of corporate law that are relevant to intellectual property.
Lecture overview:
1. Introduction to intellectual property
2. The profession of the patent attorney
3. Filing and obtaining intellectual property rights
4. Patent literature as a source of knowledge and information
5. The law regarding employee inventions
6. Active, project-integrated intellectual property management
7. Strategic patenting
8. The significance of intellectual property
9. International challenges and trends
10. Professional negotiations and dispute resolution procedures
11. Aspects of corporate law

Course: Photovoltaics [23737]

Coordinators: M. Powalla
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
Turorials, written exams, alternatively oral exam.

Conditions
Basic knowledge of thermodynamics and solid state physics.

Recommendations
Complement to “Energy Systems” and “Fundamentals of Energy Technology”.

Learning Outcomes
After the course attendants can:

- understand energy conversion in semiconductors.
- discuss emerging technological and production relevant aspects.
- capture the interaction of photovoltaic energy sytems with different system components.
- quantify losses.

Content

- The significance of photovoltaics in national and global energy supply.
- Physical fundamentals of energy conversion.
- Photovoltaic cells (specific parameters, materials, loss assessment).
- Implementation concepts (Sillicon technology, thin layer cells, concentrator cells, dye cells and organic cells).
- Modular technique and production technology.
- Photovoltaic energy systems (Components, alternative current converter, solar tracking, system design).

Literature
P. Würfel, Physik der Solarzellen, 2. Auflage (Spektrum Akademischer Verlag, Heidelberg, 2000)
R. Sauer, Halbleiterphysik, (Oldenburg Wissenschaftsverlag, 2009)
H.J. Lewerenz, H. Jungblut, Photovoltaik (Springer, Berlin, 1995)
H.G. Wagemann, Photovotoltaik, (Vieweg, Wiebaden, 2010)
Tom Markvart, Luis Castaner, Photovoltaics Fundamentals and Applications, (Elsevier, Oxford, 2003)
Heinrich Häberlin, Photovoltaik, (AZ Verlag, Aarau, 2007)

Course: Power System Analysis [23395]

Coordinators: Weber
Part of the modules: (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Course: Range Extender [2146440]

Coordinators: H. Bauer
Part of the modules: Interdisciplinary Project (p. 23)[ENTECH4IP]

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

Learning Control / Examinations
oral/written examination

Conditions
a subset of: thermodynamics, fluid mechanics, turbo machinery, combustion, rotor dynamics, power electronics, electric machines, machine elements, mechanical design and project management

Learning Outcomes
The students will be trained to work in an interdisciplinary team. Besides technical knowledge they will learn how to organise and run a project in a controlled manner within a given time frame and to a certain degree also within a limited budget.

Content
In a range extender an internal combustion engine (e.g. an SI/Diesel engine or a micro gas turbine) significantly extends the range of a normally electrically driven vehicle such as a car, a van, a truck or a bus. The internal combustion engine charges the battery of the electric vehicle only rather than to drive the vehicle directly. Hence the range extender additionally comprises an electric generator and some power electronics components.
The envisaged project focuses on a micro gas turbine as the internal combustion engine which drives an ultra-high-speed electric generator. Micro gas turbine and generator will be optimised for the design point only. As two completely different engines mechanically connected to each other will be subject of the course, i.e. a micro gas turbine and an electric generator, the task to preliminarily design a range extender will be strongly interdisciplinary. It will be solved by establishing a team consisting of students having specialised knowledge from different disciplines such as turbomachinery, combustion, rotor dynamics, electric engines and power electronics.
In an introductionary lesson the boundary conditions for the range extender will be given, such as size of the vehicle and its typical operational range and profile. A team will be formed with specific roles such as project manager, team leader(s) and specialists based on the needs of the project and the individual skills of the team members. Regular internal meetings as well as external review meetings will be agreed.
The expected result of the project will be a preliminary design of the major components of the range extender in terms of 3D CAD models, a cost estimate as well as a potential market share taking into account competing concepts. The range extender design will be presented to an external audience including the lecturers as well as industrial representatives.

Course: Reactor Safety I: Fundamentals [2189465]

Coordinators: V. Sánchez-Espinoza
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes

- Knowledge of fundamentals of nuclear safety (technology, atomic law, principles)
- Gain understanding of safety features and systems of a nuclear power plant
- Ability to understand the interactions of different areas e.g. thermal hydraulics, neutronics, materials, human factors, organisation and management of a nuclear power plant

Content
The goal of the lecture is to impart the fundamentals of nuclear safety that is needed to assess the safety of nuclear facilities. Nuclear safety is inherently of multidisciplinary character and is based on the following pillars: technology, man, organisation and measures; all together named “Safety Culture”.The nuclear facilities, coal-fired power plants, aerospace industry and gen technology for example are connected with a certain risk for the environment and society. Consequently, the erection and operation of nuclear installations needs must undergo a licensing process and a continuous surveillance by the regulatory body. This lecture will be concentrated on the following topics:

- Historical development of nuclear safety
- Risk evaluation for nuclear power plants compared to other technologies
- Scope, principles and structure of the atomic Law (national and international context)
- Fundamentals of nuclear safety
- Safety features and systems of nuclear power plants with Light Water Reactors (Generation 2)
- Safety analysis and methods for safety assessment
- Validation of numerical simulation tools for safety demonstration
- Introduction to probabilistic safety assessment (PSA)
- Nuclear events and accidents
- Safety concepts of reactors of generation 3 and 4

Literature
Lecuture notes

Course: Renewable Energy - Resources, Technologies and Economics [2581012]

Coordinators: R. McKenna
Part of the modules: Innovation and Entrepreneurship (p. 22)[ENTECH4INNO]

ECTS Credits	Hours per week	Term	Instruction language
3,5	2	Winter term	en

Learning Control / Examinations
oral/written examination

Conditions
none

Learning Outcomes
Obtain an overview of the key economic aspects relating to renewable energies
Understand the technical and economic interdependencies of these technologies
Judge the economical, ecological and social impacts renewable energies

Content
This lecture presents an overview of some of the most prevalent economic aspects of renewable energy technologies, whilst also considering the most pertinent technical aspects. Hence all renewable technologies are considered from an economic perspective, including the concept of levelized electricity generation costs and their determination with several examples. The need for and types of political support mechanisms for renewable energy technologies will also be discussed, and the diverging experience within Europe in this regard detailed. Other economic aspects of these technologies to be considered in the lecture include:

- determination of cost-potential curves
- logistics and associated requirements,
- marketing of renewable energy,
- investors and financing structures in renewable energy,
- short term forecasting of e.g. wind feed-in, and
- markets for renewable energy technologies
- externalities of renewable energies

Course: Decommissioning of Nuclear Facilities I [19435]

Coordinators: S. Gentes
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Learning Outcomes

Content

Literature
NomosGesetze: „Atomgesetz mit Verordnungen“, ISBN: 978-3-8329-2833-9
atw – International Journal of Nuclear Power, ISSN: 1431-5254

Course: Safety engineering [2117061]

Coordinators: H. Kany
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral / written (if necessary) => (see “Studienplan Maschinenbau”, version of 29.06.2011)
examination aids: none

Conditions
none

Recommendations
none

Learning Outcomes
The student:

- has basic knowledfe of safety engineering,
- knows the basics of industrial health and labour protection in Germany,
- is familiar with the national and european safety regulations and the basics for the safe methods of design of machinery.
- is able to realize these objectives by using examples in the field of storage- and conveyor-systems.

Content
The course provides basic knowledge of safety engineering. In particular the basics of health at the working place, job safety in Germany, national and European safety rules and the basics of safe machine design are covered. The implementation of these aspects will be illustrated by examples of material handling and storage technology. This course focuses on: basics of safety at work, safety regulations, basic safety principles of machine design, protection devices, system security with risk analysis, electronics in safety engineering, safety engineering for storage and material handling technique, electrical dangers and ergonomics. So, mainly, the technical measures of risk reduction in specific technical circumstances are covered.

Media
presentations

Literature
Defren/Wickert: Sicherheit für den Maschinen- und Anlagenbau, Druckerei und
Verlag: H. von Ameln, Ratingen, ISBN: 3-926069-06-6

Remarks
none

Course: Smart Energy Distribution [2199118]

Coordinators: H. Schmeck
Part of the modules: (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations
oral/written examination

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

Learning Outcomes
The students will develop an understanding of the basic problems that arise from decentralisation and an increased share of renewables in the power mix and they will know how to deal with these problems by using concepts like virtualisation and self-organisation. 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.

Content
The course addresses the role of information and communication technologies for the distribution of energy. 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 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.

Course: Software-Lab Fluid Mechanics [2199108]

Coordinators: V. Heuveline
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD], Thermal Power Plants (p. 7)[ENERGY4TPPD], Renewable Energy (p. 18)[ENERGY4RESD], Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
oral/written examination

Conditions
Some knowledge of any computer language

Learning Outcomes
Two projects must be finished.
Experience with numerical simulation and validation of results

Content
The main task of that lab is to engage deeply with applications, which are related to the courses „Optimisation and Optimal Control“ as well as „Mathematical Modelling“. Thus, the modelling, the numerical simulation with Finite Element Software and the presentation and interpretation of the results has to be accomplished.
The problems usually originate from Fluid Mechanics, but the lab is open for all kinds of problems (e.g. introduced by the students) which are modeled with Partial Differential Equations.
In general during the term a first introductary problem is solved and after that a more advanced one. We encourage to work in pairs or groups.

Course: Mechatronic Softwaretools [2161217]

Coordinators: C. Proppe
Part of the modules: (p. 11)[ENERGY4DPSD], Thermal Power Plants (p. 7)[ENERGY4TPPD], Renewable Energy (p. 18)[ENERGY4RESD], Energy in Buildings (p. 13)[ENERGY4EIBD]

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

Learning Control / Examinations
written exam, duration: 1 h

Conditions
none

Recommendations
none

Learning Outcomes
Mechatronic Softwaretools is a practical training course on using the software packages Maple, Matlab, Simulink and Adams. Mechatronic problems are solved using these packages on PCs.

Content
1. Introduction to Maple: Generating of the nonlinear equations of motion for a double pendulum. Stability and resonance investigation of a Laval-rotor.
2. Introduction to Matlab: Dynamic simulation of a basic vehicle model using the Runge-Kutta-method. Solution of the partial differential equation for a rod by a Galerkin approximation.
3. Introduction to Simulink: Block diagrams of one-mass- and two-mass-oscillators. PID-distance control of two vehicles.
4. Introduction to Adams: Modelling and dynamic simulation of a simple robotic manipulator.

Literature
Hörhager, M.: Maple in Technik und Wissenschaft, Addison-Wesley-Longman, Bonn, 1996

Hoffmann, J.: Matlab und Simulink, Addison-Wesley-Longman, Bonn, 1998

Programmbeschreibungen des Rechenzentrums Karlsruhe zu Maple, Matlab und Simulink

Course: Solar Energy [23745]

Coordinators: A. Colsmann
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
oral/written examination

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: Strategical Aspects of Energy Economy [2581958]

Coordinators: A. Ardone
Part of the modules: Energy Economics and Informatics (p. 17)[ENERGY4EEID]

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

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

Conditions
None.

Learning Outcomes

Content

Literature
Will be anounced in the lecture.

Course: [2189910]

Coordinators: X. Cheng
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
oral examination; duration: 20min

Conditions
None.

Learning Outcomes
This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the understanding of major processes in fluid dynamics and heat transfer in energy engineering. The corresponding phenomena and the methods to analyse are described and explained. In addition the lecture will be supplemented by convenient examples.

Content

1. collection of sample applications
2. heat transfer and its application
3. convective fluid dynamics and heat transfer
4. thermal radiation and its application
5. special cases

Literature

- Bahr, H.D., Stephan, K., Wärme- und Stoffübertragung, 3. Auflage Springer Verlag, 1998
- Mueller, U., Zweiphasenströmung, Vorlesungsmanuskript, Februar 2000, TH Karlsruhe
- Mueller, U., Freie Konvektion und Wärmeübertragung, Vorlesungsmanuskript, WS1993/1994, TH Karlsruhe
- W. Oldekop„Einführung in die Kernreaktor und Kernkraftwerktechnik,“Verlag Karl Thiemig, München, 1975
- Cacuci, D.G., Badea, A.F., Energiesysteme I, Vorlesungsmanuskript, 2006, TH Karlsruhe
- Jones, O.C., Nuclear Reactor Safety Heat Transfer, Hemisphere Verlag, 1981
- Herwig, H., Moschallski, A., Wärmeübertragung, 2. Auflage, Vieweg + Teubner, 2009

Course: Superconductivity in Smart Grid Power Applications [2199117]

Coordinators: M. Noe
Part of the modules: (p. 11)[ENERGY4DPSD]

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

Learning Control / Examinations
oral/written examination

Conditions
Basic knowledge of electromagnetism (Maxwell equations)

Learning Outcomes
The lecture contains the basics of superconductivity for engineers and a state-of-the-art overview about superconducting materials and their characteristics. For the most relevant superconducting applications in power systems the function and the state-of-the-art is given.
The lecture contains the basics of superconductivity for engineers and a state-of-the-art overview about superconducting materials and devices. Particular attention is given to applications such as cables, fault current limiters, magnets, motors and transformers.

Content
Superconductivity gives promise to energy transmission without losses. Many scientists and engineers are inspired by this idea since the discovery of superconductivity in 1911. In 1986 the so-called High Temperature Superconductors enable efficient and low cost cooling with liquid nitrogen. Since this breakthrough R&D in superconductivity is rapidly increasing.

Course: Engineering Mechanics I [2161245]

Coordinators: T. Böhlke
Part of the modules: (p. 6)[ENERGY4BASIC]

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

Learning Control / Examinations
written, 90 min. Additives as announced
Prerequisites by solving homework problems and attestations during the associated lab course.

Conditions
Mandatory participation in the assciated lab course.

Recommendations
None.

Learning Outcomes
The Studenten know the basics for computing statical mechanical systems in engineering. Based on the notion of force, the studens can analyse different equilibrium systems, e.g. plane and spatial force systems on rigid bodies. The students master the computation of internal forces and moments. in addition to the axion of equilibrium the students can effectively appls the principle of virtual displacements. In the framework of statics of straight bars the students can compute the internal forces and moments using elastic, thermo-elastic and elasto-plastic constitutive relations.
During the associated tutorial the students apply the basics for solving problems of statics. During the associated lab course the students develop solutions to problems of statics using the commercial software 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: Engineering Mechanics II [2162250]

Coordinators: T. Böhlke
Part of the modules: (p. 6)[ENERGY4BASIC]

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

Learning Control / Examinations
written, 90 min. Additives as announced
Prerequisites by solving homework problems and attestations during the associated lab course.

Conditions
Mandatory participation in the assciated lab course.

Recommendations
None.

Learning Outcomes
The students master the elementary theories of bending, shear and torsion of straight beams. They know the principles of elasticity theory in 3D, especially multi-axial stress and strain states and Hookes law. The students can effectively apply energy methods and know approximation methods of elastostatics. They master the concept of stability and know basics of an elasto-plastic theory.
During the associated tutorial the students apply the basics for solving problems of elastostatics. During the associated lab course the students develop solutions to problems of elastostatics using the commercial software algebra system MAPLE.

Content

- bending
- shear
- torsion
- stress and strain state in 3D
- Hookes law in 3D
- elasticity theors in 3D
- energy methods in elastostatics
- approximation methods
- stability
- inelastic material behaviour

Literature
lecture notes
Hibbeler, R.C: Technische Mechanik 2 - Festigkeitslehre. Prentice Hall. Pearson Studium 2005.
Gross, D. et al.: Technische Mechanik 2 - Elastostatik. Springer 2006.
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Parkus, H.: Mechanik der festen Körper. Springer 1988.

Course: Engineering Thermodynamics and Heat Transfer I [2165501]

Coordinators: U. Maas
Part of the modules: (p. 6)[ENERGY4BASIC]

ECTS Credits	Hours per week	Term	Instruction language
6,5	3	Winter term	de

Learning Control / Examinations
Written
Duration: 2 hours

Conditions
None

Recommendations
None

Learning Outcomes
After completing the course students can:

- describe the correlations between the 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
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
Course note packet
Elsner, N.; Dittmann, A.: Energielehre und Stoffverhalten (Grundlagen der technischen Thermodynamik Bd. 1 und 2), 8. Aufl., Akademie-Verlag, 680 S. 1993.
Baehr, H.D.: Thermodynamik: eine Einführung in die Grundlagen und ihre technischen Anwendungen, 9. Aufl., Springer-Verlag, 460 S., 1996.

Course: Technical Thermodynamics and Heat Transfer II [2166526]

Coordinators: U. Maas
Part of the modules: (p. 6)[ENERGY4BASIC]

ECTS Credits	Hours per week	Term	Instruction language
6,5	3	Summer term	de

Learning Control / Examinations
Written
Duration: 2 hours

Conditions
None

Recommendations
None

Learning Outcomes
After attending the course students are able to:

- describe the correlation between the thermodynamic properties in mixtures of different substances.
- explain the characteristics of real substances.
- define the major concepts in gas kinetics.
- determine the composition of a reacting mixture in the thermodynamic equilibrium.
- discuss the various influences on the reaction equilibrium.
- describe the fundamental laws of heat transfer.

Content
Repetition of the topics of “Thermodynamics and Heat Transfer I”
Mixtures of ideal gases
Moist air
Behaviour of real substances described by equations of state
Applications of the laws of thermodynamics to chemical reactions

Media
Blackboard and Powerpoint presentation

Literature
Course notes
Elsner, N.; Dittmann, A.: Energielehre und Stoffverhalten (Grundlagen der technischen Thermodynamik Bd. 1 und 2), 8. Aufl., Akademie-Verlag, 680 S. 1993.
Baehr, H.D.: Thermodynamik: eine Einführung in die Grundlagen und ihre technischen Anwendungen, 9. Aufl., Springer-Verlag, 460 S., 1996.

Course: Ten lectures on turbulence [2189904]

Coordinators: I. Otic
Part of the modules: Nuclear and Fusion Technology (p. 15)[ENERGY4NFTD]

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

Learning Control / Examinations
oral examination; **duration**: 20 minutes

Conditions
None.

Recommendations

- Fundamentals of fluid dynamics

Learning Outcomes
After completing the course students should be able to establish a connection between theory and numerical modeling of turbulent flows.

Content
This course is specified for Master students of Mechanical, Power and Nuclear Engineering. The problem of turbulence is of key importance in many fields of science and engineering. It is an area which is vigorously researched across a diverse range of disciplines. This course is aimed of giving the fundamentals of turbulence theory and modelling. Starting from the basic physical phenomena and governing equations the quantitative and statistical description of turbulence is introduced. An overview on computational methods for turbulent flows and turbulence modelling is given.

Course: Thermal Waste Treatment [22516]

Coordinators: T. Kolb
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Utility Facilities (p. 20)[ENERGY4UFD]

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

Learning Control / Examinations
oral/written examination

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 learn process principles and to 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: Thermische Transportprozesse [22824]

Coordinators: Kind
Part of the modules: Chemical Energy Carriers (p. 9)[ENERGY4CECD], Utility Facilities (p. 20)[ENERGY4UFD]

ECTS Credits	Hours per week	Term	Instruction language
7	5	Winter term	de

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Course: Thermal Turbomachines I [2169453]

Coordinators: H. Bauer
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral
Duration: approximately 1 hour

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
None.

Learning Outcomes
The main topics of the course are the design principles, construction and applications of modern turbo-machinery. These issues are not only addressed on the level of indi-vidual components and assamblies, but are also considered by viewing the role of the complete turbine in the power generation process. In this manner the role of physical, economic and ecological factors in the design of the machines be-comes evident. It is a recommended lecture combination with 'Thermal Turbomachines II'.

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: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral (can only be taken in conjunction with 'Thermal Turbomachines I')
Duration:approximately 60 minutes (including Thermal Turbomachines I)

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

Conditions
None.

Learning Outcomes
This lecture builds on the fundamentals learned in Thermal Turbo Machines I and focusses on the design aspects and operations of the machines. It is a recommended lecture combination with 'Thermal Turbomachines I'.

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
Course not packet
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. 20)[ENERGY4UFD], Chemical Energy Carriers (p. 9)[ENERGY4CECD]

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

Learning Control / Examinations
oral/written examination

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: Turbine and compressor Design [2169462]

Coordinators: H. Bauer, A. Schulz
Part of the modules: Thermal Power Plants (p. 7)[ENERGY4TPPD]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
Thermal Turbomachines I+II

Learning Outcomes
The lecture is intended to expand the knowledge from Thermal Turbomachines I+II. Special types of components such as radial turbines and transonic compressors are discussed with emphasis on the proper design of each individual component.

Content
Thermal Turbomaschines, general overview

Design of a turbomachine: Criteria and development

Radial machines

Transonic compressors

Combustion chambers

Multi-spool installations

Literature
Münzberg, H.G.: Gasturbinen - Betriebsverhalten und Optimierung, Springer Verlag, 1977

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

Course: Lecture „Entrepreneurship“ [2545001]

Coordinators: O. Terzidis, A. Presse
Part of the modules: Innovation and Entrepreneurship (p. 22)[ENTECH4INNO]

ECTS Credits	Hours per week	Term	Instruction language
4,5	2/1	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
The lecture as part of the module EnTechnon introduces the basic concepts of entrepreneurship and presents the individual steps of the dynamic development of corporate development. The focus here is the introduction to methods for generating innovative business ideas, the translation of patents in business concepts and general principles of financial planning. Other topics include the design and use of service-oriented information systems for start-ups, Technology Management and Business Model Generation and “Lean Startup” methods for the implementation of business ideas in the way of controlled experiments in the market.
WS 12/13: Entrepreneurship exemplified by opportunities emerging from the energy transformation
More details: www.entechnon.kit.edu

Course: Wind- and Waterpower [2157450]

Coordinators: M. Gabi, N. Lewald
Part of the modules: Renewable Energy (p. 18)[ENERGY4RESD]

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

Learning Control / Examinations
Oral exam, 30 minutes, no means

Conditions
None

Recommendations
Fluid Mechanics

Learning Outcomes
The students know basic fundamentals for the use of wind- and waterpower.

Content
Wind- and waterpower fundamental lecture. Introduction in the basics of fluid machinery.
Windpower:
Basic knowledge for the use of wind power for electricity, complemented by historical development, basic knowledge on wind systems and alternative renewable energies. Global and local wind systems as well as their measurement and energy content are dedicated. Aerodynamic basics and connections of wind-power plants and/or their profiles, as well as electrical system of the wind-power plants are described. Fundamental generator technology over control and controlling of the energy transfer.
Finally the current economic, ecological and legislations boundary conditions for operating wind-power plants are examined.An overview of current developments like super-grids and visions of the future of the wind power utilization will be given.
Waterpower:
Basic knowledge for the use of water power for electricity, complemented by historical development. Description of typical hydropower systems.
Introduction in the technology and different types of water turbines. Calculation of the energy conversion of typical hydropower systems.

Literature

- Erich Hau, Windkraftanlagen, Springer Verlag.
- J. F. Douglas er al., Fluid Mechanics, Pearson Education.
- Pfleiderer, Petermann, Strömungsmaschinen, Springer Verlag.

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