Module Description, available in: EN

Photovoltaic & storage

General Information

Number of ECTS Credits

3

Module code

TSM_PhotoStor

Valid for academic year

2020-2021

Last modification

2019-10-11

Responsible of module

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Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Berne	Lausanne			Lugano	Zurich		
Instruction		**X** E 100%				**X** E 100%		
Documentation		**X** E 100%				**X** E 100%		
Examination		**X** E 100%				**X** E 100%		

Module Category

TSM Technical scientific module

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competences

Prerequisites, previous knowledge

Basics in Physics, Electronics

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 including storage options. The goal goes beyond the competence to design a PV System, like the installer business is used to 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 ore battery types. Due to the fact, that in Switzerland some employees in the PV sector are not installing any PV system, but working for companies supplying components of turn-key PV module production lines for the world market as well others produce batteries, the main concepts of processes and different concepts of production lines of such components are included in the course Analysis of the economic parameter of state of art PV systems and batteries, together with environmental key factors like energy pay back times will complete this course. Today the numbers of PV systems including a battery system to

use PV electricity at night is growing in Switzerland with an increasing trend. The power electronic concepts, energy flows and control strategies in these grid connected PV and storage systems are discussed as well es levelized cost of electricity.

Aims, content, methods

Learning objectives and acquired competencies

The students will be able not only to know the different type of Photovoltaic components, like cell types, module types and inverters as well as battery types on the market, but they should be able to work for companies to develop improved products and system designs on the technology level. Several exercises are performed on applied aspects of solar cells, power electronic components, PV plant system design including batteries as well es levelised cost of electricity.

Contents of module with emphasis on teaching content

Chapter 1: Optoelectronic basics of different solar cell technologies 3×3 lectures

- Introduction: Overview of renewable electricity generation and storage
- Physics of solar irradiation, power and spectra, optical absorption coefficient of several solar cell 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 silicon cell, high efficiency silicon cells and loss mechanism as well as other competing technologies

Chapter 2: Industrial production of standard crystalline silicon, performance and testing 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
- Production technology of thin film solar module technologies
- Requirements on PV modules (IEC standards), quality control in the production line and failure mechanisms of PV modules
- Quality testing
- Outdoor performance, temperature coefficients, collected solar energy versus collector orientation, one and two axis tracking gains, relevant losses like shading, soiling and degradation
- PV system test methods in the field

Chapter 3: Storage 3×3 lectures

- Overview storage technologies – power, capacity, storing period
- Lithium standard batterie cell and their components, resources
- Performance, charging, discharging, decrease of capacity, life time, recycling
- Production processes of lithium batteries
- Power electronics and control of batteries

Chapter 4: PV power electronics – AC/DC inverters and battery storage 2×3 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, power optimizer versus string inverter
- PV AC and battery backup system, peak shift power electronic topologies and frequency control
- Integration of fluctuating PV generation into the grid, active and reactive power voltage control, storage and PV forecast

Chapter 5: PV power plant and storage design and system engineering 3×3 lectures

- 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, grid code
- Software based PV System design, uncertainties of annual PV electricity predictions including storage
- System performance ratio, yield, best practice results, examples of PV system monitoring, annual battery cycles
- Overall cost of photovoltaic electricity generation including storage
- Energy pay-back scenarios, LCA life cycle analysis results including PV plant and battery storage
- Trends of PV and battery market and jobs in Switzerland, global markets, incentives, net present value calculations and politics.

Teaching and learning methods

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

Literature

Assessment

Certification requirements

Module does not use certification requirements

Basic principle for exams

As a rule, all the standard final exams for modules and also all repetition exams are to be in written form

Standard final exam for a module and written repetition exam

Kind of exam

written

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

No electronic aids permitted

Other permissible aids

Course documents, lecture notes

Special case: Repetition exam as oral exam

Kind of exam

oral

Duration of exam

30 minutes

Permissible aids

No aids permitted