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List of abbreviations

HPW Hours per week
ECTS European Credit Transfer System
V Lecture
Ü Exercise
S Seminar Project
ProW Project Work
P Practical Work

Skills:
FK Professional skills
MK Technical skills
SK System expertise
SOK Social skills
Module Guide Master Geothermal Engineering

Module 1: Soft Skills & Technical Reporting

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 1
Name of the Module: Soft Skills & Technical Reporting
Course(s): Intercultural Competence, Technical Writing, Advanced Seminar Topics
Term: 1, 2
Responsible person for the module: Prof. Falcone
Lecturer: K. Böhlefeld, J. Schulze-Bentrop, Prof. Falcone
Language: English
Position within the Curriculum: Compulsory subject

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Requirements:

Learning objectives / Skills:

Intercultural Competence:
- Being able to interact with people from different cultural backgrounds
- Understanding culture and its impact on behaviour in an international working environment.
- Being aware of differences in cultural backgrounds and their influences on communication and international team work
- Being able to apply communication strategies and skills to work successfully in international teams
- Being able to solve conflicts and to improve team work
- Developing self-competence to improve team work

Technical Writing:
- Being able to comprehend complex details in technical reading and listening texts
- Express themselves clearly with a wide range of Technical English vocabulary, specific to Geothermal Engineering
- Understand and properly use specific technical-oriented grammar structures
- Students have academic and professional writing skills
- Having professional competence in grammar and technical vocabulary to write technical reports

Advanced Seminar Topics:
- Knowledge of applied state-of-the-art geothermal methods and technology
- Being able to solve Individual problems including literature search and review
- Being able to prepare a scientific report including correct scientific citation and quotation
- Presentation and discussion of research results
- Present research result in form of a scientific poster
- Moderation of a seminar presentation

Course Outline:

Intercultural Competence:
- Several critical incidents in the life of an international project team are covered: getting to know the team - building rapport and understanding; direction - working towards common goals; organisation - structuring team work; roles – expectations of individual team members; representing – managing the interface between the team and the outside; conflict – handling conflict
between team members; cooperation – working together

**Technical Writing:**
- Various writing exercises; working with authentic written texts, which will improve writing style, coherency, vocabulary, and grammar.

**Advanced Seminar Topics:**
- Students work on assigned special topics
- Writing a scientific report and structuring a poster, both including proper outline, form, and scientific citing procedure
- Preparation of a scientific presentation with regard to outline, form, references, and time limit and presentation of it in front of an audience and answer to topic-related questions

**Assessment:**
- Intercultural Competence: Individual portfolio and group portfolio with presentation
- Technical Writing: Report, Written Exam (120 min)
- Advanced Seminar Topics: Report (about 20 pages) (40 %), Presentation (about 30 min, including 10 min discussion) (40 %), Poster (10 %) and Moderation (10 %)

**Media:**
- Projector presentation, blackboard, whiteboard, flipcharts

**Literature:**
- Announcement in the lecture

**Advanced Seminar Topics:** topic related

**Additional Information:**
Module 2: Fundamentals

Degree Programme: M.Sc. in Geothermal Engineering
Number of the Module: 2
Name of the Module: Fundamentals

Course(s): Fluid Mechanics, Technical Thermodynamics II, Heat Transfer I

Term: 1, 2

Responsible person for the module: Prof. R. Weber
Lecturer: Prof. Brenner, Dr.-Ing. Mancini, Prof. R. Weber
Language: English
Position within the Curriculum: Compulsory subject

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<td>11</td>
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Requirements:

Learning objectives / Skills:
- Fluid Mechanics:
  - Having deep knowledge on fluid flow phenomena in order to develop competences for the engineering characterisation of both natural occurrences and technical energy systems and processes.
  - Understand and being able to apply conservation equations for different types of fluids.
  - To know and understand measurement techniques in fluid mechanics.
- Technical Thermodynamics II:
  - Analyse technical systems in consideration of friction and real material behaviour.
  - Reviewing of technical systems and processes regarding energetic aspects (efficiency factor, energy consumption) in consideration of friction and real material behaviour.
- Heat Transfer I:
  - To know and being able to apply balancing, basics of heat transfer (conduction, convection, radiation), basics of heat exchangers.

Course Outline:
- Fluid Mechanics:
  - Properties of fluids and flows, hydrostatics and aerostatics, kinematics and dynamics of inviscid flows, continuity and Bernoulli’s equation., conservations principles and equations for inviscid and viscous fluids, dynamics of compressible fluids and shock waves, discussion of solutions of the Navier-Stokes equations, dimensional analysis, boundary layer theory, turbulent flows, flows in porous media, experimental and measurement techniques.
- Technical Thermodynamics II:
  - Gas/steam mixtures, real gas behaviour (H2O-steam), effect of friction, chemical equilibrium.
- Heat Transfer I:

Assessment:
- Written exams: Fluid Mechanics (120 min), Technical Thermodynamics II (120 min), Heat Transfer I (120 min)
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<th>Media:</th>
<th>Projector presentation, blackboard, charts, work sheets for homework and exercises</th>
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| Literature: | Fluid Mechanics:  
Technical Thermodynamics II:  
Heat Transfer I:  
  - Announcement of additional literature in the lecture |
Module 3: Geothermal Geology & Exploration

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<td>Responsible person for the module:</td>
<td>Prof. Falcone, Prof. Moeck</td>
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<td>Lecturer:</td>
<td>Prof. Moeck, Dr. Schumacher</td>
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**Requirements:**

**Learning objectives / Skills:**

- **Geothermal Geology:**
  - A clear understanding of the different types of shallow and deep geothermal resources, how they can be found and in which geological settings.
  - To know and be able to apply the terms and definitions to classify the potential of reserves and resources.

- **Surface Geothermal Exploration:**
  - Knowledge of geophysical and other methods for geothermal exploration.
  - Understand possibilities and constraints of exploration methods.
  - Being able to integrate and process acquired data.

**Course Outline:**

- **Geothermal Geology:**
  - Description of a comprehensive range of Geothermal Play Types in terms of generic conceptual models of geological and tectonic settings in which geothermal systems might naturally develop or be engineered around the world. Terminology and definitions for a classification framework for Geothermal Potential (resource/reserve).

- **Surface Geothermal Exploration:**
  - Fundamental concepts of geothermal resources exploration: remote sensing, geochemical methods, geophysical methods (seismics, magnetics, magneto-tellurics, TEM, geoelectrics, gravity), acquisition of existing data.

**Assessment:**

- Written exam (180 min)

**Media:**

- Projector presentation, blackboard, flipchart, charts, work sheets for exercises

**Literature:**

- Further literature announced in the lectures

**Additional Information:**
Module 4: Petrophysics & Well Logging

**Degree Programme:** M.Sc. Geothermal Engineering

**Number of the Module:** 4

**Name of the Module:** Petrophysics & Well Logging

**Course(s):** Petrophysics I, Well Logging II

**Term:** 1, 2

**Responsible person for the module:** Prof. Weller

**Lecturer:** Prof. Weller

**Language:** English

**Position within the Curriculum:** Compulsory subject

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**Requirements:**

**Learning objectives / Skills:**
- Petrophysics I:
  - Knowledge of geophysical rock properties and understanding their relevance and dependencies for the characterisation of reservoirs.
- Well Logging II:
  - Knowledge of logging measurement techniques in boreholes and their interpretation
  - Being able to perform basic interpretation of well logs
  - Understanding of application of well logging tools for geothermal exploration of deep geothermal systems

**Course Outline:**
- Petrophysics I:
  - Relevance and development of Petrophysics, rock-forming minerals, influencing factors for petrophysical properties,
  - Properties of pores, e.g. like porosity, volume and content of the pores, saturation, tortuosity, inner surface etc.,
  - Density of rocks, determination in the laboratory & on-site, borehole, relationship to porosity, saturation, proctor density,
  - Magnetic properties: para-, dia-, ferro-, antiferro-, ferrimagnetism, magnetic properties of minerals and rocks, remanent magnetization, dependency of temperature and pressure.
- Well Logging II:
  - Fundamentals of geophysical well logging methods,
  - History – goals – technical equipment,
  - Radiometric methods,
  - Acoustic borehole measurements,
  - Electrical methods.

**Assessment:** Written exams (each one 90 min)

**Media:** Projector presentation, blackboard, charts

**Literature:**
- Further literature announced in the lecture

**Additional Information:** 
Module 5: Geothermics & Hydrogeology

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 5
Name of the Module: Geothermics & Hydrogeology
Course(s): Principles of Geothermics, Geothermal Practical, Hydrogeology for Geothermal Energy Production
Term: 1, 2
Responsible person for the module: Prof. Falcone, Dr. Pawellek
Lecturer: Prof. Falcone, Prof. Buntebarth, Dr. Pawellek, Dr. Bozau
Language: English
Position within the Curriculum: Compulsory subject

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Requirements:

Learning objectives / Skills:
- **Principles of Geothermics**
  - Knowledge of the thermodynamics of the earth
  - Understand the relationship between petrophysical and thermal rock properties
  - Understand underground heat transfer processes and their relation to heat recharge
  - Knowledge of methods for measuring thermal rock properties and calculating heat flow

- **Geothermal Practical**
  - Being able to measure thermal conductivity on rock samples
  - Being able to perform temperature logging measurements
  - Determine thermal properties from temperature measurements in boreholes

- **Hydrogeology for Geothermal Energy Production**
  - Knowledge about hydrological relevant tasks and processes in the development of deep geothermal reservoirs
  - Understanding the influence of hydrogeological parameters for fluid flow in porous media, especially relevant for deep geothermal systems (petrothermal and hydrothermal systems)
  - Developing methodical competence for determining hydrogeological parameters and the acquisition of water samples, relevant for shallow and deep geothermal systems

Course Outline:
- **Principles of Geothermics**
  - Physical basis of heat transfer: fundamental terms of heat conduction, heat conduction equations, thermal properties of rocks,
  - Terrestrial heat flow density: spatial and temporal variations,
  - Thermal state of the earth's interior: methods of temperature determination (of uppermost crust, at great depths),
  - Natural and technical effects to the temperature field of the subsurface, e.g. influence of meteoric water.

- **Geothermal Practical**
  - Processing of temperature data from a borehole measurements
  - Temperature logging in a borehole
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<td>Stumm, W., Morgan, J.J. (1981): Aquatic chemistry – an introduction emphasizing chemical equilibria in natural waters</td>
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Module 6: Advanced Drilling Technology

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<td>Responsible person for the module:</td>
<td>Prof. Falcone, Prof. Teodoriu</td>
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<td>Prof. Teodoriu</td>
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Requirements:

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<tbody>
<tr>
<td>• Specialised knowledge of drilling technology, including equipment and advanced applications</td>
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<tr>
<td>• Awareness of advanced drilling topics, such as underbalanced drilling, modern drilling technologies, geothermal well drilling and fishing operations.</td>
</tr>
<tr>
<td>• Having professional and methodical competence in drilling technology for deep geothermal systems</td>
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<td>• Having the necessary social skills and self-competence for work in teams</td>
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Course Outline:

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<td>• Drilling Concepts (Drilling the Limit, etc.)</td>
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<td>• Well Design and Well Construction</td>
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<td>• Drilling Optimisation</td>
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<td>• Drilling Performance Analysis</td>
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<td>• Drillstring Dynamics</td>
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<td>• Drilling Problems (Risk Analysis, Solutions)</td>
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<td>• HPHT Wells, Horizontal and Extended Reach Wells, Multilaterals</td>
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<td>• Under-Balanced Drilling</td>
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<td>• New Developments in Drilling Operations</td>
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<td>• Offshore Drilling (Well Design and Special Consideration)</td>
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<td>• Blow Out</td>
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<td>• Geothermal Drilling Technology</td>
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<tr>
<td>• Drilling through Gas Hydrates</td>
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<td>• Case Studies</td>
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Assessment: Written exam (90 min)

Media: Interactive Multimedia Presentation, Videos, Hands-on Teaching

Literature:

<table>
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<th>Literature:</th>
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<tr>
<td>• SPE.ORG the eLibrary of SPE.</td>
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<tr>
<td>• Further literature announced in the lecture</td>
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Additional Information: The Tutorial will be „Hands-on teaching”. The concept connects the theoretical topics of the lecture with practical aspects and experiments. The main goal of this approach is to handover small projects to the students, in order for them to get a better understanding of the theoretic topics of the lecture. The small projects can be the development of functioning models.
## Module 7: Geothermal Reservoir Engineering

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<td>Course(s):</td>
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<td>Responsible person for the module:</td>
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<tr>
<td>Lecturer:</td>
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<td>30 %</td>
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**Requirements:**

- Knowledge of geothermal reservoir characterisation
- Theoretical and practical knowledge of reservoir modelling and simulation techniques
- Being able to do reservoir characterisation of shallow and deep geothermal systems
- Application of reservoir modelling and simulation techniques of shallow and deep geothermal systems
- Being able to contribute to a team project work on reservoir modelling and simulation of geothermal reservoirs

**Course Outline:**

- Geothermal reservoir types
- Concepts of geothermal systems
- Mathematical foundations of single and multi-phase flow in porous media
- Analytical and numerical methods
- Phase behaviour
- Well productivity index
- Recovery factor
- Simulation
- Well Stimulation and engineered geothermal systems
- Field Examples
- Field Management

The project will give the opportunity to practise the use of geothermal reservoir simulation software (e.g. FEFLOW, TOUGH).

**Assessment:**

- Written exam (90 min)

**Media:**

- Projector presentation, blackboard, work on PCs

**Literature:**

- SPE.ORG the eLibrary of SPE.
<table>
<thead>
<tr>
<th>Additional Information:</th>
<th>Supplementary topics will be proposed and supervised by guest lecturers from the industry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Further literature announced in the lecture</td>
</tr>
</tbody>
</table>
Module 8: Completion

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 8
Name of the Module: Completion
Course(s): Completion and Work Over
Term: 2
Responsible person for the module: Prof. Falcone, Prof. Teodoriu
Lecturer: Prof. Dr.-Ing. Teodoriu
Language: English
Position within the Curriculum: Compulsory subject

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h]</th>
<th>ECTS</th>
<th>FK</th>
<th>MK</th>
<th>SK</th>
<th>SOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion and Work Over (V + Ü)</td>
<td>3</td>
<td>42/108</td>
<td>5</td>
<td>60 %</td>
<td>40 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Requirements:

Learning objectives / Skills:
- Knowledge of Completion and Workover Requirements and Design Options to meet Deliverability, Safety and Integrity Objectives.
- To know and understand the function of components for completion of wells and workover equipment
- Ability to work in teams.

Course Outline:
- Completion Objectives (Definition, Considerations, Types),
- Mechanical Aspects of Well Testing (Cased Hole Testing Equipment and Application),
- Completion Fluids & Perforation (Technology, Applications),
- Tubing String Design (Function, Classification, Tubing Selection, Design),
- Packers & Downhole Tools (Function, Types, Classification, Selection, Installation),
- Flow Control (Water, Gas, Multiphase),
- Data Acquisition & Intelligent Completion,
- Workover Objectives & Workover Operations,
- Workover Rigs & Tools,
- Workover Equipment (Wire Line, Snubbing Unit, Other),
- Workover Equipment (Coiled Tubing),
- Completion & Workover Design & Execution (Industry Expert).

Assessment: Written exam (90 min)

Media: Interactive Multimedia Presentation, Videos, Hands-on Teaching

Literature:
- SPE.ORG the eLibrary of SPE
- Further literature in the script

Additional Information:
Module 9: Geothermal Production

**Degree Programme:** M.Sc. Geothermal Engineering

**Number of the Module:** 9

**Name of the Module:** Geothermal Production

**Course(s):** Advanced Production, Geothermal Power Plants, Direct Use / Heat Pumps

**Term:** 3

**Responsible person for the module:** Prof. Falcone

**Lecturer:** Prof. Falcone, Prof. Alimonti

**Language:** English

**Position within the Curriculum:** Compulsory subject

<table>
<thead>
<tr>
<th>Course Type</th>
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<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td><strong>Advanced Production</strong></td>
<td>3</td>
<td>42/78</td>
<td>4</td>
<td>60 %</td>
<td>30 %</td>
<td>10 %</td>
<td></td>
</tr>
<tr>
<td><strong>Geothermal Power Plants</strong></td>
<td>2</td>
<td>28/92</td>
<td>4</td>
<td>60 %</td>
<td>30 %</td>
<td>10 %</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Use / Heat Pumps</strong></td>
<td>2</td>
<td>28/92</td>
<td>4</td>
<td>60 %</td>
<td>30 %</td>
<td>10 %</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>98/262</td>
<td>12</td>
<td>60 %</td>
<td>30 %</td>
<td>10 %</td>
<td></td>
</tr>
</tbody>
</table>

**Requirements:**

**Learning objectives / Skills:**
- **Advanced Production:**
  - Theoretical and practical understanding of the geothermal production system, from reservoir to point of sale for shallow and deep geothermal systems
  - Understanding geothermal production technologies
- **Geothermal Power Plants:**
  - Knowledge of the different uses of geothermal energy: power generation, heat pumps and direct heating, combined heat and power.
  - Knowledge of different types of geothermal plants, their advantages and disadvantages
  - Being able to apply methods and technologies for planning and designing a geothermal plant
- **Direct Use / Heat Pumps:**
  - Knowledge and understanding of heat exchanger, heat pumps and direct heating systems for shallow geothermal systems.
  - Being able to analyse and design systems for direct heating

**Course Outline:**

- **Advanced Production:**
  - Introduction to integrated production systems,
  - Review of reservoir inflow characterisation,
  - Single-phase and multi-phase flow modelling in wells,
  - Flow assurance issues,
  - Surface facilities,
  - Production monitoring and optimisation,
  - Integrated field management.
- **Geothermal Power Plants:**
  - Geothermal power generating systems: single-flash steam plants; double-flash steam plants; dry-steam plans; binary cycle power plants; advanced and hybrid systems,
  - Field examples.
- **Direct Use / Heat Pumps:**
  - Geothermal heat use without involving a power plant or a heat pump,
  - Geothermal heat pumps,
  - Use of spent fluids from geothermal power plants for direct use applications in
so-called "cascaded" operation.

<table>
<thead>
<tr>
<th>Assessment:</th>
<th>Written exam (180 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media:</td>
<td>Projector Presentation, blackboard</td>
</tr>
</tbody>
</table>
- Further literature recommend in the script |
| Additional Information: | Supplementary topics will be proposed and supervised by guest lecturers from the industry |
Module 10: Energy Management

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 10
Name of the Module: Energy Management
Course(s): Energy Project Management, Energy Law II, Fossil & Renewable Energy Sources
Term: 3
Responsible person for the module: Prof. Falcone, B. Harrison
Lecturer: B. Harrison, Prof. Wolkewitz, Dr.-Ing. Buddenberg
Language: English
Position within the Curriculum: Compulsory subject

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h] Contact hours-/Self-Study time</th>
<th>ECTS</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FK</td>
</tr>
<tr>
<td>Energy Project Management (V)</td>
<td>2</td>
<td>28/62</td>
<td>3</td>
<td>30 %</td>
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<tr>
<td>Energy Law II (V)</td>
<td>2</td>
<td>28/62</td>
<td>3</td>
<td>60 %</td>
</tr>
<tr>
<td>Fossil &amp; Renewable Energy Sources (V + Ü)</td>
<td>3</td>
<td>42/78</td>
<td>4</td>
<td>60 %</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>98/202</td>
<td>10</td>
<td>50 %</td>
</tr>
</tbody>
</table>

Requirements: Fundamentals of Geosciences

Learning objectives / Skills:

Energy Project Management:
- Ability to carry out Development Studies, Design Projects with the Objective to Maximize Value
- Being able to apply project management techniques and skills
- Being able to perform data acquisition, validation, integration, calculations, simulations with appropriate software under consideration of HSE and economics aspects

Energy Law II:
- Knowledge about the main contractual arrangements necessary along the value chain of energy supply activities including the relevant regulatory framework

Fossil & Renewable Energy Sources:
- Being able to explain geological, physical and chemical basics of fossil and renewable energy resources
- Deep insight into global and regional potential, ability to evaluate fossil and renewable energy sources under technical, economic, environmental constraints

Course Outline:

Energy Project Management:
- Projects Management (Definition, Elements, Process, Organization)
- Data Acquisition and Validation, Data Integration, Calculations and Design work, Application of supporting Software
- Economics

Energy Law II:
- Joint Operation Agreements as contractual arrangement within a consortium of companies
- Drilling Contracts and related agreements for energy supply subsurface activities
- Engineering Procurement and Construction Contracts as main legal feature of energy supply surface activities
- Transportation and Processing Agreements upstream
- Third party access and regulation in the midstream part of the value chain
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Gas Sales Agreements and energy supply contracts</td>
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<tr>
<td>Fossil &amp; Renewable Energy Sources:</td>
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</tr>
<tr>
<td></td>
<td>What is energy?</td>
</tr>
<tr>
<td></td>
<td>Fossil energy sources: Geological fundamentals, practical determination of reserves, oil, gas, coal, natural uranium</td>
</tr>
<tr>
<td></td>
<td>Resource environment</td>
</tr>
<tr>
<td></td>
<td>Renewable energy: CO2 balance – comparison of energy sources, wind, biomass, water power, solar energy, geothermal energy</td>
</tr>
</tbody>
</table>

**Assessment:**
Written (90 min) or oral exams (20 – 60 min)

**Media:**
Projector presentation, blackboard

**Literature:**
Literature announced in the lecture

**Additional Information:**
Module 11: Project Work

<table>
<thead>
<tr>
<th>Degree Programme:</th>
<th>M.Sc. Geothermal Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of the Module:</td>
<td>11</td>
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<tr>
<td>Name of the Module:</td>
<td>Project Work</td>
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<tr>
<td>Course(s):</td>
<td>Project Work</td>
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<tr>
<td>Term:</td>
<td>4</td>
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<tr>
<td>Responsible person for the module:</td>
<td>Prof. Falcone</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Falcone</td>
</tr>
<tr>
<td>Language:</td>
<td>English</td>
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<tr>
<td>Position within the Curriculum:</td>
<td>Compulsory subject</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h]</th>
<th>ECTS</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Contact hours-/Self-Study time</td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>Project Work (ProW)</td>
<td>4</td>
<td>52/128</td>
<td>6</td>
<td>25</td>
</tr>
</tbody>
</table>

Requirements: 60 ECTS Points from the modules 1-10, 13-16

Learning objectives / Skills:
- To be able to investigate practical/real problems in a team environment
- Having professional competence in project management and procedures to acquire, validate, and integrate data, as well as HSE aspects
- Being able to perform acquisition, validation and integration of data through the application of relevant software during the project work
- Having self-competence and social competence to work in an international team
- Being able to prepare and structure the group report and group presentation (both consisting of individual contribution of all group members)

Course Outline:
- Investigation of a practical problem by a team of students on the basis of (industry/literature) supplied data
- Project Management
- Data Acquisition and Validation, Data Integration
- Application of relevant software
- Economics / HSE

Assessment: Group Report with identification of the individual contributions of each student and final presentation of the most important results by all students (40 % individual mark for student, 60% group effort)

Media:

Literature: Depending on specific topic

Additional Information:
Module 12: M. Sc. Thesis

Degree Programme: M Sc. Geothermal Engineering
Number of the Module: 12
Name of the Module: M. Sc. Thesis
Course(s): M.Sc. Thesis + Presentation
Term: 4
Responsible person for the module: Prof. Falcone
Lecturer: Prof. Falcone and other lecturers of the Master Program
Language: English
Position within the Curriculum: Compulsory subject

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h]</th>
<th>ECTS</th>
<th>FK</th>
<th>MK</th>
<th>SK</th>
<th>SOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. Sc. Thesis</td>
<td></td>
<td>720 Contact hours-/Self-Study time</td>
<td>24</td>
<td>70</td>
<td>15</td>
<td>15</td>
<td></td>
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</tbody>
</table>

Requirements: 80 ECTS Points from the modules 1-11, 13-16

Learning objectives / Skills:
The students have the competence to individually work on a scientific problem in its full complexity based on scientific knowledge. In addition, they will be able to present and defend their insights and conclusions regarding this topic
- Being able to apply competences and skills in a specific scientific topic (given by the lecturer)
- Applying methodical competence in literature search, data acquisition, organisation and structuring a Master Thesis, with respect to scientific ethics and proper scientific citations, and in the scientific presentation of the results
- Being able to properly address the preparation of a scientific report including literature search, data acquisition and evaluation and writing the report itself and preparation for the Master Thesis defence

Course Outline: Preparation of an individual scientific report/thesis, as well as the defence of this work during a presentation and subsequent discussion

Assessment: Written thesis regarding and presentation and discussion of the results

Media:

Literature: Topic specific literature and other sources, if possible acquired through own literature search

Additional Information:
## Module 13: Well Test Analysis

<table>
<thead>
<tr>
<th><strong>Degree Programme:</strong></th>
<th>M.Sc. Geothermal Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of the Module:</strong></td>
<td>13</td>
</tr>
<tr>
<td><strong>Name of the Module:</strong></td>
<td>Well Test Analysis</td>
</tr>
<tr>
<td><strong>Course(s):</strong></td>
<td>Well Test Analysis</td>
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<tr>
<td><strong>Term:</strong></td>
<td>3</td>
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<tr>
<td><strong>Responsible person for the module:</strong></td>
<td>Dr. Reitenbach</td>
</tr>
<tr>
<td><strong>Lecturer:</strong></td>
<td>Dr. Reitenbach, Prof. Ostrowski, Prof. Falcone</td>
</tr>
<tr>
<td><strong>Language:</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Position within the Curriculum:</strong></td>
<td>Compulsory optional subject</td>
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</table>

### Work Load [h]

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>ECTS</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Test Analysis (V + Ü)</td>
<td>3</td>
<td>4</td>
<td>60 % 40 %</td>
</tr>
</tbody>
</table>

### Requirements:

**Learning objectives / Skills:**
- Knowledge of well testing and its application to geothermal reservoir characterisation
- Being able to apply well test analysis methods for the characterisation of shallow and deep geothermal reservoirs

**Course Outline:**
- Aims and methods of well testing,
- Downhole and surface equipment,
- Differential equations and analytical solution for transient and stabilised flow,
- Definition of near-wellbore effects (skin),
- Interpretation of draw-down and build-up tests,
- Interference tests,
- Type curve method,
- Interpretation methodology.

**Assessment:**
Written exam (120 min)

**Media:**
Projector presentation, blackboard

**Literature:**
- SPE.ORG the eLibrary of SPE
- Further literature announced in the lecture

**Additional Information:**
Supplementary topics with current practical applications of geothermal case studies will be given and supervised by guest lecturers from the industry
Module 14: Stimulation Technology

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 14
Name of the Module: Stimulation Technology
Course(s): Stimulation Technology
Term: 3
Responsible person for the module: Prof. Falcone, Dr. Lungwitz
Lecturer: Dr. Lungwitz
Language: English
Position within the Curriculum: Compulsory optional subject

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h]</th>
<th>ECTS</th>
<th>FK</th>
<th>MK</th>
<th>SK</th>
<th>SOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulation Technology (V + Ü)</td>
<td>3</td>
<td>42/78</td>
<td>4</td>
<td>50 %</td>
<td>30 %</td>
<td>20 %</td>
<td></td>
</tr>
</tbody>
</table>

Requirements:
Learning objectives / Skills:
- Knowledge of causes for low well productivity and of possibilities for enhancement
- Knowledge and understanding of different stimulation techniques
- Understanding the application of stimulation technologies
- Being able to evaluate stimulation technique regarding the chances of success for different cases

Course Outline:
- Objectives (Causes and Enhancement possibilities of low Well Productivity)
- Formation Damage (Causes, Diagnosis, Removal by Surfactants & Acids)
- Matrix Acidizing (Acid/Rock Interactions, Sandstone & Carbonate Acidizing Design, Economics, Execution, Evaluation)
- Hydraulic Fracturing for Reservoir Stimulation (In-situ Stresses, Fracture Mechanics, Fluid Mechanics)
- Design & Execution of Hydraulic Frac Treatments (Fracturing Fluids, Proppants, Geometry, Design, Performance Prediction, Economics, Execution)
- Performance Evaluation (Transient Response, Interpretation of Rate and Pressure Data)
- Deviated and Horizontal Well Fracturing (Design & Analysis of Horizontal Multi-Frac Treatment)
- New Technological Developments (Surgi Frac, Hydrajet, …)
- Scale Deposition and Removal (Causes, Prediction, Design, Implementation and Analysis of Prevention/Removal Techniques)
- Sand Production & Control (Prediction, Design, Implementation, and Analysis of Control Measures)
- Quality Control

Assessment: Written exam (90 min)
Media: Projector presentation, blackboard
Literature: Literature announced in the lecture
Additional Information:
Module 15: Rock Mechanics

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 15
Name of the Module: Rock Mechanics
Course(s): Rock Mechanics II
Term: 3
Responsible person for the module: Prof. Hou
Lecturer: Prof. Hou
Language: English
Position within the Curriculum: Compulsory optional subject

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h]</th>
<th>ECTS</th>
<th>FK</th>
<th>MK</th>
<th>SK</th>
<th>SOK</th>
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</thead>
<tbody>
<tr>
<td>Rock Mechanics II</td>
<td>3</td>
<td>42/78</td>
<td>4</td>
<td>60 %</td>
<td>40 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Requirements:
Learning objectives / Skills:
- Knowledge of geo-mechanic principles
- Developing methodical competence in evaluation of borehole stability, applications of hydraulic fracturing and reservoir engineering

Course Outline:
- Poroelastic theory: Hooke's law for dry rock or non-porous rock, Hooke's law for porous rock, Biot's and Skepton's Coefficient,
- Borehole stability: Effect of mud weight on well stability, Rupture modes around a borehole, Minimum mud weight at drilling,
- Sand production prediction: Sand production mechanisms, Theories to predict sanding tendencies,
- Hydraulic fracture design: Theory of hydraulic fracture, Initiation of a fracture, Calculation of breakdown pressure, Measurement of the minimal initial stress using hydraulic fracture, Fracture geometry, Fracture orientation & azimuth, Fracture area, Numerical modelling, thermal induced fracturing,
- Reservoir engineering applications: Depletion and effective stress, Compaction drive, Reservoir compaction and compressibility, Subsidence.

Assessment:
Written exam (90 min)

Media:
Projector presentation, blackboard

Literature:
- Further literature announced in the lecture

Additional Information:
Module 16: Internship

Degree Programme: M.Sc. Geothermal Engineering
Number of the Module: 16
Name of the Module: Internship
Course(s): Internship
Term: 
Responsible person for the module: Prof. Falcone
Lecturer: 
Language: 
Position within the Curriculum: Compulsory optional subject

<table>
<thead>
<tr>
<th>Course Type</th>
<th>HPW</th>
<th>Work Load [h]</th>
<th>ECTS</th>
<th>FK</th>
<th>MK</th>
<th>SK</th>
<th>SOK</th>
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</thead>
<tbody>
<tr>
<td>Internship</td>
<td></td>
<td>8 weeks</td>
<td>8</td>
<td>30</td>
<td>30</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Requirements: Agreement of the module coordinator regarding time and adequacy of the internship. Adequate companies do research development or planning (of components) for geothermal systems. The task for the theoretical or practical work has to be approved by the module coordinator in advance.

Learning objectives / Skills:
- Apply technical knowledge and competences and project management skills in real work processes
- Being able to work in interdisciplinary teams
- Keeping in mind social and sustainability aspects
- Being aware of the importance of public relations

Course Outline:
- Internship in a company, which is doing research, development or planning in the area of geothermal systems
- Responsibility in a real work situation
- Teamwork
- Developing professional competence

Assessment: Report about practical or theoretical work

Media: 

Literature: 

Additional Information: