Summer School “Renewable Energy Systems”

The students that have attended the summer school know the main states of the art regarding the application of reneable energy systems. Moreover, they can estimate and evaluate the potentials of future sustainable technologies. Beside the production of energy from sustainable sources (sun, wind, water and so on) they also know some important peculiarities of energy distribution.

The content of the summer school on renewable energy systems has to be seen in the context of environmental compatibility, climate change and availability of natural ressources.

Lecture on Wind Energy

The lectures on "Wind Energy" start with the characteristics of the wind and the wind to power conversion limited by Betz law. Then the mechanics of historical and actual wind energy converters are discussed, leading to an efficient operation and the resulting requirements concerning the electrical machine with the associated power electronics circuit.

Aspects of grid connection are as well presented as political and economic implications of wind energy use.

Lecture on Business Simulation

Engineers increasingly require business knowledge in their management environment. In this workshop, all participants win gain an insight into the extensive interaction of the single departments of companies.

In this simulation game students learn to manage a (virtual) company. They will make typical business decisions in a realistic environment.

► They learn how to apply different principles of business administration of allkinds: How to use information in decision-making, and how to handle risk and uncertainty.

► They experience decision-making processes within a team while managing time constraints.

► Management simulations offer, through virtual experiences, a high degree of transferable knowledge and skills which participants can make use of in their day to day work.

Thinking and acting strategically can only be learned by means of acting and thinking in a strategic way.

Lecture on Hydroelectric Power

Students attending this lecture, realize the present role of hydro-power in the world and can roughly estimate its future development. They know how to calculate key figures, like power output, from natural conditions like head and flow rate. They are able to name and explain components of different types of hydro-power plants. For specific site conditions, students master to choose the most appropriate type of machinery. They may justify their decision and know how to roughly

estimate the main dimensions. Students are aware of environmental concerns like fish migration and can suggest measures for minimizing negative impacts. Short electronic quizzes deepen the knowledge that is conveyed in this lecture of two times ninety minutes. An English language PDF handout is provided.

Lecture on Photovoltaics

The lecture Photovoltaics offers an insight in the fundamentals, the technology and practical applications of photovoltaic energy conversion. After attending the lecture, the students are capable to compare and evaluate different cell technologies, to design photovoltaic plants, and to calculate their profitability. Moreover, they have learned to know the existing measurement methods to analyze the modern methods of module and plant evaluation.

After the introduction of the most important base terms of photovoltaics, we deal with the availability of solar radiation, and become familiar with the features of sunlight and investigate how solar radiation can be used as efficiently as possible. As a fundament to understand solar cells, the basics of semiconductor physics are introduced as well. Here we will concentrate on the structure of semiconductors, the understanding of the p–n junction and absorption properties of semiconductors.

Then we go over to the technical details: We look at the structure, method of operation, and characteristics of silicon solar cells. Besides this, we calculate the possible efficiency of solar cells. Then cell technologies are discussed: What is the path from sand, via silicon solar cell, to the solar module? What other materials are there and what does the cell structure look like in this case? Besides these questions, we will also look at the ecological effects of the production of solar cells. Then we look at the structures and properties of solar generators. Here we will deal with the optimum interconnection of solar modules in order to minimize the effects of shading.

System technology of grid-connected plants is also discussed. Besides build-up and functionality of different inverter types, different feed-in variants are presented. Moreover, different possibilities for the home storage of solar power are introduced as well. Moreover, we discuss measures to enhance the self-consumption in grid-connected as well as in in stand-alone systems.

In addition, we concentrate on photovoltaic metrology. Besides the acquisition of solar radiation, we deal especially with the determination of the real power under Standard-Test-Conditions (STC) of solar modules. Furthermore, we become familiar with modern methods of quality analysis such as thermography and electroluminescence metrology. Hints for the optimal design and operation of grid-coupled plants and highlights the profitability calculation of plants are given.

Finally, we provide a view on the future of photovoltaics. This comprises potential estimations, the interplay of different energy generation types and sector coupling.

In parallel to the lecture, guided lab tours and practical demonstrations are organized:

- Presentation of the Photovoltaics-Test-Lab
- Survey of PV lab experiments in the lab for Optoelectronics and Sensor Technology

Lecture on Power Electronics and Smart Grids

The lecture on Power Electronics and Smart Grids starts with general electrical engineering basics related to both topics. This includes some aspects of electronic circuit design and electronic components as well as basics of electrical power systems engineering and communication systems engineering.

The power electronics part of the lecture starts with an introduction to buck and boost converters. It then advances to modern PWM voltage source converters, which are used in many regenerative power sources today. After attending the lecture, the students should know about basic operation principle, benefits and limitations of modern power inverters.

The second part of the lecture is on smart grids and starts with a comparison of various definitions of the smart grid. Some of the required technologies are then covered in more detail. These include smart meters, intelligence in the power system, smart consumers and producers and communication infrastructures for the components in a smart grid. This enables the students to describe essential properties and to assess benefits and risks of a smart grid for the different participants.

Lecture on Materials for an Energy Efficient Society

The rapid increase and dependence of our modern society on massive data storage, mobile electronics, advanced lighting, flat displays, sensor network systems, and Internet of Things (IoT) causes a strong increase in the production of electrical energy as well as a strong demand to develop battery-less and mobile power sources.

Materials for energy harvesting from environmental sources, including wind, solar radiation, mechanical vibrations, magnetic fields, and heat have thus become highly relevant for the further growth of the society needs while reducing the carbon footprint at the same time.

This lecture presents the main challenges of the 21st century, state-of-the-art energy-harvesting approaches, various material design strategies being targeted by the community, and fundamental challenges in finding an optimum solution and future roadmap. The required flexibility of energy harvesting is also discussed in view of the consequence of future material development projects. Particularly, materials for photovoltaics, wind turbines, and photocatalytic water splitting are in the focus of this lecture.

Even if more and more energy can be harvested without enhancing the carbon footprint, the need to reduce the energy consumption and thus to develop more efficient devices will remain an evergreen topic. This is particularly true for lighting and imaging systems, since these technologies consume a substantial fraction of the produced electrical energy.

The advent of new lighting and display technologies, e.g. LCD and OLED screens, Hg free discharge lamps, and solid state light sources, such as (In,Ga)N LEDs, have the potential to tremendously reduce the consumption of electric energy at least. However, these new technologies require materials with a very high (photo)chemical stability and efficiency upon a high photon flux, high electrical field strength, and elevated temperature. This demand for

stable and efficient luminescent materials with a high luminous efficacy, little thermal quenching and high linearity presently drives worldwide R&D projects towards novel luminescent materials.

Nevertheless, all of the achievements in reducing the overall energy consumption by the invention of efficient devices are partly compensated by the strong decrease in usage, i.e. increase in lighting installations and display area. This effect is known as the rebound effect and its consequences on material development will be discussed in this lecture too.

Lecture on Bio Energy

The students are introduced in different kinds of bioenergy and the importance of bioenergy concerning the energy supply and the impact of power supply on climate change. The conversion process of biomass to bioenergy is shown exemplary in different kinds of bioenergy like biofuel, biogas or solid fuels. Apart from technical preparation and conversion processes and the corresponding efficiency factors the students get familiar with the emissions, which have impact on the climate.