LUCAS-NUELLE

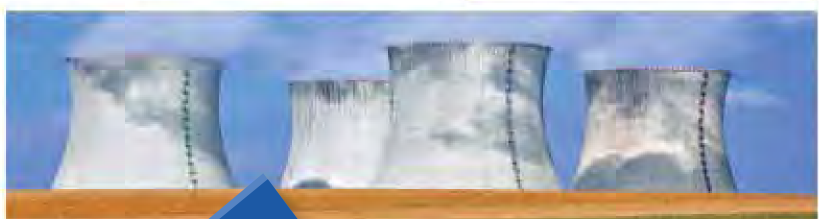
Training Systems for Smart Grid and Micro Grid

Adaptable modular design allows easy integration into existing programs.

SMART GRID
MICRO GRID







eCO_2Train

INDUSTRY

UNIVERSITY

COMMUNITY COLLEGE

Why should you choose training systems and services from Lucas-Nuelle?

Your benefits, our guarantee:

Training Benefits:

- ✓ Knowledge transfer through blended e-learning and hands-on skills through modern trainers
- ✓ Parallel and rotational training methods according to Instructor/Trainer preference
- ✓ Highly flexible experiment set-ups using unique integrated/independent modular designed trainers
- ✓ Classroom/laboratory and exam management software tools

Software Benefits:

- ✓ Local or cloud based education using our LabSoft suite software environment for all training systems
- ✓ Complete Virtual Instrumentation with curriculum integration available
- ✓ Full classroom progress transparency for educators and trainers using our management software tools
- ✓ Possible curriculum integration with popular SCORM 1.2 LMS systems, i.e. Moodle, Blackboard etc.

Hardware Benefits:

- ✓ State-of-the-art and up-to-date technology
- ✓ Durable and student proofed quality engineered trainers
- ✓ Instructionally safe for students and equipment according to IEC, DIN, UL and CSA standards
- ✓ Sole-source developed and engineered for comprehensive tailor-made laboratory solutions

Service/Support Benefits:

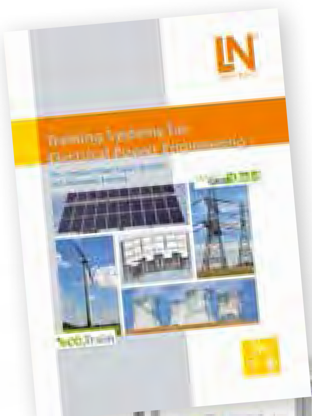
- ✓ Over 40-years experience and expertise in more than 100 countries and 30 languages worldwide
- ✓ Cost-effective one-stop turn-key laboratory solutions
- ✓ Lifetime support offered through product specialists and engineers
- ✓ Extensive after-sales-service and support with local US presence (Williamsburg, VA)

Governmental/Industrial Benefits:

- ✓ Educational programs designed to support the latest Industrial technology trends and requirements
- ✓ Industrial trained technicians, engineers and skilled workforce that encourage, promote and support local industrial growth
- ✓ Complete program development process from consulting, curriculum implementation, facility planning, setup and training
- ✓ Multiple lab options available for working with the restrictions of budget, human resources and educational time spent managing students while improving the effectiveness of your teaching staff

Contents

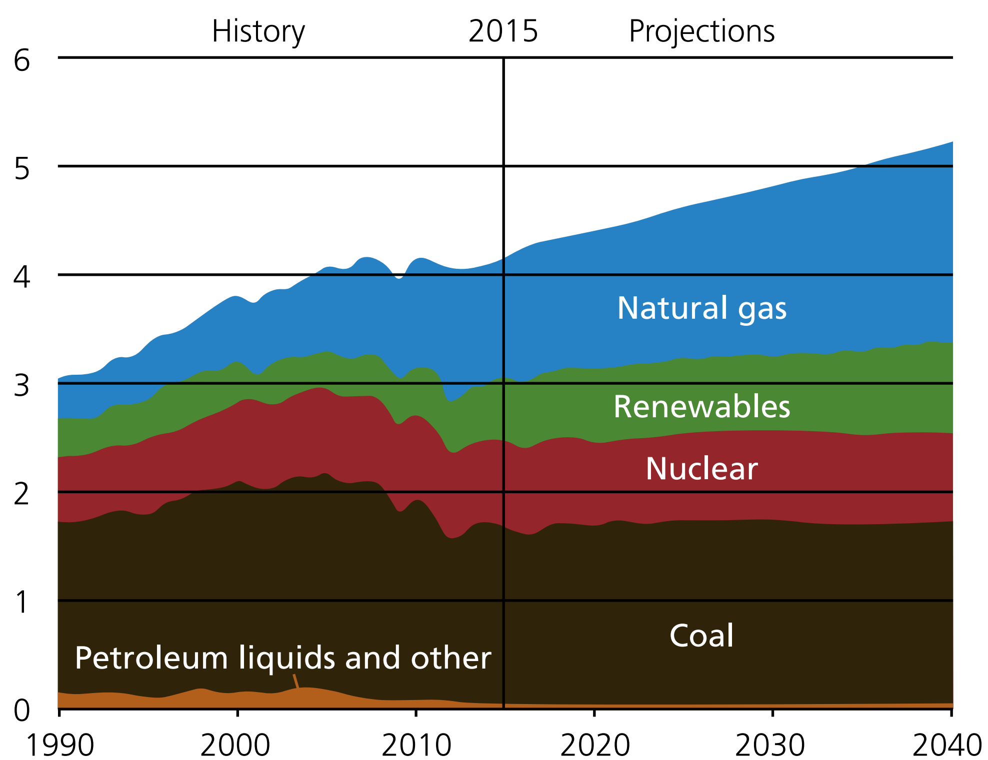
For more information about the entire Lucas-Nuelle Power Engineering Program please refer to our main catalog: "Training Systems for Electrical Power Engineering"



Background and developments in the US energy market

The Energy Information Administration (EIA) is predicting a continuous rise in the energy and electricity requirements of the US until 2035, assuming annual economic growth. It is expected that environmental regulations and political targets for CO2 reduction will lead to a massive increase in the proportion of energy and electricity contributed by renewable sources.

Diagram: US electricity generation 1990-2040 by energy sources (in trillions of kWh per annum)



Source: U.S. Energy Information Administration - Annual Energy Outlook 2014 with projections to 2040

About 33% of the annual increase in power generated between 2010 and 2035 is expected to come from renewable energy sources. Even according to conservative estimates by the EIA, renewable energy sources, including conventional hydroelectric power, will contribute 16% of the electricity generated by 2040.

Energy infrastructure and the smart grid in the USA

With increased use of renewable energy sources, which can only generate electricity at certain times (solar energy requires sunlight, wind energy needs to have wind etc.). In order to achieve improvements in the efficiency of the grid, implementation of smart-grid technologies is going to grow in importance. The term smart grid refers to a new generation of electrical grids in which IT components and provision of real-time data will make it possible to manage energy more efficiently. This is in order to handle load compensation across periods of peak loading and those when the demand is weak, as well as to enable flexible adaptation between times when energy is being generated and when it is being stored.

According to the American Society of Civil Engineers (ASCE), large parts of the electrical grid have already reached the end of their lifespans and are exhibiting problems due to their age. Investment in power supply networks has already risen considerably over the last few years.

The ASCE estimates that the investment in distribution infrastructure which will be necessary until the year 2020 will be on the order of $57 billion with another $37 billion of investment in the transmission line infrastructure.

Some communities and energy providers are attempting to compensate for capacity overloads with time-based pricing programs. Such "hourly pricing programs" have been introduced into large cities and certain other communities by the Center of Neighborhood Technologies in conjunction with the local energy suppliers. Depending on the time of day or time of year, the prices per kilowatt-hour are adjusted to market conditions (relative to demand).

The topic of smart grids has once more come to the forefront of the national political agenda thanks to President Obama's American Reinvestment and Recovery Act (ARRA). In addition to improved reliability of the national electrical grid, this also places greater efficiency, higher security (cyber security), reductions in greenhouse gases and encouraging consumers of electricity to manage their consumption more efficiently, as well as allowing the integration of non-centralized renewable energy sources

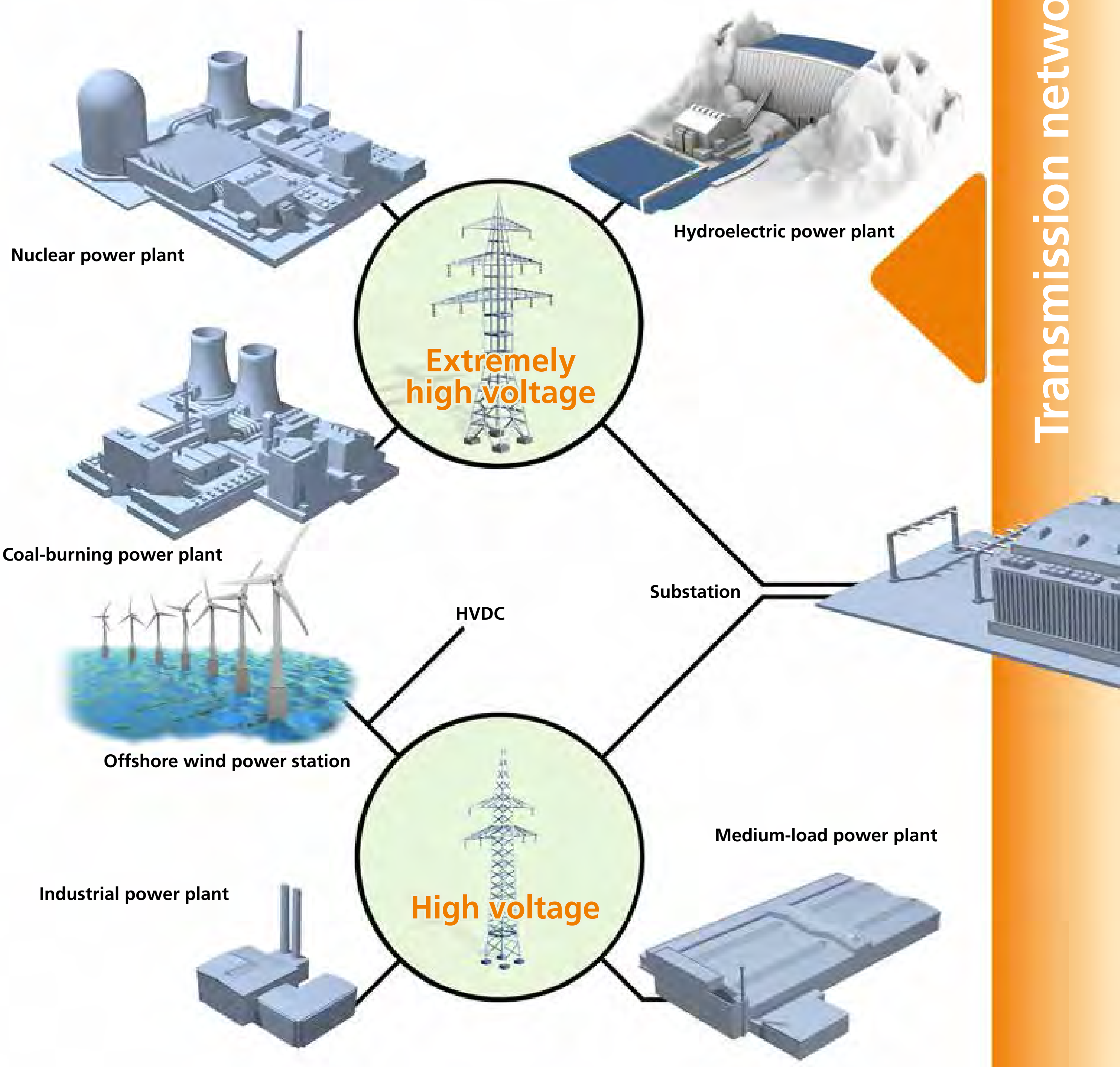
and electric vehicles, at the top of the political agenda. The ARRA is already making available $4.5 billion in funding for modernization of electricity distribution and improving resistance to failure.

The increase in renewable energy within the US electrical grid is also leading to increased demand for ways of storing electricity, since renewable energies may not be able to provide power at the time when it is actually needed.

From Power Generation Through to Consumption

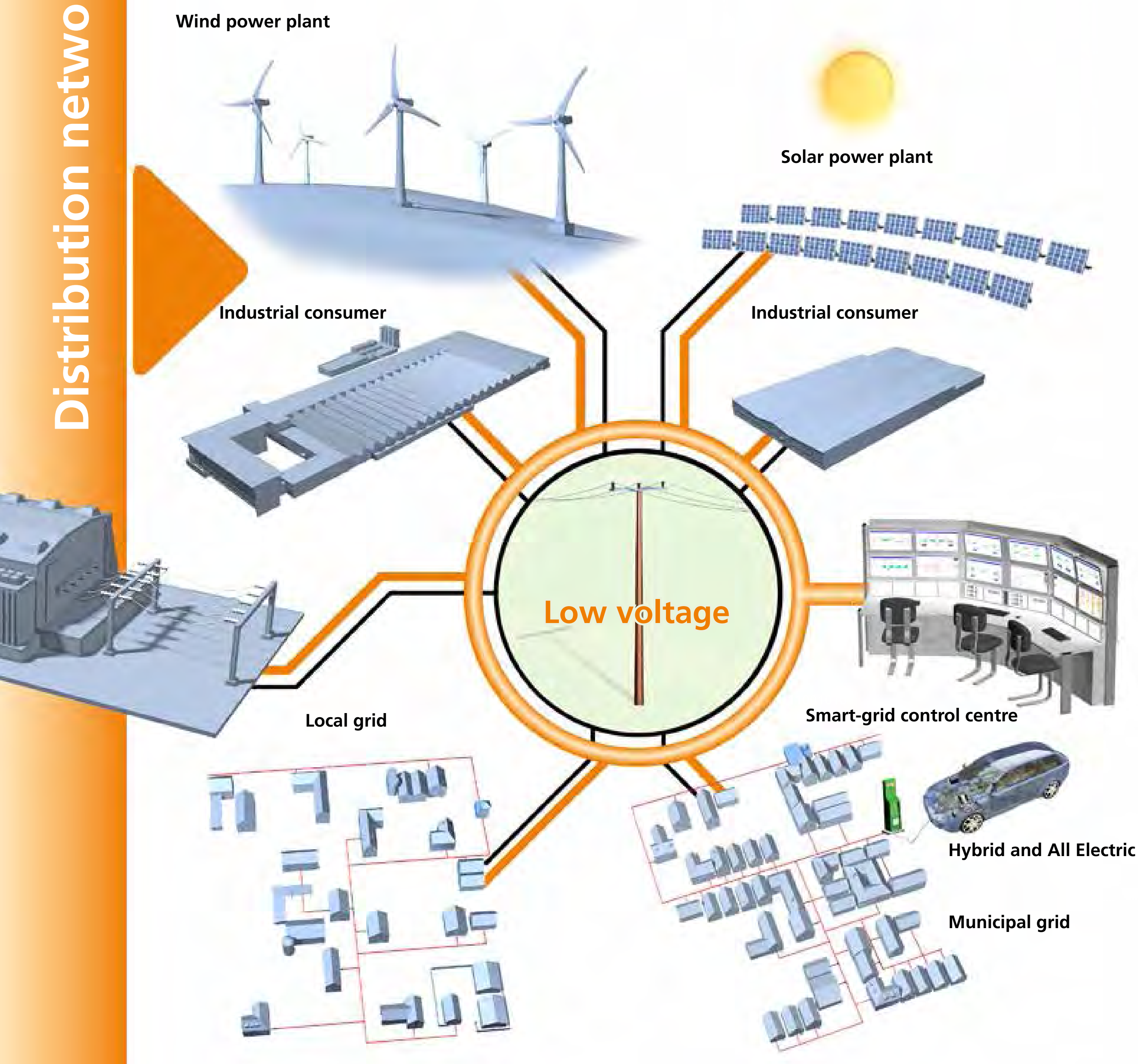
The Smart Electrical Power Grid of the Future

Using the Lucas-Nülle equipment sets, it is possible to model an entire power supply grid from power generation all the way to ultimate consumption.



Distribution network

SMART MICRO GRID

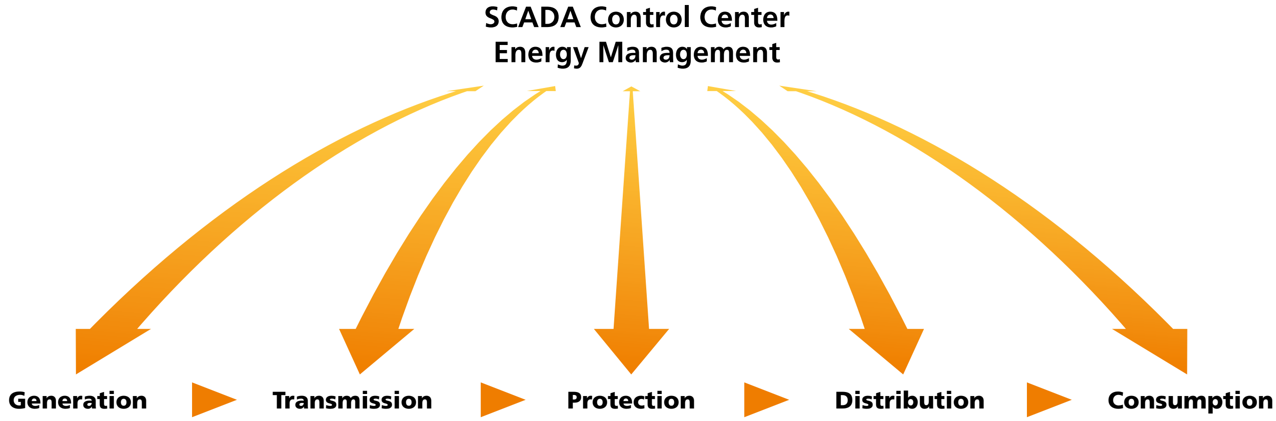


Networked Systems
in the Power Engineering Laboratory

The Smart Lab:
Safe and easy to design! Investigate intelligent power grids in the lab!

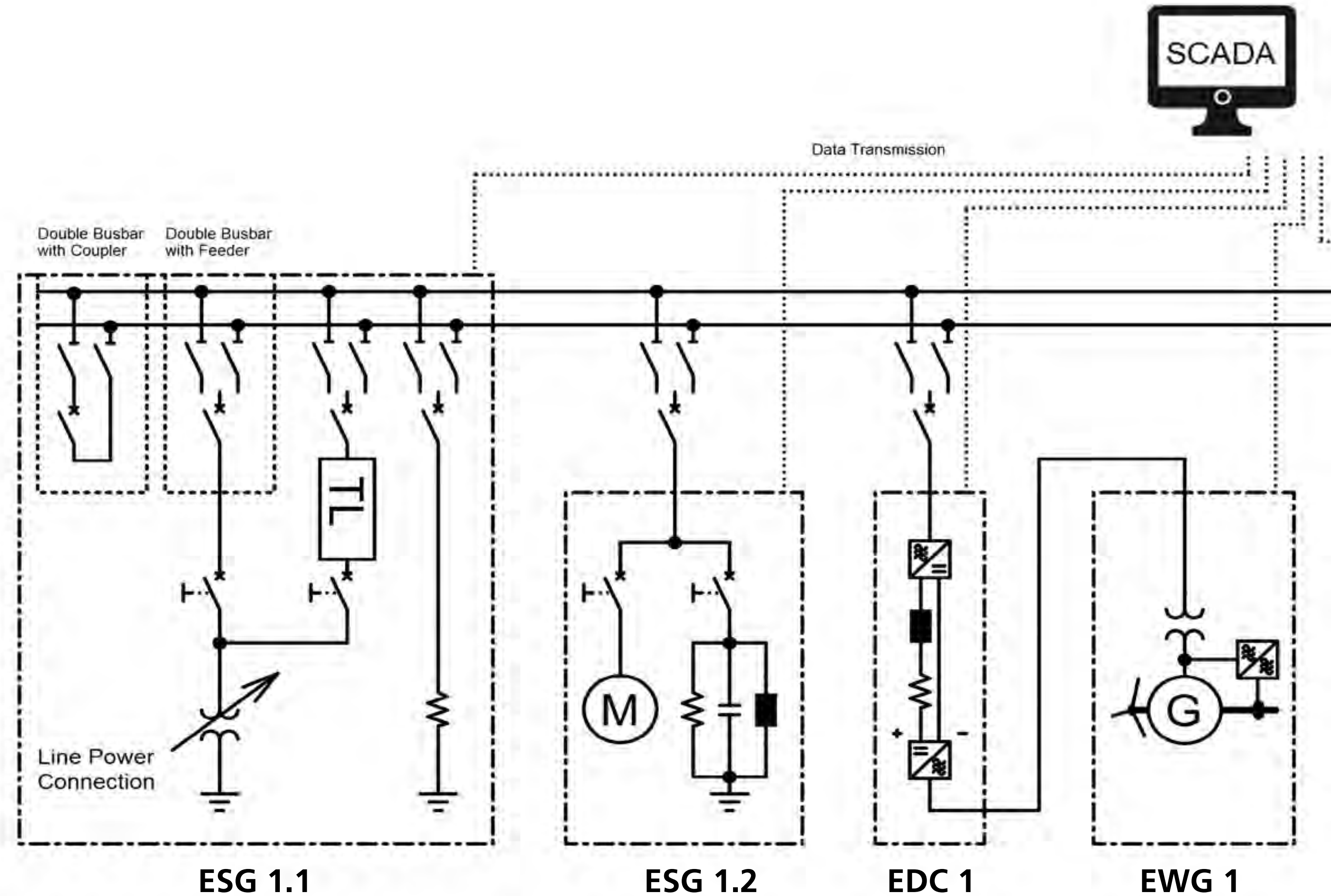
The equipment sets for Smart Grid and Micro Grid can be combined with each other as required. For example, take the power obtained from renewable energy sources and transmit this power via a line model, use a transformer to step it up or down and distribute it to any number of consumers using the double busbars. The bus systems can be centrally evaluated and controlled using our SCADA Power-Lab software. This makes it possible to study the influence of renewable energy generation in laboratories. A host of scenarios can be emulated, such as the following:

- Charging of electric cars when there is a surplus of wind energy
- Storage of excess energy in pumped-storage hydroelectric plants
- Disconnection of consumers to reduce peak load
- Compensating for energy deficits by means of pumped-storage hydroelectric power



Sample Layout

"Smart Grid Trainer" – Power with Brains



ESG 1.1

Three-phase double busbar systems
Three-phase Transmission Lines
Overcurrent time protection for lines

ESG 1.2

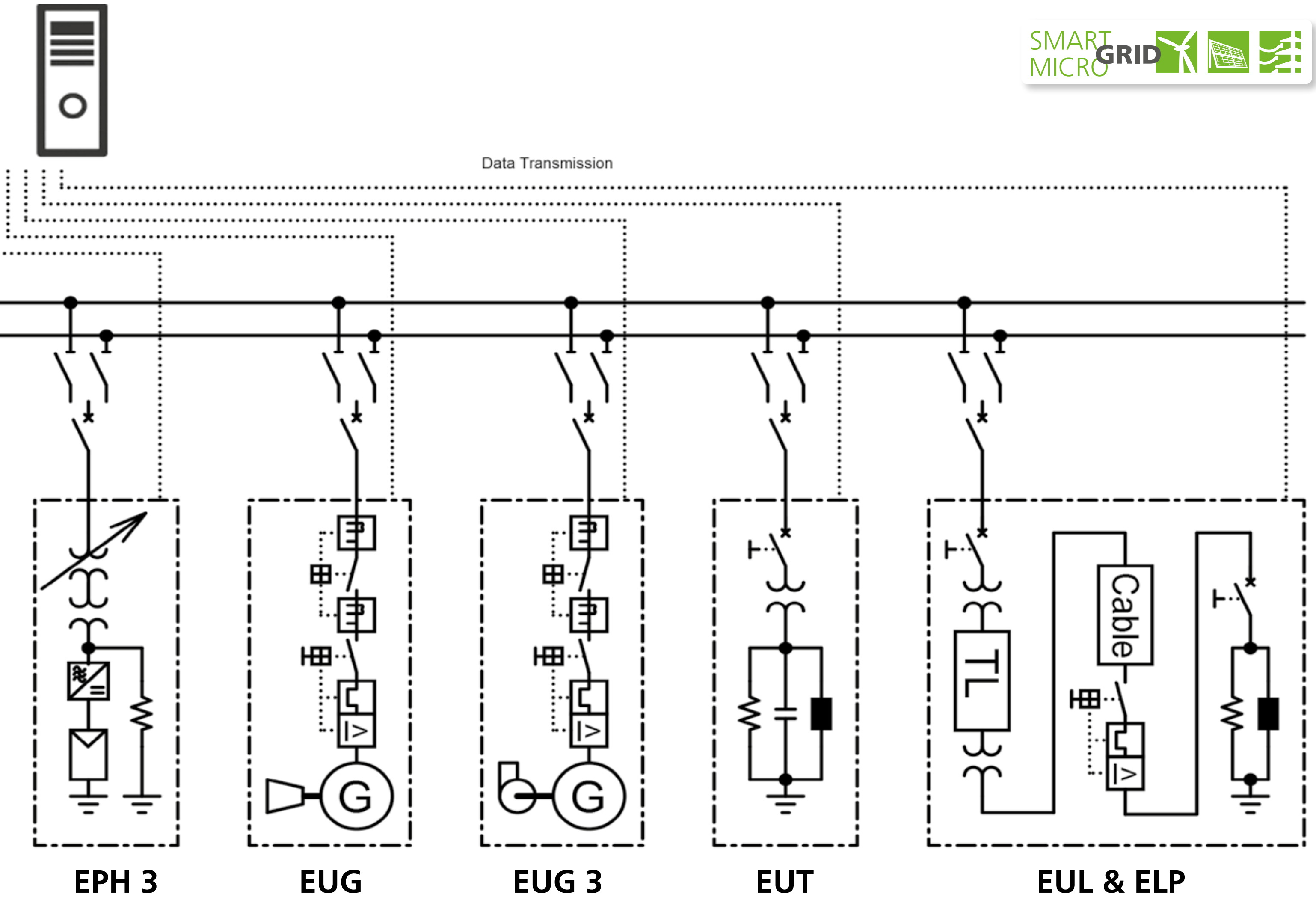
Complex loads
Power consumption measurement
Dynamic loads
Compensation of reactive power

EDC 1

HVDC High-voltage direct current transmission
Control of intermediate circuit voltage
STATCOM Static Synchronous Compensator
Synchronization with the mains
Control of HVDC reactive power
Various lengths of HVDC lines
Passive consumers with HVDC

EWG 1

Wind power plants
DFIG (Double Fed Induction Generator)
FRT (Fault Ride Through)



EPH 3

Professional photovoltaic
Emulation of PV power plants

EUG

Generator control
Manually operated synchronizing circuits
Automatic synchronizing circuits
Automatic power control
Automatic power factor control

EUG 3

Pumped storage hydroelectric power plant

EUT

Transformers
Multiphase transformer

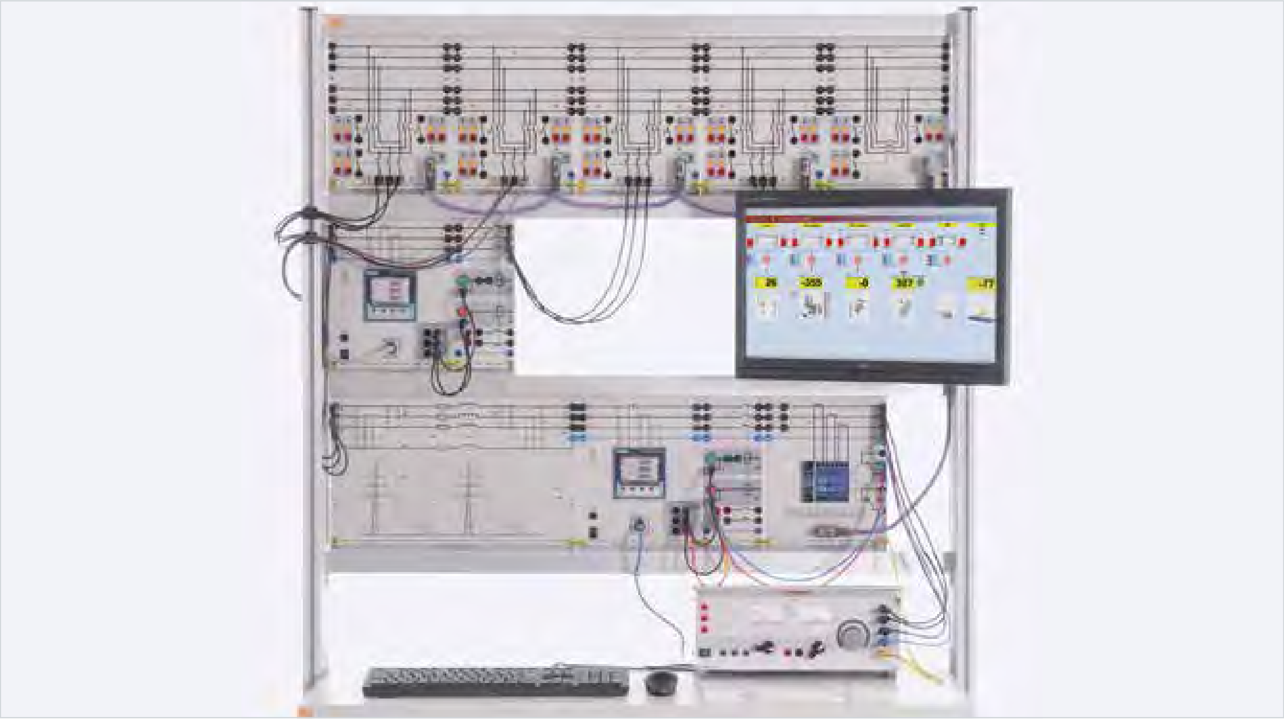
EUL & ELP

High-voltage transmission lines
Three phase cables
Combined networks of cables and lines
Load-dependent voltage regulation
Step-up transformer
Step-down transformer
Protection for high-voltage transmission lines
Overvoltage and undervoltage protection

“Smart Grid” – Intelligent Mains Networks

Smart Grid – Control Center

This equipment set forms the core for a smart grid in a power generation lab. In addition to generation, transmission and distribution of energy, the SCADA software records all relevant values and handles the requisite switching operations. This can be done manually or automatically by means of our PLC software system.



Example experiment “Smart grid: Generation, distribution and transmission of electrical power ESG 1.1”

Training contents

Three-phase double busbar system

- Basic circuits for a three-pole double busbar system
- Three-phase double busbar systems with load
- Busbar transfer without interrupting feed
- Finding switching algorithms for various switching operations
- Busbar coupling

Investigations on three-phase transmission lines

- Voltage rises in unloaded transmission lines
- Voltage drop as a function of line length
- Voltage drop as a function of cos phi
- Capacitive and inductive power losses in a transmission line as a function of voltage and current
- Phase-shift along the line

Definite time overcurrent protection for lines

- Rating and parameters for definite time overcurrent protection
- Determine returning ratio (differential) for short circuits involving one, two or three poles

Smart Grid – Energy Management

The topic of energy management includes switching off consumers to reduce peak loads as well as reactive load compensation for reducing losses along transmission lines. The asynchronous machine in our set can be dynamically loaded by means of the machine test stand in order to simulate variable changes in load over time on the entire electrical power grid. Such changes in load are recorded by the Smart Grid Control Center so that suitable corrective actions can be taken to keep the grid stable.

Optional supplementary sets are also available for the Smart Grid:
- HVDC direct current transmission (EDC1)
- Wind power plants (EWG1)
- Professional photovoltaic (EPH3)
- Power Generation (EUG)
- Pumped storage power plant (EUG3)
- Transformers (EUT)
- Power Transmission (EUL)
- Power Protection (ELP)

For more information please refer to our main catalog: "Training Systems for Electrical Power Engineering"

Example experiment "Smart grid: Energy management ESG 1.2"

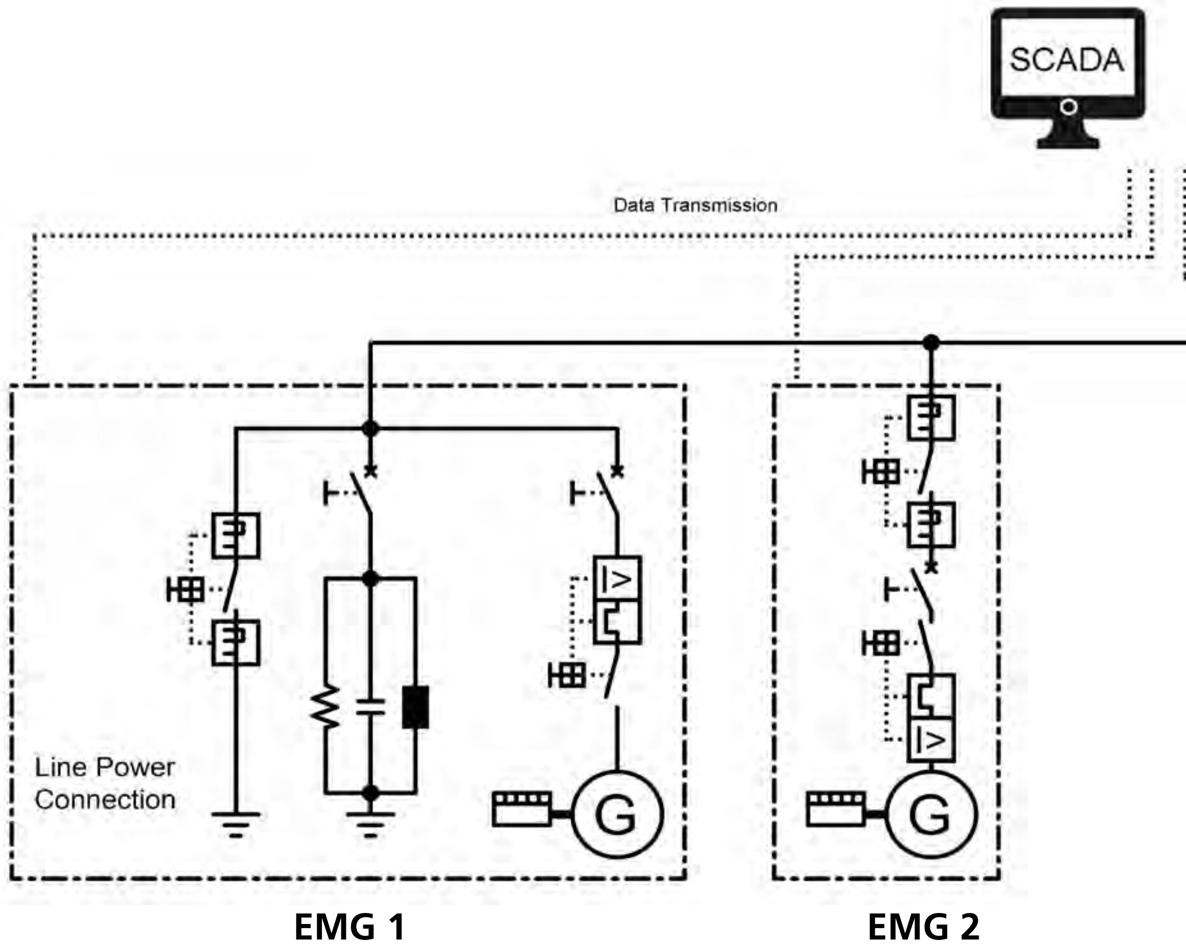
Training contents

Complex loads, metering of electricity consumption and monitoring of peak load
- Three-phase load in star and delta configurations (R, L, C, RL, RC or RLC load)
- Measurements with active and reactive work meters

Dynamic loads
- Dynamic three-phase loads (asynchronous motors)
- Power measurement when energy is being fed in and fed out

Manual and automatic reactive power compensation
- Putting asynchronous machines into operation and recording parameters
- Manual reactive power compensation
- Automatic reactive power compensation

"Micro Grid Trainer" –
Control of stand-alone networks

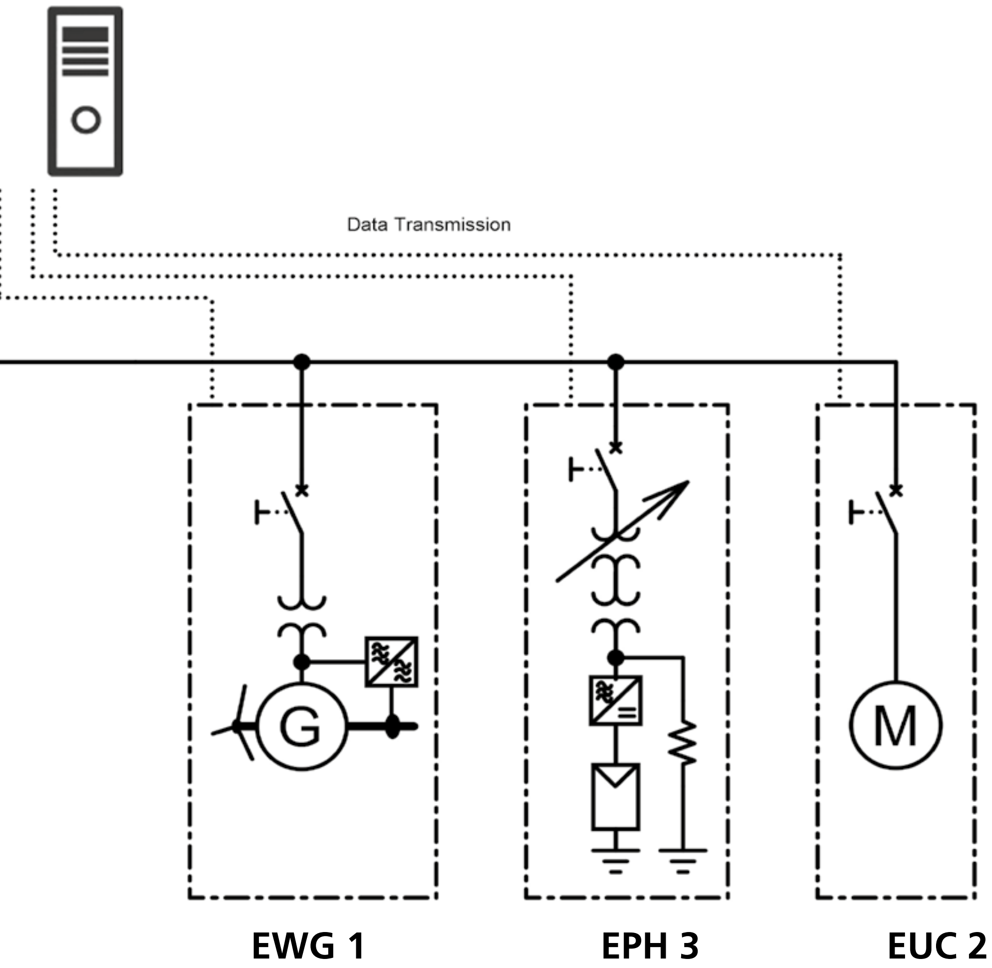


EMG 1

Stand-alone operation
Control of a generator in a stand-alone network
Coordination of energy needs and generating capacity
Networked sensors/actuators, PLC control and the SCADA operating environment
"Smart metering" of a "slack bus" to make a sub-network autonomous
Manual, Voltage and Frequency control

EMG 2

Isolated parallel operation
Control of multiple generators in a stand-alone network & parallel generation mode
Coordination of energy needs and generating capacity
Networked sensors/actuators, PLC control and the SCADA operating environment
Manual, Voltage, Frequency, Torque, Power factor (cos phi) and Droop control



EWG 1

Wind power plants
DFIG (Double Fed Induction Generator)
FRT (Fault Ride Through)

EPH 3

Professional photovoltaic
Emulation of PV power plants

EUC 2

Dynamic loads
Dynamic, three-phase load (asynchronous motor)
Power measurement in the case of energy-flow reversal

"Micro Grid" – Off-grid Control / Island Mode

Stand-alone or off-grid operation

The stand-alone power network is a type of power supply network that is isolated and has no active coupling lines to other mains power systems. An off-grid or stand-alone network is noticeably smaller than an interconnected power grid system and as a rule does not incorporate any extra-high-voltage lines. For these kinds of grids, a distinction is drawn between two different operating modes, stand-alone mode and isolated parallel mode. This type of power network is frequently used in industrial power systems found in large-scale businesses.

Experiment example "Isolated mode" EMG1

Training content

- Fundamentals of stand-alone off-grid networks.
- Controlling a generator in an off-grid network.
- Coordinating power consumption (requirements) and generation in an off-grid network.
- Use of modern information technology, e.g. networked sensors/actuators, PLC control systems and SCADA user interfaces
- "Smart Metering" of a balanced node in order to make a subnetwork autonomous.
- Manual control
- Voltage control
- Frequency control

Isolated parallel mode / micro grid

When this off-grid network is connected to the smart grid it is referred to as a micro grid. This grid has three different operating modes: on-grid, off-grid and dual mode. The micro grid features the following benefits:

- Reduction of transmission and transformer losses
- Independence from large power suppliers (utilities)
- Smart-grid as back-up system
- Intelligently controlled power supply and consumption thanks to SCADA
- Power generation with renewable energy sources
- Optimum electrical power quality, reliability and sustainability

Micro grids are playing an ever more prominent role in the smart grids of tomorrow.

Experiment sample "Island parallel mode with two generators" EMG2

Optional supplementary sets are also available for the standalone Micro Grid:

- Wind power plants (EWG1)
- Professional photovoltaic (EPH3)
- Dynamic consumers (EUC2)

For more information please refer to our main catalog: "Training Systems for Electrical Power Engineering"

Training content

- Control of multiple generators in a stand-alone (off-grid) network
- Control of multiple generators in parallel operating mode
- Coordinating of energy needs and generation inside a stand-alone network
- Use of state-of-the-art information technology like networked sensors/actuators, PLC control and SCADA operating environment
- "Smart Metering" of a "slack bus" or balanced node to make subnetworks autonomous.
- Manual control
- Voltage control
- Frequency control
- Torque control
- Power factor (cos phi) control
- Droop control

Additional Features of Smart Grid / Micro Grid

Modular Integration of Regenerative Power Generation into a Smart Grid:

- Photovoltaic
- Wind power
- Storage of electrical energy by means of pumped storage hydroelectricity
- Conventional power generation
- Transmission and distribution
- Energy management (coordination of dynamic power generation and consumption)

SCADA Software in a Smart Grid

- Implementation, control and analysis of complex, intelligent grids (smart grids)
- SCADA software adapted for education
- **SCADA PLC:** Integrated software PLC (IEC 61131)
- **SCADA Logger:** Recording, display, evaluation and export of all values recorded in a given period
- **SCADA Designer:** Symbolic layout of all equipment from Lucas-Nülle's energy supply range on a user interface
- **SCADA Viewer:** Display and control of measurements and status from all computers on the network
- **SCADA Net:** The client/server concept makes it possible to remotely access systems on the smart grid from multiple (student) PCs at the same time.
- **SCADA Panel Designer:** Design your own control panels

Smart measuring instruments:

- Smart measuring instruments with a variety of controls and ability to communicate via various interfaces (e.g. LAN, RS485, USB)
- Measurement and control of all relevant variables by means of smart meters and high-powered switches
- **SCADA Net-compatible:** Display and control of measurements and status from any PC on the network

The Whole is Greater than the Sum of its Parts

Lucas-Nuelle is a byword for custom occupational training courses in all of the following areas:

- Building management systems
- Telecommunications
- Refrigeration and air-conditioning technology
- Electrical power engineering
- Process control
- Microcontrollers
- Renewable energies
- Electropneumatics, hydraulics
- Automation technology
- Power electronics, electrical machines, drive technology
- Instrumentation
- Automotive technology
- Fundamentals of electrical engineering & electronics
- Metal technology
- Lab systems

Further information on our products can be found at www.lucas-nuelle.com

Technology from around the world, service from around the corner.

LN Expertise:

- Supply of laboratory equipment and furniture
- Target oriented project design
- All-in-one services from concept to realization
- One-stop turn-key solutions
- Trusted and experienced in the field of technical and engineering education for more than 40 years

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Ref.-Nr. K-E2-1154-US • Training Systems for Smart Grid and Micro Grid • 05/15 (Printed in Germany) • Subject to technical alterations