Modulbeschrieb

Photovoltaic

Allgemeine Informationen

Anzahl ECTS-Credits

3

Modulkürzel

TSM_Photo

Version

25.04.2011

Modulverantwortliche/r

F. Baumgartner, (Author of the first draft) and contributions from A. Vezzini, U. Muntwyler, H. Keppner

Sprache

	Lausanne	Bern	Zürich
Unterricht	☑ E ☐ F	☐ D ☑ E ☐ F	☐ D ☑ E
Unterlagen	☑ E ☐ F	☐ D ☑ E ☐ F	☐ D ☑ E
Prüfung	☑ E ☐ F	☐ D ☑ E ☐ F	☐ D ☑ E

Modulkategorie

☐ Erweiterte theoretische Grundlagen

X Technisch-wissenschaftliche Vertiefung (Advanced scientific technical courses)

☐ Kontextmodule

Lektionen

X 2 lectures and 1 tutorial each week

☐ 2 Vorlesungslektionen pro Woche

Kurzbeschreibung /Absicht und Inhalt des Moduls in einigen Sätzen erklären

This course focuses on the advanced understanding of the main components of Photovoltaic PV power generation systems. The goal goes beyond the competence to design a PV System, like the installer business is used do, but also to understand how the components are working in detail, either for different PV module technologies as well as for different inverters power electronic topologies. The students will be able not only to know the different type of components on the market, but they should be able to work for companies to be able to improve these products on the technology level. Due to the fact, that in Switzerland thousands of employees in the PV sector are not installing any PV system, but working for companies supplying component of turn-key PV module production lines for the world market, the main concepts of processes and different concepts of PV module production lines are discussed in the course also. Calculations of the economic parameter of state of art PV systems, together with environmental key factors like energy pay back times will complete this PV course.

Ziele, Inhalt und Methoden

Lernziele, zu erwerbende Kompetenzen

To understand the main parts in the photovoltaic sector, the starting points from, basics in semiconductor physics, manufacturing, power electronics and system engineering have to be addressed. The first chapter is dealing with applied optoelectronics and semiconductor physics to understand the different working principles of solar cell technologies, such as thin- film-, compound-, polymer-based- and crystalline silicon technology. In this context, the student will become familiar with the state of the art and must be sensitized to the still remaining space for improvement. In the second chapter currently widely used industrial production processes of standard crystalline silicon as well as thin film solar modules are discussed, together with used test and measurement methods. In the third chapter, power electronics with DC/DC converters including MPP tracking and DC/AC inverters including battery storage circuits and safety regulations and codes are treated. The final chapter is dealing with all aspects of design and planning of a PV power plant, including electrical and mechanical installations of PV modules, inverters and economical and environmental issues are calculated.

Applied examples of the lecture are calculated and discussed during the weekly tutorials. Thus some remarks on state of the art technical publications will help to get a deep insight in the field of photovoltaic. A few basic measurements performed on solar cells and PV modules of different technologies in a PV Laboratory will help to establish first practical PV experience. At the end of the lectures the students are qualified to perform creative contributions to the progress of photovoltaic technologies and application to help reaching a double-digit share of solar power within the overall electricity supply.

Modulinhalt mit Gewichtung der Lehrinhalte

Chapter 1: *Optoelectronic basics of different solar cell technologies*

4×3 lectures

- Introduction: Different concepts of renewable electricity generation
- Physics of solar irradiation, power and spectra
- Optical absorption coefficient of several solar cell materials – thin film materials, organic materials
- Band gap, PN junction, diffusion and drift, diode current voltage characteristics
- Basics of solar cell STC IV curve, equivalent circuit of a solar cell and equations
- Spectral Photocurrent, diffusion length, surface recombination, homo-heterojunctions, tandem solar cell
- State of the art cell efficiencies and loss mechanism

Chapter 2: *Industrial production of standard crystalline silicon and thin film solar modules*

3×3 lectures

- Cross section of standard crystalline silicon and thin film module, current flow, junction boxes
- Production process standard cryst. Si module: poly Silicon, wafering, cell production, stringing, lamination, testing
- Packaging, lamination process on glass
- Production process of thin film modules: TCO production, PECVD (others), laser scribing, lamination, back end, test
- Requirements on PV modules (IEC standards), quality control in the production line
- Quality testing and nominal power measurement methods outside the module fab. prior to plant installation

Chapter 3: *PV power electronics – AC/DC inverters and battery storage*

3×3 lectures

- Principles of DC/DC converter and MPP tracking
- PV battery charger, topologies, costs
- DC/AC PV inverter topologies: transformer less concepts and transformer types, DC earth potential
- Control circuits, anti-islanding techniques, power electronic components, efficiency and life time
- Key figures of the PV Inverter; average efficiency calculation methods incl. DC-voltage and partly load condition
- PV inverters on the market, efficiency, costs, regulations and grid code,
- PV AC and battery back up system, peak shift power electronic topologies, reactive power and frequency control

Chapter 4: *PV power plant design and system engineering aspects*

4×3 lectures

- Collected solar energy versus collector orientation, shading losses, one and two axis tracking gains
- Grid connected AC System design; components, inverter MPP voltage window matching
- Electrical and mechanical installation and system components, residential roof top, utility scale MW plants
- Electrical grid code, lightning protection
- Relevance of energy rating Parameters; temperature coefficient, low light irradiance, spectra, degradation…
- Software based PV System Design (PVGIS, PVSYST…), uncertainties of annual PV electricity predictions
- System performance ratio, yield, best practice results, examples of PV system monitoring
- Over all cost of photovoltaic electricity generation
- Integration of fluctuating PV generation into the grid, weather based forecast, storage costs
- Energy pay-back scenarios, LCA life cycle analysis results
- Trends of PV market increase and jobs in Switzerland, global PV market, incentives and politics

Lehr- und Lernmethoden

- *Lecture, discussion and tutorials*
- *Exercises using basic mathematics and several public software tools*

Voraussetzungen, Vorkenntnisse, Eingangskompetenzen

Basics in Physics, Electronics

Bibliografie

Electronic documentation, some text books are recommended but not obligatory;
Chapter 1: Physics of Solar Cells; Peter Würfel; ISBN-10*: 3527408576;*
The Physics of Solar Cells, Jenny *Nelson,* ISBN-10*: 9781860943492*
Chapter 4: Heinrich Häberlin, Photovoltaics, English in press ISBN-13**:** 978-3800730032;
Regenerative Energiesysteme, Volker Quaschning, Deutsch, English in press?; ISBN-13**:** 978-3446421516

Leistungsbewertung

Zulassungsbedingungen für die Modulschlussprüfung (Testatbedingungen)

Two accepted exercise of two different chapters

Schriftliche Modulschlussprüfung

Prüfungsdauer :	120 minutes
Erlaubte Hilfsmittel:	*- open book*
	- calculator no PC