

**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		
<b>Instruction</b>					X E 100%		
<b>Documentation</b>					X E 100%		
<b>Examination</b>					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 2x3 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 2x3 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 2x3 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 2x3 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 3x3 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 2x3 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