Module Energy Science and Technology I General Aspects

Energy Science and Technology I

Learning objectives: Student 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.

Syllabus:

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.

Literature:

- Lecture manuscript, materials on E-learning platform ILIAS.
- Any physics textbook on magnetics.
- Fitzgerald, A.E., Charles Jr. Kingsley and Stephen D. Umans: Fitzgerald and Kingsley´s Electric Machinery. McGraw-Hill Higher Education. (Paperback) 7th Edition, 2013.
- Kothari, D.P. and I.J: Nagrath: Electrical Machines. Tat McGraw-Hill Education, 3rd Edition, 2004.
- Maloney, Timothy J: Modern Industrial Electronics. Prentice-Hall, 2001.
- Nasar, Syed: Schaum´s Outlines, Electric Machines and Electromechanics. McGraw-Hill Professional. (Paperback) 2nd Edition, 1997.
- Potter, Merle C. and Craig W. Somerton. Schaum's Outline, Thermodynamics for Engineers. McGraw-Hill Education, 2nd Edition, 2006, 3rd Edition 2013.
- Wildi, Theodore. Electrical Machines, Drives and Power Systems. Prentice Hall, 2002.

Energy Science and Technology II

Learning objectives: 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.
- to 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:

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.

Literature:

- Lecture manuscript, materials on E-learning platform (ILIAS).
- Small Hydropower Systems; DOE/GO-102001-1173, FS217 July 2001.
- Distributed Generation in Liberalised Electricity Markets; OECD/IEA 2002.
- Bubenzer, Achim (Ed.): Photovoltaics Guidebook for Decision Makers, Technological Status and Potential Role in Energy Economy. Springer, Berlin, Heidelberg u.a, 2003
- Goetzberger, Adolf and Volker Hoffmann: Photovoltaic Solar Energy Generation. Springer, Berlin, Heidelberg u.a., 2005.
- Goetzberger, A. und V. Wittwer: Sonnenenergie: Thermische Nutzung. Teubner, 1989.

- Kaltschmitt , Martin (Ed.): Renewable energy technology, economics and environment. Springer, Berlin, Heidelberg u. a., 2007.
- Kleemann, M. und M. Meliß: Regenerative Energiequellen. Springer, Berlin, 1993.
- Luque, Antonio [Ed.]: Handbook of photovoltaic science and engineering. Wiley, New York, Chichester , 2003.
- Messenger, Roger and Jerry Ventre: Photovoltaic Systems Engineering. CRC Press, Boca Raton u.a., 2000.
- Sörensen, Bent: Renewable Energy. Elsevier 4th Edition, 2010.
- Spera, David A. (Ed.): Wind turbine technology, Fundamental concepts of wind turbine engineering. Asme Press, New York, 1994.
- Wagner, Hermann-Josef and Jyotirmay Mathur: Introduction to Hydro-Energy-Systems. Springer, Berlin, Heidelberg, 2011.
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