Module label: System Integration of Renewable Energy
Module code: pre141
Credit points: 12.0 KP
Workload: 360 h (360 hours)

Used in course of study:
- Master's Programme Postgraduate Programme Renewable Energy > Mastermodule

Contact person:
- Module responsibility: Sebastian Lehnhoff

Entry requirements:
Skills to be acquired in this module:
- After successful completion of the module students should be able to:
  - explain the management, modelling and power balancing within future electricity grid configurations with high shares of fluctuating and distributed generation and the requirements for successful application to real power balancing regarding capacity utilization, robustness, and flexibility.
  - appraise the main components (incl. chemical storage options) involved in future AC-grid concepts, to soundly assess the reciprocal constrains between them to propose solutions for improving its performance.
  - explain necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems.
  - estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants.
  - explain necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems.
  - explain the technical principles and resulting limiting factors for different components required for power control within “Smart City”, “Smart Grid”, “Smart Home” concepts, estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems and analyse their safety, reliability, real time capability and flexibility.

Module contents:
The module is designed to give specialized insight on the management, modelling and power balancing within future grid configurations. It gives the students a thorough overview on the challenges and solutions in electricity grids that shall accommodate a high share of fluctuating distributed generation. It deals with the technical and economic framework for a permissible electrical network as well as mathematical modelling and calculation methods to analyse conditions of electrical energy networks (in stationary conditions). Technology, economical energy industry and technical basic knowledge and methods are analysed by using concrete Smart Grid approaches. The basic calculation methods for an intelligent net management are introduced.

Future Power Supply Systems (Lecture & Seminar – 180 h workload):
- Technology and characteristics of conventional power plants based e.g. on coal, gas, and nuclear
- Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.)
- Fluctuating distributed generation: Characteristics and solutions on the transmission and distribution grid levels, incl. storage, vehicle-to-grid-concepts, smart inverters, heat pumps / CHP, etc.
- Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world
- “Smart City”, “Smart Grid”, “Smart Home”
- Mini- and Micro-Grids
- Energy scenarios and modelling
- Chemical energy carriers in the energy system: power-to-gas (e.g. methane) and power-to-liquids (e.g. methanol)
Smart grid management (Lecture and Exercises – 180 h workload):

- Organisation of the EU energy market (regulatory framework, responsibility in liberalisation of electrical energy systems)
- Establishment and operation of electrical energy supply networks (network topology, statutory duties of supply, supply quality/system services, malfunctions and protection systems)
- Network calculation (complex pointer, effective/idle power, mathematical performance models/net model, transformation: node performance to node voltage and electricity, calculation of conductive current, power-flaw calculation, fix-point-iteration, Newton-Raphson-Method, voltage drop, transformer model)
- Intelligent network management (Smart Grids), Aggregation forms, machine learning approaches
- Detailed description of involved balance of system components (e.g. inverter, charge controllers)
- System Operation
- Detailed System Design – from meteorological input across component rating to energy service output

Reader’s advisory

Future Power Supply Systems:


Smart grid management:

- Konstantin, P.: „Praxisbuch Energiewirtschaft“, Springer 2006
- Lehnhoff, S.: „Dezentrales vernetztes Energiemanagement“, 2010

Links

- Language of instruction: English
- Duration (semesters): 1 Semester
- Module frequency: once a year
- Module capacity: unlimited
- Reference text: Helpful previous knowledge:

  - For the course “Smart grid management” is basic knowledge in Python Programming advisable.
  - Basic knowledge on chemical processes (Chemistry-Primer: 1CP) and energy storage (course “Energy storage”) are also advantageous.
  - Knowledge in Semiconductor Physics is desired (Semiconductor Physics Primer: 1CP)

Modullevel: MM (Mastermodul / Master module)
Modulart: Wahlpflicht / Elective
Lern-/Lehrform / Type of program: Lectures, Exercises, Seminar
Vorkenntnisse / Previous knowledge

Examination

- Time of examination
- Type of examination
  - 2 Examinations
  - Report (presentation: 50 min, paper: 5 pages)
  - or Exercises (8 exercises): Future Power Supply, 50% weight.
  - Oral Exam (ca. 30 minutes) or Exercises (8
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**Total time of attendance for the module** 112 h