LUCAS-NÜLLE

Training Systems for Renewable Energies

Acquiring Practical Skills and Project-oriented Expertise

Qualifications through Quality

Inexhaustible, sustainable, real – the future is green

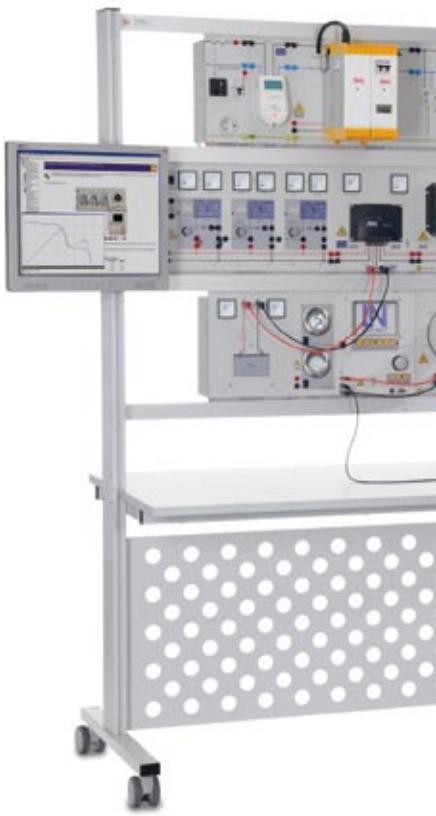
The move away from coal, oil and nuclear power to renewable forms of energy is gaining momentum. Today, technology has evolved to a point where solar energy, wind power, hydrogen fuel and biomass can be exploited as environmentally friendly energy sources. In order to sustain this trend, the search is on to find and train well-qualified technical staff worldwide.

Bright outlook with photovoltaics

- Abu Dhabi has announced it will invest about two billion US dollars in technology for manufacturing thin-film photovoltaic modules in Masdar.
- The USA's largest solar power plant with a rated output of 25 megawatts is being established in Silicon Valley.
- Photovoltaic facilities capable of generating a total of five gigawatts have already been realized in Germany. This output is equivalent to that of five modern power-plant units. By 2020, photovoltaic power generation capacity is to be increased gradually to 40 GW.

A clean future with wind energy

- Forecast for Germany: By 2030, 25% of electricity will be produced by means of wind power.
- A 3.0-megawatt wind farm annually saves 13,000 barrels of oil or 10,000 tons of CO_2.



Fuel cells –
Long-term energy storage elements

- Used widely as a standby power source
- Used in zero-emission vehicles
- Used by co-generation units

Lucas-Nülle training systems –
The guarantee for a successful future

Technologies are continuing to change rapidly, as are related requirements for training. Lucas-Nülle has the training systems to meet increasingly complex educational demands. In the area of renewable energy sources, these systems include:

- UniTrain-I "Photovoltaics"
- Training panel system "Advanced Photovoltaics"
- UniTrain-I "Fuel cell technology"
- Training panel system "Advanced fuel cell technology"
- Training panel system "Small wind plants"
- Training panel system "Wind plants with double-fed asynchronous generator"

Photovoltaics

Sunny prospects with the photovoltaics course

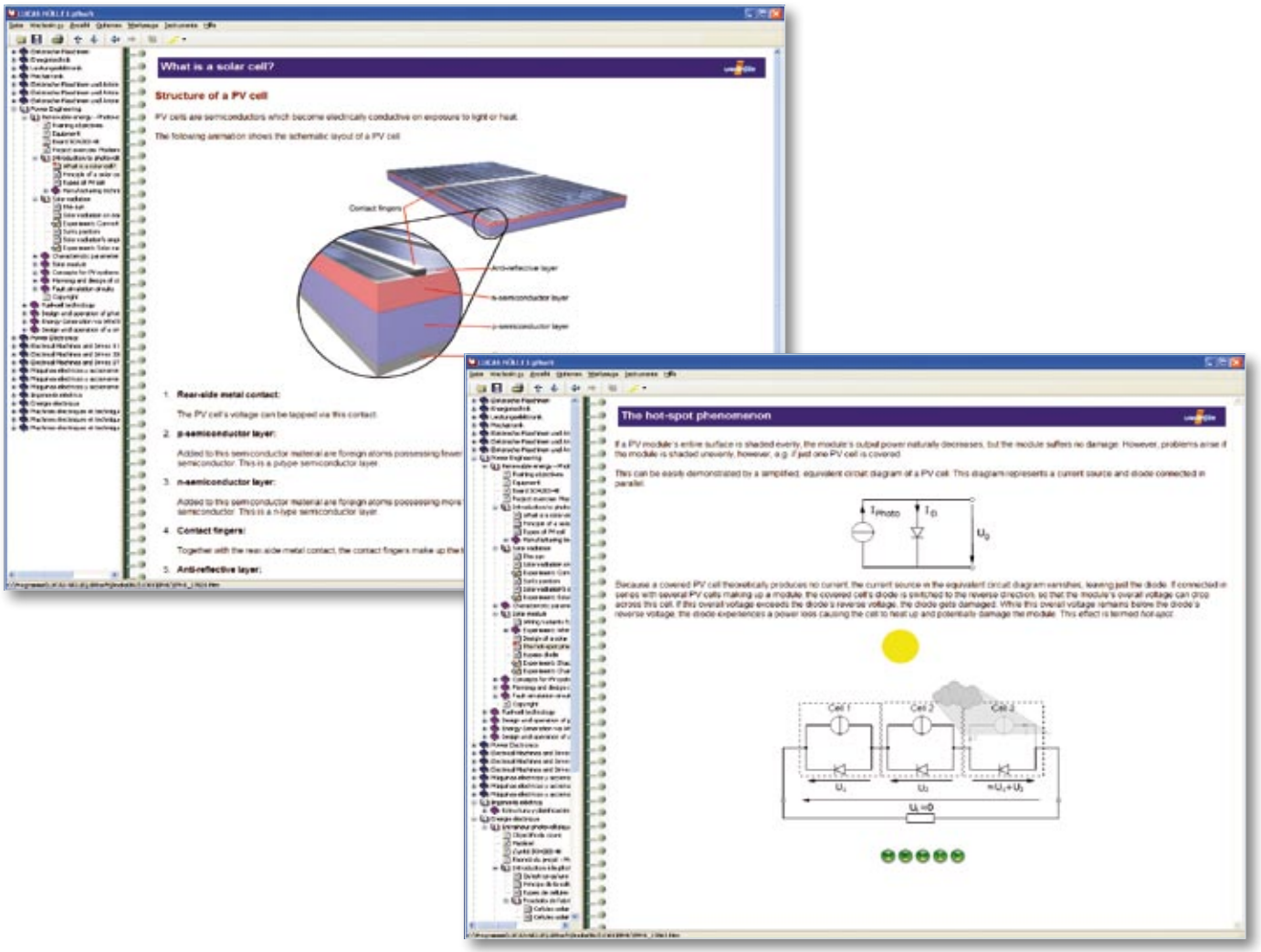
In times of soaring energy costs and increased environmental awareness, photovoltaic technology constitutes a very interesting alternative to traditional power generation. With the photovoltaics course, you can learn and investigate not only the basics of solar cells but it also offers you the opportunity of simulating a photovoltaic system for direct or standalone operation.

UniTrain SYSTEM

Training contents

- Functional and operating principles of solar cells
- Recording the characteristics of a solar cell
- Dependency of I and V on temperature, irradiance and angle of incidence
- Series, parallel and other circuits for solar cells
- Manufacture of solar cells
- Various types of solar cell
- Design of a rechargeable solar cell
- Various types of solar plant
- Set-up of an off-grid power system with solar cells

Multimedia course consolidates the experiment



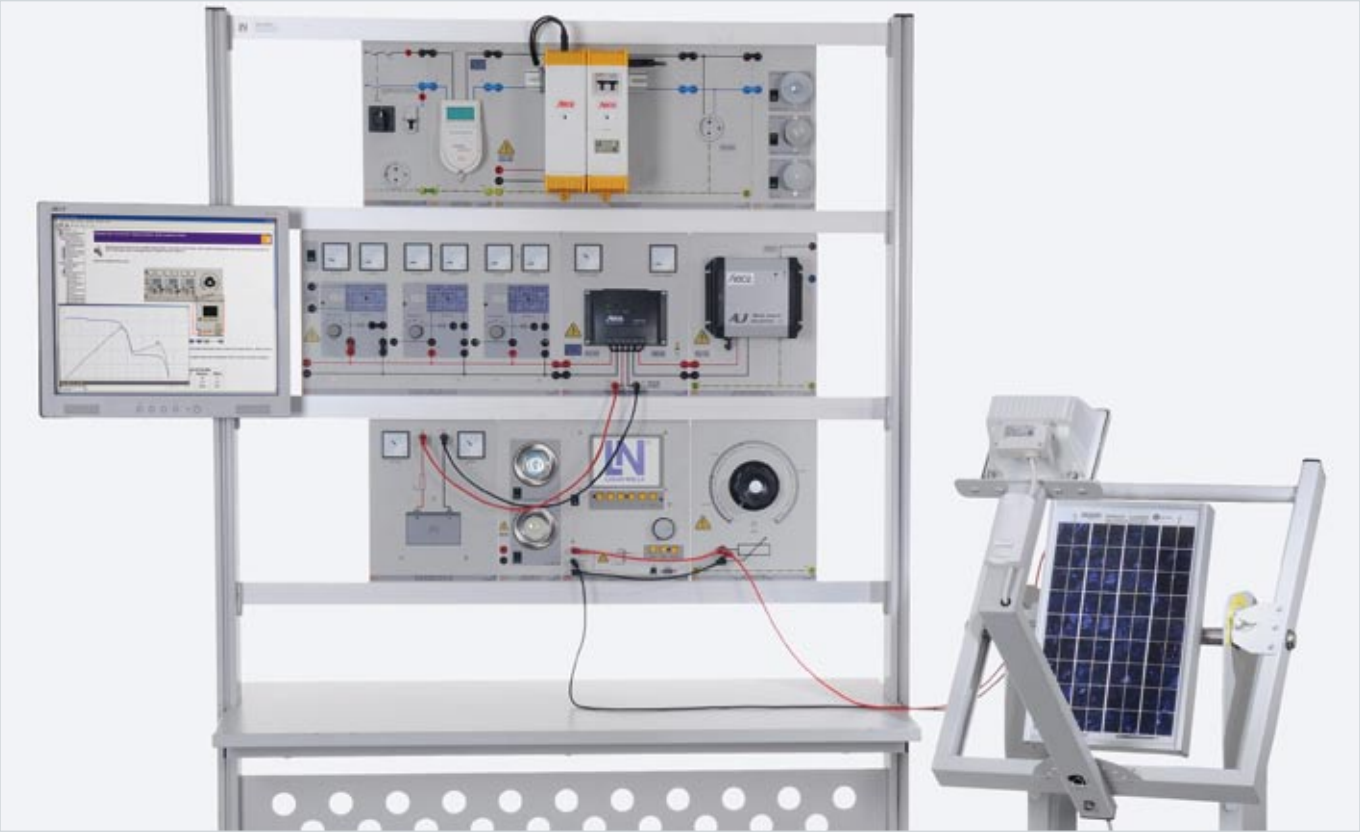
Your benefits

- Theoretical knowledge and practical know-how is conveyed using the UniTrain-I-multimedia
- Basic equipment set for operation
- PC-supported evaluation of measurement data
- System operates with 12 V
- System supports simulation of faults

Advanced Photovoltaics

Project work with industrial components

The training system permits realistic simulation of the progression of the sun. Emulators make it possible to carry out the experiments in the laboratory without the sun.
The Advanced Photovoltaics multimedia course is designed to convey both theoretical information and practical know-how, and performs the PC-supported evaluation of measurement data.



Sample experiment: "EPH2 Advanced Photovoltaics"

Training contents

Investigating solar modules
- Testing the optimum alignment of solar modules
- Recording the characteristics of solar modules
- Investigating the modules' response to shadow formation
- Investigating how bypass diodes operate
- Learning about various types of wiring and connection configurations for solar modules

Set-up of PV systems in standalone operation
- Installation of PV systems
- Set-up and test of an off-grid PV system in direct operation
- Set-up and test of an off-grid PV system in storage operation
- Set-up and test of an off-grid PV system for the generation of 230 V AC voltage

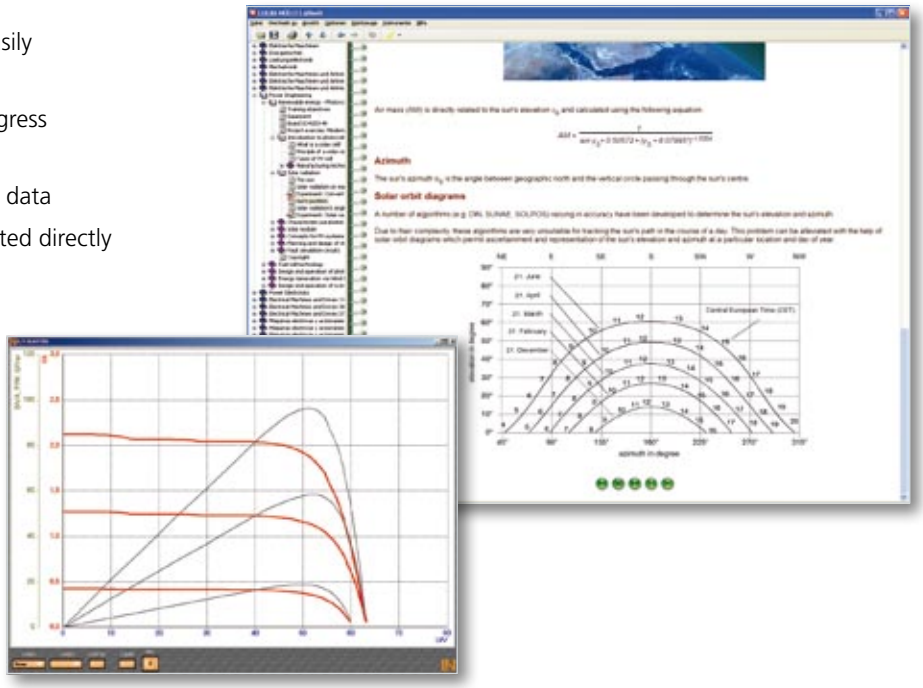
Set-up of PV systems in parallel mains operation
- Installation, set-up and test of a PV system with mains power feed
- Measure generated power of a PV system
- Determine efficiency of the grid-connected inverter
- Investigate response of a PV system to mains failure

Advanced Photovoltaics

A little sunshine for your lab

"Interactive Lab Assistant"

- Multimedia step-by-step instructions
- 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



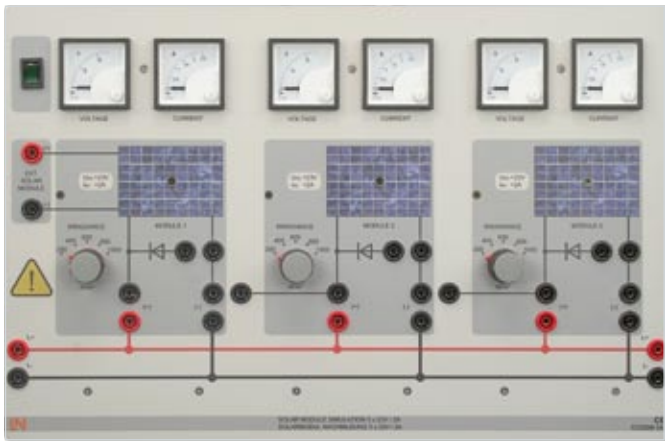
Solar module with altitude emulator

- 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

Solar emulator

- Three independent solar emulators permit experiments even without sunlight
- Adjustable light intensity for each emulator
- Bypass diodes are included for connection into the circuits
- 120 VA power



Industrial components

- Solar charge controller
- Off-grid inverter
- Grid-connected inverter
- Simple operation and investigation of industrial components

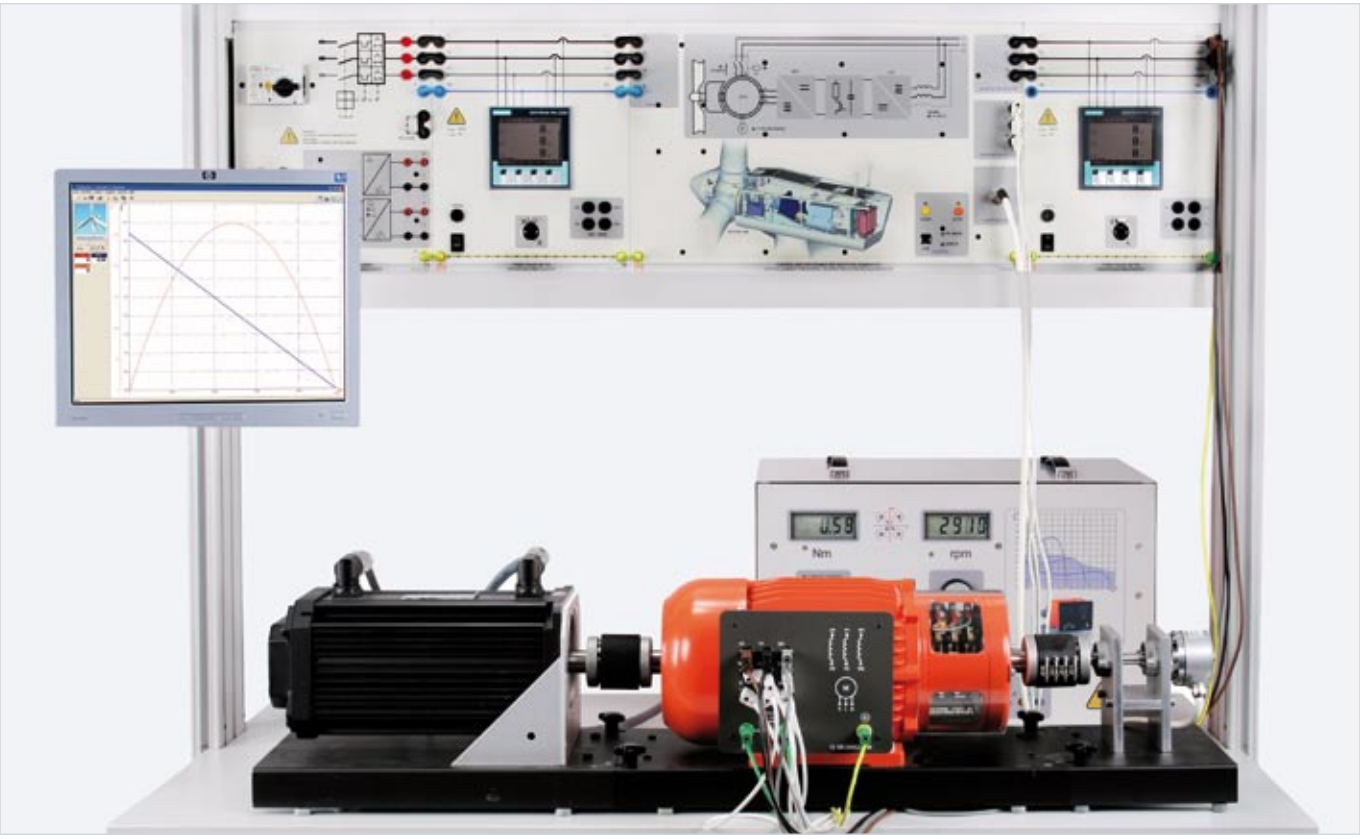
Your benefits

- Theoretical knowledge and practical know-how is conveyed using the "Interactive Lab Assistant" multimedia course
- Use of industrial components
- Flexible experimentation by means of a real solar module or solar simulation model
- PC-supported evaluation of measurement data

Wind Power Plants

Double-Fed Induction Generator (DFIG)

This equipment set is designed for investigating modern wind power plants incorporating double-fed asynchronous generators. The wind can be emulated realistically by means of a servo-machine test stand and "WindSim" software. A PC can be connected for convenient operation and visualization during the experiments. The associated multimedia course titled "Interactive Lab Assistant" imparts theory besides supporting experiment procedures and evaluation of measurement data.



Sample experiment: "Wind power plant" EWG 1

Training contents

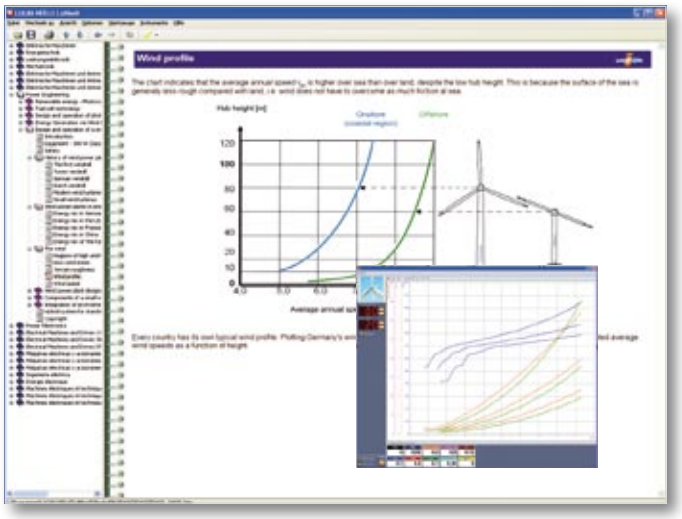
- Understand the design and operation of modern wind power plants
- Explore the physical fundamentals "from wind to shaft"
- Learn about different wind power plant concepts
- Set up and put into operation a double-fed asynchronous wind generator
- Operate the generator at varying wind force levels and regulate the output voltage and frequency
- Determine optimum operating points under changing wind conditions
- Investigate the operating response during mains malfunctions fault ride-through

Wind Power Plants

Fresh wind in the laboratory

"Interactive Lab Assistant"

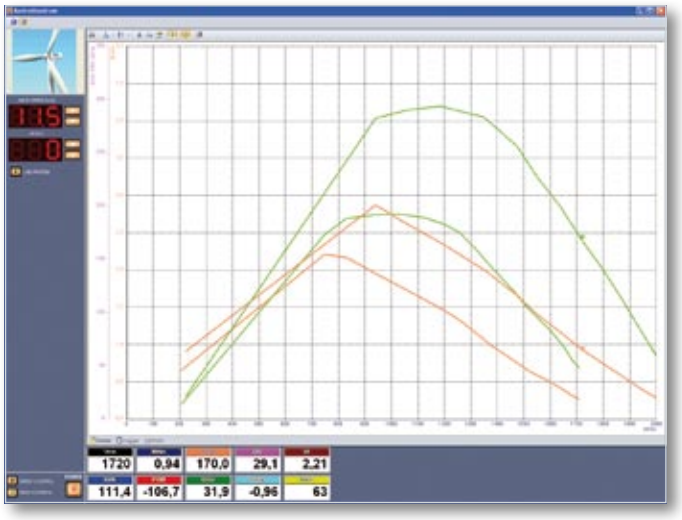
- Multimedia step-by-step instructions
- Explanation of physical principles using easily comprehensible animations
- Quiz and assessment tools for testing progress made during the course
- PC-supported evaluation of measurement data
- Virtual measuring instruments can be started directly from the experiment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



Wind emulator

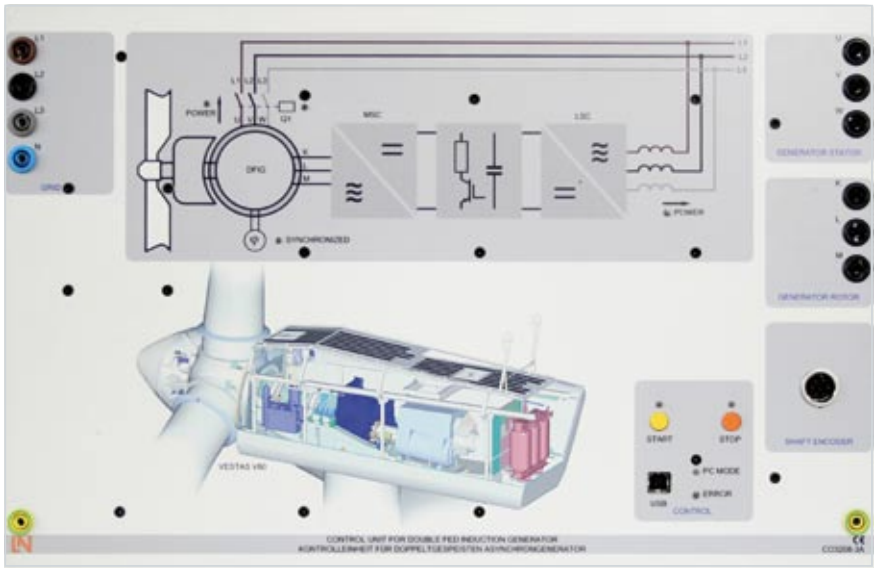
Wind and airfoil geometry serve to drive the generators at a real wind power plant. In the laboratory, this task is performed instead with the help of a servo-machine test stand and "WindSim" software. This permits precise laboratory simulation of conditions prevailing at a real wind power plant.

- Realistic emulation of wind and airfoil geometry
- Speed and torque are matched automatically to wind strength and pitch
- Independently adjustable pitch and wind strength
- Wind profiles can be specified
- Mechanical and electrical variables can be recorded



Double-fed asynchronous generator with measuring instrument

- Control unit with two controlled inverters
- Generator control in sub-synchronous and super-synchronous modes
- Integrated power switch for connecting the generator to the network
- Automatic control of active and apparent power, frequency and voltage
- Manual and automatic synchronization
- Measurement and display of all system variables
- Fault ride-through experiments



Your benefits

- Theoretical knowledge and practical know-how is conveyed using the "Interactive Lab Assistant" multimedia course
- Wind power and mechanical design of wind power plants can be emulated with precision using the servo machine test stand
- The microcontroller-operated control unit for the double-fed asynchronous generator permits user-friendly operation and visualisation during experimentation
- Use of up-to-date technology with fault ride-through

Small Wind Power Plants

Decentralized electricity supply

Small wind power plants producing up to 5 kW of are being deployed today for decentralised power supplies. These plants generate DC voltage. The energy can be stored in accumulators using charge controllers. AC voltages are generated via inverters for operation of loads connected to a grid.
The effects of wind power and the mechanical design of wind power plants can be emulated down to the last detail using the servo machine test stand and the "WindSim software".

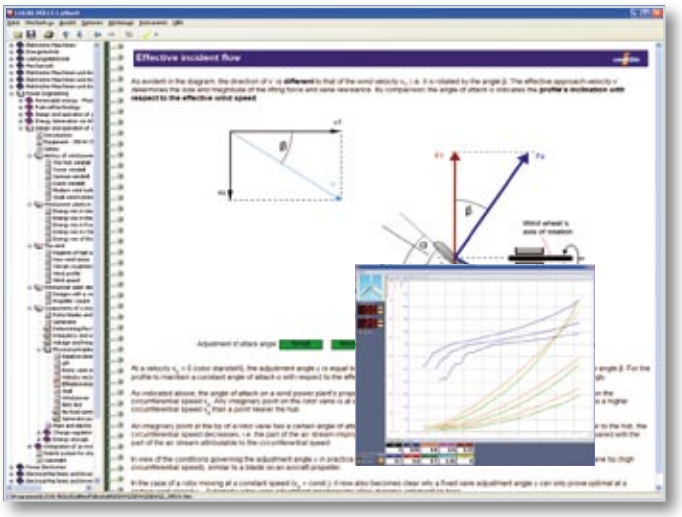
Sample experiment: "Small wind power plant" EWG 2

Training contents

- Understand the design and operation of modern small wind power plants
- Explore the physical fundamentals "from wind to shaft"
- Become familiar with different wind power plant concepts
- Set-up and put into operation a small wind power generator
- Operation with varying wind force levels in offline operation
- Energy storage, optimisation of the system
- Set-up of a standalone system for the generation of a 230-V AC voltage
- Explore hybrid systems for autonomous power supply using wind power and photovoltaic systems

"Interactive Lab Assistant"

- Multimedia step-by-step instructions
- 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



Synchronous generator

- Wind power and mechanical design of wind power plants can be emulated with precision using the servo machine test stand
- Same generator in laboratory as in the real wind power plant
- Using the real wind power plant outside

Your benefits

- Theoretical knowledge and practical know-how is conveyed using the "Interactive Lab Assistant" multimedia course
- Wind power and mechanical design of wind power plants can be emulated with precision using the servo machine test stand
- The generator responds the same way in the laboratory as it does in the real plant
- Real small wind power plant suitable for outdoor operation

Fuel Cell Technology

Design and operation of fuel cells

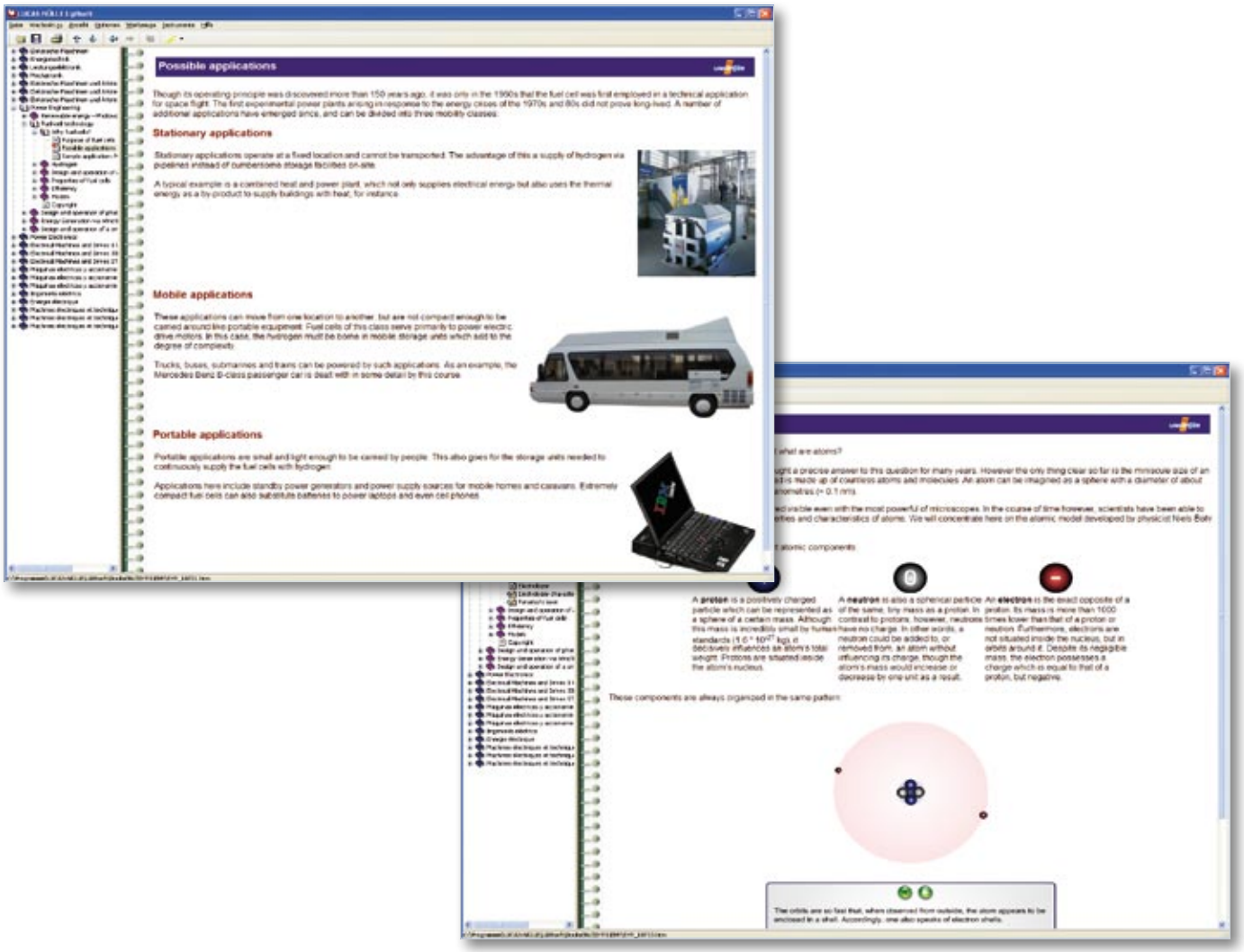
Renewable energies are already considered a solution today for dealing with expected energy shortages in the 21st century. The hydrogen-based fuel cell is part of this solution. As a complementary technology, it will be used in future energy systems to generate clean energy from renewable hydrogen.

UniTrain SYSTEM

Training contents

- Functional and operating principles of fuel cells
- Recording the characteristics of a fuel cell
- Learn to explain the electrochemical processes of electrolysis (Faraday's first and second laws)
- Faraday's laws and determining the energy efficiency of a fuel cell
- Series and parallel configuration of fuel cells
- Considerations regarding the power of fuel cells
- Functional and operating principles of electrolysers
- Recording the VI characteristic of the electrolyser
- Faraday's laws and determining the energy efficiency of an electrolyser

Multimedia course consolidates the experiment



Your benefits

- Theoretical knowledge and practical know-how is conveyed using the "Interactive Lab Assistant" multimedia course
- Compact device with PEM double fuel cell and PEM electrolyser with gas storage device
- Safe handling of hydrogen
- 2-V/2.5-A power supply for supplying electrolyser already integrated
- A variety of loads (lamps, ventilator)
- Variable load for characteristic recording

Advanced Fuel Cell Technology

Independent electricity supply with fuel cell

The generation of electrical energy using fuel cells continues to develop into a significant area with diverse application potential in electrical engineering and automotive technology. The training panel system permits a safe experimenting environment in connection with hydrogen and fuel cells. At the same time, it permits interesting investigations and is well suited for both practical lab work as well as demonstrations. Animated theory, experiment guidelines and information including results are realised using the "Interactive Lab Assistant".

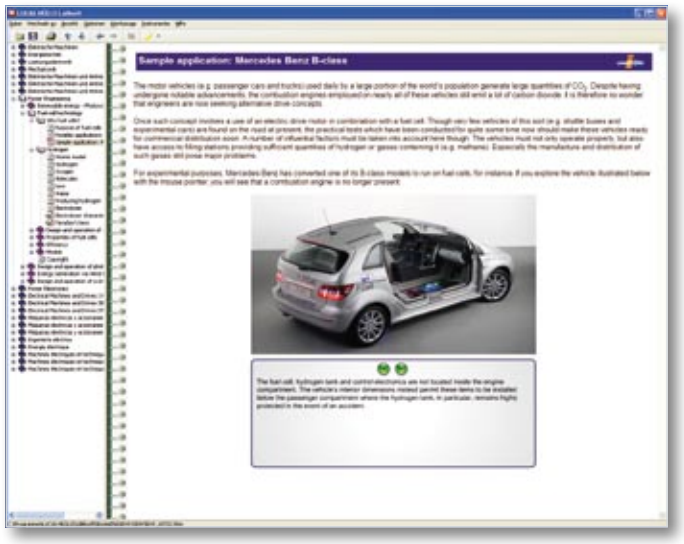
Sample experiment: "50-VA fuel cell stack with loads" EHY1

Training contents

- Design and operation of a fuel cell
- Design and operation of an electrolyser
- Design and operation of a metal hydride storage cell
- Thermodynamics of the fuel cell
- Characteristics and power curves of the fuel cell
- Efficiency
- Required components for autonomous power supply
- Power electronics and voltage conversion

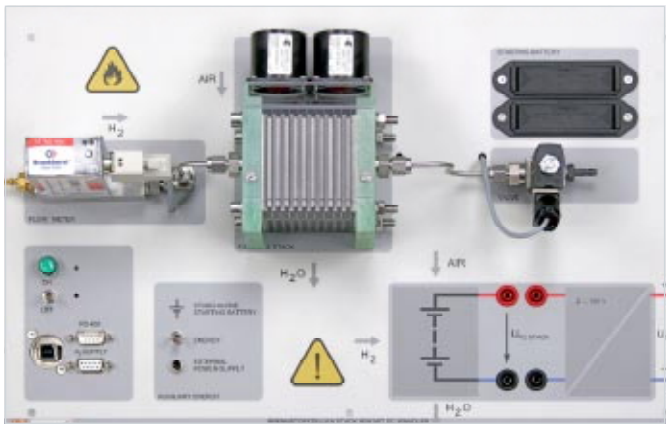
"Interactive Lab Assistant"

- Multimedia step-by-step instructions
- 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



Fuel cell stack

- 50-VA stack
- Hydrogen supply flow meter
- Variable-speed fan for fuel cell ventilation
- Measurement of all relevant variables



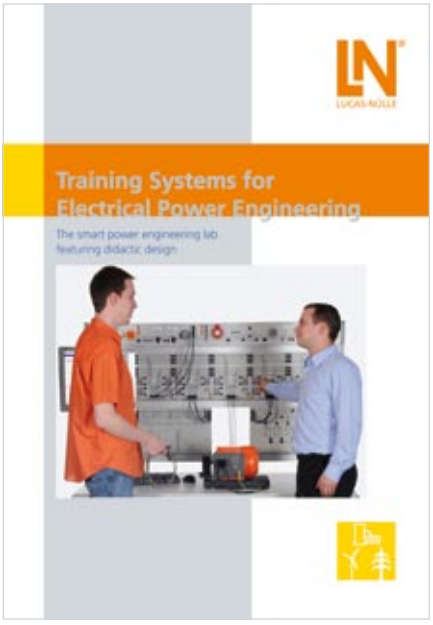
50-VA fuel cell stack

Your benefits

- Theoretical knowledge and practical know-how is conveyed using the "Interactive Lab Assistant" multimedia course
- Simple introduction to the subject of fuel cells
- Safe experiments using hydrogen
- 50-VA fuel cell stack
- Connection terminal for hydrogen storage device
- High-performance electrolyser
- A variety of loads
- Variable load for characteristic recording

Lucas-Nülle
Lehr- und Meßgeräte GmbH

Siemensstrasse 2 · D-50170 Kerpen-Sindorf
Telephone: +49 2273 567-0 · Fax: +49 2273 567-39
www.lucas-nuelle.com



Further information can be found in our Power Engineering catalogue.

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