Module label: Energy Meteorology & Storage Technologies
Module code: pre314
Credit points: 7.0 KP
Workload: 210 h
Used in course of study: Master's Programme European Master in Renewable Energy (EUREC) > Mastermodule

Module responsibility
- Carsten Agert
- Detlev Heinemann

Module counseling
- Carsten Agert
- Robin Knecht
- Robert Steinberger-Wickens

Entry requirements
Skills to be acquired in this module
- have a critical understanding of the conditions concerning the availability of solar radiation
- have a good understanding of fundamental atmospheric processes
- understand the close interaction of radiation with the atmosphere and the constraints on wind flows relevant for wind power generation
- will be able to apply basic radiation laws and to practically perform simple wind power assessments
- have a good understanding of various concepts of electrical storage systems and state of the art technical developments
- be able to critically understand the efficiency of conversion steps in storing and activation of energy
- have an overview of the electrochemical, thermodynamic, engineering, and materials science basics of Fuel Cell and Hydrogen technologies, their development status, and their applications areas
- have learned about the sensitivity of sensors
- have understood the performance of a battery/load system and are able to perform state of charge measurements to express the performance of a battery

Module contents
Solar Energy Meteorology:
- Radiation laws
- Solar geometry
- Interaction of solar radiation with the atmosphere
- Climatology of solar radiation
- Solar radiation modelling and measurements

Wind Energy Meteorology:
- Origin of atmospheric air flow, energy balance of the atmosphere
- Basic physics of atmospheric motion
- Wind climatology: Atmospheric circulation, local wind systems
- Wind in the atmospheric boundary layer (characteristics, vertical profile)
- Wind energy resource assessment and measurements

Electrical Energy Storage Technologies:
- Primary and secondary batteries
- redoxflow batteries
- super-capacitors
Non-electrical storage concepts:
- fly wheels
- adiabatic-compressed air storage
- superconductors
- pumped storage systems

„Bridging technologies“ to heat storage:
- Heat pumps and Combined heat and power systems (CHP’s)

Fuel Cells and Hydrogen:
- Introduction and technology overview
- Hydrogen generation, handling and storage
- hydrogen applications and markets
- Low Temperature Fuel Cells
- High Temperature Fuel Cells
- Fuel Cells Market Introduction

Lab Work:
- Solar Spectrum
- Lead-Acid Battery

Reader’s advisory
### Links

<table>
<thead>
<tr>
<th>Language of instruction</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (semesters)</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Module frequency</td>
<td>jährlich</td>
</tr>
<tr>
<td>Module capacity</td>
<td>unlimited</td>
</tr>
<tr>
<td>Modullevel</td>
<td>MM (Mastermodul)</td>
</tr>
<tr>
<td>Modulart</td>
<td>Pflicht</td>
</tr>
<tr>
<td>Lern-/Lehrform / Type of program</td>
<td>Lecture, Laboratory</td>
</tr>
</tbody>
</table>

### Examination

<table>
<thead>
<tr>
<th>Type of examination</th>
<th>Time of examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Meteorology (35%): Written exam (1.5 hours)</td>
<td>Energy Meteorology: At the end of lecture period (end of January)</td>
</tr>
<tr>
<td>Energy Storage (35%): Written exam (1.5 hours)</td>
<td>Energy Storage: At the end of lecture period (end of January)</td>
</tr>
<tr>
<td>Hydrogen &amp; Fuel Cells (15%): Written exam (0.5 hours)</td>
<td>Hydrogen &amp; Fuel Cells: After end of lectures (mid-January)</td>
</tr>
<tr>
<td>Battery Lab (15%): Written report (10 - 20 pages)</td>
<td>Battery Lab: During Semester</td>
</tr>
</tbody>
</table>

### Course type

<table>
<thead>
<tr>
<th>SWS</th>
<th>Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>0 h</td>
</tr>
<tr>
<td>Workload attendance</td>
<td>0 h</td>
</tr>
</tbody>
</table>