Module Descriptions

Master of Science Energy
Science and Technology

Examination Regulations in the Version of: 2012
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Chemistry for Energy Science and Technology

Code 8833270976

ECTS credits 18

Attendance time 15

Language of instruction English

Duration 2 Semester

Cycle each academic Year

Coordinator Prof. Dr. Rolf Jürgen Behm

Instructor(s) Lecturers of the Faculties of Natural Sciences and Engineering & Computer Science

Allocation of study programmes Energy Science and Technology 1. to 3. semester

Recommended prerequisites BSc Degree

Learning objectives The students will learn and understand

• the fundamentals of general chemistry and chemical synthesis with respect to the preparation of organic polymeric and inorganic materials
• the principles of quantum chemistry
• practical aspects of thermodynamics
• basics of surfaces and interfaces
• fundamental principles of modern catalysis like structures, properties, syntheses and applications.

Syllabus

Inorganic and Organic Chemistry:
Atoms, Hydrogen, Halogens, Chalcogens
Basics of organic chemistry and fundamental applications of analytical methods in organic chemistry.

Polymeric Materials:
Fundamental terms of polymer chemistry, chemical structure of polymers, molar mass and its distribution, configuration and stereo-isomers, step- and chain-growth polymerisation, anionic polymerisation, insertion polymerisation, metathesis polymerisation, free radical polymerisation, polymerisation techniques (solution, suspension, emulsion), copolymerisations, polyaddition, polycondensation, networks, technical polymers.

Physical Chemistry:
Quantum Chemistry: Some simple systems, postulates and Schrödinger equation, atomic structure and qualitative molecular orbital theory.

Practical Aspects of the Laws of Thermodynamics, Boltzmann and Fermi-Dirac statistics

Reaction kinetics and catalysis: Concept of activation energy, interfaces, electrocatalysis, application on fuel cells

Fundamental concepts of spectroscopy and photochemistry: Correlation between molecular structures and spectra, principle of Laser, applications for solar cells.

**Surface - Interfaces - Heterogenous Catalysis and Electrocatalysis**

Surfaces: Phenomenologic thermodynamics of surfaces, Properties and characterization of solid surfaces, Interactions of particles in the gas phase with surfaces

Heterogeneous Catalysis - Catalytic Surface Reactions: Studies of catalytic reactions - methodic approach, Fundamental reaction types, Activity, selectivity, Electronic and structural effects, Model reactions (CO oxidation, Ammonia synthesis)

Electrochemistry: Potentials in electrochemistry, Electrochemical double layer, Electrode kinetics, Experimental methods

Electrocatalysis: Influence of the electric potential on the energetics and kinetics of electro catalytic reactions, limitations in electrocatalytic reactions, Internal resistance effects, Examples of electrocatalytic reactions

**Literature**


any basic textbook of Organic Chemistry


John R. Dean: Practical Skills in Chemistry Prentice Hall 2002

G.A. Somorjai: Introduction to Surface Chemistry (Wiley – VCh, Weinheim, 2000)

handouts

**Teaching and learning methods**

Physical Chemistry (L, E) 3 h/week, graded exam

Introductory Laboratory (P), 4 h/week, seminars and reports, passed or failed

Surface - Interfaces - Heterogeneous Catalysis- Electrocatalysis, (L), 4 h/week, graded exam

Polymeric Materials (L), 4 h/week, graded exam

**Workload**

126 h lecture and exercises (presence)

118 h preparation and revision of lecture

84 h lab and seminar (presence)

70 h solution of exercises, revision

94 h home writing report and revision, seminar talk preparation

48 h exam preparation

Total: 540 h

**Assessment**

Surfaces - Interfaces - Heterogeneous Catalysis - Electrocatalysis (5 CP), written exam

Physical Chemistry (4 CP), written exam, Prerequisite for exam registration is passing the pre-course (to be defined by the examiner).

Polymeric Materials (4 CP), written or oral exam

Introductory Laboratory (5 CP), not graded
<table>
<thead>
<tr>
<th><strong>Grading procedure</strong></th>
<th>Weighted average of graded exams according to credit points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basis for</strong></td>
<td>MSc Energy Science and Technology</td>
</tr>
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</table>
Engineering

Code 8833270977

ECTS credits 15

Attendance time 14

Language of instruction English

Duration 2 Semester

Cycle each academic Year

Coordinator Prof. Dr. Herbert Kabza

Instructor(s) Prof. Dr. Herbert Kabza, Prof. Dr. Ferdinand Scholz

Allocation of study programmes Energy Science and Technology 1. to 2. semester

Recommended prerequisites BSc Degree

Learning objectives Students will be able to

• perform circuit analysis of linear DC and AC (RLC) circuits and analyze transient problems of RLC circuits
• explain the basics of crystal and semiconductor physics, how basic semiconductor devices work, basic treatment/evaluation of measured data, conversion of analogue data into digital data, basic treatment of digital data, advantages and problems of digital data processing
• recall the background and basic facts, components, and interactions in the field of energy technology.

Students will learn to

• understand and explain the basic physical principles underlying mechanic and electric energy conversion
• describe the functional mechanisms of the different thermal power plants and explain the basic components
• solve simple problems in the field of technical thermodynamics
• solve simple problems in the field of hydro and wind power applications
• understand and explain the construction and functional mechanisms of hydro - , wind - , solar thermal - and photovoltaic power plants of different kinds
• understand and explain the balance terms "cumulated energy input, energy harvest factor, energy pay-back time" and use them for approximative calculations
• distinguish the different kinds of potentials in the use of regenerative sources with different technologies and give approximative quantities for them
• show the technical possibilities for long-distance energy imports from regenerative sources and point out the necessary effort and cost
• describe possible storage technologies together with their problems
• understand and describe structure and functional mechanisms in cogeneration and absorption cooling technologies

**Syllabus**

**Electrical Engineering:**

- Circuit analysis
- Analysis of transients
- Semiconductors
- Diodes, Transistors
- Devices for measurement
- Signal filtering, Noise
- Digital Signal Processing
- Microcontrollers

**Energy Science and Technology I and II:**

The courses gives an overview on technologies using renewable sources and the concepts of distributed power technologies:

- development and status of energy consumption and resources; its limitations and consequences
- physical basics of mechanical - electrical energy conversion
- types of electric machines: DC separately excited, parallel and series wound; asynchronous; synchronous, special forms like AC machines, linear drives, electronically commutated machines
- structure and function of the electric power grid and its components
- electric power generation by means of thermal power plants and their thermodynamical fundamentals: entropy, Carnot -, (Joule) Brayton - and (Clausius) Rankine cycle
- nuclear power plants, nuclear fusion technology
- electric power generation from renewable sources: hydro and wind power, photovoltaics, further technologies in the field of renewables
- primary energy input
- energy pay-back time and energy harvest factor
- consumption of materials, resources and area
- ecological impact
- economy and cost
- the necessities for storage technologies and the problems associated
- cogeneration concepts and absorption cooling

**Literature**

• Dirk Peier: Einführung in die elektrische Energietechnik, A. Hüthig Verlag, Heidelberg, 1987
• O. Seinsch: Grundlagen elektrischer Maschinen und Antriebe, B.G. Teubner Verlag Wiesbaden, 1993
• J.D. Pinske: Elektrische Energieerzeugung, B.G. Teubner Verlag, Wiesbaden, 1993
• M. Kleemann, M. Melliß: Regenerative Energiequellen, Springer, 1993
• S. Heier: Windkraftanlagen, Systemauslegung, Integration und Regelung, Teubner, Stuttgart 2003
• A. Goetzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik; Teubner
• U. Rindelhardt: Photovoltaische Stromerzeugung, Teubner
• A. Goetzberger, V. Wittwer: Sonnenenergie Thermische Nutzung, Teubner
• J. Karl, Dezentrale Energiesysteme, Oldenbourg, München 2004

### Teaching and learning methods

<table>
<thead>
<tr>
<th>Course</th>
<th>Details</th>
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<tbody>
<tr>
<td>Electrical Engineering (L)</td>
<td>3 h/week, graded exam</td>
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<tr>
<td>Electrical Engineering (E)</td>
<td>1 h/week</td>
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<tr>
<td>Energy Science and Technology I (L)</td>
<td>lecture, 3 h/week, graded exam</td>
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<td>Energy Science and Technology I (E)</td>
<td>exercises, 1 h/week</td>
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<td>Energy Science and Technology I (T)</td>
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<td>Energy Science and Technology II (L)</td>
<td>lecture, 3 h/week</td>
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<td>Energy Science and Technology II (E)</td>
<td>exercises, 1 h/week</td>
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<tr>
<td>Energy Science and Technology II (P)</td>
<td>lab, 1 h/week, pass or fail</td>
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</table>

### Workload

- 126 h lecture (presence)
- 126 h preparation and postprocessing lecture
- 63 h exercises, practical training (presence)
- 87 h solution of exercises, postprocessing
- 48 h exam preparation

Total: 450 h

### Assessment

- Electrical Engineering (5 CP), written exam
- Energy Science and Technology I (5 CP), written exam
- Energy Science and Technology II (5 CP), written exam

### Grading procedure

Weighted average of graded exams according to credit points

### Basis for

MSc Energy Science and Technology
Materials Science

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<td>Language of instruction</td>
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<tr>
<td>Duration</td>
<td>2 semester Semester</td>
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<td>Cycle</td>
<td>each academic Year</td>
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<tr>
<td>Coordinator</td>
<td>Prof. Dr. U. Herr, Faculty of Engineering and Computer Science</td>
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<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. U. Herr and lecturers of the Faculty of Engineering and Computer Science</td>
</tr>
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</table>

**Allocation of study programmes**
First and second semester MSc Energy Science and Technology

**Recommended prerequisites**
Fundamentals of mathematics, physics and chemistry

**Learning objectives**

**Materials Science I**

Students should be able to

• classify metallic, ceramic and polymeric materials based on their structure on the atomic scale, microstructure and macroscopic properties.
• analyze different materials with respect to mechanical strength.
• understand the physical basis for thermal, electrical and magnetic properties of solid materials.

**Materials Science II**

Students should be able to

• interpret the influence of the processing of a metallic alloy, ceramic and polymeric substance on its microstructure and properties.
• relate the structure of a composite material to improved strength and toughness.
• select appropriate materials and processing routes for the realization of an engineering design goal, based on properties and performance characteristics.
Syllabus

Materials Science I

• Classification of materials with respect to chemical bond and structure.
• Crystal structure: Symmetry classes, lattices, reciprocal lattice, diffraction.
• Defects in solids: Point defects, dislocations, grain and phase boundaries.
• Characterization of the microstructure: Microscopic methods (optical, SEM),
diffraction techniques (XRD, TEM ),scanning probe techniques (introduction).
• Phase diagrams: Thermodynamics of solutions, chemical potential, phase
equilibrium, basic types of phase diagrams, important examples.
• Transport: Diffusion (macroscopic and microscopic description), diffusion at
surfaces and interfaces, electromigration, thermotransport.
• Phase transformations: Thermodynamics and kinetics, diffusive transformations,
non-diffusive transformations.
• Mechanical properties: Elasticity, plastic deformation, viscous flow and creep,
fracture.

Materials Science II

• Application of basic concepts introduced in part I of the lecture to different
classes of materials: Metallic alloys, ceramics, glasses, polymers.
• Processing/optimization of materials, heat treatment
• Electrical properties of materials
• Semiconductors
• Magnetic properties of materials
• Optical properties of materials
• Micro- and nanostructure of materials: preparation, characterization and stability
of micro- and nanostructures, relationship between structure and properties.

Literature

• Ashby M. F. and D. R. H. Jones: Engineering Materials 1. 2nd ed., Butterworth-
• Ashby, M.F. and D. R. H. Jones: Engineering Materials 2. 2nd ed., Butterworth-
• Callister, W.D.: Materials Science and Engineering: An Introduction. 6th ed.,

Teaching and learning methods

Materials Science I

5 credit points
Lecture 3 h/week
Solving problems 1 h/week

Materials Science II

5 credit points
Lecture 3 h/week
Exercise 1 h/week

Workload

Materials Science I:
Total 150 h
Lecture: 48 h lecture (presence)
38 h preparation and revision
Solving problems: 16 h presence
32 h revision
Exam: 16 h preparation
Materials Science II:
Total 150 h
Lecture: 42 h presence
      50 h preparation and revision
Solving problems: 14 h presence
      28 h revision, solution of exercises
Exam 16 h preparation

Assessment
Derzeit steht keine deutsche Modulbeschreibung zur Verfügung.

Grading procedure
Weighted average of graded exams according to credit points

Basis for
Module Energy Science and Technology III-Electrochemical EST MSc Energy Science and Technology
Energy Science and Technology

**Code**  
8833270979

**ECTS credits**  
27

**Attendance time**  
20

**Language of instruction**  
English

**Duration**  
2 Semester Semester

**Cycle**  
each academic Year

**Coordinator**  
Prof. Dr. Herbert Kabza

**Instructor(s)**  
Lecturers of the Faculties of Natural Sciences and Engineering & Computer Science

**Allocation of study programmes**  
Energy Science and Technology 2. and 3. Semester

**Recommended prerequisites**  
Modules Chemistry; Materials Science; Engineering

**Learning objectives**  
The students should be able to understand the physical and mathematical background which is necessary for the development of polymer-electrolyte fuel cells and solid oxide fuel cells models

The student is able to present a detailed understanding of Fuel Cell technology and rechargeable Battery technology – alkaline and acid systems, electrochemical double layer capacitors

**Syllabus**

- Formulation of (dynamic) models, Component balance in different reactors, Energy balancing, Component and energy balance of a fuel PEFC stack, Fluid dynamics, Heat transfer, Classification of partial differential equations, Discretization scheme, Models for describing SOFC behavior, Two phase flow, Models for describing PEFC behavior

- The role fuel cells and batteries as key technologies in the modern energy world, fundamentals of fuel cell technology, fuel cell systems: key components and operational characteristics, performance testing, degradation principles of fuel cells, application of fuel cells (automotive, bus, stationary CHP and back up power, leisure market), fundamentals of rechargeable batteries and electrochemical double layer capacitors, characterization of batteries (charge, discharge, degradation), battery systems, battery management, thermal management, maintenance, safety aspects of batteries
- Fuel Cells, Fuel Cell Systems and Batteries, based on practical work with such technologies

<table>
<thead>
<tr>
<th>Literature</th>
<th>- handouts and presentation (downloads)</th>
</tr>
</thead>
</table>
| **Teaching and learning methods**   | Simulation and Modeling (L), 3 h/week, graded exam  
|                                     | Simulation and Modeling (E), 1 h/week  
|                                     | Energy Science and Technology III (L), 3 h/week, graded exam  
|                                     | Energy Science and Technology III (E), 1 h/week  
|                                     | Seminar Energy Science and Technology, 2 h/week, presentation and report, graded  
|                                     | Energy Technology Lab I, 6 h/week, seminars and reports, passed or failed  
|                                     | Energy Technology Lab II, 4 h/week, seminars and reports, passed or failed |
| **Workload**                        | 84 h lecture (presence)  
|                                     | 28 h exercise (presence)  
|                                     | 100 h preparation and postprocessing of lecture  
|                                     | 56 h solution of exercises  
|                                     | 168 h lab and seminar (presence)  
|                                     | 342 h home writing report and revision, seminar talk preparation  
|                                     | 32 h exam preparation  
|                                     | Total: 810 h |
| **Assessment**                      | Energy Technology Laboratory I (9 CP), not graded  
|                                     | Energy Technology Laboratory II (5 CP), not graded  
|                                     | Energy and Science and Technology III (5 CP), written or oral exam written exam  
|                                     | Seminar Energy Science and Technology (3 CP), oral presentation, graded  
|                                     | Simulation and Modeling (5 CP), written or oral exam |
| **Grading procedure**               | Weighted average of graded exams according to credit points |
| **Basis for**                       | MSc Energy Science and Technology |
Elective Courses (Energy Science and Technology)

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<td>Language of instruction</td>
<td>English</td>
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<tr>
<td>Duration</td>
<td>2 Semester Semester</td>
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<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. R. J. Behm, Faculty of Natural Science</td>
</tr>
</tbody>
</table>

**Instructor(s)**

- Prof. Dr. S. Altmann, BASF Ludwigshafen
  *Innovation Management for Nanotechnology*
- Prof. Dr. C. Mohrdieck, Daimler AG, Kirchheim-Teck, Nabern
  *Hydrogen as Energy Carrier*
- Prof. Dr. W. Münch, EnBW, Karlsruhe
  *Scientific, Economical and Ecological Aspects of the Energy Economy*
- Dr. M. Wohlfahrt-Mehrens, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)
  *Lithium Ion Batteries*
- Dr. R. Zeis, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)
  *Characterization Techniques for Fuel Cells and Batteries*
- Prof. Dr. U. Ziener, Faculty of Natural Sciences
  *Polymeric Materials*

**Allocation of study programmes**

Second and third semester *Energy Science and Technology*

**Recommended prerequisites**

*not specified*

**Learning objectives**

Innovation Management for Nanotechnology (Altmann)

Students should be able to

- analyze and discuss the linkage between fundamental science, technology push and market demand in the field of nanotechnology.
- Hydrogen as Energy Carrier (Mohrdieck)
Students should be able to

- describe and analyze scientific, technological and economic aspects of hydrogen usage.
- discuss future potentials of hydrogen usage.

Scientific, Economical and Ecological aspects of the Energy Economy (Münch)

Students should be able to

- describe the German energy system
- analyze the interdependency of economy and ecology

Lithium Ion Batteries (Wohlfahrt-Mehrens)

Students should be able to

- understand the general parameters of Lithium ion batteries
- interpret performance data sheets of batteries and to select a suitable battery for a given application profile
- calculate specific capacity, energy density and voltage profile from thermodynamic data
- to calculate the amount of reversible lithium for insertion materials with different host structure

Characterization Techniques for Fuel Cells and Batteries (Zeis)

Student should be able to

- describe and explain diagnostics employed in the characterization and determination of Proton Exchange Membrane (PEM) fuel cells and battery performance.
- gain a more precise understanding of the physical and chemical processes that occur in PEM fuel cells and batteries based on knowledge of these diagnostic tools.
- start working on a master thesis in the field of electrochemical energy converters and storage devices.

Polymeric Materials (Ziener)

Students should be able to

- describe the fundamental properties of macromolecular materials and modern applications these materials.

Syllabus

Innovation Management for Nanotechnology (Altmann)

- Nanotechnology as key technological developments in the 21st century, interdisciplinary field of research (engineering, natural, medical science)
- From science to technology to markets
- Tools of nanotechnology: Chromatographies, spectroscopies, microscopies, nanomanipulation
- Nanoscience: Nanochemistry, nanophysics, nanobiology, nanomedicine
- Innovation management for nanoscience (IMfN): Principles, project management for nanotechnology, new business development, business development
- Nanotechnology as enabler for industries: transportation, construction, optics, electronics, pharma and medicine
• Nanomarkets: Technology push from nanotech-solutions needed; market pull for nanotech—where it comes from; opportunities created by nanoscience; markets today
• Nanofinance: Financing R&D, financial tools for start-ups, portfolio management
• Nanofinance: Societal concerns, real and apparent dangers
• Ensuring sustainable business success

Hydrogen as Energy Carrier (Mohrdieck)

• Overview: Hydrogen as energy carrier, research fields, areas of application
• Hydrogen production: Methods, logistics and infrastructure
• Hydrogen storage: Non-compressed, compressed
• Hydrogen for Storage of Fluctuating Energies
• Hydrogen fueling technology
• Pathways of hydrogen production and use: Complete energy chain efficiency, emissions, comparison with other energy sources
• Fuel cell vehicles
• Visit of hydrogen and fuel cell laboratory, leakage test
• Visit of a hydrogen fueling station and fuel cell vehicle test drive
• Safety, regulations, codes and standards
• Tool for the visualization of energy chain efficiency results
• Future perspectives of hydrogen as an energy carrier
• Process, stationary and alternative applications
• Hydrogen - Fuel Cell - Efficiency – Entropy

Scientific, Economical and Ecological Aspects of the Energy Economy (Münch)

• German energy supply industry
• Energy sources exploited
• Technologies employed for energy provision
• Energy supply and consumption and the impact on the environment
• Future energy supply: Sustainable energy sources

Lithium Ion Batteries (Wohlfahrt-Mehrens)

• Secondary batteries (accumulators): Design principles, characteristics
• Lithium Ion Batteries: Basic principles, battery design, characteristics
• Lithium insertion materials: Basic mechanism, structural considerations, anodes and cathodes
• Electrolytes: Requirements, conductivity, stability window
• Solid Electrolyte Interface (SEI)
• Charge and discharge behavior of LIB, control strategies
• Degradation and corrosion mechanisms
• Current research topics
• Applications of LIB, related markets and energy policies
• Laboratory visit: Development of materials, test centre

Characterization Techniques for Fuel Cells and Batteries (Zeis)

1. In situ cell tests

• Steady state voltage-current measurements
• Polarisation and charge-discharge curves
• Impedance spectroscopy
• Neutron scattering
• Synchrotron radiation

2. Evaluation of cell components (Membranes, Separators, Electrolytes, Electrodes, Catalysts, Gas Diffusion Layers …)

• Structural analyse (SEM, TEM, XRD, microtomography, porosity determination)
• Elemental analysis (XRF, ICP-MS, EDX)
• Electrochemical surface area (BET, cyclic voltammetry)
• Catalytic activity (Rotating Ring Disk Electrode)
• Membrane degradation (Neutron scattering, Fenton test)

Polymeric Materials (Ziener)

• Block copolymers for nanoparticle synthesis
• Conductive polymers
• Liquid crystalline polymers
• Molecular imprinting
• Nanostructuring
• Porous polymeric materials
• Thermoreversible gels
• Shape memory polymers

Literature
Characterization Techniques for Fuel Cells and Batteries (Zeis):

• Handouts

Hydrogen as Energy Carrier (Mohrdieck)

• Züttel, Andreas; Borgschulte, Andreas; Schlapbach, Louis (eds.): Hydrogen as a Future Energy Carrier (Wiley-VCH, Weinheim, 1. Aufl.2008)

Innovation Management for Nanotechnology (Altmann):

• Handouts

Lithium Ion Batteries (Wohlfahrt-Mehrens):

  Chemical reviews (2004) 104 (10) Gesamter Band

Polymeric Materials (Ziener):

• Polymeric materials; J. M. G. Cowie, Polymers: chemistry and physics of modern materials, 2nd ed., 1994 and further references from scientific (materials) journals

Scientific, Economical and Ecological Aspects of the Energy Economy (Münch):

• Handouts

Teaching and learning methods
Lecture, seminar, excursions, depending on the course
3 credit point, 2 h/week
except Polymeric Materials 4 credit points, 3 h/week

Workload
Innovation Management for Nanotechnology (Altmann)
Winter term, total 90 h
• 16h lecture (presence)
• 28h preparation and revision of lecture
• 16h seminar (presence)
• 30h preparation of presentation

Hydrogen as Energy Carrier (Mohrdieck)

Summer term, total 90 h
• 28h lecture (presence) incl. excursion (Daimler)
• 46h preparation and revision of lecture
• 16h exam preparation

Scientific, Economical and Ecological Aspects of the Energy Economy (Münch)

Summer term, total 90 h
• 28h lecture (presence)
• 46h preparation and revision of lecture
• 16h exam preparation

Lithium Ion Batteries (Wohlfahrt-Mehrens)

Winter term, total 90 h
• 32h lecture (presence)
• 42h preparation and post processing of lecture
• 16h exam preparation

Characterization Techniques for Fuel Cells and Batteries (Zeis):

Winter term, total 90 h
• 32h lecture (presence)
• 42h preparation and post processing of lecture
• 16h exam preparation

Polymeric Materials (Ziener)

Winter term, total 120 h
• 48h lecture (presence)
• 56h preparation and post processing of lecture
• 16h exam preparation

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**Assessment**
According to elective course either written exam(s) or oral presentation(s)

**Grading procedure**
Weighted average of graded exams according to credit points

**Basis for**
Master thesis
### Additive Key Qualifications

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<td>8</td>
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<tr>
<td>Attendance time</td>
<td>keine Angaben</td>
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<tr>
<td>Language of instruction</td>
<td>English or German</td>
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<tr>
<td>Duration</td>
<td>1 Semester</td>
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<tr>
<td>Cycle</td>
<td>each Semester</td>
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<tr>
<td>Coordinator</td>
<td>Head of Examination Committee (Prof. Dr. Rolf Jürgen Behm)</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Lecturers of Ulm University and external lecturers</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Energy Science and Technology 1. to 3. semester</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>none</td>
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| Learning objectives   | Students will acquire and/or improve their knowledge of German language. For Non-German students the „German Language“ courses are mandatory enabling them to handle every-day-situations in German. German students have the choice between various courses offered by the University's Language Center and Humboldt Center. Additionally, the ASQ Module will enhance the intercultural competence of all students as well as improve their abilities  
  - to work in a team,  
  - to orally communicate and present a specific scientific or non-scientific topic  
  - to search literature related to a specific scientific topic  
  - to plan and write a scientific report  
  - to participate in project management |
<p>| Syllabus              | see course descriptions |
| Literature            | see course descriptions |
| Teaching and learning methods | see course descriptions |</p>
<table>
<thead>
<tr>
<th><strong>Workload</strong></th>
<th>see course descriptions</th>
</tr>
</thead>
</table>
| **Assessment** | German language I, written exam  
Germany language II, written exam  
Germany language III, written exam  
or equivalent for German native speakers |
| **Grading procedure** | Weighted average of graded exams according to credit points |
| **Basis for** | MSc Energy Science and Technology |
### Additive Key Qualifications

Modules referring to Additive Key Qualifications

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<td><strong>Coordinator</strong></td>
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<td><strong>Instructor(s)</strong></td>
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<tr>
<td><strong>Recommended prerequisites</strong></td>
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<tr>
<td><strong>Learning objectives</strong></td>
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<tr>
<td><strong>Syllabus</strong></td>
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<tr>
<td><strong>Literature</strong></td>
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Basis for

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<th><strong>German Language</strong></th>
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# Master Thesis

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<tr>
<td><strong>Coordinator</strong></td>
<td>Head of Examination Committee (Prof. Dr. Rolf Jürgen Behm)</td>
</tr>
<tr>
<td><strong>Instructor(s)</strong></td>
<td>Habilitated permanent members of Ulm University, in case of external master theses complemented by scientists qualified on a comparable level and individually assigned by the Examination Committee.</td>
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<tr>
<td><strong>Allocation of study programmes</strong></td>
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<tr>
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<td>minimum of 75 ECTS points</td>
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| **Learning objectives** | Students are able  
  • to survey the project related literature  
  • to design or optimize an experimental set-up  
  • to project specific preparational and analytical tools  
  • to acquire data acquisition & analysis including error considerations  
  • to apply their acquired knowledge on writing scientific reports in order to deliver a scientifically consistent and formally complete thesis  
  • to prepare and deliver a scientific presentation based on the accomplishments gained during the thesis work. |
<p>| <strong>Syllabus</strong>     | Research topic |
| <strong>Literature</strong>   | depends on research topic |</p>
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>independent work (experimental work, lab work etc.)</th>
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<td><strong>Assessment</strong></td>
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<td><strong>Grading procedure</strong></td>
<td>Reports by two examiners</td>
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<td><strong>Basis for</strong></td>
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