Module Description, available in: EN

Photovoltaic & storage

General Information

Number of ECTS Credits

3

Module code

TSM_PhotoStor

Valid for academic year

2025-26

Last modification

2024-10-18

Coordinator of the module

Hartmut Nussbaumer (ZHAW, nusu@zhaw.ch)

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.

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

The objective of the course is to gain the competence to understand the current scientific topics in the field of photovoltaic and battery research and to have the opportunity to familiarise oneself with a special area of research. After a short compact course on the basics of photovoltaics, the current module technology, production of modules and topics from systems engineering will be covered. Another focus of the course is battery technology.

Aims, content, methods

Learning objectives and competencies to be acquired

The aim of the course is to gain an in-depth understanding of photovoltaic and battery technology. Students gain a broad knowledge of the subject area and are able to apply the knowledge they have acquired to assess specific practical issues. After completing the course, students should be able to understand the content of scientific conferences in the field of photovoltaics and battery technology and provide new impulses for the further development of the technology themselves.

Module content with weighting of different components

Chapter 1: Basic photovoltaics 2×3 lectures

Fundamentals of photovoltaic systems: Solar resources, irradiance vs. irradiation, energy yield estimation, components of PV systems, types of PV systems, operating principles of PV inverters, hybrid inverters and backup systems LCOE, ecology.

Semiconductor basics, p/n junction, working principle of solar cells, absorption edge, I/V curve, efficiency limit, recombination losses

Chapter 2: Solar modules 2×3 lectures

Production of silicon solar modules: metallurgical silicon, polysilicon, ingot, wafer, solar cell, module

Thin film modules, production technology, electrical characteristics, applications

Crystalline silicon solar modules 1: Module construction, encapsulants, solar glass, wafer size, half cells, PERC, TOPCon, HJ, IBC, perovskite silicon tandem

Chapter 3: Solar modules in operation 2×3 lectures

Crystalline silicon solar modules 2: Electrical characteristics. Study of IV curve, partly shading, shading tolerant modules

Crystalline silicon solar modules 3: Reliability, lifetime degradation rates, types (LID, LeTID, PID, UV), Accelerated aging

Chapter 4: System technology 2×3 lectures

PV inverters, MPP tracking strategies, power optimisers, inverter behaviour in partial shading conditions

Energy yield and loss calculation of PV systems

Chapter 5: Battery technologies 3×3 lectures

Energy Storage introduction, Battery history, Electrochemistry basics and Li ion battery materials

Battery Performance, System design and lifetime mechanisms

Battery Safety, End of life options, Market overview and Application example

Chapter 6: PV integration 2×3 lectures

PV system design: Matching modules, inverters and power optimisers

Choice of system topologies for specific situations

PV in the power system: Grid integration strategies

Teaching and learning methods

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

Literature

Assessment

Additional performance assessment during the semester

The module does not contain an additional performance assessment during the semester

Basic principle for exams

As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.

Standard final exam for a module and written resit exam

Kind of exam

Written exam

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

Laptops as PDF readers, but no internet access

Other permissible aids

Offline electronic documents allowed as course documents, lecture notes

Exception: In case of an electronic Moodle exam, adjustments to the permissible aids may occur. Lecturers will announce the final permissible aids prior to the exam session.

Special case: Resit exam as oral exam

Kind of exam

Oral exam

Duration of exam

30 minutes

Permissible aids

No aids permitted