LUCAS-NÜLLE

Training Systems for Renewable Energies

Acquiring Practical Skills and Project-oriented Expertise

2nd Edition

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 giga-watts 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

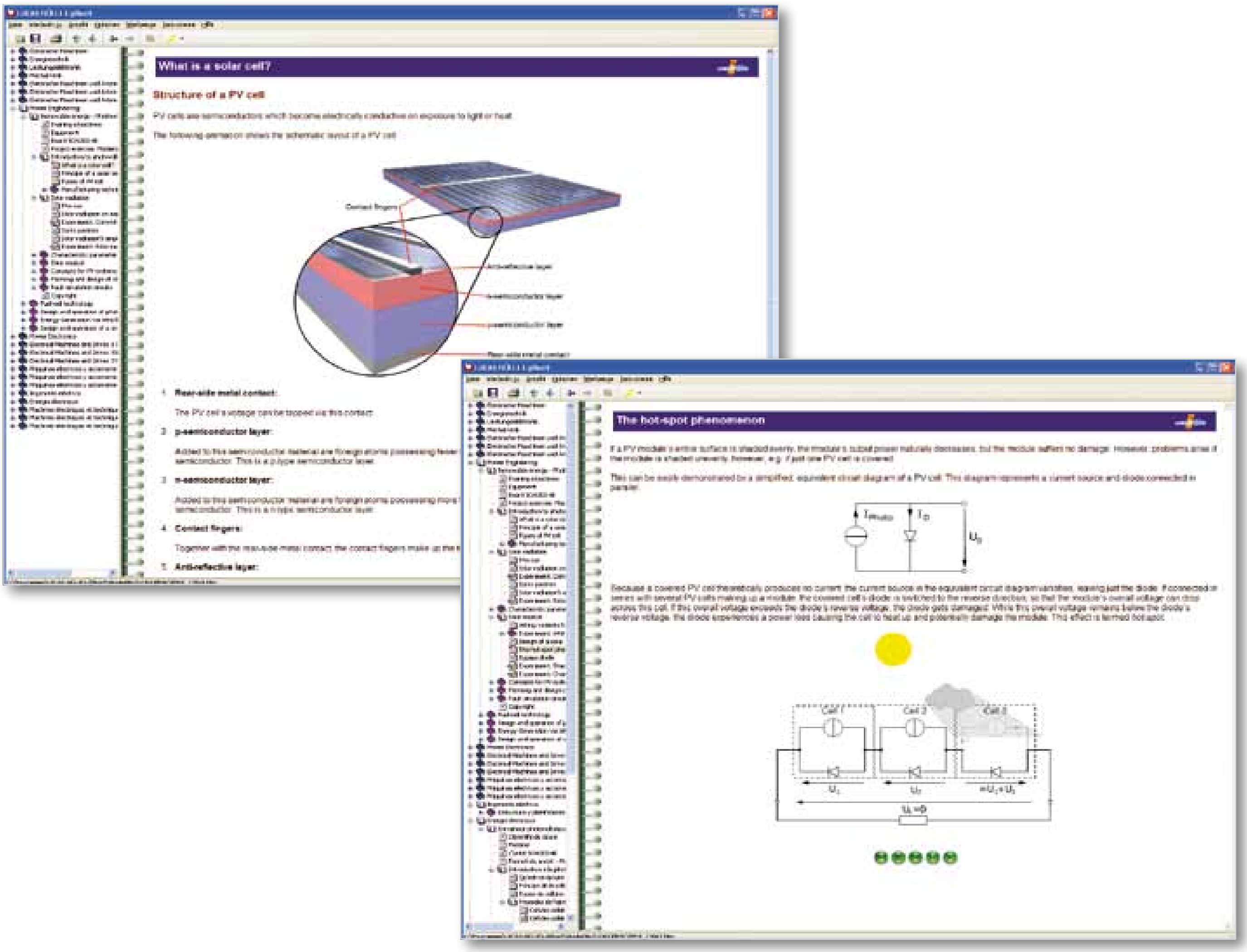
In times of soaring energy costs and increased environmental awareness, photovoltaic technology constitutes a very interesting alternative to traditional power generation. With the photovoltaics course, you can not only research the fundamentals of solar cells, but also simulate operation of a photovoltaic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

UniTrain SYSTEM

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 rechargeable solar cell
- 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 12 V
- System supports fault simulation

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

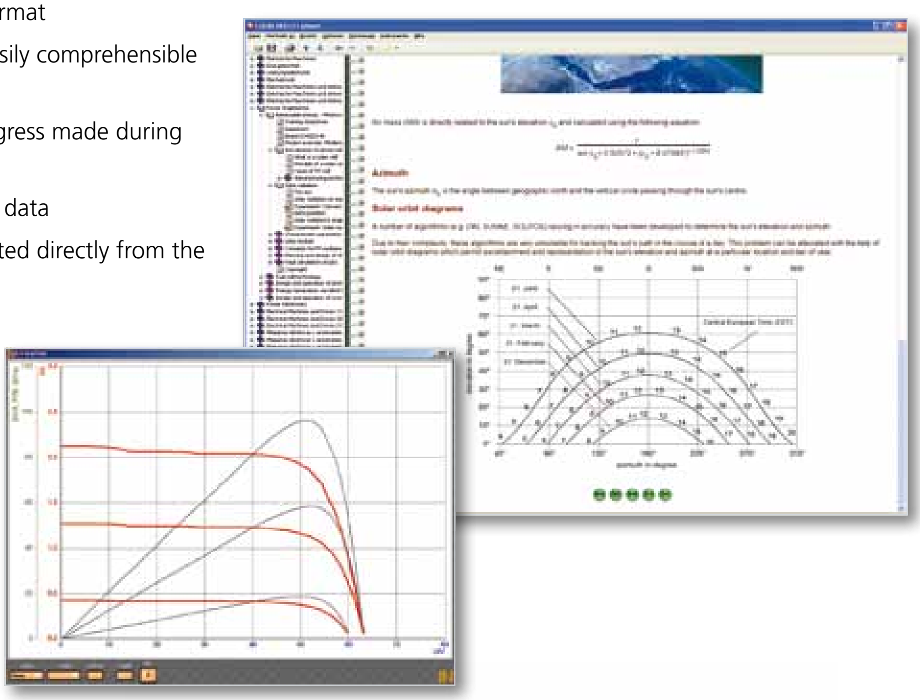
- Installing, setting up and testing a PV system with network feed
- Measuring the energy produced by a PV system
- Determining a grid-connected inverter's efficiency
- Investigating a PV system's response to mains failure

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

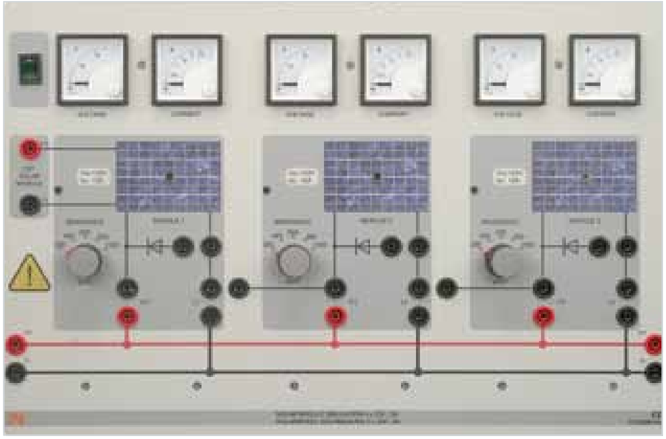


Solar module with altitude emulator

- 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

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 are conveyed using the Interactive Lab Assistant
- Use of industrial components
- Flexible experimentation by means of a real solar module or solar simulation model
- PC-supported evaluation of measurement data
- Integration into energy technology systems

Wind Power Plants

Double-fed Induction Generator (DFIG)

This equipment set is designed for investigating modern wind power plants incorporating double-fed induction 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

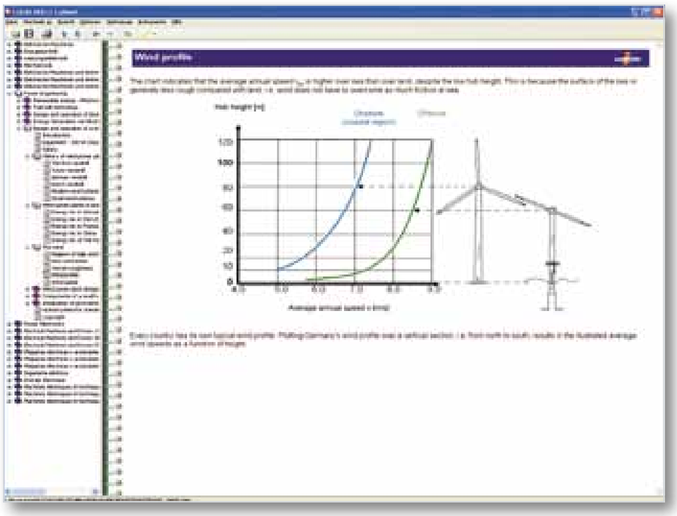
- Understanding the design and operation of modern wind power plants
- Exploring physical fundamentals from "wind to shaft"
- Learning about different wind power plant concepts
- Setting up and operating a double-fed asynchronous wind generator
- Operating the generator at varying wind force levels as well as adjustable output voltages and frequencies
- Determining optimum operating points under changing wind conditions
- Investigating responses to "fault-ride-through" grid mal-functions

Wind Power Plants

Fresh Wind in the Laboratory

Interactive Lab Assistant

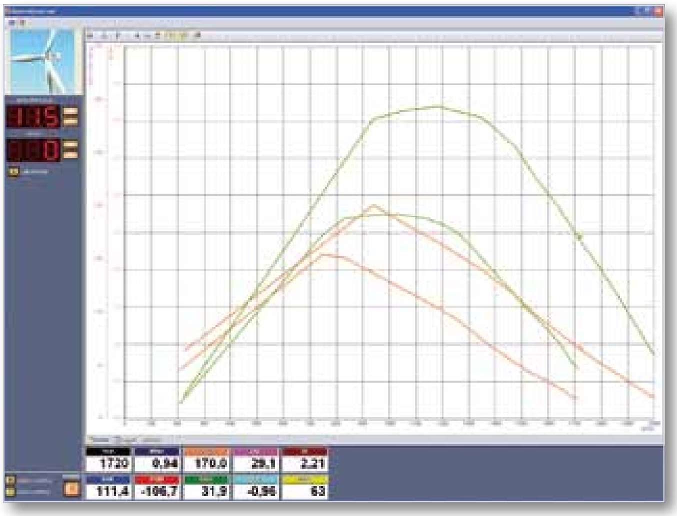
- Step-by-step instructions in multimedia format
- Explanation of physical principles using easily comprehensible animations
- Quiz and assessment tools for testing progress made during the course
- PC-supported evaluation of measurement data
- Virtual measuring instruments can be started directly from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



Wind emulator

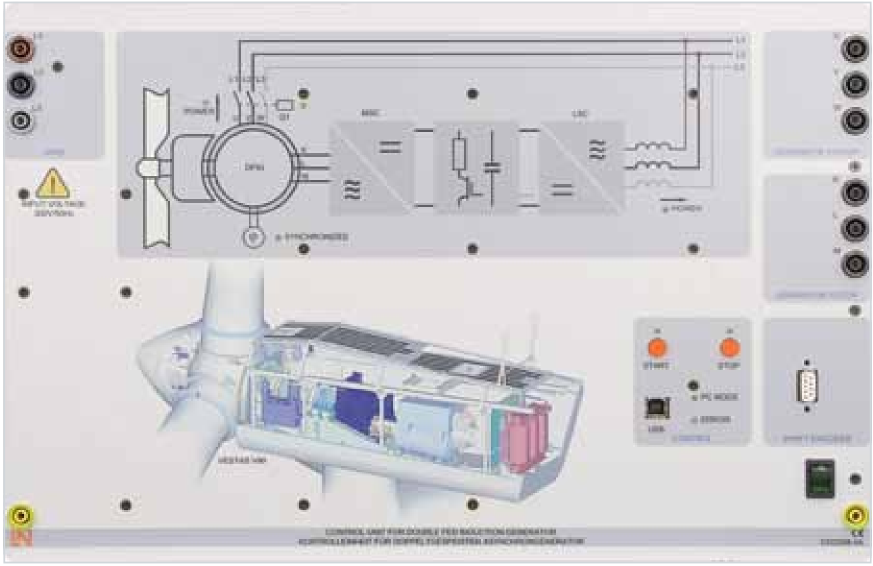
Wind and airfoil geometry serve to drive the generators at a real wind power plant. In the laboratory, this task is performed instead with the help of a servo machine test stand and "Wind-Sim" software. This permits precise laboratory simulation of conditions prevailing at a real wind power plant.

- 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 induction generator with control unit

- 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
- Experiments on fault-ride-through



Your benefits

- Theoretical knowledge and practical know-how are conveyed using the Interactive Lab Assistant
- Wind power and mechanical design of wind power plants can be emulated accurately and in detail using the servo machine test stand
- The microcontroller-operated control unit for the double-fed induction generator permits user-friendly operation and visualisation during experimentation
- State-of-the-art technology incorporating "fault-ride-through"
- Integration into energy technology systems

Small Wind Power Plants

Decentralized Electricity Supply

Small wind power plants with outputs ranging up to 5 kW are deployed today for decentralized electricity supply. These plants generate direct voltages. The energy can be stored in batteries via charge controllers. Inverters produce alternating voltages to supply electrical consumers in the 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

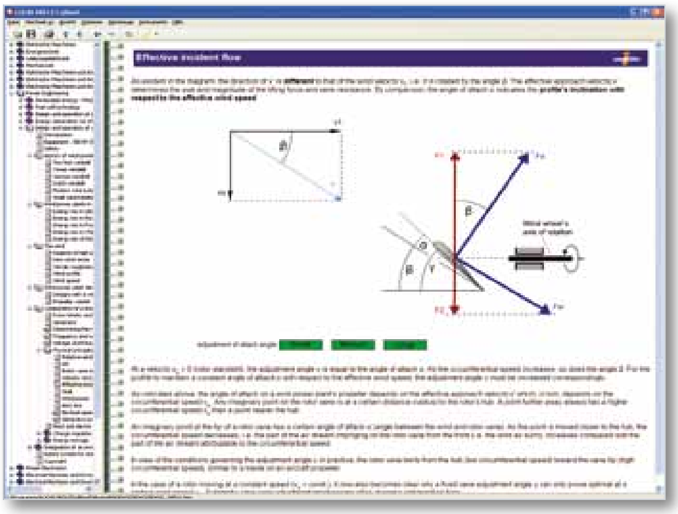
Training contents

- Understanding the design and operation of small, modern wind power plants
- Exploring physical fundamentals from "wind to shaft"
- Learning about different wind power plant concepts
- Setting up and operating a small wind power generator
- Operation at varying wind forces in storage mode
- Energy storage
- System optimization
- Setting up an off-grid system for generating 230-V alternating voltage
- Investigating hybrid systems for autonomous power supply using wind power and photovoltaic systems

Convincing Product Characteristics

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



Synchronous generator

- Wind power and mechanical design of wind power plants can be emulated accurately and in detail using the servo machine test stand
- The laboratory generator's response is identical to that of one forming part of a real system
- The small wind power plant is suitable for outdoor operation

Training contents

- Understand the design and operation of modern small wind power stations
- Explore the physical fundamentals "from wind to wave"
- Become familiar with different wind power station concepts
- Design and initial operation of a small wind power generator
- Operation with fluctuation wind force in offline operation
- Energy storage, optimisation of the system
- Design of an off-grid system for the generation of a 230V AC voltage
- Explore hybrid systems for off-grid power supply using wind power and photovoltaic systems

Fuel Cell Technology

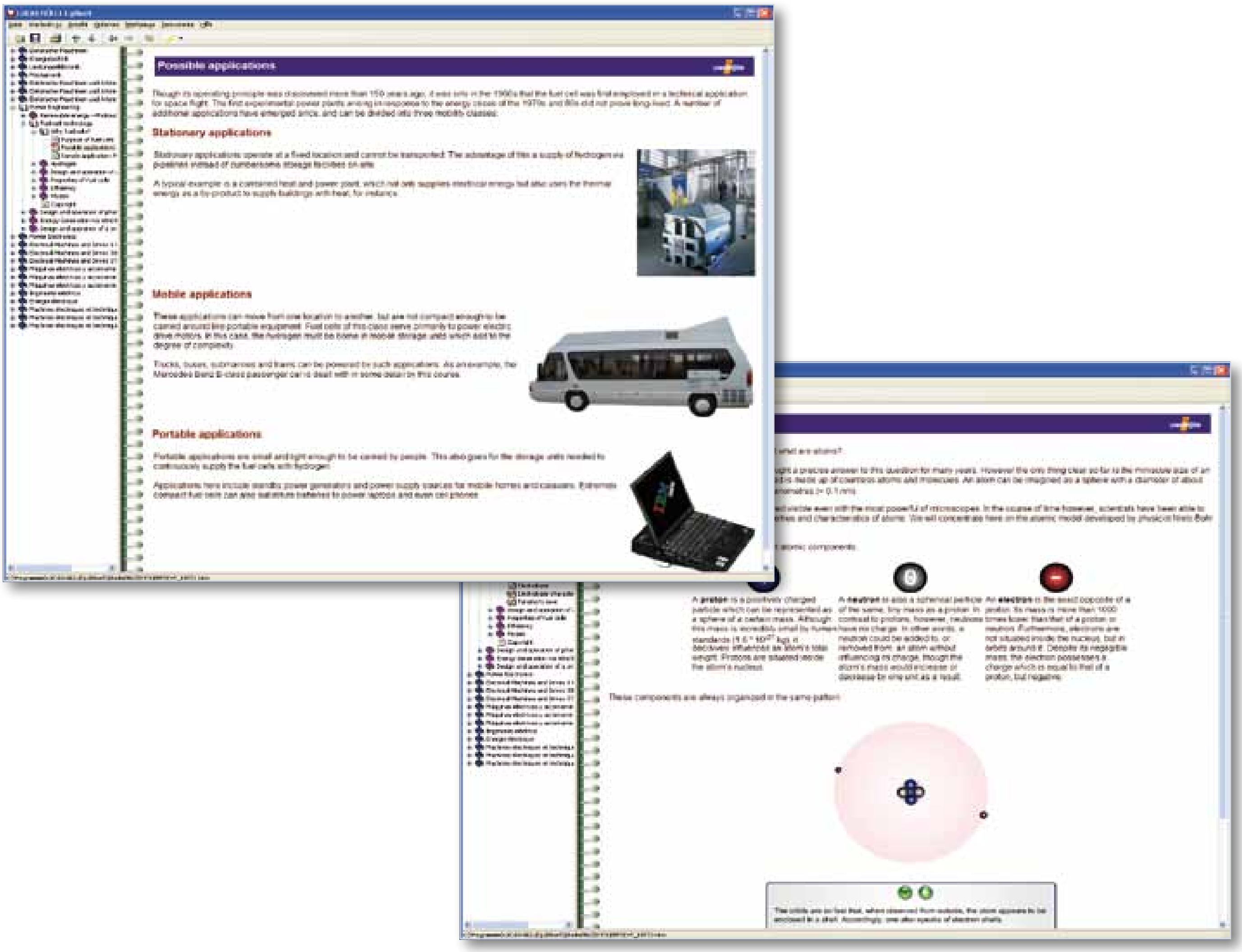
Design and Operation of Fuel Cells

Renewable energies are already considered a solution 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.

Training contents

- Functions and operating principles of fuel cells
- Recording the characteristics of a fuel cell
- Understanding the electrochemical processes of electrolysis (Faraday's first and second laws)
- Determining a fuel cell's Faraday and energy efficiencies
- Series and parallel connections of fuel cells
- Power aspects of fuel cells
- Functions and operating principles of electrolysers
- Recording an electrolyser's UI-characteristic
- Determining an electrolyser's Faraday and energy efficiencies

Multimedia Course Consolidates the Experiment



Your benefits

- Theoretical knowledge and practical know-how are conveyed using the Interactive Lab Assistant
- Compact device with PEM double fuel cell and PEM electrolyser including a gas storage element
- Safe handling of hydrogen
- 2V/2.5A for supplying power to the integrated electrolyser
- Diverse loads (lamps, fans)
- Variable load for recording characteristics

Advanced Fuel Cell Technology

Independent Electricity Supply with Fuel Cells

Generation of electrical energy using fuel cells continues to develop into a significant area with diverse potential applications in electrical and automotive engineering. Allowing safe handling of hydrogen and fuel cells, this experimentation system can be used for a number of interesting investigations and is suited for demonstrations as well as practical lab work. The "Interactive Lab Assistant" includes animated theory, experiment guidelines and result evaluation fields.

Sample experiment "50-VA fuel cell stack with loads" EHY 1

Training contents

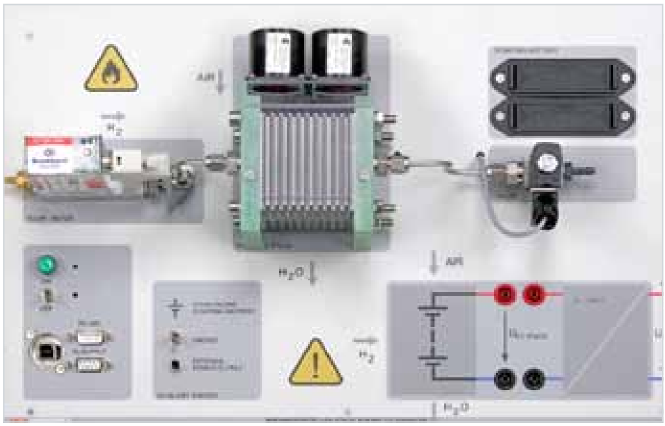
- Design and operation of a fuel cell
- Design and operation of an electrolyser
- Design and operation of a metal hydride storage cell
- Fuel cell's thermodynamics
- Fuel cell's characteristic and power curve
- Efficiency
- Components needed for autonomous power supply
- Power electronics and voltage conversion

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

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 are conveyed using the "Interactive Lab Assistant"
- Simple introduction to the subject of fuel cells
- Safe experimentation with hydrogen
- 50-VA fuel cell stack
- Connection for pressurized hydrogen tank
- High-performance electrolyser
- Wide variety of loads
- Variable load for recording characteristics

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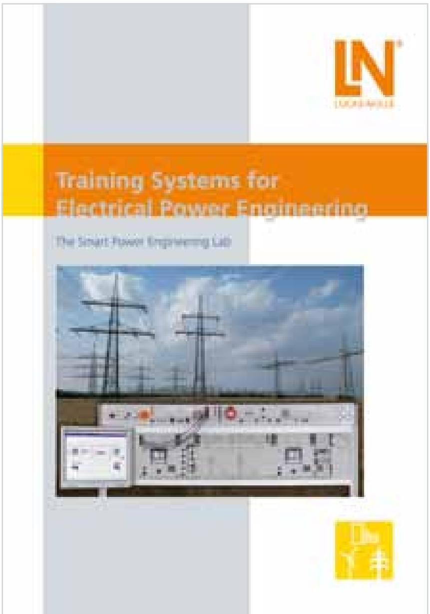

Further information can be found in our Power Engineering catalogue.

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