Excerpt from Module Descriptions

Master of Science Energy
Science and Technology

Examination Regulations in the Version of: 2014

Sub-Section: Energy Science and Technology
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Energy Science and Technology

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Energy Science and Technology I - General Aspects

Modules referring to Energy Science and Technology

<table>
<thead>
<tr>
<th>Code</th>
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<td>ECTS credits</td>
<td>10</td>
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<td>Attendance time</td>
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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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<tr>
<td>Cycle</td>
<td>starts every Winter Semester</td>
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<tr>
<td>Coordinator</td>
<td>Dean of Studies, Chemistry, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. J. Kallo, Faculty of Engineering, Computer Science and Psychology</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Master Energy Science and Technology, compulsory courses, semester 1 and 2</td>
</tr>
<tr>
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<td>Master Chemical Engineering, compulsory courses, semester 1 and 2</td>
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<tr>
<td>Recommended prerequisites</td>
<td>Energy Science and Technology:</td>
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<td></td>
<td>Module Engineering</td>
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<td>Chemical Engineering: Bachelor's competences in engineering</td>
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<td></td>
<td>Course Energy Science and Technology II is based on course Energy Science and Technology I</td>
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Learning objectives

Students should be able to

- comprehend the background and basic facts, components, and interactions in the field of energy technology.
- understand and explain the basic physical principles underlying mechanical-electrical energy conversion
- describe the structure and functional mechanisms of the basic types of electric machines (DC separately excited, parallel and series wound; asynchronous; synchronous), and sketch their equivalent circuits as well as torque-speed characteristics
- solve simple problems related to the interrelations between voltage, current, power and torque in the different types of electric machines
• describe the structure of the electric grid with its various voltage levels and name its basic components
• describe the functional mechanisms of the different thermal power plants (gas turbines, steam process) and explain the basic components
• solve simple problems in the field of technical thermodynamics
• describe the functional mechanisms of hydro and wind power plants as well as explain the main components (such as e.g. types of water turbines) and their application
• solve simple problems in the field of hydro and wind power applications

Energy Science and Technology II

Students should be able to

• understand and explain the construction and functional mechanisms of hydro-, wind -, solar thermal - and photovoltaic power plants of different kinds and describe and explain their components.
• perform base calculations for the design, for the dimensioning of component parameters and for the operation of such power plants.
• explain the balance terms "cumulated energy input, energy gain ratio, 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.
• reproduce approximative quantities of real use and perform elementary calculations in these fields.
• describe and explain the reasons for limitations in the use of regenerative sources.
• understand the technical possibilities for long-distance energy imports from regenerative sources and can point out the necessary effort and cost.
• describe possible storage technologies together with their problems.
• understand and describe structure and functional mechanisms in cogeneration as well as absorption cooling technologies together with their advantages/disadvantages.

Syllabus

Energy Science and Technology I

The course gives an overview on conventional (electric) power technology:

• 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; their construction, function, characteristics and applications
• Structure and function of the electric power grid and its components
• Electric power generation by means of thermal power plants and their thermodynamic 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

Energy Science and Technology II

The course gives an overview on technologies using renewable sources and the concepts of distributed power technologies. At the center of the course is a comparison of various technologies to produce electricity or thermal energy for room heating and warm water production in terms of
• primary energy input
• energy pay-back time and energy gain ratios
• consumption of materials, resources and area
• ecological impact
• economy and cost

To do so the physical fundamentals, the peculiarities and the degree of usage as well as the potential for use of the following technologies are discussed in detail:

• hydro power
• wind power
• photovoltaics
• low-temperature solar thermal power
• high-temperature thermal solar power for electricity generation and thermal processing

Further topics:

• Possibilities and implications of renewable energy imports over long distances like e.g. from North Africa to Europe
• Necessities for storage technologies and the problems associated
• Cogeneration concepts and absorption cooling

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**Literature**

**Energy Science and Technology I**

- Lecture manuscript, materials on E-learning platform ILIAS.
- Any physics textbook on magnetics.

**Energy Science and Technology II**

- Lecture manuscript, materials on E-learning platform (ILIAS).
- Distributed Generation in Liberalised Electricity Markets; OECD/IEA 2002.
Teaching and learning methods

Energy Science and Technology I
5 credit points
Lecture 3 h/week
Tutorial 1 h/week

Energy Science and Technology II
5 credit points
Lecture 3 h/week
Tutorial 1 h/week

Workload

Energy Science and Technology I:
Total 150 h
Lecture: 48 h presence
48 h preparation and revision
Tutorial: 16 h presence
22 h solving problems, revision
Exam: 16 h preparation

Energy Science and Technology II:
Total 150 h
Lecture: 42 h presence
42 h preparation and revision
Tutorial: 14 h presence
36 h solving problems, revision
Exam: 16 h preparation

Assessment

The credit points will be awarded once the written or the oral exams have been passed (depending on the number of participants). No prerequisites are necessary for exam registration.

Grading procedure

The grade of the module will be the arithmetic mean of the respective grades of the partial module exams weighted by their credit points.

Basis for

Module Energy Science and Technology II-Applications
Energy Science and Technology II - Applications

Modules referring to Energy Science and Technology

Code 8833271941

ECTS credits 11

Attendance time keine Angaben

Language of instruction English

Duration 2 Semester Semester

Cycle starts every Summer Semester

Coordinator Dean of Studies - Electrical Engineering

Instructor(s) Prof. Dr. R.J. Behm, Prof. Dr. A. Latz, Prof. M. Fichtner, Prof Dr. W. Tillmetz, Dr. R. Zeis, Faculty of Natural Sciences
Prof. Dr. U. Herr, Prof. Dr. J. Kallo, Prof. Dr. F. Scholz, Faculty of Engineering, Computer Science and Psychology

Allocation of study programmes Master Energy Science and Technology, compulsory courses, semester 2 and 3
Master Chemical Engineering, compulsory courses, semester 2 and 3

Recommended prerequisites Module Engineering Module Energy Science and Technology I – General Aspects

Learning objectives Students should be able to

• integrate scientific principles of energy conversion and catalysis, knowledge about properties of the materials employed and engineering aspects of energy usage, conversion and storage and apply this to practical application
• conduct advanced experiments and write corresponding reports
• prepare and give a presentation on a topic in the field of energy science and technology based on literature and internet research

Syllabus Energy Technology Lab I

• Solar cells
• DC / DC Converter
• CHP system (combined heat and power)
• H2 – storage
• Lambda Probe
• Impedance Spectroscopy
- Heterogeneous Catalysis - CO oxidation
- Electro catalysis – Methanol electrooxidation
- Electro catalysis – Fuel Cell

Seminar Energy Science and Technology

- Current topics in the field of Energy Science and Technology
- Supervised preparation of student presentation
- Presentation and discussion in the seminar

<table>
<thead>
<tr>
<th>Literature</th>
<th>Check references for module <em>Energy Science and Technology I – General Aspects</em></th>
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</table>

| Teaching and learning methods | Energy Technology Lab I  
Second semester, 9 credit points  
Preparation of experiments (self-study + colloquium), experiments, presentations, writing reports  
Seminar EST  
Third semester, 2 credit points  
Preparation of presentations, presentations, discussion in the seminar; attendance minimum 80% |

| Workload | Energy Technology Lab: Total 270 h  
126 h presence in lab and accompanying seminar  
144 h preparation, writing reports, presentation  
Seminar Energy Science and Technology: Total 60 h  
32 h presence  
28 h preparation, search of literature, preparation of presentation and handout |

| Assessment | The grade of the module is based on completion of the assignment (presentation and paper) and participation in the discussion. No prerequisites are necessary for exam registration |

| Grading procedure | The grade of the module will be the arithmetic mean of the respective grades of the partial module exams weighted by their credit points. |

| Basis for | M.Sc. Energy Science and Technology  
and M.Sc. Chemical Engineering |
# Energy Science and Technology III - Electrochemical EST

Modules referring to Energy Science and Technology

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<tr>
<td>Coordinator</td>
<td>N.N., Faculty of Natural Sciences, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Jörissen, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg</td>
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**Allocation of study programmes**

- Master Energy Science and Technology, compulsory courses, semester 3
- Master Chemical Engineering, compulsory courses, semester 3

**Recommended prerequisites**

- Energy Science and Technology:
  - Modules *Chemistry I* and *Chemistry II Module Engineering*

- Chemical Engineering:
  - *Formal prerequisites (according to Study order and examination regulations): none*
  - Prerequisites regarding to the contents: Bachelor's competences in the field related to the subject

**Learning objectives**

The students should be able to

- describe fuel cells and batteries with respect to components and their function
- analyze the operating features of fuel cells and batteries
- discuss research and development in the field of fuel cells and batteries

**Syllabus**

- Energy Science and Technology III
  - 1) Fuel cells
• Types, components, operational characteristics, degradation
• Catalysts, electrodes, bipolar plates, electrolytes,
• Test of performance
• Applications: Automobiles, buses, stationary CHP and back-up power, leisure market

1) Batteries:
• Rechargeable batteries and electrochemical double layer capacitors: types, characteristics, charge, discharge, degradation
• Electrolytes and electrodes, design principles
• Battery systems, battery management, thermal management, maintenance, safety

Energy Technology Lab II

• I/U characteristics of electrolyzer and fuel cell single cells
• Characteristics of a fuel cell system; hydrogen powered operational features of a fuel cell system combined with a battery (hybrid)
• Characteristics of a fuel cell test bench: Flow and pressure control, temperature and humidity control, sensors and data recording
• Operation of commercial fuel cell products: DMFC for remote power and on board power supply; Hydrogen Fuel Cell System for Back Up and Emergency Power Supply
• Characteristics of lead acid and alkaline batteries, electrochemical double layer capacitors, (charge/discharge behavior)

Literature

Teaching and learning methods

Energy Science and Technology III
5 credit points
Lecture 3 h/week
Solving problems 1 h/week

Energy Technology Laboratory II
4 credit points
4 h/week

Workload

Energy Science and Technology III:
Total 150 h
Lecture: 48 h presence
50 h preparation and revision
Solving problems: 16 h presence
20 h solving problems, revision
Exam: 16 h preparation

Energy Technology Laboratory II:
Total 120 h
64 h experiments in lab (presence)
16 h preparation of experiments
40 h writing of lab reports

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<td>Basis for</td>
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## Energy Science and Technology IV - Simulation and Modeling

Modules referring to Energy Science and Technology

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<tr>
<td>Coordinator</td>
<td>Prof. Dr. A. Latz, Faculty of Natural Sciences, Helmholtz Institute Ulm</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. A. Latz, Faculty of Natural Sciences, Helmholtz Institute Ulm</td>
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<td>Third Semester MSc Energy Science and Technology</td>
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### Recommended prerequisites

Student will be able to

- understand the basic theoretical concepts of electrochemistry, non-equilibrium thermodynamics and chemical kinetics
- distinguish between the modeling approaches for different length and time scales
- perform discretization of transport equations using Finite difference, Finite Volume and Finite Element Techniques
- solve numerically ordinary and partial differential equations using standard software tools
- describe mathematically the operation of batteries and fuel cells

### Syllabus

- Transport theory
- Thermodynamics and chemical kinetics of electrochemical systems
- Introduction to simulation techniques
- Discretization of transport equations and kinetic equations
- Fundamentals of systems theory
- Modelling of Batteries
- Modelling of fuel cells
- Software exercises
### Literature


### Teaching and learning methods

<table>
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<th>Activity</th>
<th>Hours/week</th>
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<tr>
<td>Lecture</td>
<td>2</td>
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<tr>
<td>Solving problems</td>
<td>2</td>
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### Workload

- Total: 150 h
- Lecture: 32 h presence
  - 50 h revision
- Solving problems: 32 h presence
  - 36 h preparation and revision

### Assessment

The credit points will be awarded once the written or the oral exam has been passed (depending on the number of participants). No prerequisites are necessary for exam registration.

### Grading procedure

The grade of the module will be the grade of the exam.

### Basis for

Master thesis