Lucas Nülle is proudly and exclusively
represented in Australia and New Zealand by

Training Systems Australia
First in Vocational Training Equipment
A Division of Pullman Learning Group

300 Centre Road, Bentleigh, Victoria, 3204
p: +613 9557 7993 e: info@trainingsystemsaustralia.com.au

LUCAS-NÜLLE

OPAL-RT TECHNOLOGIES

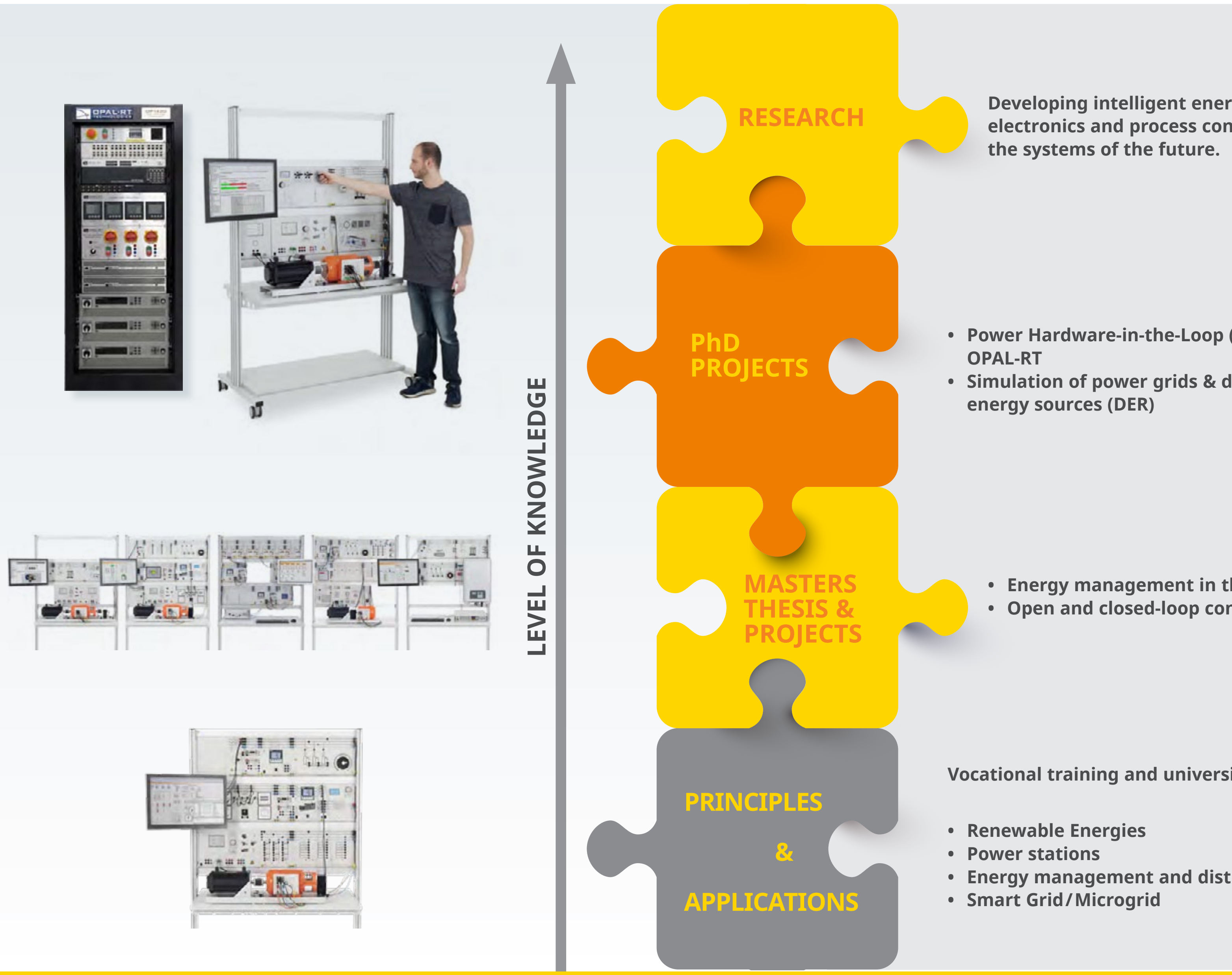
MATLAB® & SIMULINK®

# HARDWARE-IN-THE-LOOP

## A Training System for Renewable Energies in Smart Grids, Microgrids and PHIL

1st Edition

# FROM BASIC TRAINING TO RESEARCH




The training systems from Lucas-Nuelle are used to cover everything from basic principles up to research and development. That way, acquired know-how and applications developed with the training systems can also be seamlessly integrated into research projects. This means you can do research without having to bother with the cost-intensive and time-consuming business of learning new systems.

**Your benefits:**

- Fundamentals and applications with digital multimedia course
- Modular systems
- Rapid prototyping systems
- Hardware-in-the-Loop (HIL)
- Power Hardware-in-the-Loop (PHIL)

gy systems, power
ntrol software for

(PHIL) with

ecentralised

he Smart Grid/Microgrid with SCADA
ntrol with SCADA

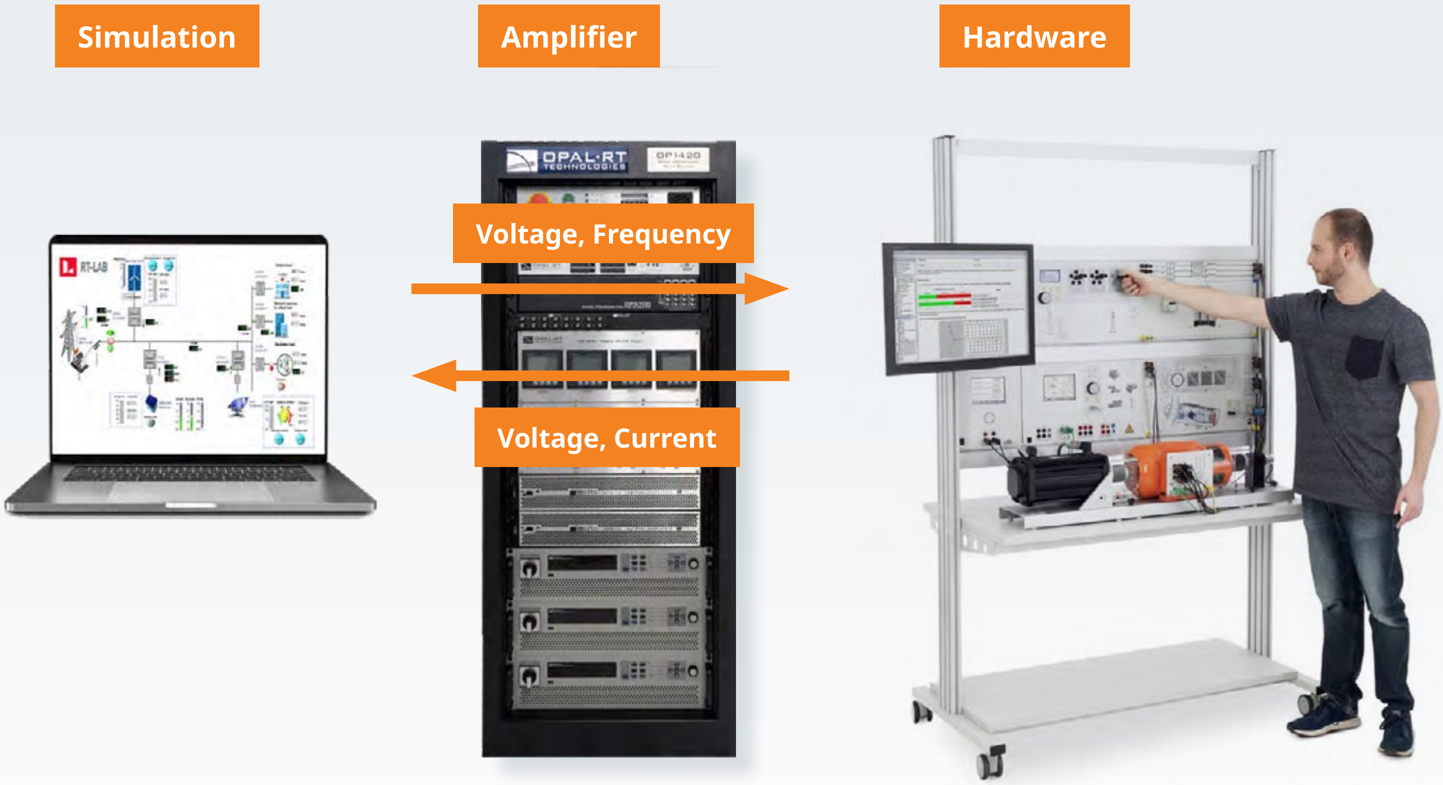
ity level

ribution

**Challenges facing power engineering**
New and innovative concepts are needed for system-stabilizing automatic controls and improved strategies for operating power systems.

**Power grid in transformation**
Renewable energies like wind power and photovoltaic systems are frequently based on inverter technology. With more and more renewable energy, the number of fossil-fuelled (large-scale) power stations with synchronous generators will decline. Thus the properties promoting system stabilization in synchronous machines that reduce mechanical inertia also permit reactive power to be made immediately available in large amounts during transient processes brought about by potential short-term overloading.

# POWER-HARDWARE-IN-THE-LOOP (PHIL)

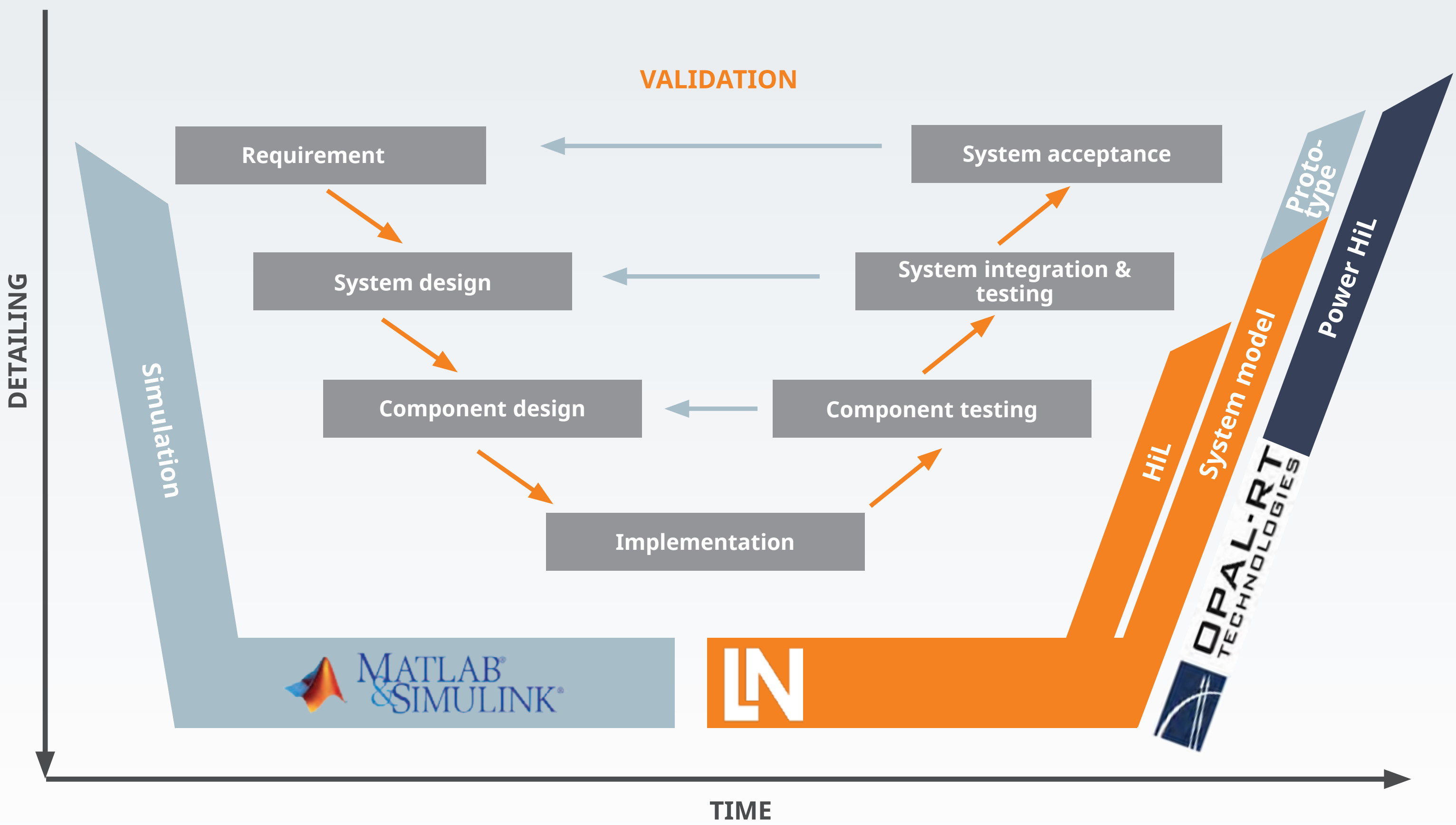



*Note: This image has been significantly simplified*

**Power-Hardware-in-the-Loop (PHIL)**

PHIL is an expansion of the Hardware-in-the-Loop (HIL) tests, in which the real-time simulation environment is able to exchange power with the DUT (device under test). The DUTs are connected to the simulator via a power amplifier which is controlled by the simulation.

- **Fast simulation of power grids, energy sources and distributed energy sources (DER)**
- **Development of energy systems, power electronics and process control software**
- **System validation prior to installation into productive systems**




**Using training systems in the research and development process**

Using simulations, many design choices can be made at the very beginning of the development phase. During implementation, these decisions have to be validated for quality assurance purposes.

**Benefits with Lucas-Nülle training systems**

- Modular system
- Simple configuration
- Rapid prototyping systems / Hardware-in-the-Loop (HIL) with Matlab Simulink
- Smart Grid / Microgrid system models

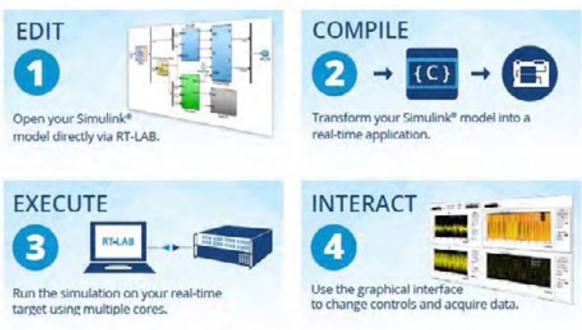
**In conjunction with OPAL-RT**

- Power Hardware-in-the-Loop (PHIL)

# SMART GRID AND PHIL WITH OPAL-RT

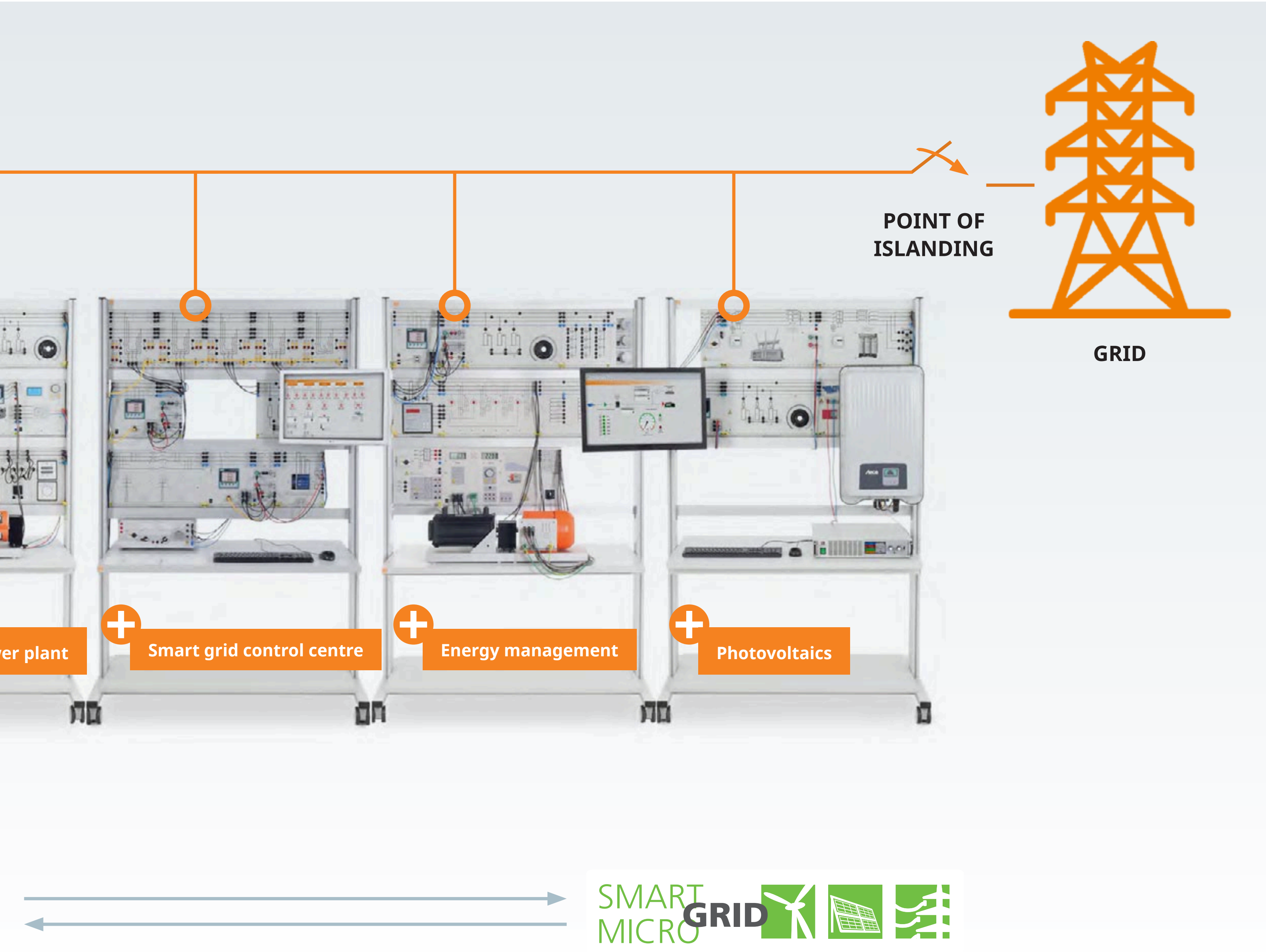

**OPAL-RT RT-LAB**

Easy to commission and configure parameters in 4 steps




**OPAL-RTOP1420 – Power amplifier**

- 4Q Power amplifier up to 15 kW
- Innovative soft-switching cell based on SiC transistor technology
- 100% energy recovery, no power losses
- Very high efficiency >96%
- Voltage and current mode
- Up to 10 kHz (-3dB), THD
- Microgrid Simulink Model
- FPGA real-time simulation possible
- Microgrid-grid emulator with busbar and measuring devices
- Safety measurement connections
- Protection against overloading, short-circuit and with temperature monitoring




**Lucas-Nuelle Smart Grid –
Networked Systems in the Power Engineering Laboratory**

Simulation of an entire power supply grid from energy generation all the way to end consumer

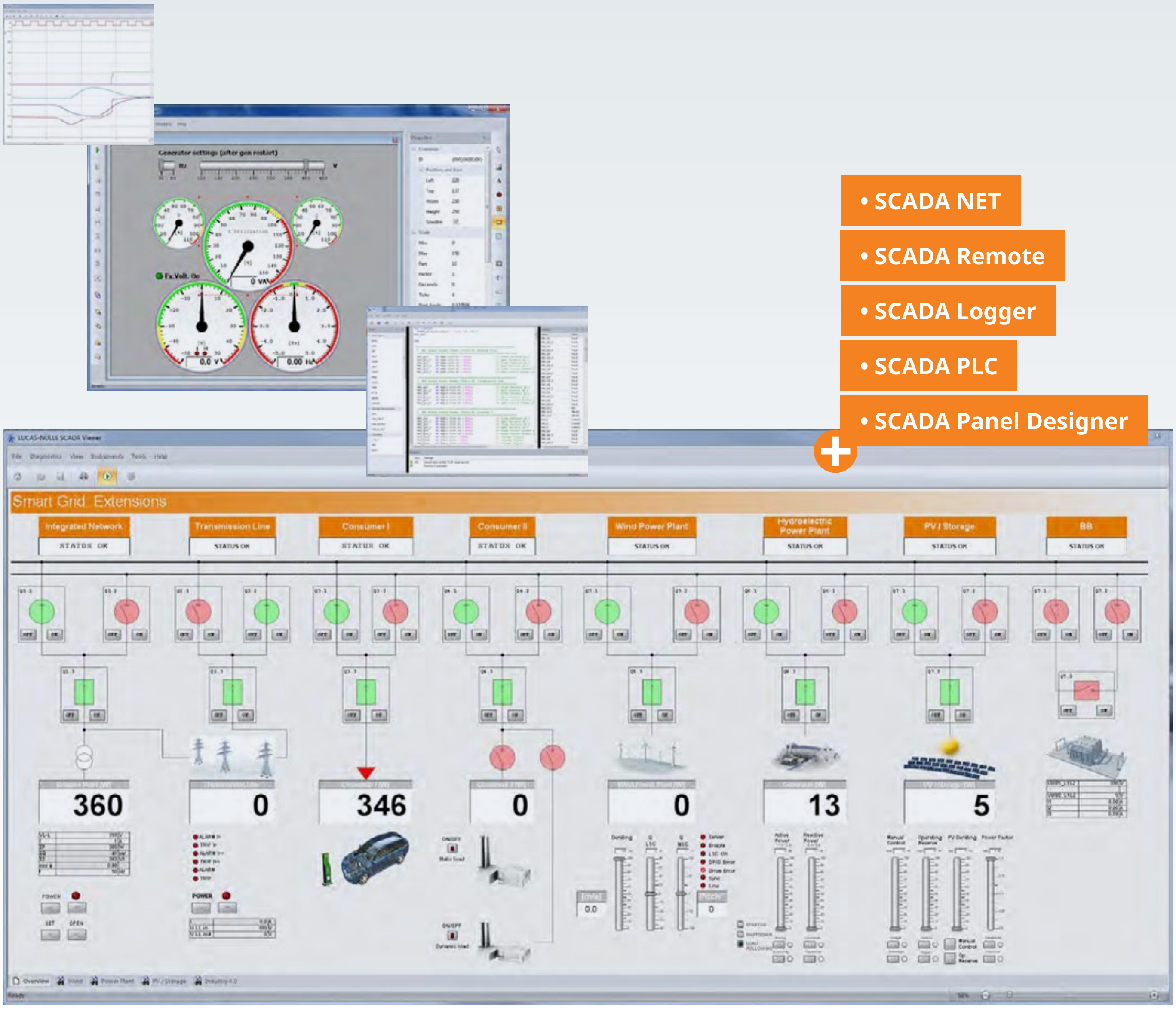
- Renewable energies with fluctuating power generation
- Power distribution with transmission lines, transformers and double busbars
- Systems, measurement and protective devices integrated in SCADA
- Centralized evaluation and control using SCADA
- Unlimited potential for design and investigation of smart grids and power systems in the lab

**Smart grid and power amplifier**

**Benefits:**

- Realistic training systems for training fundamental principles and applications
- Combination of simulation, real and industrial hardware
- Modular design means rapid configuration and adaptation
- Fast and easy PHIL implementation
- Fault-protected hardware
- Pre-assembled models for fast immersion into PHIL

# SCADA FOR POWER LAB



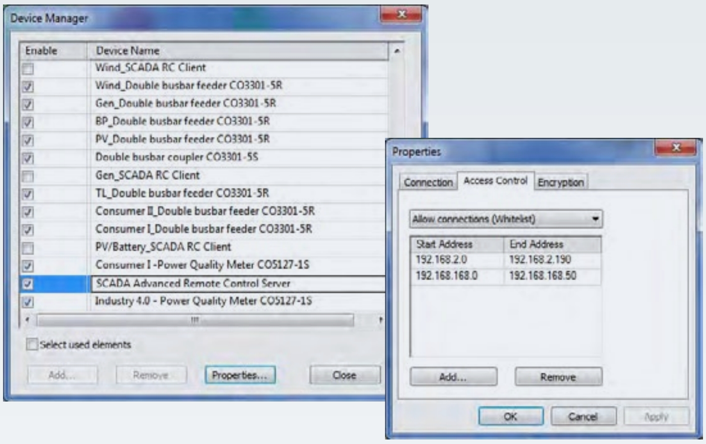

- **SCADA Viewer | Designer**
  - Custom configurable user interface
  - All Lucas-Nuelle power engineering equipment symbolically represented and arrayed
  - Standardized electronic circuit symbols for clear visualization of the circuitry
  - Individually configurable value lists to display any relevant measurement value
  - Display of measured values and operating states in real time
  - Implementation and analysis of intelligent power networks (Smart Grid)
  - Design of several worksheets per system

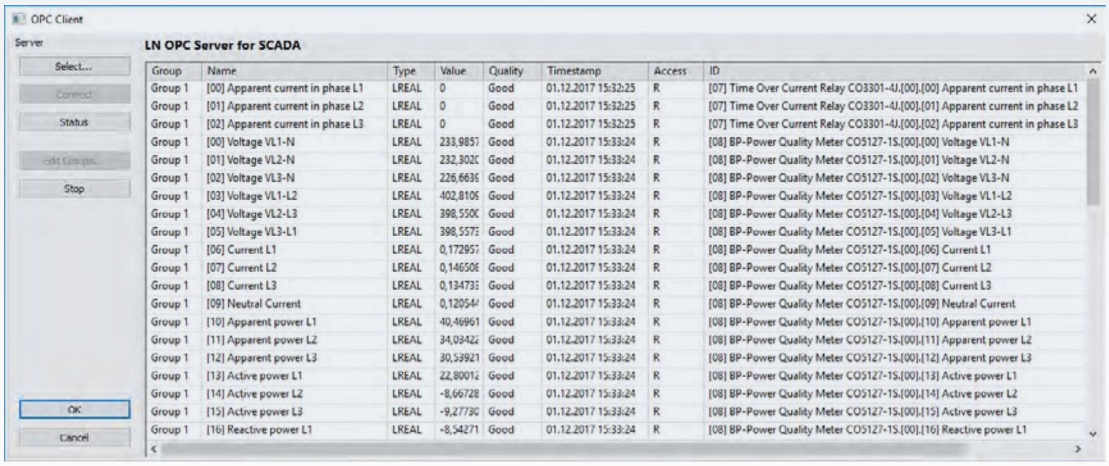
**Ready-made sample files (templates) are available for all experiments of the multimedia courses.**

- **SCADA Logger**
  - Recording diagrams of the measured values and signals over time
  - Editing, analysing and exporting the diagrams
  - Measuring the values

- **SCADA Panel Designer**
  - Design and configuration of user interfaces

- **SCADA Client Server**
- **SCADA OPC**
- **SCADA IEC 61850**



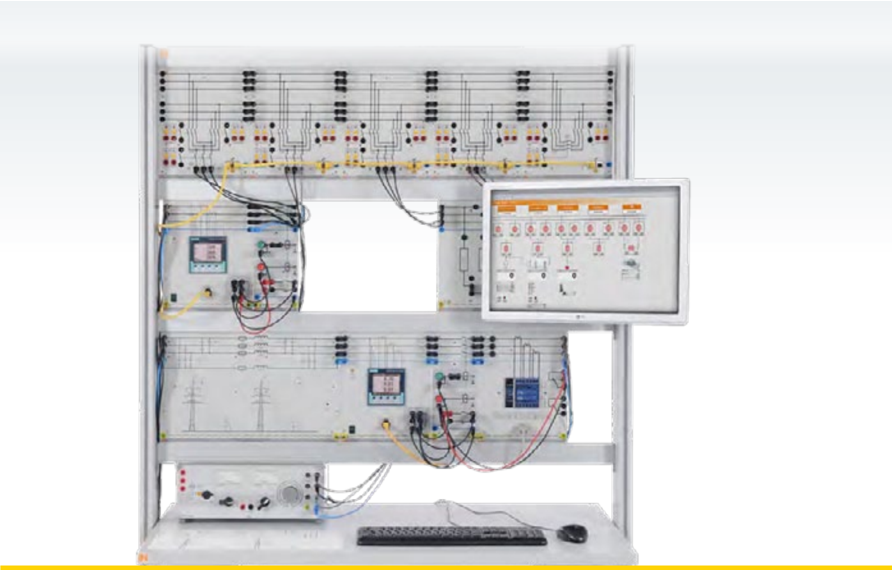


- **SCADA Remote Client / Server**
  - Monitoring and operating all systems at every PC in the laboratory
  - The power engineering lab in the cloud
- **SCADA OPC Client**
  - Connection to external devices, e.g. PLC
  - OPC DA V2.02
- **SCADA OPC NET Server**
  - Real-time connection, e.g. to the MATLAB®/Simulink® and LabVIEW via the OPC-Server

- **SCADA PLC**
  - Integrated Soft PLC (IEC61131 compliant)
  - Access to all values and signals in the smart grid
  - Automatic generation of the variable lists
  - Monitor variables

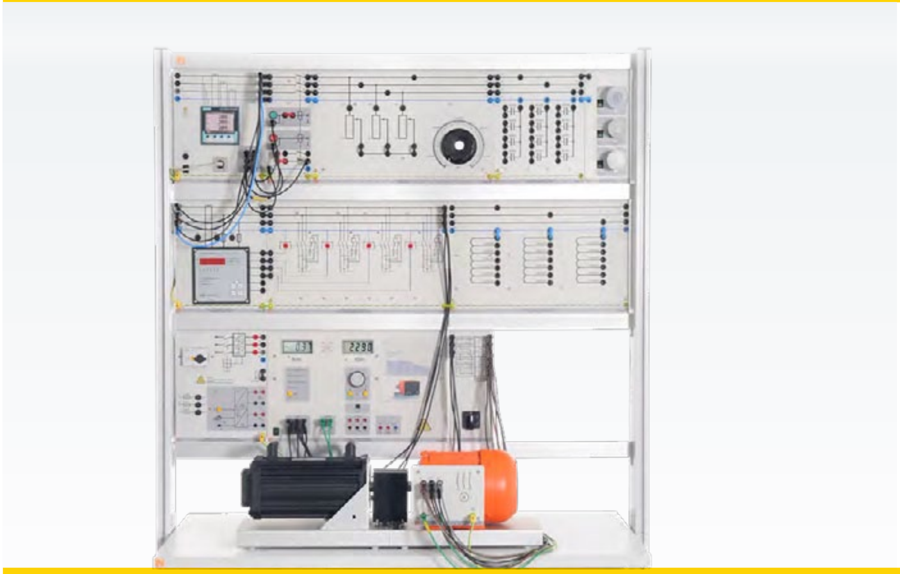
- **Other supported protocols include:**
  - SCADA IEC 61850 Client (Links up external devices, e.g. PMU)
  - TCP/IP Client/ Server
  - MODBUS
  - SML (Smart Message Language)
  - HTTP

# SMART GRID | MICROGRID SYSTEMS



**Smart Grid –
Control centre**

**Training contents**
- Three-phase double busbar system
- Investigating three-phase power lines
- Overcurrent time protection for power lines



**Smart Grid –
Energy management**

**Training contents**
- Complex loads, power consumption metering and peak load monitoring
- Manually operated and automatic reactive power compensation
- Load management - Demand-side management

**Modern PV systems in
parallel operation with power grid**

**Training contents**
- Measurement of the power generated by a PV system
- PV inverter power limiting (derating)
- Determining the efficiency of the grid inverter
- Control response of the grid inverter, MPP tracking
- Recording magnitude data using the solar path emulator

**Pumped storage power station / Power stations**

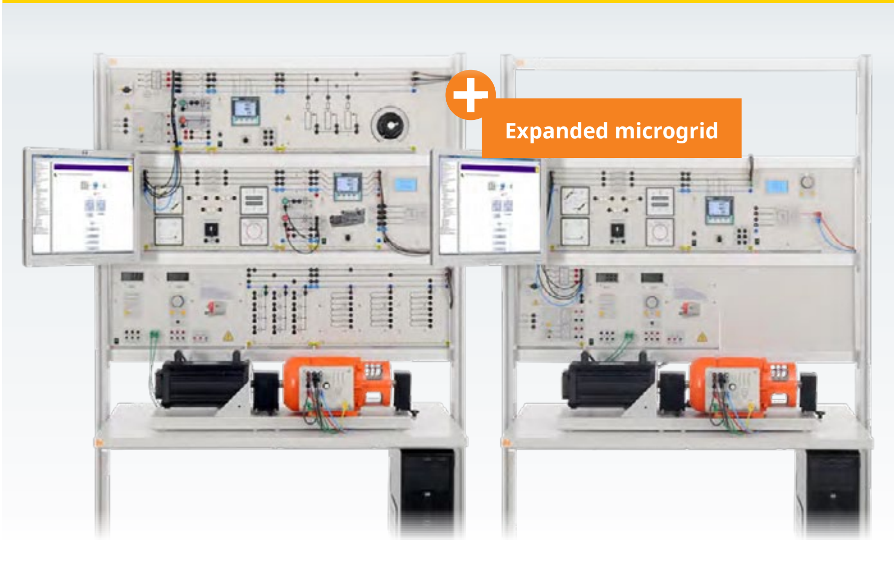
**Training contents**

- Synchronisation mechanism
  - Putting the multifunction relay into operation
- Generator operation
- Mains grid synchronization
  - Configuring the parameters of a multifunction relay
  - Automatic synchronization
- Manual power regulation: generator and motor modes
- Automatic generator control using SCADA

**Double-fed asynchronous (induction) generators (DFIG)**

**Training contents**

- Understanding the design and operation of modern wind power plants
- Exploring the physical principles of "from wind to shaft"
- Become familiar with various wind power plant concepts
- Design and commissioning of a double-fed induction generator




**Island parallel operation Microgrid**

**Training contents**

- Automatic control of several generators in off-grid (island) operation
- Automatic control of several generators in mains parallel operation with grid
- Coordination of power requirement and generation in island (offgrid) mode
- Use of modern information technology, e.g. networked sensor/actuator configurations, PLC control and SCADA user interface

LUCAS-NÜLLE

OPAL-RT TECHNOLOGIES

MATLAB & SIMULINK

# HARDWARE-IN-THE-LOOP

## A Training System for Renewable Energies in Smart Grids, Microgrids and PHIL

Training Systems Australia
First in Vocational Training Equipment
*A Division of Pullman Learning Group*

p +61 3 9557 7993
e info@trainingsystemsaustralia.com.au
w www.trainingsystemsaustralia.com.au
a 300 Centre Road, Bentleigh, VIC, 3204