Module Description

Photovoltaic

General Information

Number of ECTS Credits

3

Abbreviation

TSM_Photo

Version

16.04.2014

Responsible of module

Franz Baumgartner, ZHAW

Language

	Lausanne	Bern	Zürich
Instruction	☒ E ☒ F	☐ D ☐ E ☐ F	☐ D ☒ E
Documentation	☒ E ☐ F	☐ D ☐ E ☐ F	☐ D ☒ E
Examination	☒ E ☐ F	☐ D ☐ E ☐ F	☐ D ☒ E

Module category

☐ Fundamental theoretical principles

☒ Technical/scientific specialization module

☐ Context module

Lessons

☒ 2 lecture periods and 1 tutorial period per week

Brief course description of module objectives and content

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. 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.

Aims, content, methods

Learning objectives and acquired competencies

The students will be able not only to know the different type of Photovoltaic components on the market, but they should be able to work for companies to be able to improve these products on the technology level. Thus in the course exercises this technology knowledge will be trained focused on the applied research needs in the industry in power electronica as well as PV module production technologies and PV plant design.

Contents of module with emphasis on teaching content

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 4×3 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
- Integration of fluctuating PV generation into the grid, weather based forecast, storage costs

Chapter 4: PV power plant design and system engineering aspects 3×3 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
- Energy pay-back scenarios, LCA life cycle analysis results
- Trends of PV market increase and jobs in Switzerland, global PV market, incentives and politics

Teaching and learning methods

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

Prerequisites, previous knowledge, entrance competencies

Basics in Physics, Electronics

Literature

none

Assessment

Certification requirements for final examinations (conditions for attestation)

none

Written module examination

Duration of exam :	120 minutes
Permissible aids:	none