

# Photovoltaics

## Sunny Prospects with the Photovoltaics Course

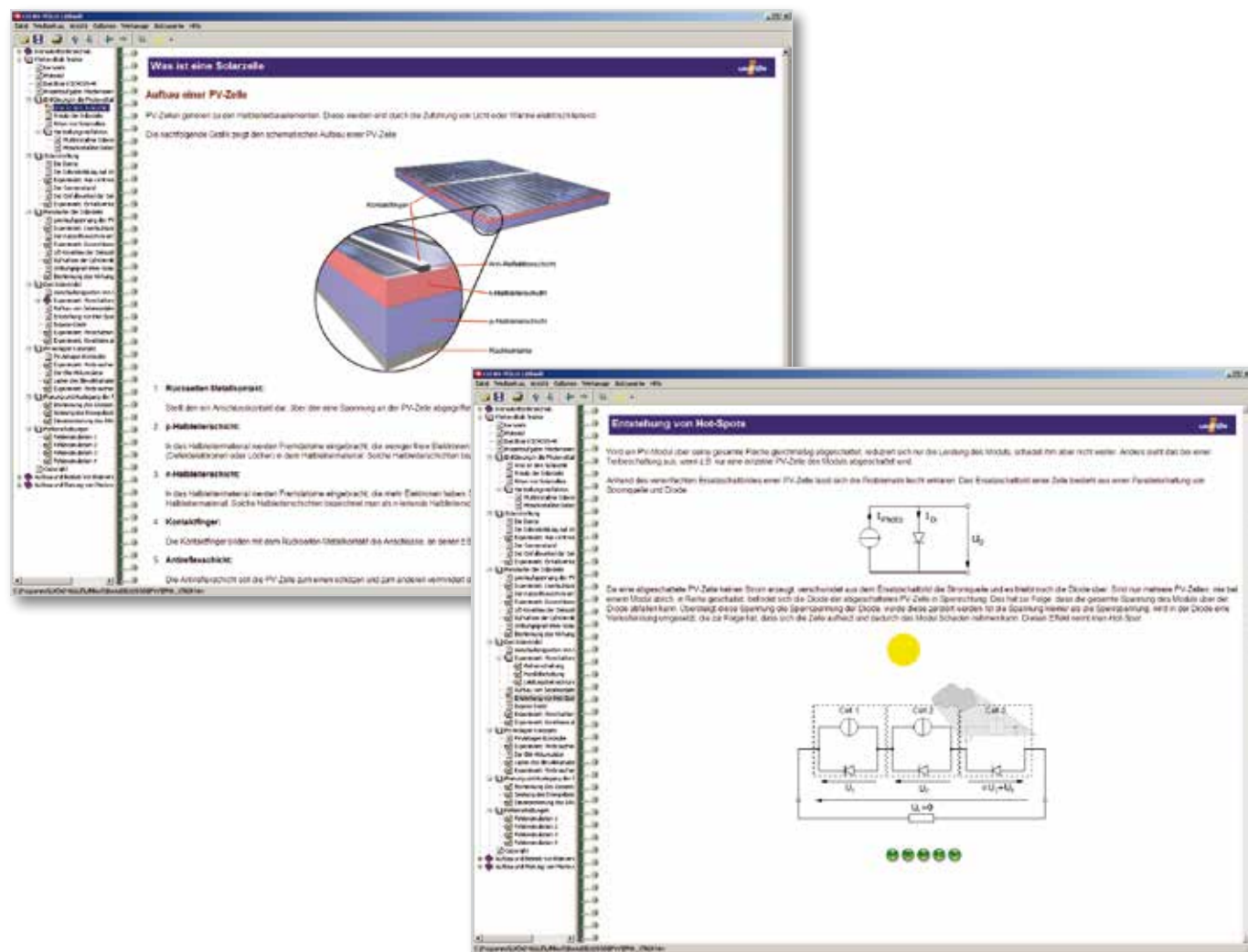
In times of soaring energy costs and increased environmental awareness, photovoltaic technology constitutes a very interesting alternative to traditional power generation. With the photovoltaics course, you can not only research the fundamentals of solar cells, but also simulate operation of a photovoltaic system in direct or storage mode.



### Training contents

- Functions and operating principles of solar cells
- Recording the characteristics of a solar module
- Dependency of a solar module's current and voltage on temperature, irradiance and angle of incidence
- Series, parallel and other types of circuit for solar cells
- Manufacture of solar cells
- Various types of solar cell
- Design of a photovoltaic battery
- Various types of solar plant
- Setup of an off-grid power system with rechargeable solar cells

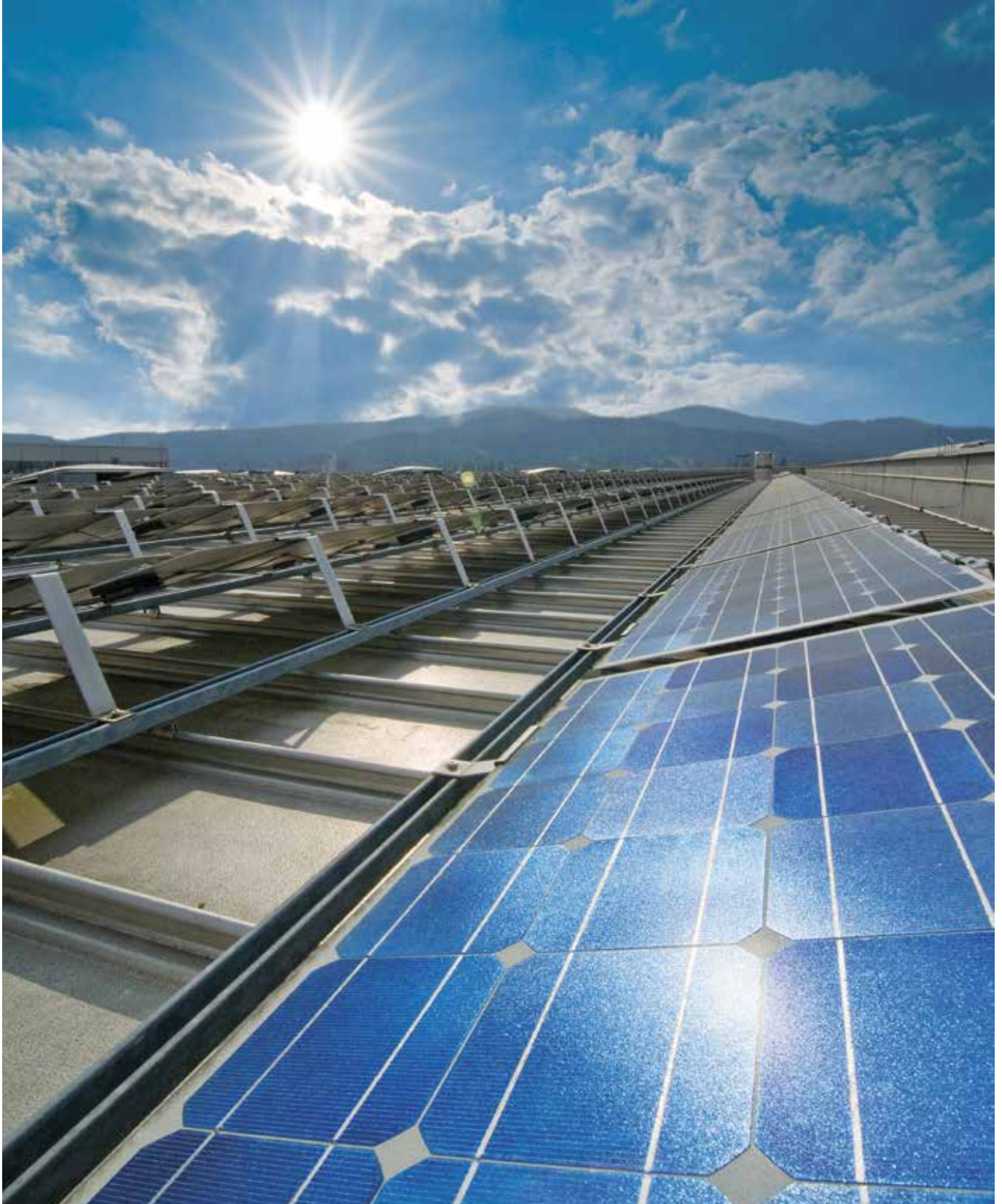
## Multimedia Course Consolidates the Experiment



### Your benefits

- Theoretical knowledge and practical know-how are conveyed using the UniTrain-I multimedia course
- Complete equipment set including all relevant components
- PC-supported evaluation of measurement data
- System operates with secure extra-low voltage of 12 V
- System supports fault simulation
- Course duration: 4.5h approx.

# Advanced Photovoltaics



## Project Work with Industrial Components

The training system permits realistic simulation of paths taken by the sun. Emulators make it possible to conduct practical experiments in the laboratory without the sun.

Permitting PC-supported evaluation of measurement data, the advanced photovoltaics multimedia course is designed to convey both theoretical information and practical know-how.



Sample experiment "Advanced photovoltaics" EPH 2

### Training contents

#### Investigating solar modules

- Testing the optimum alignment of solar modules
- Recording the characteristics of solar modules
- Investigating response to partial shading
- Investigating how bypass diodes operate
- Learning about various types of wiring for solar modules

#### Setting up photovoltaic systems for off-grid operation

- Installing PV systems
- Setting up and testing an off-grid PV system in direct mode

- Setting up and testing an off-grid PV system in storage mode
- Setting up and testing an off-grid PV system for generating 230-V alternating voltage

#### Setting up photovoltaic systems for grid-parallel operation

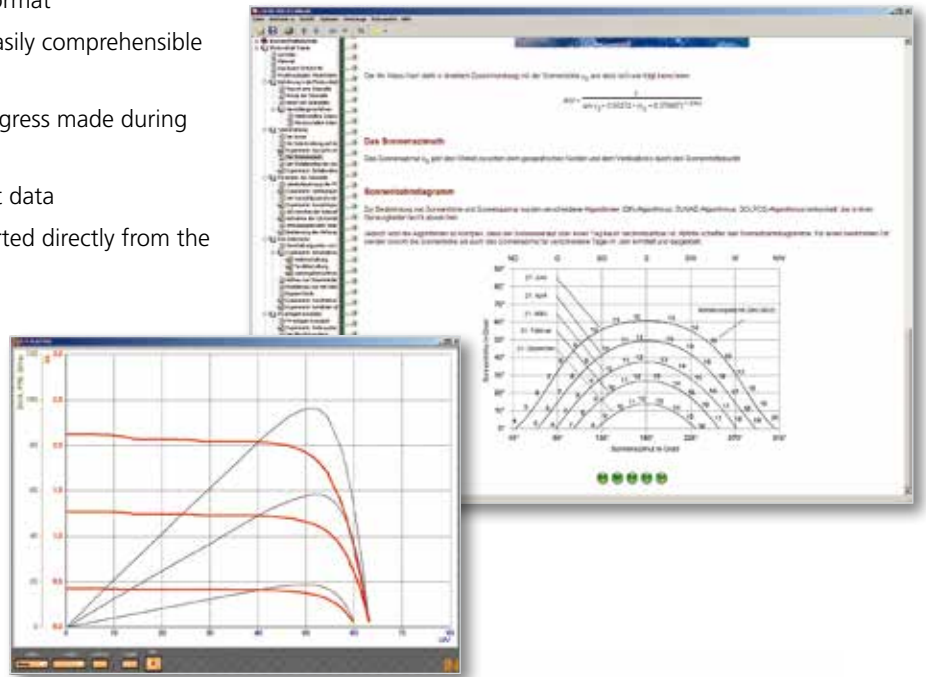
- Installing, setting up and testing a PV system with network feed
- Measuring the energy produced by a PV system
- Determining a grid-connected inverter's efficiency
- Investigating a PV system's response to a power outage on the electricity grid

# Advanced Photovoltaics

## A Little Sunshine for Your Lab

### Interactive Lab Assistant

- Step-by-step instructions in multimedia format
- Explanation of physical principles using easily comprehensible animations
- Quiz and assessment tools for testing progress made during the course
- PC-supported evaluation of measurement data
- Virtual measuring instruments can be started directly from the experiment manual



### Solar module with altitude emulator

- The sun's angle can be adjusted as a function of position (latitude), date and time
- The solar module's inclination can be adjusted
- 10-W polycrystalline solar module
- 500-W halogen lamp with dimmer
- Realistic emulation of the sun's path



EPH 2 equipment set  
Lucas-Nülle

# Professional Photovoltaics

## Modern Photovoltaic Systems Operating Parallel to the Grid

The design of photovoltaic systems operating in parallel with the electric power grid is realistic. In order to stabilise the electricity grid, the techniques of derating the power inverter and controllable local transformers are used. Knowledge and practical skills along with computer-based assessment of measured data are made possible by the advanced photovoltaics multimedia course along with SCADA Power Lab software.



Example experiment: "Setup for photovoltaic systems operating parallel to the grid" EPH 3



### Training contents

#### Investigation of solar modules

- Recording of module response over days and years
- Testing optimum alignment of solar modules (to increase energy output)
- Recording characteristics of solar modules

#### Configuration of photovoltaic systems to operate in parallel with the power grid

- Measurement of energy generated by photovoltaic systems
- Limiting the power of the photovoltaic inverter (derating)
- Determining the efficiency of the power grid inverter

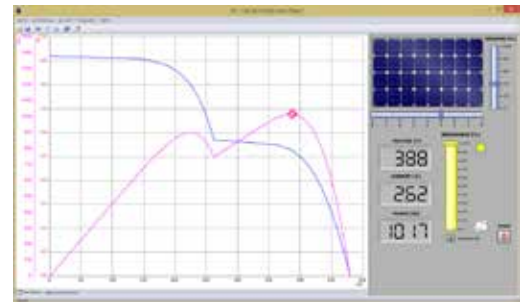
- Response to control of the power grid inverter, MPP Tracking
- Recording output data using sun passage emulator
- Investigating the response of a photovoltaic system when there is a power outage on the grid
- Economic benefits of photovoltaic systems

#### Voltage control in a local power grid

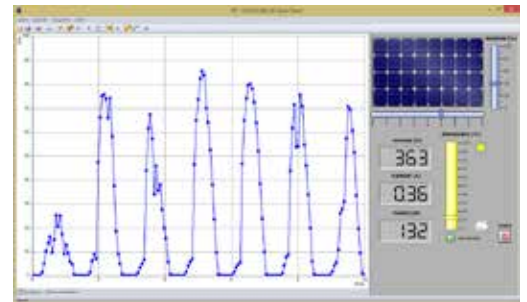
- Local-area network transformer
- Limiting the power of the photovoltaic inverter (derating)
- Automatic voltage control in a local power grid
- Operation and monitoring using SCADA

# Professional Photovoltaics

## Emulation of solar illumination via solar emulator

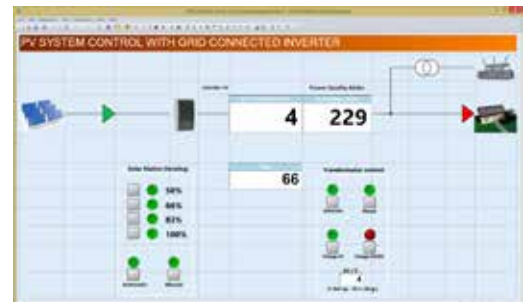


*Photovoltaic emulator with shadow*



*Sunshine over the course of a week*

## Industrial inverter for photovoltaics with SCADA control



*SCADA with derating of photovoltaic inverter*

### Your benefits

- Solar illumination emulator
- Latest technology featuring derating
- 3-phase feed into electricity grid
- Operation, observation and control via SCADA
- Use of industrial components
- Provision of reactive power
- Teaching via "Interactive Lab Assistant" course
- Flexible experimenting thanks to actual solar module or solar emulation

## Investigation of battery storage units in conjunction with photovoltaic systems

An electrochemical energy storage device with a photovoltaic system is intended as a means of shifting or transferring power generation to periods of consumption or peak consumption periods to power generation periods. For this purpose, existent and available (solar) energy must be generated and subsequently stored so that it can be used in times of energy demand. The most important objectives of an electrochemical energy storage device are therefore:

- To increase own or private consumption
- To ensure dependable supply through backup power



### Training contents

- Design and installation of the battery storage unit
- Putting the storage unit into operation
- Interaction between PV systems and storage units
- Boosting intrinsic consumption thanks to energy storage units