EDITION 2

RENEWABLE ENERGIES

AMTEC TECHNIQUIP
Engineering The Future

Suppliers Of Educational Engineering Equipment & Accessories

MADE IN SOUTH AFRICA

30 YEARS OF ENGINEERING EXCELLENCE

BEE LEVEL 2 company 125% recognition

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Amtec Techniquip applies 30 years of knowledge & experience in the design, manufacture and import of educational engineering equipment, accessories, instrumentation and consumables.

During this time, we have been a market leader in innovation, bringing many new concepts and products to the educational industry while expanding our comprehensive range of quality teaching equipment to a level unsurpassed by any other company in the industry.

This includes unique new methods of introducing and educating the learners in all facets of modern engineering. Our products are visual and/or demonstrational to best teach and explain concepts from basic engineering, all the way up to research and thesis levels in the most advanced forms of engineering.

Amtec Techniquip's commitment to the end user...

AMTEC offers a personal approach to each and every end user as we are always available to meet and discuss any requirements face-to-face basis to provide a tailor-made solution.

AMTEC have a large footprint throughout Southern Africa and regularly visit the countries and provinces we service while also keeping our customers up-to-date with any new products and innovations we bring to the market.

AMTEC supplies expert training on all our products. Our team of experts offer training at the end user or alternately at our head office in Jhb. All our products are supplied with their relevant manuals, course materials and exercise guides.

AMTEC offers unmatched after-sales service and customer support. All our equipment is supplied complete with ICT (Installation, Commissioning & Training). Our sales and support teams are at the end user's disposal should any assistance be needed during the life of a product.

AMTEC offers an extended Service and Maintenance plan to make sure that your equipment and apparatus are maintained to ensure a long lifespan with little or no downtime.

AMTEC makes use of only quality components to ensure reliability and longevity of all our manufactured equipment. This provides the end user with peace of mind and a product that will stand the test of time in an educational environment.

AMTEC has the manufacturing capability to R+D and manufacture "one-off" designs and customise any equipment within our range to meet the end users requirements. We have many accessories, add-ons and tooling that can work in conjunction with our equipment and trainers.

AMTEC offers a 24-month factory warranty on all our products supported by the backing of our local & international suppliers.

AMTEC SOLAR ENERGY

AMTEC SOLAR WATER HEATER AND GEYSER TRAINING

AMTEC Solar geyser trainer with fault simulation panel

Includes:

- Manual
- Faulty Components simulation box
- Starter
- Geyser
- Panel
- Steal Powder coated Station with lockable casters
- Electrical Fault Simulation

AMTEC SOLAR WATER HEATER AND GEYSER TRAINING

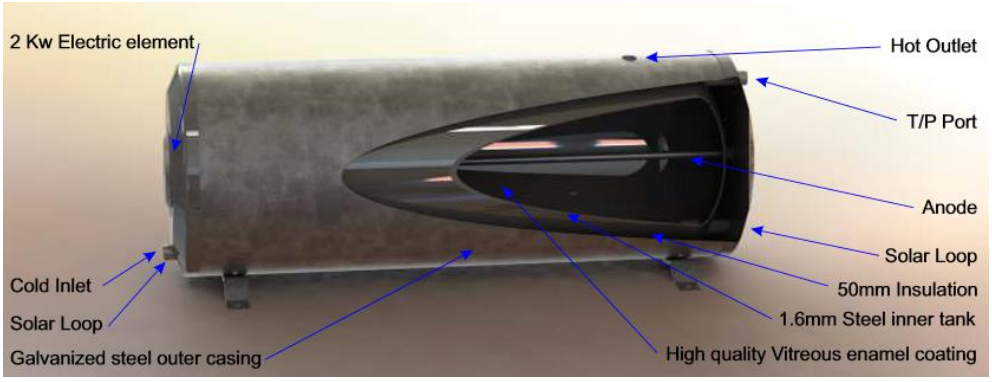
Solar Water Heating (SWH) is the conversion of sunlight into heat for water heating using a solar Thermal Collector.

Amtec Techniquip has a variety of configurations available used to simulate solutions in different climates, SWH is widely used in Africa and around the world for residential and some industrial applications.

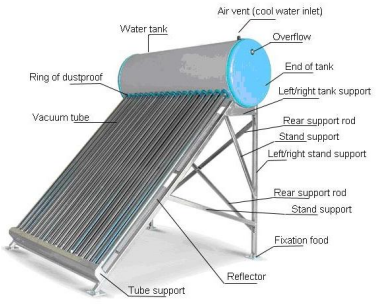
We have designed and developed various for training purposes to study the various parameters and configurations available on the market, these are available as complete units (wired and plumbed) or alternately available as configurable units to demonstrate how one would install and test the various systems.

Systems available:

Direct Pumped Vertical Flat Plate Solar Water Heating System



- Available in kit form and/or assembled Training System
- Includes, 150L, 400kpa Solar Geyser.
- Vertical Flat Plate Solar Collector.
- 12V Sustainable Circulating Pump.
- Valves, air release valve and ball valve.
- Portable Workstation with mounting kit
- Probes to measure various temperatures, flow rates and radiation intensity throughout the system.



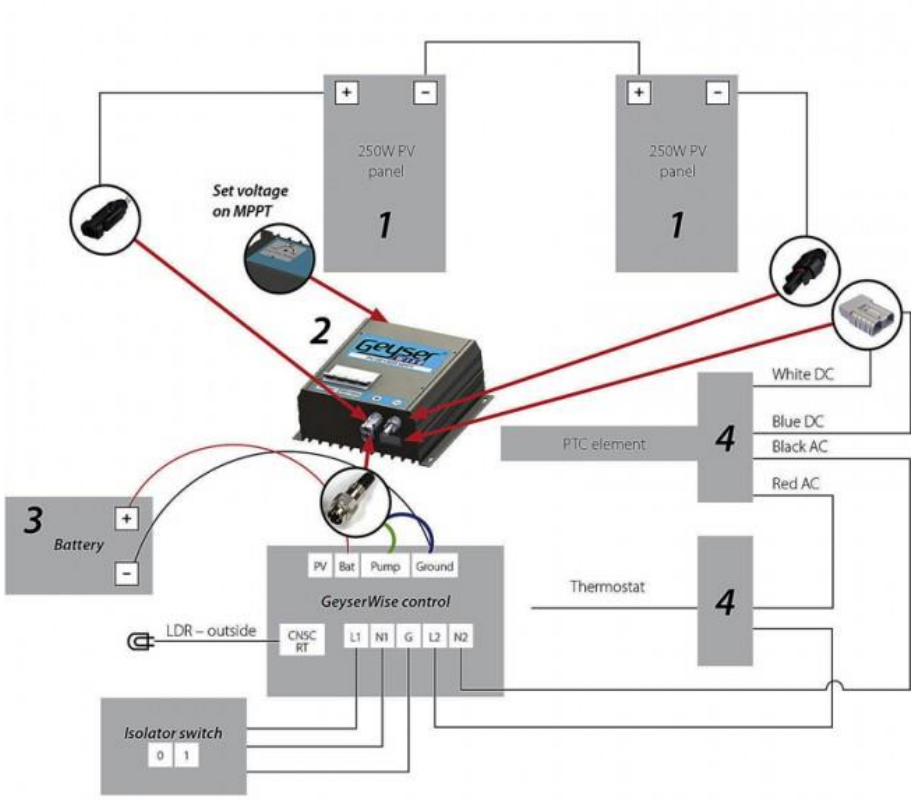
High Pressure Close Coupled Solar Water Heating System

- Available in Kit Form and/or assembled Training System
- Includes 100L Tank
- 12 Evacuated Tube Collector
- 1Kw Heating Element
- Standard Thermostat
- Portable Workstation and mounting Kit
- Probes to measure various temperatures and radiation intensity throughout the system.

Low Pressure Close Coupled Solar Water Heating System

- **Consists of the following:**
- Available in Kit Form and/or assembled Training System
- Includes 100L Tank
- 6L Auxillary Tank
- 12 Evacuated Tube Collector
- 1500W Pus in Element
- Standard Thermostat
- Portable Workstation and Mounting Kit
- Probes to measure various temberatures and radiation intensity throughout the system.

PV Solar Water Heating System

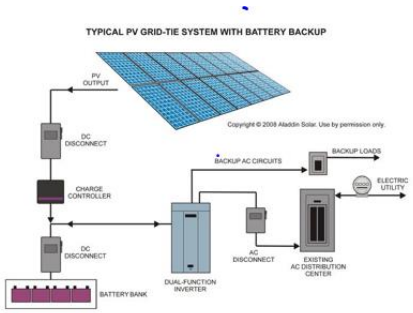


- Available in Kit Form and/or assembled Training System.
- Includes 100L Conventional Geyser
- 2 x 250W PV Panels
- Smart Solar Geyser Controller
- Depp Cycle Battery
- PTC Element
- Isolator Switch
- Thermostat
- Cabling and connections
- Portable Workstation and Mounting Kit
- Probes to Measure various temperatures, voltages, flow rates and radiation intensity throughout the system.

AMTEC PHOTOVOLTAIC TRAINERS

Solar Photovoltaic Trainers:

Photovoltaic system, also PV system or a solar power system is a power system designed to supply useable solar power by means of photovoltaics. The system consists of an arrangement of several components including solar panels to absorb and convert sunlight into electricity, a solar inverter to convert the electric current from DC to AC as well as mounting, cabling and other electrical accessories to set up a working system.



Amtec Techniquip has designed and manufactured an array of training systems to aid the learner to understand the various parameters and installation of PV systems and networks, the trainers are available as complete prewired systems or in kit form as configurable units to demonstrate how one would install and test the various systems

Current Systems available:

i) A1594 – Amtec Photovoltaic Basic Installation Trainer

- Consists of the following:
- Inverter 12V to 220Vdc (+/-300w)
- PV panel large +/- 300 x 400mm 50 Watt
- Artificial Sun (lamp) with rotation of 180deg and adjustment towards and away from the PV panel
- Safety fusing for battery, PV panel and Inverter
- Control module with display for energy inputs and outputs
- Room simulation with switches and lights
- DC room simulation
- Battery with separate 5 stage charger to prolong the life of the battery
- Manual with wiring and all individual components information

ii) <u>Off Grid Solar PV Training System (200Wh – 500Wh)</u>

Consists of the following:

- 40W Solar Panel (Mounted to portable frame with tilting Inclination Scale)
- 12V Sealed Deep Cycle Battery
- 12V 250V – 200W Inverter
- Charge Controller
- Cabling / plug in type cables, battery terminals
- Portable Workstation complete with fixed or configurable didactic components.
- System includes instrumentation & probes to measure various parameters such as DC / AC voltage, current, temperature & radiation intensity at various points throughout the system
- Kit form includes halogen Free Solar Cables.

Optional:

- Portable Lighting system to simulate Sunlight indoors with dimmer function
- Inclined Trussed Roof Station (Tiled / Corrugated) for panel installation

iii) **Grid-Tied Solar PV Training System with Battery Back-up and Controller. (1.5kWp – 5kWp)**

Consists of the following:

- 1.5kW Grid Tie Inverter
- 5 x 310W PV Modules
- Grid Tie Limiter
- Battery Back up (Grid Tied)
- Deep cycle Battery Set
- Grid Simulation
- Cabling / plug in type cables, battery terminals
- Portable Workstation complete with fixed or configurable didactic components.
- System includes instrumentation & probes to measure various parameters such as DC / AC voltage, current, temperature & radiation intensity at various points throughout the system
- Kit form includes halogen Free Solar Cables.

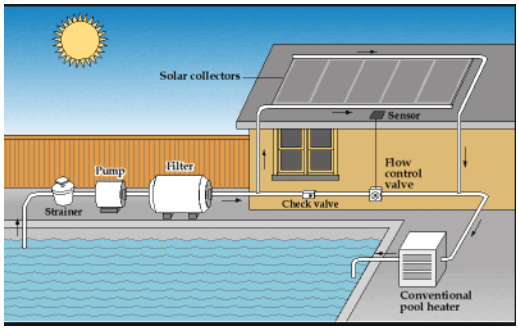
Optional:

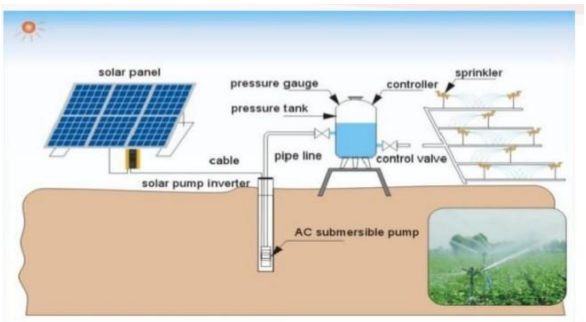
- Portable Lighting system to simulate Sunlight indoors with dimmer function
- Inclined Trussed Roof Station (Tiled / Corrugated) for panel installation

Other Trainers Available:

iv) **Solar PV Electric Gate Trainer / Installation Set**

v) **Solar PV Pool Pump / Irrigation System Trainer / Installation Set**





vi) **Solar Rainwater pump system with JOJO Reservoir Trainer / Installation Set**

vii) **Solar PV Basic USB Charging Kit – Mobile Phone**

RENEWABLE ENERGIES

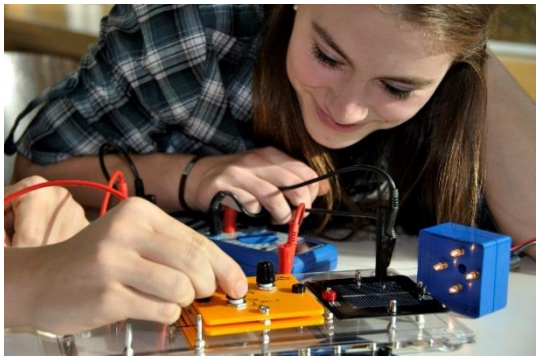
DL SOLAR-L

Solar photovoltaic energy

The kit DL SOLAR-L allows correlating school physics with practical usage of the photovoltaic cells. The system has been conceived in such a way that most experiments can be conducted in normal room lighting. An external current is not necessary for these experiments. The lighting module (included) is required only for a few experiments, which can be operated with a students' power supply.

COMPONENTS

- 3x Solar panel 0.5 V, 420 mA
- 1x Solar panel 0,5 V, 840 mA
- 1x Solar panel 1,5 V, 280 mA
- 1x Base unit
- 1x Lighting module
- 1x Diode module
- 1x Resistor module
- 1x Potentiometer module
- 1x Gear motor module
- 1x Buzzer module
- 1x Motor module without gear
- 1x Colour filter
- 1x Capacitor module
- 1x Solar cell cover set (4 pieces)
- 1x CD with manuals
- 1x Lid for tray
- 1x AV-module
- 1x Power module
- 1x Power supply
- 2x Test lead - black 25 cm
- 2x Test lead - red 25 cm
- 1x Thermometer

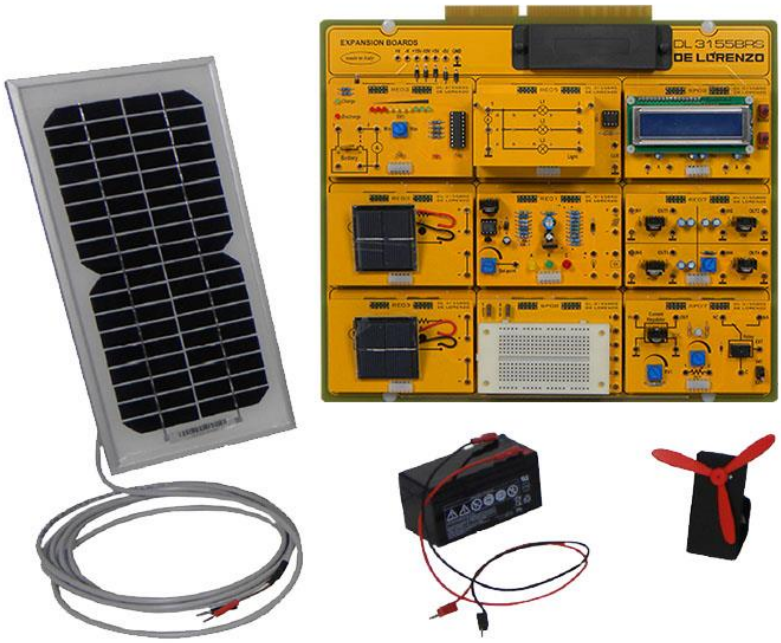


EXPERIMENTS

Series and parallel connection of solar cells
Dependence of the power of the solar cell on its area
Dependence of the solar cell power on the angle of incident of the light
Dependence of the solar cell power on the illumination intensity
Dependence of the on-load power on the illumination intensity
Efficiency of an energy conversion
Dependence of the internal resistance on the illumination intensity
Diodes character of the solar cell: I-V-characteristics under dark conditions, reverse and forward biasing in the dark and under illumination
I-V-characteristics, MPP and filling factor of the solar cell
Dependence of the I-V-characteristics on the illumination intensity and of the solar cell on the temperature
Dependence of the power of the solar cell on the temperature
Shading of series-connected and parallel-connected solar cells
Dependence of the solar cell power on the frequency of the incident light
Working with the plugging module
Comparing series and parallel connected solar cells with the buzzer module and light bulbe
Comparing series and parallel connected lamps
Direct comparison of series and parallel connection of the light bulbs
Direction of rotation and speed of the motor
Differences in brightness
Tilting of the solar cell
Diffuse,direct e albedo radiation
Basic structure: rotating disks
Color qualities
Mixing colors
Color-deception with the Benham-disk
Relief-disk
Centrifugal force

RENEWABLE ENERGIES

KIT FOR THE STUDY OF PHOTOVOLTAIC SOLAR ENERGY



The design and construction of electronic circuits to solve practical problems is an essential technique in the fields of electronic engineering and computer engineering.

The kit is a complete configuration for photovoltaic energy study in an off grid system. Its covers the fundamentals of solar cell and its operation in a storage system mode.

DL 3155BRS-PSE

LEARNING EXPERIENCES

- Electrical characteristics of a single solar cell
- Electrical characteristics of two solar cells connected in series
- Electrical characteristics of two solar cells connected in parallel
- Electrical characteristics of a solar panel
- Monitoring of the charge level and analysis of the discharging process in a gel battery
- Charging a battery by using a current regulator
- Charging a battery by using a charge regulator
- Analysis and comparison of two light sources
- Smart energy management system
- Study of energetic efficiency by means of a breadboard

CIRCUIT BLOCKS

- Base board
- Solar cell mini board x2
- Battery charge regulator mini board
- Double voltmeter mini board
- Voltage regulators mini board
- Battery level monitor mini board
- Light Tester mini board Kit
- Current driver and relay mini board
- Bread Board mini board
- Battery module (12V)
- Solar panel module 5W
- Fan module (load)

ACCESSORY INCLUDED:

DL 2555ALG - DC POWER SUPPLY

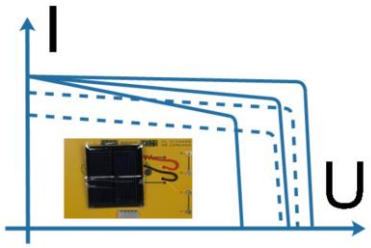
- ± 5 Vdc, 1 A
- ±15 Vdc, 1 A

Complete with manual (theoretical and practical) and cable kit.

Dimensions of the board: 297x260mm

RENEWABLE ENERGIES

EXPERIMENTS DESCRIPTION



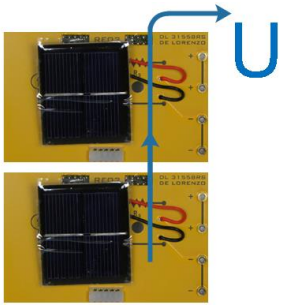
Electrical characteristics of a single solar cell

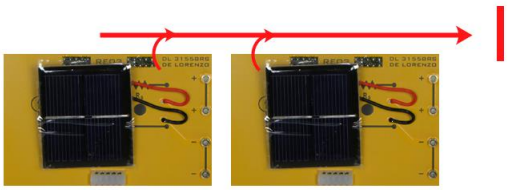
With a simple, small, and cheap solar cell you can prove the concept and draw the complex I-U characteristics, including the temperature influence on it.

Electrical characteristics of two solar cells connected in series

In real life we need some time higher voltage than one single panel can provide. In simple words, by adding two cells in series we obtain higher output voltage.

Through simple experiments we get conclusions about how cells are working in different conditions.



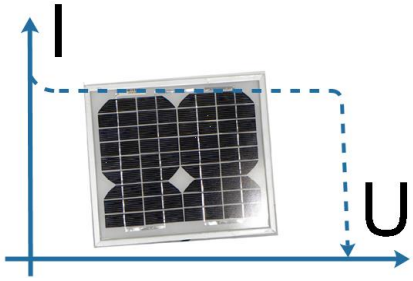


Electrical characteristics of two solar cells connected in parallel

Parallel connection of two power supplies offer higher current capabilities. In this experiment we test the working conditions of this connection between solar cells

Electrical characteristics of a solar panel

When we have many cells, and, after we understood what effects we obtain when we are connecting them in series and parallel, we can try to see how they are working together. A commercial solar pannel offers the possibility to expand the studies for higher amount of captured energy.



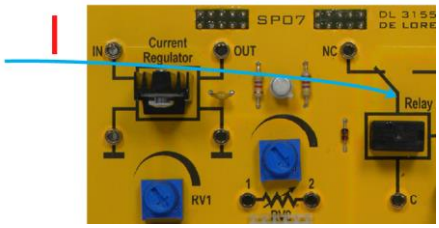
RENEWABLE ENERGIES

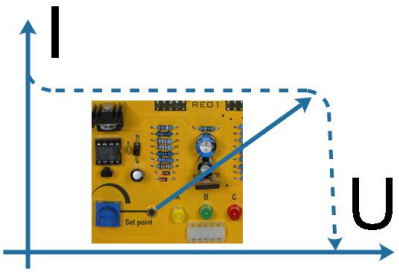
Monitoring of the charge level and analysis of the discharging process in a gel battery

Storing captured energy during a sunny day and using it in the night is a necessity of every energy user. In this experiment we learn the use of an accumulator to store the energy.

Charging a battery by using a current regulator

The charge of an accumulator is not a simple procedure, the solar panel and the battery are influencing each other. The solution consists in a current regulator.





Charging a battery by using a charge regulator

I-U characteristic of the solar panel needs control for maximum power injection into the accumulator. In the same time we must control the level of voltage in accumulator to avoid over charging.

Analysis and comparison of two light sources

After learning system connections, energy storage, we now learn how we can use energy in our daily lives. Through the use of lights as loads we learn how to use our system, through the system or directly from the energy source

RENEWABLE ENERGIES

PHOTOVOLTAIC SOLAR PANEL MEASUREMENT TRAINER

DL SOLAR-PV

Didactic system for the theoretical and practical study of photovoltaic solar panels.

With the photovoltaic solar panel measurement trainer, it is possible to perform experiments indoor and outdoor to determine and measure the characteristics of different types of photovoltaic panels and connections.

The system is provided with connecting cables, instruments and an experiments and learning activities manual.

TRAINING OBJECTIVES

- Solar panels under a variety of effects.
- Short-circuit current of a PV panel.
- Open-circuit voltage of a PV panel.
- Current at maximum output of a PV panel.
- Voltage at maximum output of a PV panel.
- Relationship between panel tilt, illuminance, short-circuit current and electrical output: Relationship between panel tilt and irradiation, Relationship between the solar panel output voltage and the irradiation, Relationship between the solar panel short-circuit current and irradiation.
- Determining the efficiency of a PV panel.
- Comparing different panel types.
- Series and parallel connections: Series connection of two solar panels, Parallel connection of two solar panels.

TECHNICAL SPECIFICATIONS

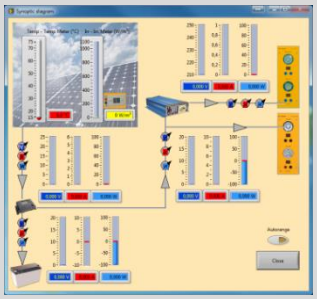
- One polycrystalline inclinable photovoltaic panel: approx. 90W, 12V, complete with a cell for measuring the solar irradiance and a temperature sensor.
- Two monocrystalline inclinable photovoltaic panels: approx. 85 W, 12V, complete with a cell for measuring the solar irradiance and a temperature sensor.
- Two Sun simulators consisting of halogen lamps to provide energy to the photovoltaic modules for indoor use.
- One active DC load used in the renewable energies laboratories configurable as constant resistance or constant current.
- One multifunction Photovoltaic panel measurement module with 2 solar irradiance and solar panel temperature meters, 2 DC multi-meters (current, voltage and power) and Modbus RTU serial communication for remote data acquisition. It includes diodes to connect the solar panels in series and parallel and a potentiometer to control the power of the sun simulator modules.
- Temperature and solar irradiance sensor module.

RENEWABLE ENERGIES

SOLAR ENERGY MODULAR TRAINER

DL SOLAR-B

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

TRAINING OBJECTIVES

- Measurement of solar irradiation
- Measurement of the voltage of the photovoltaic panel at no-load
- Graph of current – voltage of the photovoltaic panel
- Measurement of the voltage of the panel in overload
- Regulation and charge of the battery
- Direct current solar plant
- Alternate current solar plant
- Dimensioning criteria

Average training hours: 8h.
Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.
Net weight: 51 kg.

OPTION: DL SIMSUN

Composed of 12 halogen lamps, 120 W each, for lighting the solar tracking system. Possibility to adjust the light intensity.

TECHNICAL SPECIFICATIONS

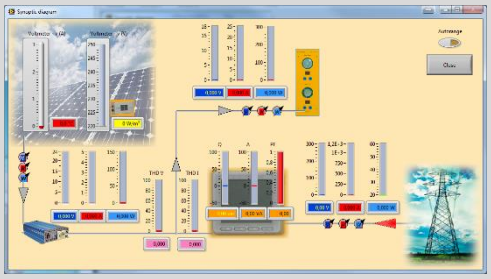
- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting frame for the modules.
- A battery.
- A battery control module, 12V, 32A.
- A load module. It includes two 12V lamps, dichroic 20W and LED 3W, with independent switches.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- An electronic regulation module, with LCD screen.
- A rheostat.
- A module for the measurement of: solar irradiation (W/m^2), solar panel temperature (°C), current up to 30V, ± 15A (two dc ammeters), voltage up to 40V and power up to 300W.
- A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.

RENEWABLE ENERGIES

SOLAR ENERGY MODULAR TRAINER WITH CONNECTION TO MAINS

DL SOLAR-D1

Didactic system for the study of the generation of electric energy from photovoltaic panels and its inlet in the mains network.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

TRAINING OBJECTIVES

- Measuring the mains voltage
- Measuring the load current, voltage, power, and energy
- Setting the solar panel to the most irradiated position
- Changing the inclination of the solar panel
- Changing the azimuth of the solar panel
- Covering the solar panel with different materials
- Obtaining the solar irradiation data
- Obtaining the solar panel voltage-irradiation curve
- Calculating the inner resistance of the solar panel
- Obtaining the solar panel current-voltage curve
- Measuring the electricity delivered to the mains grid
- Measuring the electricity produced by the solar panel and delivered/taken from the mains grid
- Measuring the electricity produced by the solar panel, delivered/ taken from the mains grid, and the loading of lamps

Average training hours: 8 h.
Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.
Net weight: 51 kg.

TECHNICAL SPECIFICATIONS

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting frame for the modules.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- A power rheostat, 6 A, 80 W.
- A differential magneto-thermal switch module.
- A module for the measurement of: solar irradiation (W/m^2), solar panel temperature (°C), solar panel current, load current, solar panel voltage and active power at mains voltage.
- A grid tie inverter, with output at mains voltage, 12 V, 300 W.
- An electric energy measurement module in kW/h.
- A network distributor.

OPTION: DL SIMSUN

Composed of 12 halogen lamps, 120 W each, for lighting the solar tracking system. Possibility to adjust the light intensity.

RENEWABLE ENERGIES

PHOTOVOLTAIC SOLAR ENERGY ADVANCED TRAINER

DL SOLAR-AT

Modular trainer for the theoretical and practical study of the electric energy generation from photovoltaic panels. With the Photovoltaic Solar Energy Advanced Trainer it is possible to perform experiments to determine the characteristics of a photovoltaic panel, study its off-grid operation with a battery charge regulator and its on-grid operation with the connection to the mains network.
The complete system is supplied with a sun simulation module for indoor use.

TRAINING OBJECTIVES

- Measuring solar radiation: Changing the inclination and azimuth of the solar panel
- Investigating the PV module response to shadow formation
- Recording the characteristics of the solar modules: Solar Panel Voltage-Irradiation Curve, Solar Panel Current-Irradiation Curve (calculating the inner resistance of the solar panel), Obtaining the solar panel current-voltage curve, Obtaining the solar panel current-power curve, Measurement of the voltage and current of the photovoltaic module with overload
- Off grid system: Measuring the generated power of a PV system and battery charging
- Off grid system: Using Solar Panel and Battery to supply a DC Load
- Off grid system: Design and testing of a standalone PV system in direct storage operation and 230V AC

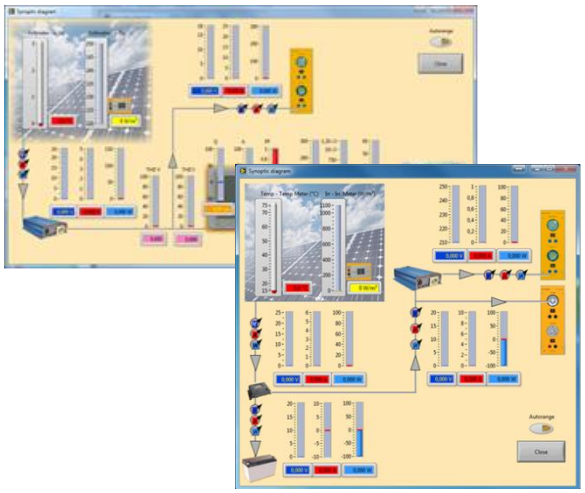
TECHNICAL SPECIFICATIONS

- Electronic charge regulation module, with LCD display, MPPT tracking and energy monitor.
- Load management module with three independent single-phase outputs for the dynamic study of different load types.
- Active DC load used in the renewable energies laboratories configurable as constant resistance or constant current.
- Network monitor module used to measure electrical parameters in a single phase circuit
- Circuit breaker module.
- Fixed single phase power source rated at mains voltage with auxiliary 12 Vdc fixed regulated voltage output to power measurement modules
- DC load module. It includes a 20W dichroic lamp and a 3W LED lamp, with independent switches.
- Inclinable photovoltaic panel, approx. 90W, 12V, complete with a cell for measuring the solar irradiation and a temperature sensor.
- Battery and battery protection module.
- A Grid-tie inverter output at mains voltage, 12V, 300W.

RENEWABLE ENERGIES

- On grid system: Measuring the electricity delivered to the mains grid
- On grid system: Measuring the electricity produced by the solar panel, delivered/taken from the mains grid, and the loading of AC lamps
- On grid system: Determining the efficiency of the grid connected inverter
- On grid system: Investigating the response of a PV system to a mains failure

- Multifunction measurement module: solar irradiation (up to 1000 W/m2), solar panel temperature (up to 400°C), 2 DC power meters (65Vdc, 20Adc, 1000W) and 1 AC power meter (512Vac, 20Aac, 1000W).
- Off-grid inverter module, with sinusoidal output at mains voltage. Average power: 300 W.
- Sun simulator consisting of halogen lamps to provide energy to the photovoltaic module for indoor use.
- Three level frame.



The Photovoltaic Solar Energy Advanced Trainer is supplied with a software developed in LabVIEW that communicates with the main components of the modular system via RS485 serial communication using Modbus RTU protocol to perform data acquisition and processing.

RENEWABLE ENERGIES

ON-GRID SOLAR ENERGY WITH STORAGE

DL SOLAR-GTS

Modular trainer for the theoretical and practical study of the electric energy generation from photovoltaic panels. With the on-grid solar energy with storage, it is possible to perform experiments to determine the characteristics of a photovoltaic panel, study its on-grid operation with the connection to the mains network and its operation with a grid-tie battery charge controller for storage.
The complete system is supplied with a sun simulation module for indoor use.

TRAINING OBJECTIVES

Solar panel characterization:

- Measuring solar radiation: Changing the inclination and azimuth of the solar panel
- Investigating the PV module response to shadow formation
- Recording the characteristics of the solar modules: Solar Panel Voltage-Irradiation Curve, Solar Panel Current-Irradiation Curve (calculating the inner resistance of the solar panel), Obtaining the solar panel current-voltage curve, Obtaining the solar panel power-voltage curve, Measurement of the voltage and current of the photovoltaic module with overload.

Solar on-grid system:

- Measuring the electricity delivered to the mains grid
- Measuring the electricity produced by the solar panel, delivered/taken from the mains grid, and the loading of AC lamps
- Determining the efficiency of the grid connected inverter
- Investigating the response of a PV system to a mains failure

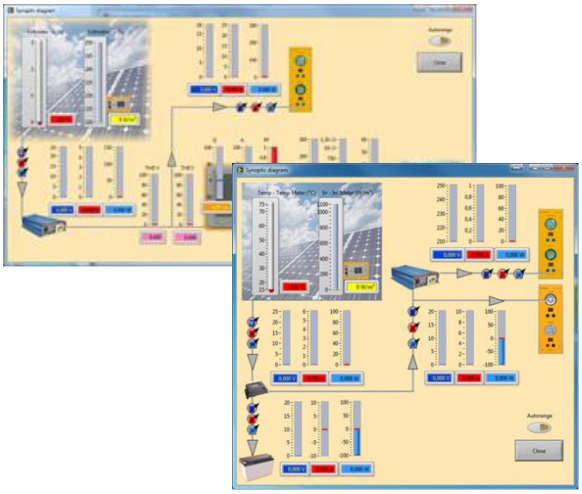
TECHNICAL SPECIFICATIONS

- Inclinable photovoltaic panel, approx. 90W, 12V, complete with a cell for measuring the solar irradiation and a temperature sensor.
- Sun simulator consisting of halogen lamps to provide energy to the photovoltaic module for indoor use.
- Multifunction measurement module: solar irradiation (up to 1000 W/m2), solar panel temperature (up to 400°C), 2 DC power meters (65Vdc, 20Adc, 1000W) and 1 AC power meter (512Vac, 20Aac, 1000W).
- Load management module with three independent single-phase outputs for the dynamic study of different load types.
- Active DC load used in the renewable energies' laboratories configurable as constant resistance or constant current.
- Single phase transformer with full-wave rectifier and capacitive filter to power DC load from AC single phase supply.
- A Grid-tie inverter output at mains voltage, 12V, 300W.

RENEWABLE ENERGIES

Solar on-grid storage system:

- Measuring the generated power of a PV system and battery charging.
- Using Solar Panel and Battery to supply an AC Load.



The ON-GRID solar energy with storage is supplied with a software developed in LabVIEW that communicates with the main components of the modular system via RS485 serial communication using Modbus RTU protocol to perform data acquisition and processing.

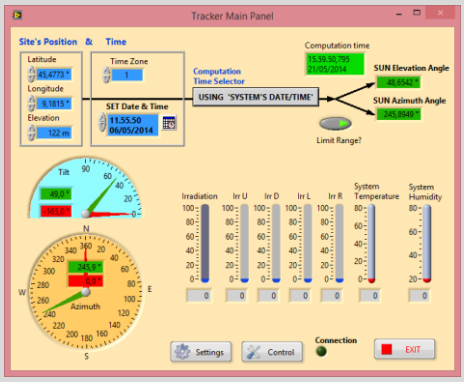
- Three-phase power analyser. Measurement of voltages, currents, frequencies, active power, reactive power, apparent power.
- Inverter charger module used in on grid system to manage the energy stored in the battery, combining with solar & utility charging and AC output. It offers four charging modes including Solar priority, Utility priority, Solar and Utility & Solar and two output modes for Battery and Utility. It utilizes the MPPT technology. Its output is protected against over current and reverse polarity.
- Single-phase supply at the mains voltage and frequency. Key operated Output: Phase + N + T though 4mm safety terminals, protected with differential magneto-thermal switch.
- Variable DC power supply that emulates a photovoltaic panel. The V/I characteristic of the output varies in function of the irradiation setting. Local or remote control via serial communication using Modbus RTU.
- Three-level frame.

RENEWABLE ENERGIES

SOLAR POSITION TRACKING SYSTEM

DL SUN-TRACKER (bench not included)

For the study of the operation of a solar panel that follows the sun light direction thanks to a motor system.



Complete with connecting cables, experiment manual and **software for control and data acquisition**.

TRAINING OBJECTIVES

With the trainer, it is possible to monitor the most meaningful parameters of the sun tracker and to compare them with the expected optimal setting according to the actual sun position.

Average training hours: 3h approx.
Approx. packing dimensions: 0.50 x 1.05 x 0.90 m.
Net weight: 32 kg.

TECHNICAL SPECIFICATIONS

The trainer is composed of the following:

- A two-axis solar tracking system, 2 x 20W, 12V, to allow the tracking of the sun light direction.
- A supporting frame for the modules.
- A battery.
- A battery charge regulator, 12V, 10A.
- A circuit breaker.
- A load module. It includes two 12V lamps, dichroic 20W and LED 3W, with independent switches.

OTHER FEATURES:

- Automatic or manual tracking.
- Temperature sensor.
- Humidity sensor
- Compass sensor.
- Protection against gust.
- RS485 Modbus RTU communication.

RENEWABLE ENERGIES

DL THERMO-L
Thermal energy

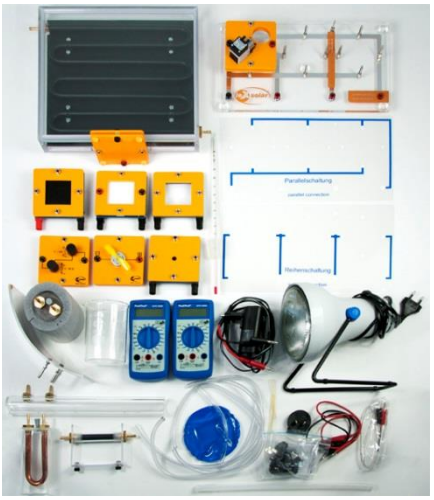
This kit provides a basic understanding of solar thermal energy conversion. The most important component is the solar collector, which can be powered both by sunlight as well as by the infrared light source.

MAIN COMPONENTS

- base
- potentiometer module
- solar collector
- reflector collector
- absorber tube
- lens module
- absorber module for lens
- absorber B/W
- pump module
- Peltier module
- water heat exchanger
- paraffin heat exchanger
- hose-set
- power supply
- motor module
- lamp
- multimeters
- thermometer
- temperature sensor
- propeller
- Borosilicate beaker glass
- Illuminat infrared
- Cooling pad
- test leads
- CD with manuals

EXPERIMENTS

- Absorptivity and reflectivity of different materials
- Focusing of light by a Fresnel lens
- Thermal convection and layering
- Thermal conduction
- Thermal insulation
- Solar thermal collector with pump circulation
- Solar thermal collector with thermosiphon circulation
- Variation of the flow speed
- Collector circuit with heat exchange
- Collector circuit with paraffin heat reservoir
- Parabolic channel collector with pump cycle
- Defocussing
- Qualitative demonstration of the functional principle
- Investigating the thermoelectric generator
- Quantitative determination of the electrical power



RENEWABLE ENERGIES

SOLAR THERMAL ENERGY TRAINER

DL THERMO-A12

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation, air conditioning and similar services.
It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at four different points, and a solar irradiation sensor that is used to calculate energy.

Complete with connecting cables, experiment manual and software for data acquisition from the solar controller and processing.

TRAINING OBJECTIVES

- Identification of all components and how they are associated with its operation.
- Interpretation of the technical parameters of all components.
- Local control of the processor
- Heating and check of the convector heater
- Forcing the reserve energy
- Forcing the recirculation pump
- Sizing criteria for domestic hot water facilities, air conditioning, etc.
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control.

2x SOLAR PANEL

In this trainer there are two solar panels. The first one is a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves. The second one is a simulator of a solar panel supplied by the mains for the use in classroom. Both panels can be connected to the main module, one at a time.

CONVECTOR HEATER

As a means of applying the hot water produced, a convector heater is available for use. It is connected through flexible pipes. This component allows us to experiment with the effects of hot water obtained with this system. However, the system is sufficiently open to permit easy use with other applications, such as hot sanitary water supply, under-floor heating, etc.

TECHNICAL SPECIFICATIONS

The trainer is composed of four operating units, as follows:

MAIN MODULE

Dimensions 1000 x 650 x 1650 mm., front panel with the block diagram of the system. It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for assembly and disassembly operations carried out during the practical sessions described in your handbook. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. The hydraulic sockets for cold water inlet, hot sanitary water outlet, connection to the solar panel, etc., are located at the back of the module.

THERMOTRONICS

PHOTOVOLTAIC AND THERMAL PANELS

DL TM11

The simulator allows the study, the performing of experiments and the troubleshooting for the following systems:

- Photovoltaic silicon single crystal cell, squared, side 135 mm
- Two photovoltaic cells with series connection
- Two photovoltaic cells with parallel connection
- Panel composed of 36 photovoltaic cells with series connection
- Thermal panel with liquid circulation

These systems are reproduced on the panel, through a color representation which allows a complete analysis of the fluid circuit, of its components and of the electrical/electronic circuit for control and regulation.

TRAINING OBJECTIVES

It is possible to simulate the behaviour of components and systems, on the basis of the operating conditions which can be monitored directly on the panel or through Personal Computer by teacher and students.

The Personal Computer constantly keeps under control the simulation in progress and displays its behaviour through analog and digital signals and meters; in this way the student, through measurements and tests, can go on with the troubleshooting.

Average training hours: 10h (including 2h for fault finding).
Dimensions: 0.66 x 1.04 x 0.35 m.
Net weight: 16 kg.

The system is supplied with a Student Navigator software that allows students to perform their learning activities through a Personal Computer, without the need for any other documentation.

Moreover, the Student Navigator is provided with an interface to the Laboratory Management software.

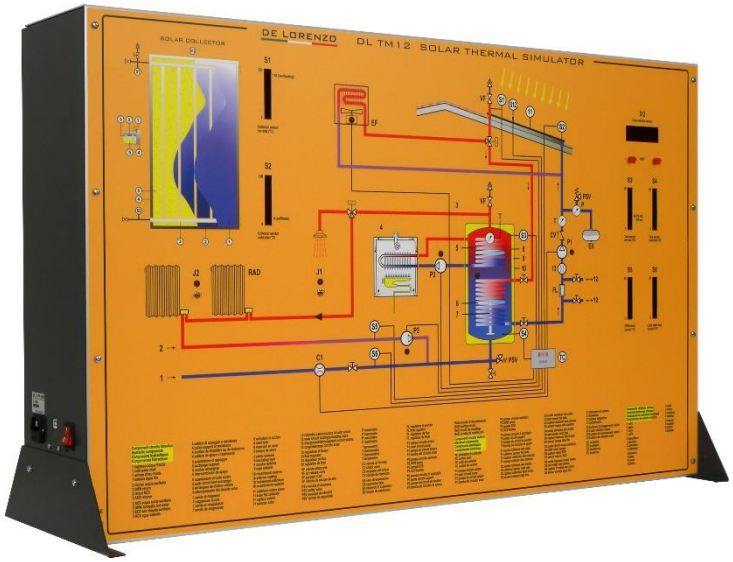
TECHNICAL DESCRIPTION

The experimentation on the photovoltaic systems (described here under) is organized as follows:

- Possibility to simulate several values of the solar radiation intensity (W/m2)
- Possibility to simulate several values of the photovoltaic cells temperature
- Possibility to change the electrical load of the above- mentioned photovoltaic systems
- Detection of the characteristic voltage-current (V-I), supplied by the photovoltaic systems, as a function of solar radiation intensity and cells temperature
- Detection of the characteristic voltage-power (V-P), sup- plied by the photovoltaic systems, as a function of solar radiation intensity and cells temperature
- Evaluation of the conversion efficiency (radiating energy-electric power) of the photovoltaic systems

RENEWABLE ENERGIES

SOLAR THERMAL HOME PLANT SIMULATOR



DL TM12

Didactic system for the theoretical study of solar plants that are used to get hot water for sanitary and air conditioning purposes or other civil applications.

The simulator allows a wide range of didactic applications. It also simulates six temperature probes available in different points of the circuit and a solar irradiation sensor that is used to calculate the absorbed energy.

TRAINING OBJECTIVES

It allows performing the following teaching activities:

- Identification and study of all the components of solar thermal circuits and of their connections.
- Interpretation of the technical parameters of all the components.
- Dimensioning criteria for of sanitary hot water installations, etc.
- Criteria for assembly and maintenance of the plants.
- Interpretation of the data provided by the control system.

Average training hours: 10h (including 2h for fault finding).

Dimensions: 0.66 x 1.04 x 0.35 m.
Net weight: 16 kg.

The system is supplied with a manual containing exercises and the theory about solar thermal systems and that addresses the following topics:

- The solar energy
- Systems for exploiting the solar energy
- Types of solar thermal systems
- Main components of a solar thermal system
- Sizing of collectors, pipes and tanks
- Examples of how to dimensioning a plant

TECHNICAL DESCRIPTION

The trainer simulates the following three operating sections:

PRIMARY SYSTEM

Represented on the panel by the diagram of the circulation of the liquid, coming from the collector, that heats the water contained in the storage tank.

SOLAR THERMAL COLLECTOR

Provided with two temperature probes for the hot (inlet) and cold (return) liquid. A light sensor detects the solar radiation and allows the plant to be operational or not operational (night). This part of the circuit is complete with an automatic lowering of the temperature where it is too high in the primary circuit.

SECONDARY CIRCUIT (use of the hot water)

As an application of the production of hot water, the circuit of the use of the hot water that has been obtained is here represented. In this part of the circuit we have: a tank sensor on the hot side, one on the cold side, one at the cold water inlet and one at the used hot water outlet. Displays and led bars allow the visualization of the temperature values in order to control the operation of the plant.

RENEWABLE ENERGIES

SOLAR THERMAL ENERGY TRAINER

DL THERMO-A3

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation and similar services.

It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at different points, and a solar irradiation sensor that is used to calculate energy.

TRAINING OBJECTIVES

- Identification and familiarization of the components
- Interpretation of the technical parameters of all components.
- Functioning of the collector and the heating circuits and how they operate.
- Observation and analysis of the collector efficiency
- Local control of the processor
- Definition of the net power
- Study of the relationship between flow and net power
- Determining the correlation between the temperature variation (collector/environment) and the collector efficiency
- Heating and checking of the convector heater
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control

TECHNICAL SPECIFICATIONS

The trainer is composed of operating unit composed of:

MAIN UNIT AND CONTROL PANEL

It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for a display of the actual components used in systems. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. Through the control panel it is possible to determine the set points and visualize the temperature changes, flow, etc.

HOT WATER CIRCUIT AND SOLAR THERMAL STATION

In the lower part there is mounted a 65-liter tank for the accumulation of domestic hot water. The heat exchange between the collector (primary circuit) and the buffer tank (secondary circuit) is obtained by a plate heat exchanger. The relevant circulation pumps, controlled by the main unit, manage the two circuits.

SOLAR THERMAL COLLECTOR

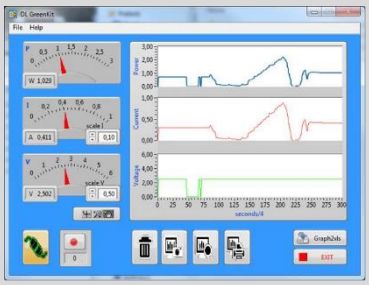
The solar collector is mounted on the rear side of the panel and it is adjustable.

The system comes complete with all necessary components, such as thermometers, pressure relief valves, expansion tank, flow meters, etc.

RENEWABLE ENERGIES

SOLAR-WIND-FUEL CELLS ENERG

This trainer has been designed for the study of renewable energies sources: **solar energy, wind energy and hydrogen fuel cell systems.**



Complete with connecting cables, experiment manual, connection to PC through the RS485 serial port and **software for data acquisition and display**.

DL GREENKIT

TRAINING OBJECTIVES

Study of a solar system

- Voltage and current in a solar panel as a function of light intensity
  - Measuring V_{oc} and I_{sc} characteristics of a solar panel
  - Influence of temperature on solar panels
  - Connecting solar panels in parallel
  - Connecting solar panels in series.
  - Influence of tilt angle on solar panels
  - Effect of shade on solar panels
- Current-Voltage characteristic, power curve and efficiency of a solar panel.
  - Study of solar panel under load. (Tracing the VI and power curve to determine MPP).
  - Solar panel efficiency

Study of a wind system

- The wind energy experiment-study of influence of wind speed and direction
  - Studying and understanding the power from the wind

COMPONENTS INCLUDED

- Reversible PEM fuel cells
- PEM Electrolyser
- Reversible hydrogen fuel cell to assemble
- Hydrogen and oxygen tanks
- Syringe
- Motor and fan with propeller blade
- 1 Watt solar panel
- 0.75 Watt solar cell
- Mini wind turbine (wind power generator)
  - Blade pitch, blade profile and number of blades can be evaluated
  - Vane aligns the turbine automatically to the direction of the wind
  - Special 3 phase alternator for higher output power
- Vehicle chassis with LED light & motor
- Battery pack with connecting leads
- Three DC instruments: range 10 V, 2 A.
- Decade Resistor
- Double spotlight with 2 halogen lamps

RENEWABLE ENERGIES

- Influence of wind speed on generated power.
- Influence of wind direction on generated power.

- The study of influence of the wind turbine characteristics on generated power.
  - Influence of the number of rotor blades.
  - Influence of the pitch.
  - Influence of the blades shape.
- The study of current-voltage characteristic of the wind generator; the influence of the load over rotor movement
  - Trace the current-voltage characteristic curve of a wind generator
  - Finding the MPP for different wind speeds (Tuning for max. power)
  - Study the "stability" of the wind turbine when it is influenced by the load (braking mode)

Study of a fuel cell system

- Understanding Fuel Cell General Installation
- Understanding Fuel Cell Structure (Assembling a fuel cell)
- Electrolyser: Producing Hydrogen as an electrical energy storage method
  - Determining the Minimum Voltage for Water Decomposition
  - Determining the flow of gas generated by the electrolyser
  - Determining the characteristic V-I curve of PEM electrolyser.
  - Energy efficiency and faraday efficiency of PEM electrolyser.
- Fuel cell: Producing electrical energy from stored Hydrogen.
  - Determining the V-I characteristic and power curve of a PEM fuel cell.
  - Energy efficiency and faraday efficiency of PEM fuel cell.

Study of a hybrid (Autarkic) system

- Implementing hybrid wind solar power system with hydrogen storage.
- Implementing hybrid fuel cell solar power system: studying the autonomy of a hydrogen powered car.

GENERAL FEATURES

Average training hours: 8h.
Approx. packing dimensions: 0.81x0.61x0.61 m.
Net weight: 29 kg.

Note:

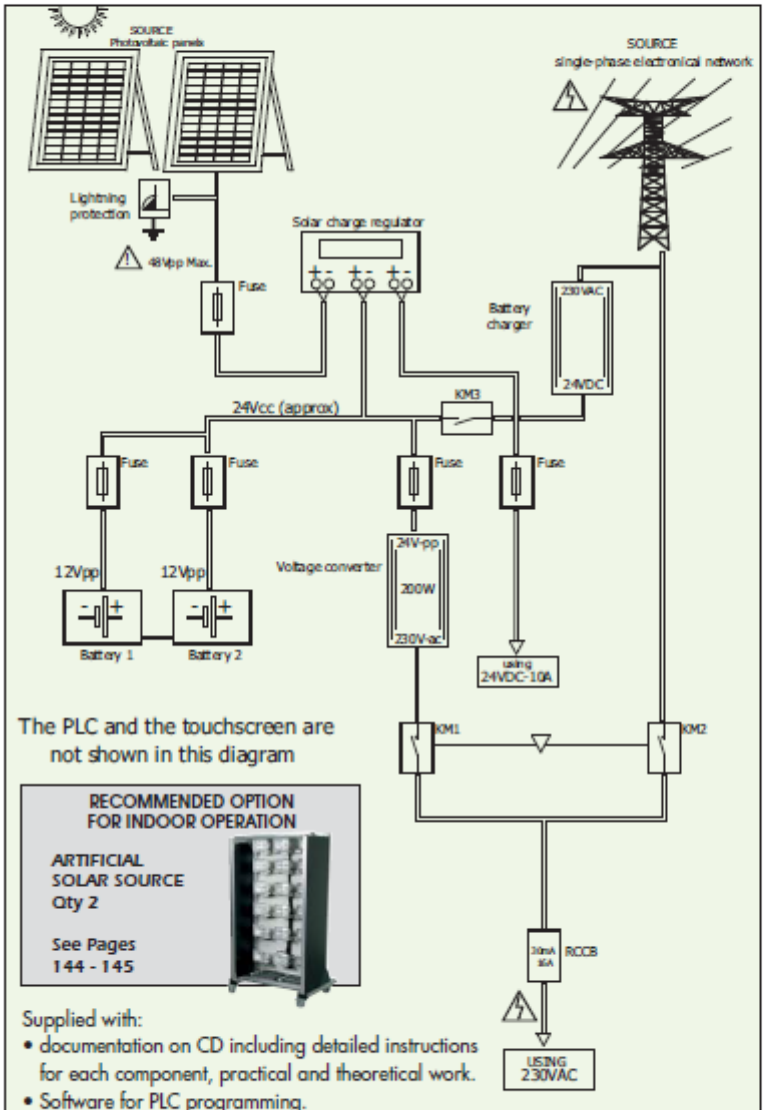
DL GREENKIT requires table fan. It is not included in the kit.

SOLAR CENTRAL UNIT WITH SUPERVISOR

Top view

ref. SOLHAB

ref. SOLHAB-N Sold without panel.



Supplied with:
- documentation on CD including detailed instructions for each component, practical and theoretical work.
- Software for PLC programming.
- VIJEODESIGNER software for touchscreen programming.
- 2 photovoltaic panels with link cable

EDUCATIONAL OBJECTIVES

- **Studying of a photovoltaic system in a isolated site.**
- **Creation of a PLC program.**
- **Creation of a supervision application of a touch screen.**
- **Using a clamp-on ammeter.**
- **Studying the efficiency of a photovoltaic system.**

TEACHING RESOURCES STUDENT & TEACHER

Feasible practical works

- Theoretical work on the positioning of solar panels.
- Studying the sizing of photovoltaic components in a isolated site.
- Understanding of the wiring.
- Calculation of powers.
- Programming of the PLC and the touch screen.
- Producing or modification of a supervision application.

Possible scenarios

Alterable by the programming software of the PLC and the touch screen

- Using of the energy provided by the solar panels.
- Batteries recharging by the charger.
- Automatic sources switching.
- Use of solar energy during the day and electrical network at night.
- Use of the energy provided by the electrical network.

Technical characteristics

On the top surface:

- 1 main ON/OFF switch + 1 emergency stop button.
- 1 24VDC batteries charging switch.
- 1 touchscreen 3x4" colour QVGA, 320 x 240 pixels, Ethernet socket.
  Control interface between the user and the system, it displays electrical parameters necessary for the understanding of the functioning.
  It allows a simple and complete supervision, monitoring and control.
- 1 solar load regulator.
- 1 set of signalling indicator lamps.
- 2 synoptics / complete diagram of the system with terminals and indicator lamps.
- Safety terminals for 230V-AC use output.

On the side:

- 2 safety terminals for voltage input from the solar panel.
- 1 main isolating switch from the public network.
- 1 solar panel isolating safety switch
- 1 RJ45 Ethernet connector.

In the cabinet

- 2 batteries 12VDC-12Ah + 1 battery charger 24V.
- 1 pure sine inverter 24VDC/230VAC-50Hz - 300W.
- 1 PLC Ethernet.
- 1 analogue board 2 Inputs 0-10V/4-20mA and 1 Output 0-10V/4-20mA
- 1 4-port Ethernet coupler.
- 1 set of protection devices included 1 open door safety device.

Photovoltaic solar panel on tilting frame

- Useful surface area of the cells 1.5m².
- Open circuit voltage: 57V DC, Optimum operating voltage: 47V DC
- Short-circuit current: 4.6A
- Optimum operating current: 4.3A
- Maximum power: 200Wc (variation of ± 10% depending on the series)
- Device for measuring the tilt angle
- Tilt adjustable from 5° to 70°
- Light and easy to move.

Dimensions:
Folded position: 1620 x 1060 x 100mm
Unfolded to 70° position: 2100 x 1060 x 700mm

System power by power cord. 2P+E. 230VAC 50/60Hz

SOLAR CENTRAL UNIT WITH NETWORK COMPLETE SOLUTION FOR INJECTION AND ISOLATED SITE

ref. SOL-1	SEE PAGE 130
Electrical cabinet + 2 Photovoltaic panels + 1 link cable	
ref. HABITAT-1	SEE PAGE 133
Loading zone	

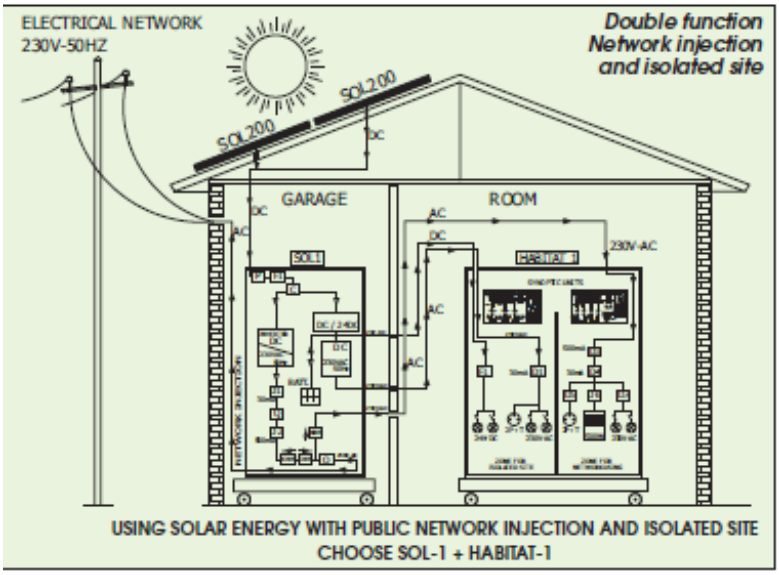
SOLAR CENTRAL UNIT PARTIAL SOLUTION WITH NETWORK INJECTION

ref. SOL-2	SEE PAGE 131
Electrical cabinet + 2 Photovoltaic panels + 1 link cable	
ref. HABITAT-2	SEE PAGE 133
Loading zone	

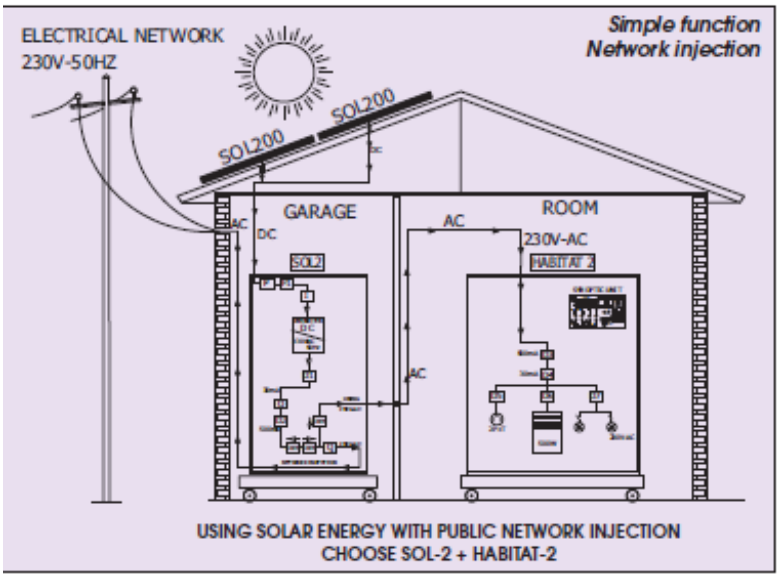
SOLAR CENTRAL UNIT PARTIAL SOLUTION WITH ISOLATED SITE

ref. SOL-3	SEE PAGE 132
Electrical cabinet + 2 Photovoltaic panels + 1 link cable	
ref. HABITAT-3	SEE PAGE 133
Loading zone	

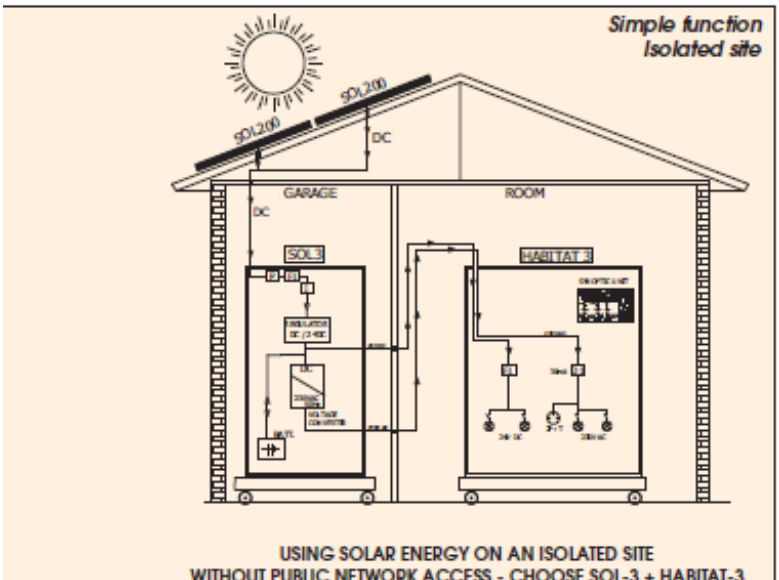
ACQUISITION FOR CENTRAL UNIT



USING SOLAR ENERGY WITH PUBLIC NETWORK INJECTION AND ISOLATED SITE
CHOOSE SOL-1 + HABITAT-1

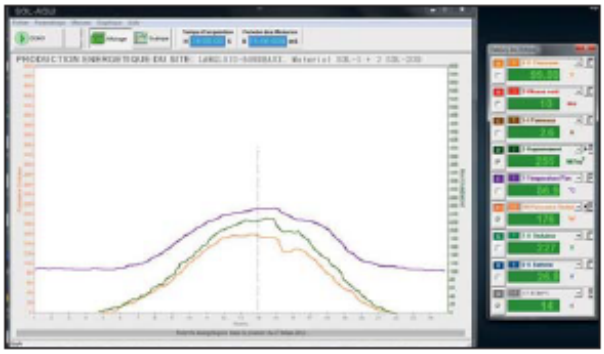


USING SOLAR ENERGY WITH PUBLIC NETWORK INJECTION
CHOOSE SOL-2 + HABITAT-2



USING SOLAR ENERGY ON AN ISOLATED SITE
WITHOUT PUBLIC NETWORK ACCESS - CHOOSE SOL-3 + HABITAT-3

ref. ACQUI-SOL



Set of sensors, interfaces and software for the real time data monitoring of a photovoltaic installation.

COMPRISES

- Three 4-20mA sensors for reading wind speed (m/s), solar irradiation (W/m2) and the temperature of the solar panel (°C).
- 1 sealed "solar panel power interface" box for reading the voltage and current supplied by the photovoltaic panels.
  This interface transmits information (U / I / Wind speed /temperature / irradiance) to the data interface as 4-20mA signals. Voltage 250VDC Max./Current 25A Max.
- 1 "inverter power interface" box to be installed near the inverter reads the voltage and current supplied to the installation. U/I information is transmitted to the data interface as 4-20mA signals. Voltage 250VDC Max./Current 20A Max
- 1 "battery power interface" box to be installed near the batteries reads the voltage supplied to the installation. U information is transmitted to the data interface as 4-20mA signals. Voltage 250VDC.
- 1 "data interface" box collects the 4-20mA signals from the different power interfaces to transmit them to your PC. Mains power supply 230VAC - PC link by USB lead supplied.
- 1 Software for monitoring photovoltaic settings and data
  Allows:
  - you to create your photovoltaic installation.
  - real time display as curves and numeric blocks of the different data of: wind speed, solar irradiation, panel temperature; U / I supplied by the solar panel; U / I supplied by the inverter; U supplied by the battery
  - the display, after acquisition, of the curves of electrical power supplied by the solar panels, electrical power supplied by the inverter, installation efficiency
  - selection of the sampling frequency for data acquisition (1 to 60 minutes), the acquisition period (1 minute to 24H), the display scales of the curves and their colours, data export to a spreadsheet like Excel®.

The Software is compatible with Windows XP, W7. Supplied on CD.
All the connection cables and mounting accessories are supplied.

SOLAR CENTRAL UNIT WITH NETWORK INJECTION AND ISOLATED SITE

RECOMMENDED OPTION FOR INDOOR OPERATION

ARTIFICIAL SOLAR SOURCE
Qty 2

See Pages 144 - 145

Supplied with 1 pyranometer

EDUCATIONAL OBJECTIVES

- Understanding the different elements of a photovoltaic system.
- Understanding the safety components involved in the system.
- Electrical measurements of different parameters.
- Analyzing and interpreting results.
- Studying the efficiency and impacts related to the positioning of the solar panels.
- Studying of the chain of solar energy (production, storage, consumption, resale, energetic behavior).
- Wiring of a photovoltaic system.

TEACHING RESOURCES STUDENT & TEACHER

ref. SOL-1 Electrical cabinet + 2 Photovoltaic panels + 1 link cable

ref. SOL-1-N Electrical cabinet only
Sold without panel. Use your own panels with characteristics comprise between 35 and 150VDC.

PARTIAL OR TOTAL RESALE OPERATION

In the cabinet a DC/AC inverter converts the DC from the photovoltaic panels to AC 220VAC 50Hz, and injects its power in synchronism into the network through an isolation transformer. This inverter is protected against any polarity reversal and any overload on the DC or AC side. When the panels are not lit, the inverter consumes no current.

Technical characteristic for the inverter coupled to the public network.

INVERTER	Voltage	Max current	Power
INPUT	65~125VDC	8A	
OUTPUT	230VAC-50Hz	2,25A	500W

OPERATION IN ISOLATED SITE WITH NO RESALE

The photovoltaic current charges two 12V sealed batteries cabled in series through a charging controller. This DC voltage is either available on safety terminals at the rear of the cabinet or converted to 250VAC 50Hz by a 200W voltage converter.

Technical characteristics for the isolated site converter

VOLTAGE CONVERTER	Voltage	Max Current	Power
INPUT	20~32 VDC	11A	210W
OUTPUT	230VAC 50Hz	1,5A	300VA

1. ELECTRICAL CABINET

Technical cabinet of standardized solar central unit on wheeled frame.
Dimensions: 810 x 600 x 1890mm

Comprises

- 2 disconnectors
- 1 500mA -30A differential
- 1 30mA differential
- 1 lightning arrester + fuses
- 3 100 Wh resolution meters
- 1 Mushroom head emergency stop
- 1 source inverter
- 1 charging controller 12/24VDC-20A
- 2 batteries 12V-12Ah
- 1 set of photovoltaic connectors
- 1 500W inverter for network synchronisation
- 1 Voltage converter 24VDC/230VAC-200W

2. LINK CABLE

30-m cable for connecting the solar panels to any type of solar system.

3. PHOTOVOLTAIC SOLAR PANEL 200WC ON TILTING FRAME (FOR EACH PANEL)

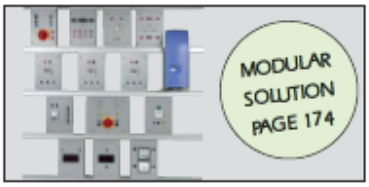
- Open circuit voltage: 57V DC
- Short-circuit current: 4.6A
- Optimum operating voltage: 47V DC
- Optimum operating current: 4.3A
- Maximum power: 200Wc (variation of ± 10% depending on the series)
- Sealed connections IP65 – 1000V on the rear of the panel.
- Type of cells: Monocrystalline silicon
- Robust aluminium frame.
- Useful surface area of the cells 1.5m².
- Output 47VDC – 4.2A – 200Wc per panel on 2 photovoltaic terminals.
- Device for measuring the tilt angle
- Tilt adjustable from 5° to 70°
- Two ball joints with clamping levers for positioning the panel to the required tilt angle.
- Light and easy to move.
  Folded position: 1620 x 1060 x 100mm
  Unfolded to 70° position: 2100 x 1060 x 700mm

SOLAR CENTRAL UNIT WITH NETWORK INJECTION

RECOMMENDED OPTION FOR INDOOR OPERATION

ARTIFICIAL SOLAR SOURCE
Qty 2

See Pages 144 - 145



EDUCATIONAL OBJECTIVES

- **Understanding the different elements of a photovoltaic system.**
- **Understanding the safety components involved in the system.**
- **Electrical measurements of different parameters.**
- **Analyzing and interpreting results.**
- **Studying the efficiency and impacts related to the positioning of the solar panels.**
- **Studying of the chain of solar energy (production, storage, consumption, resale, energetic behavior).**
- **Wiring of a photovoltaic system.**

TEACHING RESOURCES STUDENT & TEACHER

ref. SOL-2 Electrical cabinet + 2 Photovoltaic panels + 1 link cable

ref. SOL-2-N Electrical cabinet only
Sold without panel. Use your own panels with characteristics comprise between 35 and 150VDC.

PARTIAL OR TOTAL RESALE OPERATION

In the cabinet a DC/AC inverter converts the DC from the photovoltaic panels to AC 220VAC 50Hz, and injects its power in synchronism into the network through an isolation transformer. This inverter is protected against any polarity reversal and any overload on the DC or AC side. When the panels are not lit, the inverter consumes no current.

Technical characteristic for the inverter coupled to the public network.

INVERTER	Voltage	Max current	Power
INPUT	65~125VDC	8A	
OUTPUT	230VAC-50Hz	2,25A	500W

1. ELECTRICAL CABINET

Technical cabinet of standardized solar central unit on wheeled frame.
Dimensions: 810 x 600 x 1890mm

Comprises

- 2 disconnectors
- 1 500mA -30A differential
- 1 30mA differential
- 1 lightning arrester + fuses
- 1 Mushroom head emergency stop
- 3 100 Wh resolution meters
- 1 set of photovoltaic connectors
- 1 500W inverter for network synchronisation

2. LINK CABLE

30-m cable for connecting the solar panels to any type of solar system.

3. PHOTOVOLTAIC SOLAR PANEL 200WC ON TILTING FRAME (FOR EACH PANEL)

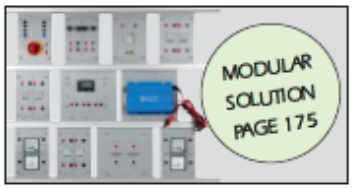
- Open circuit voltage: 57V DC
- Short-circuit current: 4.6A
- Optimum operating voltage: 47V DC
- Optimum operating current: 4.3A
- Maximum power: 200Wc (variation of ± 10% depending on the series)
- Sealed connections IP65 – 1000V on the rear of the panel.
- Type of cells: Monocrystalline silicon
- Robust aluminium frame.
- Useful surface area of the cells 1.5m².
- Output 47VDC – 4.2A – 200Wc per panel on 2 photovoltaic terminals.
- Device for measuring the tilt angle
- Tilt adjustable from 5° to 70°
- Two ball joints with clamping levers for positioning the panel to the required tilt angle.
- Light and easy to move.
  Folded position: 1620 x 1060 x 100mm
  Unfolded to 70° position: 2100 x 1060 x 700mm

SOLAR CENTRAL UNIT FOR ISOLATED SITE

RECOMMENDED OPTION FOR INDOOR OPERATION

ARTIFICIAL SOLAR SOURCE
Qty 2

See Pages 144 - 145



1. ELECTRICAL CABINET

Technical cabinet of standardized solar central unit on wheeled frame.
Dimensions: 810 x 600 x 1890mm

Comprises

- 2 disconnectors
- 1 lightning arrester + fuses
- 1 Mushroom head emergency stop
- 1 charging controller 12/24VDC-20A
- 2 batteries 12V-12Ah
- 1 set of photovoltaic connectors
- 1 Voltage converter 24VDC/230VAC-200W

2. LINK CABLE

30-m cable for connecting the solar panels to any type of solar system.

3. PHOTOVOLTAIC SOLAR PANEL 200WC ON TILTING FRAME (FOR EACH PANEL)

- Open circuit voltage: 57V DC
- Short-circuit current: 4.6A
- Optimum operating voltage: 47V DC
- Optimum operating current: 4.3A
- Maximum power: 200Wc (variation of ± 10% depending on the series)
- Sealed connections IP65 – 1000V on the rear of the panel.
- Type of cells: Monocrystalline silicon
- Robust aluminium frame.
- Useful surface area of the cells 1.5m².
- Output 47VDC – 4.2A – 200Wc per panel on 2 photovoltaic terminals.
- Device for measuring the tilt angle
- Tilt adjustable from 5° to 70°
- Two ball joints with clamping levers for positioning the panel to the required tilt angle.
- Light and easy to move.
  Folded position: 1620 x 1060 x 100mm
  Unfolded to 70° position: 2100 x 1060 x 700mm

ref. SOL-3 Electrical cabinet + 2 Photovoltaic panels + 1 link cable

ref. SOL-3-N Electrical cabinet only
Sold without panel. Use your own panels with characteristics comprise between 18 and 150VDC.

EDUCATIONAL OBJECTIVES

- **Understanding the different elements of a photovoltaic system.**
- **Understanding the safety components involved in the system.**
- **Electrical measurements of different parameters.**
- **Analyzing and interpreting results.**
- **Studying the efficiency and impacts related to the positioning of the solar panels.**
- **Studying of the chain of solar energy (production, storage, resale, energetic behavior).**
- **Wiring of a photovoltaic system.**

TEACHING RESOURCES STUDENT & TEACHER

OPERATION IN ISOLATED SITE WITH NO RESALE

The photovoltaic current charges two 12V sealed batteries cabled in series through a charging controller. This DC voltage is used directly by low energy consumption lamps 24VDC, and/or converted to 250VAC 50Hz by a 200W voltage converter.

Technical characteristics for the isolated site converter

VOLTAGE CONVERTER	Voltage	Max current	Power
INPUT	20~32 VDC	11A	210W
OUTPUT	230VAC 50Hz	1,5A	300VA

LOADING PANELS FOR SOLAR CENTRAL UNITS

Wheeled frame which reproduces domestic electrical installations on a vertical panel and enables the use of the voltage sources (AC + DC) produced by our solar central units SOL-1 to SOL-5. At the back another blank panel protects the electrical cables.
Dimensions: 1000 x 500 x h 1600mm
The frame is supplied assembled, fully cabled, ready to operate, with safety leads for the measuring units, and a CD including the technical data and cabling diagram.

Measurement with a clamp

NETWORK INJECTION AND ISOLATED SITE

ref. HABITAT-1

LOADING ZONE FOR ISOLATED SITE USE
This part includes a standard unit with standardized protection described below, and the different loads.
- 1 differential circuit-breaker 16A/30mA
- 1 two-pole fuse holder with fuse cartridges gPV 10x38 1000V
- 2 24V DC low energy consumption light fittings with switches
- 2 light fittings 230VAC with switches
- 1 230VAC 50Hz 2P+E socket
- 1 mimic unit with safety terminals for I and U measurements in different circuits.

LOADING ZONE FOR USE ON SITE WITH ELECTRICITY NETWORK
This part includes a standard unit with standardized protection described below, and the different loads.
- 1 connection circuit-breaker 500mA
- 1 differential circuit-breaker 16A/30mA
- 3 thermal-magnetic circuit breakers
- 2 light fittings 100W-230VAC with switches
- 1 500W convector
- 1 230VAC 50Hz 2P+E socket
- 1 mimic unit with safety terminals for I and U measurements in different circuits.

NETWORK INJECTION

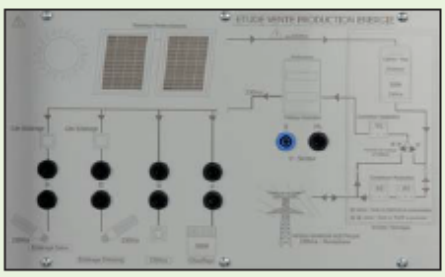
ref. HABITAT-2

LOADING ZONE FOR USE ON SITE WITH ELECTRICITY NETWORK
This part includes a standard unit with standardized protection described below, and the different loads.
- 1 connection circuit-breaker 500mA
- 1 differential circuit-breaker 16A/30mA
- 3 thermal-magnetic circuit breakers
- 2 light fittings 100W-230VAC with switches
- 1 500W convector
- 1 230VAC 50Hz 2P+E socket
- 1 mimic unit with safety terminals for I and U measurements in different circuits.

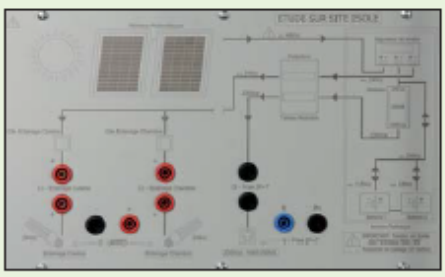
ISOLATED SITE

ref. HABITAT-3

LOADING ZONE FOR ISOLATED SITE USE
This part includes a standard unit with standardized protection described below, and the different loads.
- 1 differential circuit-breaker 16A/30mA
- 1 two-pole fuse holder with fuse cartridges gPV 10x38 1000V
- 2 24V DC low energy consumption light fittings with switches
- 2 light fittings 230VAC with switches
- 1 230VAC 50Hz 2P+E socket
- 1 mimic unit with safety terminals for I and U measurements in different circuits.



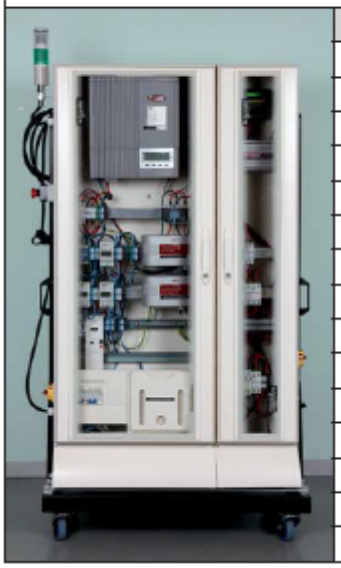
Synoptic sale of energy production



Synoptic for isolated site use

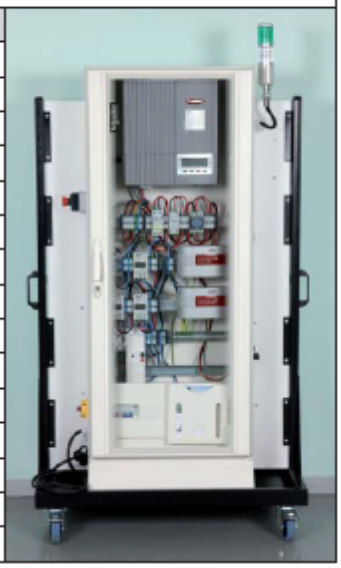
SOLAR CENTRAL UNITS - **800WC** - WITH DATAS ACQUISITION

NETWORK INJECTION + ISOLATED SITE



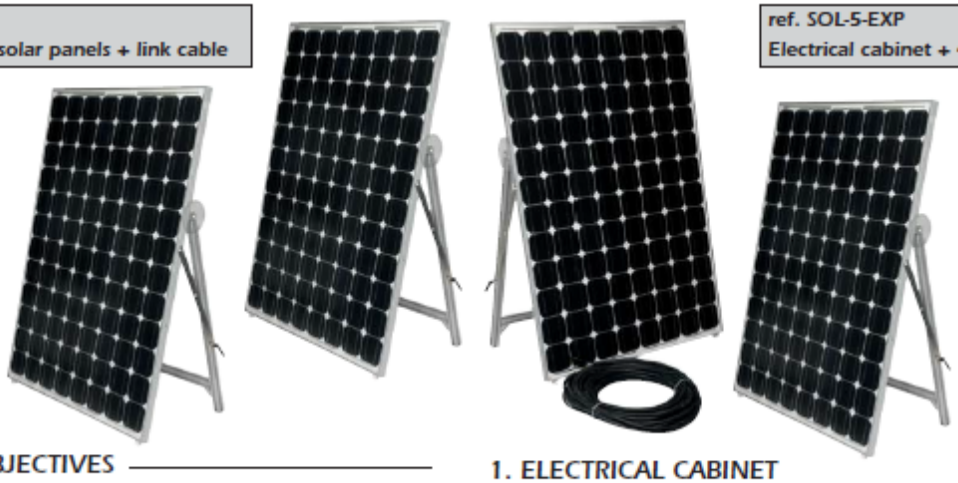
SOL-4-EXP	ELECTRICAL CABINET	SOL-5-EXP
1	1500W inverter for network synchronisation	1
1	Interface + 4-20mA sensors	1
1	Voltage converter 24VDC/230VAC. 200W	-
1	Charging controller 12/24VDC-20A	-
2	batteries 12V-12AH	-
3	100Wh resolution meter	3
1	lightning arrester	1
1	2P-45A circuit breaker with residal current protection 500mA	1
1	Residual current circuit breaker 30mA/16A	1
2	Thermal magnetic circuit breaker 2A (controls)	2
5	2-pole fuse holder and fuses	1
2	Power switch	2
2	Disconnector	2
1	Mushroom head emergency stop	1
1	Power socket 2P+E 230VAC	1

NETWORK INJECTION



ref. SOL-4-EXP
Electrical cabinet + 4 solar panels + link cable
Version without panel
Contact us

ref. SOL-5-EXP
Electrical cabinet + 4 solar panels + link cable
Version without panel
Contact us

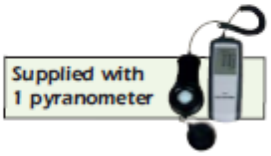


EDUCATIONAL OBJECTIVES

- **Understanding the different elements of a photovoltaic system.**
- **Understanding the safety components in the system.**
- **Electrical measurements of different parameters.**
- **Analyzing and interpreting results.**
- **Studying the efficiency and impacts related to the positioning of the solar panels.**
- **Studying of the chain of solar energy (production, storage, consumption, resale, energetic behavior).**
- **Wiring of a photovoltaic system (coupling of panels).**

TEACHING RESOURCES STUDENT & TEACHER

SOL-4-EXP and SOL-5-EXP are solar centrals with an electric power of 800Wp (+/- 10%) necessary to inject a significant current on the electrical network by the inverter and the other components of the housing part, to load the batteries and to allow equivalent measures as in a real housing installation. The system of data acquisition (temperature, radiation, wind speed and all the electrical parameters) allows making some practical works even in the absence of sun.



1. ELECTRICAL CABINET

See the table

2. LINK CABLE

30-m cable for connecting the solar panels to any type of solar system.

3. PHOTOVOLTAIC SOLAR PANEL 200WC ON TILTING FRAME (FOR EACH PANEL)

- Open circuit voltage: 57V DC
- Short-circuit current: 4.6A
- Optimum operating voltage: 47V DC
- Optimum operating current: 4.3A
- Maximum power: 200Wc (variation of ± 10% depending on the series)
- Sealed connections IP65 – 1000V on the rear of the panel.
- Type of cells: Monocrystalline silicon
- Robust aluminium frame.
- Useful surface area of the cells 1.5m².
- Output 47VDC – 4.2A – 200Wc per panel on 2 photovoltaic terminals.
- Device for measuring the tilt angle
- Tilt adjustable from 5° to 70°
- Two ball joints with clamping levers for positioning the panel to the required tilt angle.
- Light and easy to move.
  Folded position: 1620 x 1060 x 100mm
  Unfolded to 70° position: 2100 x 1060 x 700mm

PARTIAL OR TOTAL RESALE OPERATION (SOL-4-EXP AND SOL-5-EXP)

In the cabinet a DC/AC inverter converts the DC from the photovoltaic panels to AC 220VAC 50Hz, and injects its power in synchronism into the network through an isolation transformer.
This inverter is protected against any polarity reversal and any overload on the DC or AC side.
When the panels are not lit, the inverter consumes no current.

TECHNICAL CHARACTERISTIC FOR THE INVERTER COUPLED TO THE PUBLIC NETWORK.

INVERTER	Voltage	Max current	Power	Cos	Distorsion	Rendement
INPUT	150–450VDC	10,8A				
OUTPUT	230VAC-50Hz	6,5A	1,5kW	1	≤3,5%	91%

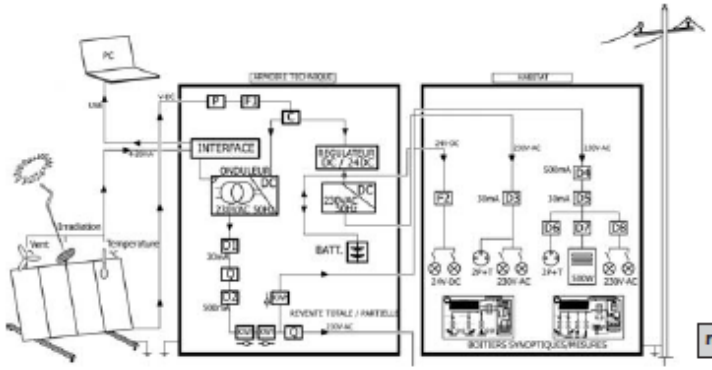
OPERATION IN ISOLATED SITE WITH NO RESALE (SOL-4-EXP ONLY)

The photovoltaic current charges two 12V sealed batteries cabled in series through a charging controller.
This DC voltage is used directly by low energy consumption lamps 24VDC, and/or converted to 250VAC 50Hz by a 200W voltage converter.

TECHNICAL CHARACTERISTICS FOR THE ISOLATED SITE CONVERTER

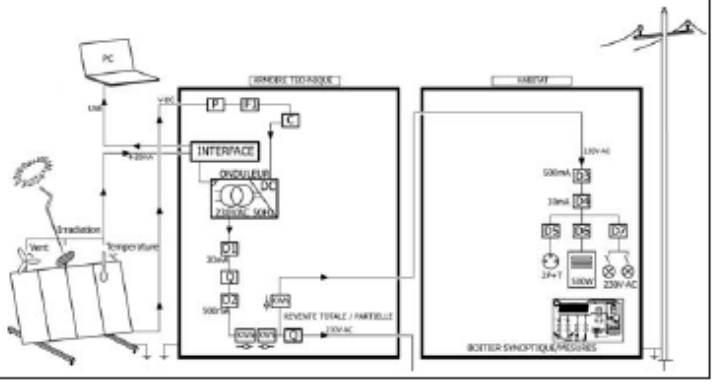
VOLTAGE CONVERTER	Voltage	Max current	Power
INPUT	20–32 VDC	11A	210W
OUTPUT	230VAC 50Hz	1A	200VA

FUNCTIONING DIAGRAM OF SOL-4-EXP + HABITAT-1



ref. HABITAT-1 PAGE 133

FUNCTIONING DIAGRAM OF SOL-5-EXP + HABITAT-2



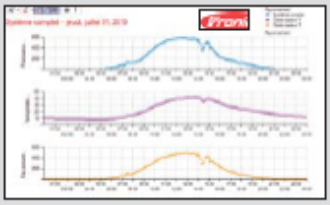
ref. HABITAT-2 PAGE 133

INTERFACE AND SENSORS DELIVERED WITH SOL-4-EXP AND SOL-5-EXP

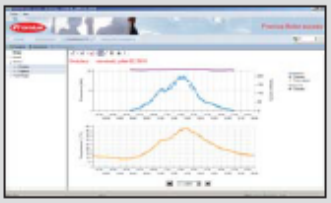
Measure of the solar radiation
Temperature of the solar panels
Wind speed

These physical parameters and also the electrical parameters (voltage and current AC/DC), the power and the energy are recorded (1 year of data maximum) by an interface placed in the electrical cabinet and monitored by a PC.

The software provided with SOL-5 and SOL-4 allows to display one or several curves on the screen, diagrams, ...
All data can be exported to Excel®.



Screenshoot of 3 recordings made during the day : instant alternative power, temperature of panels, intensity of solar radiation.



Screenshoot showing the voltage and the power at the output of the invertor, the temperature of panels. Scales are specified with units.

SUPPLIED ACCESSORIES

- A connection cable of 30 meters – 3x 6mm² panels/electrical cabinet
- A connection cable of 30 meter for the link sensors/interface for signal 4-20mA
- A CD-rom with all the pratical works
- A software for the exploitation of data
- A pyranometer for measuring the solar radiation (200 and 2000 W/m² range)

WARRANTY

Factory guarantee of the inverter: 5 years
The website of Fronius offers the free update of the software, and answers the Frequently Asked Questions.

PORTABLE SOLAR CENTRAL UNIT FOR ISOLATED SITE WITH ARTIFICIAL LIGHT SOURCE

ref. SOL-PRO

The SOL-PRO solar unit includes:
1 technical case + 2 photovoltaic panels + 1 artificial light source (3 spotlights) + 2 cords for connecting the panels to the case.

EDUCATIONAL OBJECTIVES

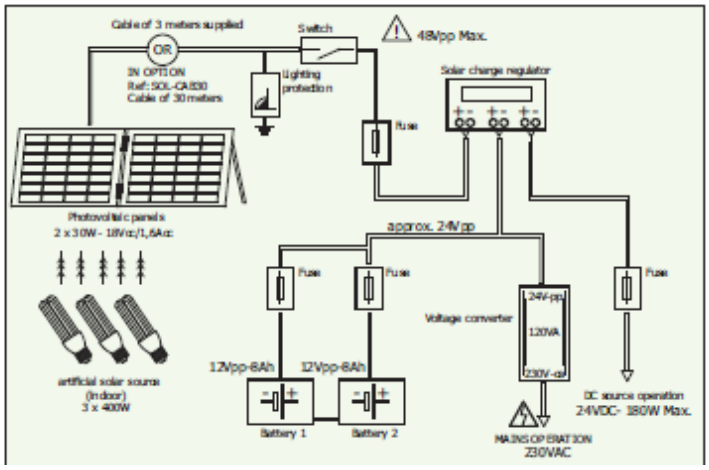
- **Understanding of a photovoltaic system in an isolated site.**
- **Understanding the safety components involved in the system.**
- **Understanding of the wiring of a photovoltaic system.**
- **Make electrical measurements of different parameters.**
- **Analyzing and interpreting results.**
- **Studying the performance and impacts related to the positioning of the solar panels.**
- **Studying of the the chain of solar energy (production, storage, use of the solar charge regulator for battery).**

TEACHING RESOURCES STUDENT & TEACHER

A synoptic shows the different components and the interconnections.
Connection in jump wires by safety leads 4mm.
Connection of the panels to the technical case by 2 photovoltaic leads (delivered).
Measures are possible indoor by using the artificial solar source.

Electrical characteristics of the solar unit

- photovoltaic panel (panel features):
  - nominal power Pmpp: 30 Wc
  - max power voltage Vmpp: 18V DC
  - max power current Impp: 1.67 A
  - open circuit voltage Voc: 22.5V DC
  - short-circuit current Isc: 2A
- Power injected, with artificial source: 17 Wc (24V/0.7A)
- Output voltage 230 V - 50 Hz pure sinusoidal. 120 VA max.
- Output voltage 24V DC. 180W max



Composition of the technical case

- Case made of impact-resistant polypropylene. It can be closed without disconnecting the safety cords from the front. Light and easy to carry by its handle.
- 2 photovoltaic sockets for connecting solar panels.
- 1 surge arrester.
- 1 Start/Stop switch to isolate the solar panel circuit from the technical case.
- 4 two-pole fuse holders with gPV cartridge protecting the solar panel circuit, batteries and use.
- 1 24V/20A solar charge controller with display showing:
  - battery charge
  - current supplied by the solar panels
  - battery charge current
  - current consumed by the use circuit
  - battery voltage.
- 1 voltage converter pure sinusoidal 50 Hz - 24/230V AC, 120 VA. Auto-protection by resettable thermal fuse.
- 1 set of 4 mm safety cords.
- 1 output 230V AC - 120 VA on 4 mm safety terminals
- 1 use output 24V DC - 180 VA on 4 mm safety terminals
- Dimensions: 540 x 430 x 215mm

Composition of the photovoltaic panels frame

- Aluminium frame
- 2 mono-crystalline photovoltaic panels, each 30 Wc.
- 2 hinges for folding them together.
- Separate cabling for series or parallel connection.
- Useful surface area of the cells on each panel 0.2 m^2
- 2 ball joints for putting the panels at the tilt angle required.
- 1 device for measuring the tilt angle.
- 2 3-metre photovoltaic cords.
- Light and easy to move (Carrying handle).
- Dimensions in unfolded position: 1140 x 470 x 200 mm
- Dimensions in folded position: 570 x 470 x 100 mm

Composition of the artificial light source

- 3 400W spotlights with variable tilt.
- Power supply 230V AC 50/60 Hz by 2-metre mains cord.
- Spotlight dimensions: 300 x 220 x h 360 mm

Supplied with CD containing

- Theoretical summary of the different types of photovoltaic cells and energy.
- The detailed wiring diagram of the solar unit
- 5 theoretical assignments and 3 complete practical assignments as student/instructor book.
- Full instructions for each component

SOLAR KIT

ref. VALSOL

EDUCATIONAL OBJECTIVES

- **Studying the principles of solar energy, storage and conversion.**
- **Electrical measurements of different parameters.**
- **Analyzing and interpreting results.**
- **Studying the efficiency and impacts related to the positioning.**

TEACHING RESOURCES STUDENT & TEACHER

Suggested tutorials

One of the jumpers isolates the photo-voltaic panels from the rest of the electronics. In this way, students can measure

- The voltage in the no-load circuit (approximately 21V)
- The short-circuit current (approximately 1.9A)
- The current and the voltage according to the lighting, by covering one of the two panels or by varying the tilt of the kit's lid in relation to the sun by an angle α; and check that the power output is a function of the power factor
- Using a rheostat (e.g. ECO1/2-330), students can look for the charge which corresponds to a maximum power supplied by the panel

The second jumper measures the DC level delivered by the battery. The third jumper allows the current measuring at the converter's input. Students can:

- Measure the no-load voltage and current at the converter's input, and calculate the no-load power input
- Measure currents and voltages upstream and downstream of the converter and calculate the converter's efficiency and losses by loading the 220V AC output.
- Check that the converter can supply up to 150W. Compare this power with the power supplied instantly by the panels. Draw conclusions about the role of the battery.

Angle of incidence of sun rays measurement

The solar kit VALSOL is supplied with a protractor and a simplified targeting system ❸ allowing the measuring (within a few degrees of precision) the angle of incidence of sun rays on the solar panels. This targeting system which is placed on side can be removed and stored in the side compartment ❷ dedicated to accessories storage. A stand ❶ (also removable) allows the stepless adjustment of the inclination of the solar panels.

When closed, the panels are protected against impact and scratches. The following can be found underneath the solar panel:

- a standard 15V DC 15 Ah Li-ion battery
- a 12V DC/220V AC, 50Hz, 150W converter
- a safety and monitoring electronics device

Control panel

- On/Off button
- a circuit breaker to protect against over-currents
- 4mm safety terminals for voltage and electric current inputs, with jumpers
- the converter's On/Off button
- a 230V AC 50Hz socket with on and defect lamps
- a two-line LCD display delivering messages about the battery: temperature, % charge, charging current and voltage, usage current and voltage, undercharged battery, overcharged battery and overheating, etc., as well as the power output. NB: these are indications, rather than highly accurate measurements.

PROTECTION OF COMPONENT IN THE CASE OF

- battery overcharge: when its voltage reaches 16.5V the charging current is automatically cut, in order to preserve the battery's service life.
- excessive battery discharge: When its voltage reaches 11.5V, an audible alarm will be triggered.
  When it falls below 10.5 V the output will be disconnected automatically.
- overload or short-circuit on the converter's output

SPECIFICATIONS OF THE SOLAR PANEL

- Total surface area: 420 x 680mm
- Typical voltage: 17.5V
- Short-circuit current: 1.9A
- Total power: 30W
- Typical current: 1.7A
- No-load circuit: 21.5V

OTHER CHARACTERISTICS

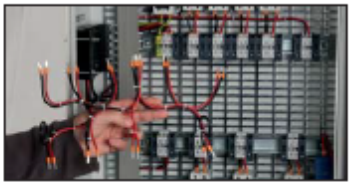
- Fitted side compartment for the storage of leads, jumpers, the targeting system and the inclination stand ❷. Dims: 570 x 380 x 160mm. Weight 17kg.

SOLAR PUMPING STATION

EDUCATIONAL OBJECTIVES

- **Understanding a photovoltaic system dedicated to the power supply of a water pump.**
- **Measurements of electrical parameters.**
- **Analyzing and interpreting results.**
- **Understanding live wiring tests with putting into service and functioning.**
- **Studying the efficiency and impacts related to the positioning of the solar panels.**
- **Studying the solar charge regulator.**

TEACHING RESOURCES STUDENT & TEACHER



Simply remove the strand before asking students to do the cabling.

Dictatical solar pumping station simulating the water supply of a population in a desert area.

ref. SOLPUITS

ref. SOLPUITS-N Sold without panel.
Use your own panels with characteristics comprises between 18 and 50VDC.

RECOMMENDED OPTION FOR INDOOR OPERATION

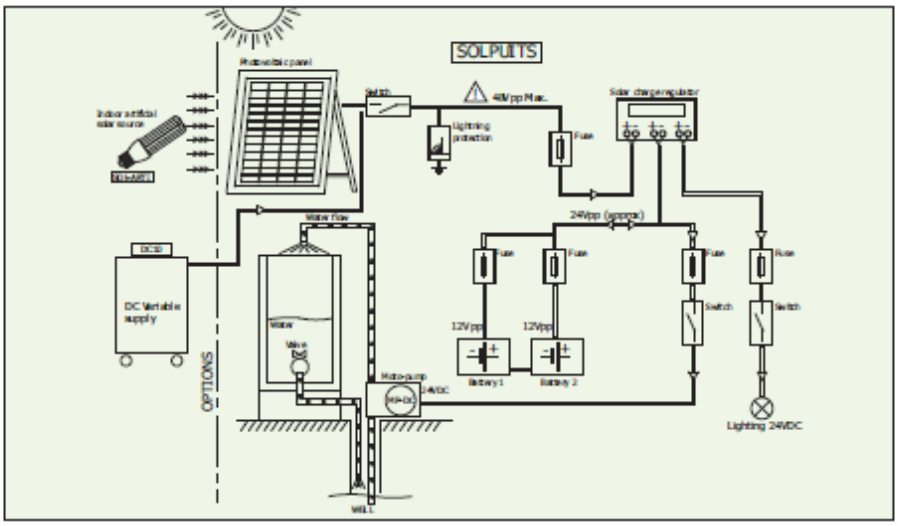
ARTIFICIAL SOLAR SOURCE
Qty 1

See Pages 144 - 145

Comprises

- 1 photovoltaic solar panel 200Wc mounted on a robust frame that tilts from 5° to 70°.
  Open circuit voltage: 57V DC.
  Optimum operating voltage: 47V DC.
  Short-circuit current: 4.6A.
  Optimum operating current: 4.3A.
- 1 30m. link cable.
- 1 100-l tank simulates the underground water source.
- 1 60-l transparent container acts as water reserve.
  A tap simulates user consumption and returns water to the tank.
- 1 sealed motor pump 140W- 24DVC-6A. 13l/min capable of pumping dry. It takes water from the tank and fills the reserve water container.
- 2 12V/6Ah batteries supply the pumping station when sunlight is absent.
- 1 24VDC-20A regulator controls battery charging. One 2-button display accessible outside the cabinet enables configuration and viewing of the currents of the solar panel, the battery charge and the lamp and the battery voltage.
- 1 electrical cabinet includes the cabling of all the solar components on connection terminals. A lightning arrester protects the installation and each component is protected by fused circuit-breaker type gPV. The cabling is fully marked and students can easily remove the original strand to do their cabling.
  Students can also take voltage and current readings. A main switch isolates the solar panel from the electrical cabinet.
- A switched 24VDC lamp lights the area.

A wheeled frame for passing under doors.
SOLPUITS requires no direct water connection. Once the 80-l tank is filled with water, the system is totally self-contained.
Supplied cabled with detailed instructions and complete practical works.
Dimensions: 750 x 670 x 1980mm. Weight 141kg.



SELF-CONTAINED PUBLIC LIGHTING WITH LEDS

MAQ-LED demonstrates public lighting with LEDS which is increasingly found in new housing schemes. Completely self-contained, the assembly operates using solar energy (Polycristalline panel combined with a large capacity battery).
Two artificial solar sources, for connection to the mains 230VAC, enable the battery to be recharged for better organization of the explanations and practical assignments.

ref. MAQ-LED

EDUCATIONAL OBJECTIVES

- **Studying street lighting with LED lamp and solar energy.**
- **Putting a solar system into service.**
- **Demonstrating the ecological operation of LED technology.**
- **Discovering the different technologies of solar panels.**
- **Wiring the components of a lighting installation with presence sensor & light sensor.**
- **Reading the different electrical values of a production system of solar energy.**
- **Calculating the installation's efficiency.**

TEACHING RESOURCES STUDENT & TEACHER

Practical works

- Lessons on the different solar panel technologies (Monocristalline, Polycristalline, Amorphous)
- Study on the positioning of solar panels for maximum output.
- Study of solar radiation.
- Reminder on Direct, Diffused and Reflected solar radiation.
- Interpretations of the theoretical curves produced from the 3 solar sensors.
- Study and creation of the wiring for a solar energy system in an isolated site.
- Reading the currents and voltages at different points of the wiring.
- Interpreting the measurements then calculation of the efficiency.
- Calculation of the discharge time of the battery according to the load.

Comprises

- Easy-to-move wheeled frame with large heavy-duty wheels.
- 1 Battery 12VDC – 90Ah.
- 1 Solar load regulator 12VDC-20A.
- 1 Plastic unit that is easy to remove to directly access the wiring of the battery, solar panel and load regulator.
- 1 Solar panel 12V/80W pivoting and swivelling on an easy-to-remove pole.
- 1 Lamp with LEDS 12VDC-50W equipped with a presence and light sensor.
- 2 artificial solar sources 230VAC on removable pole.

Battery + load regulator unit.

Dimensions : 600 x 800 x 1700mm. Weight : 92kg.

WORKSITE TRAFFIC LIGHTS - LED TECHNOLOGY – SELF-CONTAINED

Simulator of worksite traffic lights powered with solar energy.
Two artificial and variable light sources simulate sunlight and enable the batteries to be recharged.
Fully self-contained, operation of the FEU-LED is managed with a Schneider® PLC.
One solution for manually recharging the batteries is included in the electrical unit for better organization of the explanations and practical work.

ref. FEU-LED

EDUCATIONAL OBJECTIVES

- **Study and putting into service of solar energy worksite traffic lights.**
- **Reminder on the different solar panel technologies.**
- **Wiring of the components of a photovoltaic installation at an isolated site.**
- **Reading the different electrical values of the production system of solar energy.**
- **Calculation of the efficiency of the installation.**
- **Programming a controller (PLC).**

TEACHING RESOURCES STUDENT & TEACHER

Practical works

- Lessons on the different technologies of solar panels (Monocristalline, Polycristalline, Amorphous)
- Study on the positioning of solar panels for maximum output.
- Study of solar radiation.
- Reminder on Direct, Diffused and Reflected solar radiation.
- Interpretations of the theoretical curves produced from the 3 solar sensors.
- Study and creation of the wiring of a solar energy system at an isolated site.
- Reading the currents and voltages at different points of the wiring.
- Interpreting the measurements then calculation of the efficiency.
- Calculation of the discharge time of the battery according to the load.
- Creation of a controller program in contact language.

Comprises

Electrical cabinet

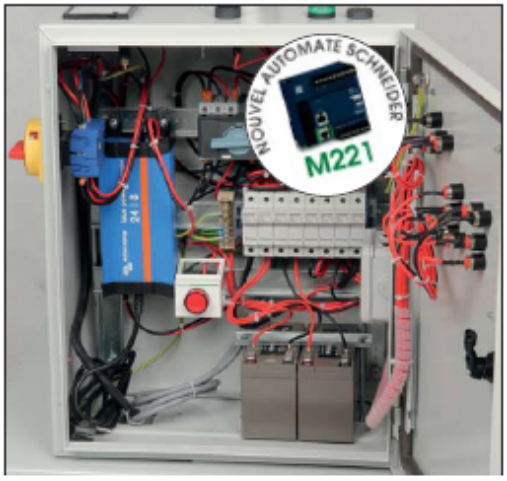
- 1 Voltmeter measures the voltage of the photovoltaic panels.
- 1 Voltmeter measures the voltage of the 2 batteries.
- 1 Set of pushbuttons, switches and indicator lights.
- 1 front synoptic gives the overall diagram of the system.
  4mm connection terminals enable reading of U/I panels, U/I batteries, U/I charge and I charger.
- 1 SCHNEIDER® programmable logic controller (PLC).
- 1 solar load regulator 12VDC/20A.
- 1 battery charger 12V.
- 2 batteries 12V-8Ah.
- 1 set of electrical protection with gPV cartridge fuses.

Pole

- 2 traffic lights with Red / Orange / Green LEDS.
- 2 photovoltaic panels 30W/12V Monocristalline.
- 2 artificial sources with light controller.

Features

- 3-metre mains lead included, for the charger and artificial source.
- Dimensions: 1000 x 1000 x 2035mm. Weight: 68kg.
- The pole and the panels are easy to remove for going through doorways.



DUAL ENERGY ELECTRIC GATES, SOLAR OR MAINS 230VAC

ref. POA-1 swing gates

ref. POA-2 sliding gate

EDUCATIONAL OBJECTIVES

- **To observe and understand the operation of electric gate automation.**
- **Reminder about the different solar panel technologies.**
- **To study the operation of an assembly of solar panel, battery, charge regulator.**
- **To take measurements of electrical values.**
- **To study the operation of photo-electric cells.**
- **To learn how to program gate automation according to several operating criteria.**
- **To perform industrial maintenance operations.**

TEACHING RESSOURCES STUDENT & TEACHER

Practical works

- Study and identification of the different components of the gate.
- Measurement of the current, voltage and power absorbed by the motors.
- Measurement of the current, voltage, and solar power.
- Study of the operating principle of photo-electric cells.
- Configuring the different gate operations.

Automated solar swing gates (POA-1).
Automated solar sliding gate (POA-2).
All the electrical connectors of the components (motors, cells, light, control board) are brought to one front using 4mm safety terminals. Thus the student can wire, using the safety leads, all the operations of the gate with no risk of deterioration of the screws or connectors of the components. They can also quite safely read the different voltages and currents of the system. The many operating parameters can be modified in the electrical cabinet using the programming console with digital display. There are two types of power supply wiring for the gates:

- Wiring by solar energy power supply.
  The solar panel is linked to the gate's electrical cabinet.
  Operation is autonomous thanks to the 24VDC batteries.
- Wiring directly to the electricity mains 230VAC using its mains lead with plug 2P+E.

The assembly is supplied fully functional with examples of operation. A CD contains the user instructions and tutorials.
Dimensions:
Overall: H 1700 x W 1400 x 630mm (POA-1)
Overall: H 1700 x W 1800 x 630mm (POA-2)

Composition of the gates

- One electronic unit with control board equipped with digital display and three pushbuttons for configuring the assembly.
- One console with printed diagram of the different components including all the gate's connectors. Interconnection with safety leads supplied.
- Two gear motors 24VDC with hinged arm (version POA-1) and one motor 24VDC (version POA-2).
- One signalling light.
- One pair of photocells.
- One face equipped with 2 indicator lights to simulate lighting in the gate opening area and garden lighting.
- One two position switch for opening/closing of the gate, or a single leaf (for version POA-1).
- One unit with battery 24V-12Ah and charge regulator 24VDC

The gates POA-1 and POA-2 are supplied with an autonomous wheeled frame comprising a solar panel 25W-24VDC and two spotlights simulating the sun.

Non-solar versions
Ref. POA-11 and POA-22

STUDY OF FAULT DIAGNOSTICS ON A SOLAR INSTALLATION

SOL-DIAG is a solar model for producing faults at different points of the wiring. The assembly is comprised of an aluminium frame on casters, a wiring frame with solar components, a set of switches and a separate photovoltaic panel.
The faults can be produced by the instructor by rotating single switches.
The voltage of the circuit does not exceed 30VDC. Thus students can take measurements or perform tests in complete safety, regardless of the fault type.

EDUCATIONAL OBJECTIVES

- **To learn and understand the operation of a photovoltaic installation.**
- **To diagnose faults on a photovoltaic installation in isolated site.**
- **To take the measurements of the different electrical values.**
- **Analysing and interpreting the results.**
- **To study the efficiency of the solar panels.**
- **To study the energy system (production, storage, use, energy performance).**

TEACHING RESSOURCES STUDENT & TEACHER

Practical works

- Identification of the different components of the energy system.
- Producing the electrical diagrams.
- Calculation of the efficiency of the photovoltaic panel.
- Reading the currents and voltages in the circuit.
- Finding the faults on the circuit using measuring devices.

Model supplied wired, operational, with teaching manual on CD.
Autonomous power supply. Recharges the batteries using the supplied charger.

Composition of the model

- Frame with casters, two with brakes
- One wiring frame equipped with:
  1 surge arrester
  6 two-pole fuse holders
  1 maintenance switch
  2 batteries 12VDC-8Ah
  1 20A charge regulator with LCD
  1 voltage converter 24VDC/230VAC-200VA
  2 bulkhead lights, one with 230VAC, the other with 24VDC
  1 battery charger 12VDC
- One unit containing 7 switches for creating faults
  One key operated flap for hiding the switches
- Melamine shelf 750x400mm
- Dimensions of the frame: H 1800 x 800 x 700mm

Flap for access to the switches

Composition of the solar source

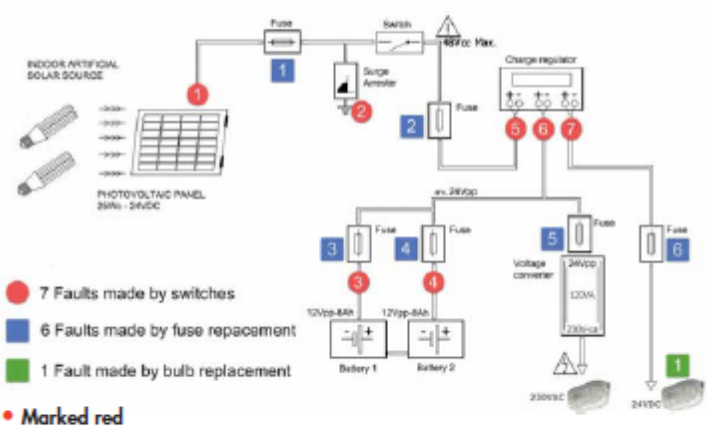
- Solar panel 25W-24VDC on frame with casters (2 with brakes)
- 2 projectors for simulating the sun's rays
- 2 photovoltaic cables 3 metres for linking the panel to the wiring frame
- Dimensions of the panel frame: H 1300 x 900 x 620mm

Model + Solar source (panel and spotlights) for indoor operation

ref. SOL-DIAG

aref. SOL-DIAG-N Sold without solar panel
Use your own panels with specifications comprises between 18 & 50VDC.

DESCRIPTION OF THE FAULTS



- **Marked red**
  Faults 1/2/4: switch for wire break
  Fault 3: Insertion of high resistance in series
  Faults 5/6/7: faults on the 3 inputs of an electronic component inside the charge regulator. The voltages are present on the + and – terminals but the regulator does not work.
- **Marked blue**
  Faults 1/2/3/4/5/6: change of fuse with defective one.
  6 OS fuses are supplied with the model.
- **Marked green**
  Fault 1: change of bulb 24V with a defective one.
  Defective bulb supplied with the model.

PHOTOVOLTAIC INSTALLATION ANALYZER

ref. VA1011
Complete datasheet
www.langlois-france.com

Professional device for testing, maintaining, troubleshooting and checking the efficiency of solar panels.

The VA1011 analyzer measures and displays:

- the search for maximum solar energy (Pmax) with the AUTO SCAN function (1000V, 12A)
- the maximum voltage (Vmaxp) at Pmax
- the maximum current (Imaxp) at Pmax
- the open circuit voltage (Vopen)
- the short-circuit current (Ishort)
- the I / V curve of a panel or set of solar panels.
- The efficiency calculation (%) of your installation
- Solar radiation as W/m²
- The temperature of your solar panel
- The series resistance (Rs) of solar panels

All these functions are accessible through the software.

Using the amps and watts clamps

- P min/max as DC/AC upstream and downstream of the inverter.

Digital display and as curves.

- U and I min/max as DC / AC upstream and downstream of the inverter.
- The power factor as AC.

All the readings taken can be saved as easy to recover dated files.
3980 measurements by file.

Scope of supply

- 1 portable solar analyzer, power supply by lithium battery with its mains charger 230V AC 50/60 Hz. Dim: 257x155x57 mm. Weight: 1.55 kg
- 1 software + cord for USB link to PC.
- 1 amps clamp (direct link to analyzer using specific cord).
- 1 watts clamp (direct link to analyzer using specific cord).
- 1 solar radiation sensor with its support for attaching to solar panel
- 1 temperature sensor for attaching to solar panel.
- set of safety and photovoltaic cords.
- 1 carrying case.
- Detailed instructions with connection diagrams.

SOLAR ANALYSER

- Current/voltage graph drawing (characteristic of the solar panel)
- Autoscan search of the solar panel maximum power – Pmax (60V – 6A)
- Maximal voltage Vmaxp at Pmax power
- Maximal voltage Imaxp at Pmax power
- Opened circuit voltage Vopen
- Short-circuit opened Ishort
- I = f(V) graph with a cursor
- Efficiency calculation in %
- Power by area unit (in W/m2)
- Manual test for a particular point
- Range 10V / accuracy 0.001V
  Range 60V / accuracy 0.01V
  Range 1A / accuracy 0.1mA
  Range 6A / accuracy 1mA
  Accuracy 1% + 18dgt

Battery info: 8 x LR6

ref. VA200

Package includes:
- bag
- AC power
- accumulators
- cables connecting panels
- USB cable & software.

PYRANOMETER

The PYR1307 pyranometer measures the power of solar radiation in watts per m2: W/m2

- Ratings: 199.9 W/m2 and 1,999 W/m2
- Measuring error: < 10W/m2 or 5% of the reading
- Display: 2,000 pixel LCD
- Captures min. and max. values
- "Hold" key allows one to freeze the display
- Backlighting
- Supplied with a carry case
- Dimensions: 162 x 63 x 28mm
- Weight: 250g

Battery info: 2 x LR03

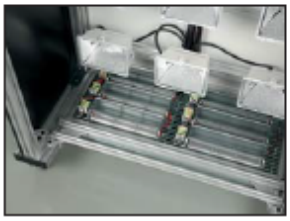
ref. PYR1307

ARTIFICIAL SOLAR SOURCE




REF	Photovoltaic panel delivered installed	Side protection against the direct access to the lamps	Forced ventilation to simulate the wind	Poles and chains for zone boundary
SOL-ARTI2	Yes	Yes	Yes	No
SOL-ARTI2-N	No	Yes	Yes	No
SOL-ECO2	Yes	No	No	Yes
SOL-ECO2-N	No	No	No	Yes

The versions without "installed photovoltaic panels" are compatible with the reference SOL-200 of page 146.



Ventilation system with protection grid.

This source for getting around the loss of sunlight by illuminating the solar panel with artificial light whose spectrum is close to sunlight. While not having as much luminosity as unclouded sunlight, it illuminates with sufficient intensity for the panel to generate 1/3 of its peak power Wc (corresponding to sunlight at 1kW/m²).
The solar panel can be removed easily in order to replace a spotlight quickly if necessary.
The unit located on the back of the spotlights panel includes

- a key-operated emergency stop button for cutting the electricity supply to the spotlights
- a digital thermometer shows the temperature at the surface of the solar panel. Accuracy 1°C.
- a potentiometer for lighting adjustment, by dimmer built into the unit
- a flow control for the forced ventilation
- automatic power supply cut-off to the spotlights in the event of abnormal temperature rise of the solar panel

ELECTRICAL FEATURES OF THE SOLAR PANEL AT 25°C

LIGHTING	SOLAR	ARTIFICIAL
Maximum power	220Wc	70Wc
Open circuit voltage	43V	43V
Short-circuit current	6.2A	2.3A

- Sealed connections IP65 – 1000V
- Power supply: 230VAC.
- Dimensions/Weight: 1228 x 665mm height 1926mm.
- 4 casters including 2 with brake

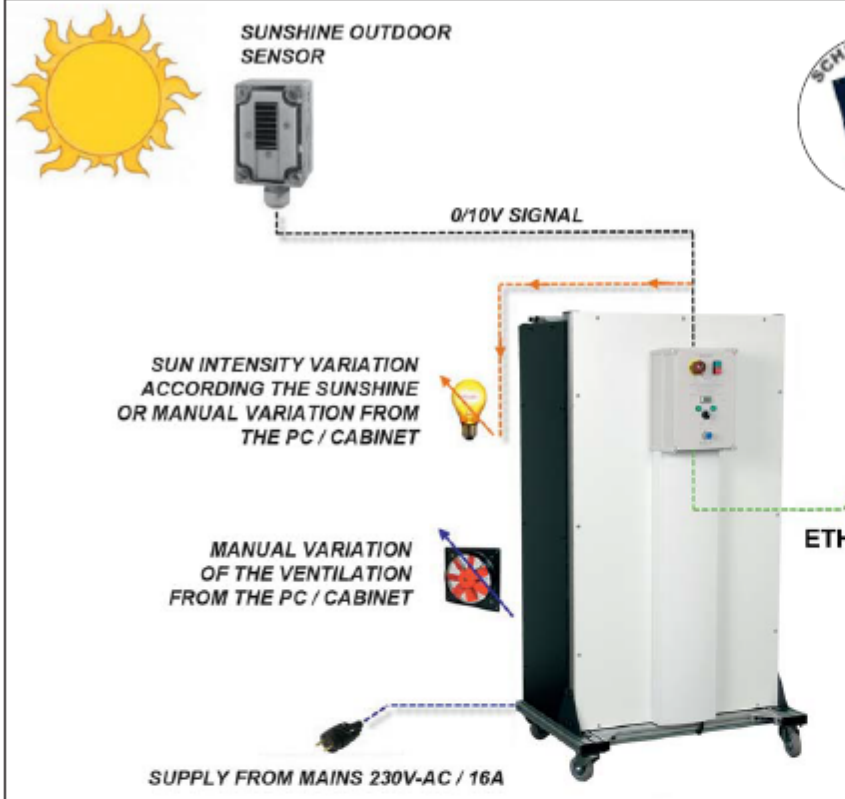
PRACTICAL WORK
Adjustment of the light intensity demonstrates the correlation between the light flow and the current delivered by the photovoltaic panel, at constant voltage.
A temperature probe linked to the unit thermometer is located on the solar panel. This shows its instantaneous temperature. Any reduction of the ventilation flow causes the panel temperature to rise, and lowers the photovoltaic current in constant lighting.

Special characteristics for SOL-ARTI2 et SOL-ARTI2-N
Two opaque side panels prevent the accidental blinding of a student. With the solar panel and spotlight support they also make a closed duct for evacuating heat by an air current going from bottom to top. Centrifugal fans, located in the bottom part, inject fresh air that runs up the panel.
Grids in the bottom and top parts let the air flow pass evacuating the heat, and prevent accidental contact by hand with a burning spotlight or with the fan blades.

The versions SOL-ECO2 and SOL-ECO2-N have no lateral protection, no forced ventilation. Versions delivered with 4 poles and 2 chains for the delimitation of a safety zone around the system.

SOL-ECO2, protection by bounded safety zone

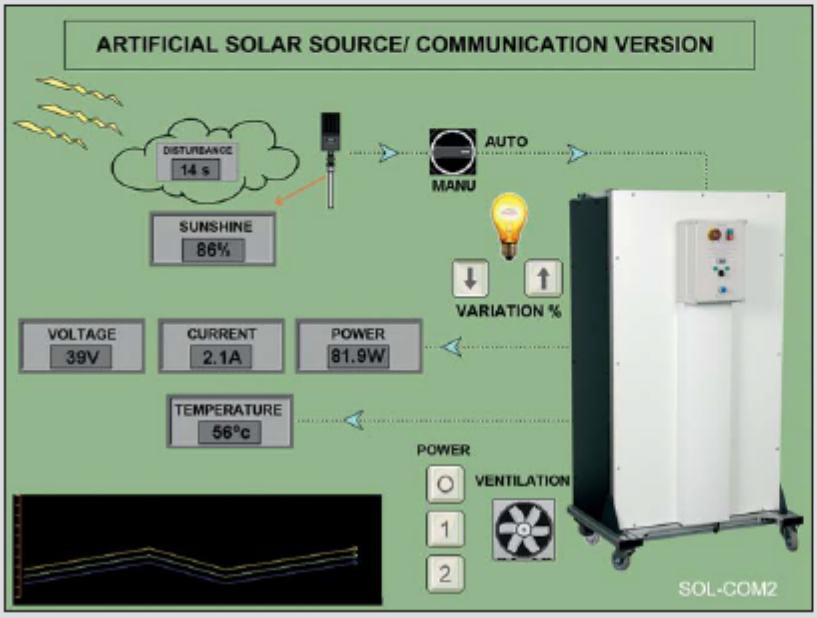
ARTIFICIAL SOLAR SOURCE : COMMUNICATING VERSION



ref. SOL-COM2

ref. SOL-COM2-N
Supplied without panel.
Compatible with our panel SOL-200 and all panels sold with our solar systems

Version identical to SOL-ART1 but with these additional features:
- 1 Schneider programmable PLC with its Ethernet interface
- 2 analog card I/O for PLC
- 1 electronic interface to retrieve the voltage/current parameters of the photovoltaic panel.
- 1 RJ45 connector for the connection to a PC.



SUPERVISION SOFTWARE SUPPLIED
Vijeo designer of Schneider®.

Allows:
- the acquisition and the display of PLC variables
- the supervision and the process control
- the programming of your own supervision
- the creation of your own Ethernet computer network

Displays:
- The values of U(V) / I(A) / P(W) supplied by the solar panel
- The temperature (°C) of the solar panel
- The level of sunshine (solar radiation)
- The level of ventilation

Controls:
- The level of the artificial light intensity
- The disturbance which simulate the passing of a cloud (you can select the duration if the effect).
- The level of ventilation

PRACTICAL WORKS

- Theoretical study on the solar panel functioning
- Theoretical study on the solar panel positioning
- The Ethernet networking of the system
- The influence of the panel temperature on the intensity supplied
- The programming of the PLC
- The setting of the analog cards
- The creation of a supervision programming

PHOTOVOLTAIC SOLAR PANELS AND FRAME

FEATURES OF EACH PANEL

- Open circuit voltage: 57VDC
- Short-circuit current: 4.6A
- Optimum operating voltage: 47VDC
- Optimum operating current: 4.3A
- Maximum power: 200Wc (variation of ± 10% depending on the series)
- Sealed connections IP65 – 1000V on the rear of the panel.
- Type of cells: Monocrystalline silicon

PHOTOVOLTAIC SOLAR PANELS 200Wc ON TILTING FRAME (1 PANEL)

- Robust aluminum frame.
- Useful surface area of the cells 1.5m².
- Device for measuring the tilt angle
- Tilt adjustable from 5° to 70°
- Two ball joints with clamping levers for positioning the panel to the required tilt angle.
- Several SOL-200 can be coupled electrically to increase power.
- Light and easy to move.
  Dimensions Folded position: 1620 x 1060 x 100mm
  Dimensions Unfolded to 70° position: 2100 x 1060 x 700mm
  Weight 27kg

ref. SOL-200

LINK CABLE

30-m cable for connecting the solar panels to any type of solar system.

ref. SOL-CAB30

PHOTOVOLTAIC SOLAR PANELS 400WC (2 PANELS) AND 800Wc (4 PANELS) ON TILTING WHEELED

- Compact wheeled frame.
- Sufficiently compact to be rolled through a door-way.
- An instantly removable stand is fixed to the wheeled frame
- Four actuators to a stable and horizontal position
- Tiltable from the vertical to the horizontal position in 5° increments.
- A protractor measures the panel tilt.

VERSION 400Wc (2 panels)

- Unfolded stand wheelbase: 225 x 260cm
- Overall folded stand dimensions: 227 x 75cm high 195cm
- Effective surface area of cells: 3.1m²
- Total power of the panels 400Wc (may vary by 10%)

ref. SOL-400 2 panels

VERSION 800Wc (4 panels)

- Unfolded stand wheelbase: 225 x 260cm
- Overall folded stand dimensions: 227 x 75cm high 195cm
- Effective surface area of cells: 6.3m²
- Total power of the panels 800Wc (may vary by 10%)

ref. SOL-800 4 panels

PHOTOVOLTAIC SOLAR PANEL 25 Wc FOR INDOOR OPERATION

NEW

- Solar panel 25W-24VDC on frame with casters (2 with brakes)
- 2 projectors for simulating the sun's rays
- 2 photovoltaic cables 3 metres for linking the panel to the wiring frame
- Dimensions of the panel frame: H 1300 x 900 x 620mm

ref. SOL-100

SOLAR TRACKER WITH BATTERY

ref. TRACSOL

The solar tracker is a technical innovation for tracking the sunlight, in order to increase the efficiency of photovoltaic panels. The productivity gain can reach 40% with a 2-axis tracking installation. TRACSOL is a teaching solution for learning this technique. Equipped with 2 axes and 4 cells for automatic sunlight tracking, it is completely self-contained. No connection to the mains 230V is required. Only the artificial solar source enabling TRACSOL to be used indoors is powered with 230VAC. The transparent sides of the mechanical box enclosing the two axes provide a full view of the chain drive linkages.
4 BNC attached to the front of the cabinet enable the reading on oscillocope of the signals generated by the 4 solar cells.
The voltage of the solar panels is available on the two safety terminals.
The assembly is mobile thanks to 4 heavy-duty wheels attached under the frame.

EDUCATIONAL OBJECTIVES

- **Study and putting into service of a solar tracker.**
- **Understanding the operation of solar cells.**
- **Mastering the wiring of the components of a photovoltaic installation at an isolated site.**
- **Taking measurements using an oscilloscope and clampammeter.**

TEACHING RESOURCES STUDENT & TEACHER

Practical works

- Lessons on the different solar panel technologies (Monocristalline, Polycristalline, Amorphous)
- Study on the positioning of solar panels for maximum output.
- Study of solar radiation.
- Reminder on Direct, Diffused and Reflected solar radiation.
- Comparison of the read powers with fixed panels and tracking panels.
- Study and creation of the wiring of a solar energy system at an isolated site.
- Reading the currents and voltage at different points of the wiring.
- Interpreting the measurements then calculate the efficiency.
- Calculation of the discharge time of the battery according to the load.

Comprises

- 2 solar panels 30W-12V Monocristalline.
- 1 azimuth rotation motor of 160° maximum, that is more than 8 hours of tracking in position perpendicular to the sun.
- 1 zenith rotation motor 43° for full tracking of the sun's elevation.
- 1 set of solar cells.
- 1 cabinet with door.
- 1 Solar load regulator 12V/20A.
- 1 battery 12V-14Ah.
- 1 output 12VDC-60W available on 4mm terminal.
- Protection with gPV cartridge fuse.
- Emergency stop and switch + 'on' indicator light.
- 1 printed side with 4 BNC plugs.
- 1 artificial solar source mounted on telescopic stand.

Features

- 3-metre mains lead for the artificial source.
- Dim.: 800 x 600 x h 1700mm. Weight: 80kg.
- The pole and the panels are easy to remove for going through doorways.

SIMULATION OF A SOLAR PANEL

Given that photovoltaic panels do not produce significant power in cloudy conditions, it is not possible to complete the related tutorials. DC10 is a source which, by replacing the solar panels, overcomes unpredictable sunshine.

• Mains input	230V single-phase
• Stop/start switching	Push-button + LED indicator lights
• Emergency stop	Key operated
• DC output	Adjustable from 0 to 230V DC
• Maximum current	10A
• Filtering	5% of residual ripple at 10A.
• Adjustment method	Button on the top
• Display of outputs	1 voltmeter and 1 ammeter
• Output terminals in parallel	2 photovoltaic type connectors 2 4mm safety terminals
• Upstream protection	By fuse
• Output protection	By circuit breaker
• Protection of individuals	By safety isolation transformer
• Dimensions/Weight	330 x 280mm height 510mm/49kg
• Castors	4 including 2 with brakes

Suitable for indoor operation with our products.

SOL-1
SOL-2
SOL-3
SOL-4-EXP
SOL-5-EXP
SOLPUITS
SOLHAB

ref. DC10

Supplied with cable (1m) for connection to the management system of photovoltaic panels.

AMTEC WIND ENERGY

AMTEC WIND TURBINE TRAINER

A wind Turbine is a device that coverts the winds kinetic energy into electrical energy.

Wind turbines are manufactured in a wide range of vertical and horizontal axis types. Smaller turbines are used for applications such as battery charging for various low consumption applications and larger turbines can be used for making contributions to a domestic power supply while selling unused power back to the Utility via the electrical grid.

We have designed and developed various units for training purposes to study the various parameters and configurations available. These trainers are available as complete didactic training systems or as configurable units to demonstrate how one would install and test various systems:

Systems Available:

i) **<u>Battery Charging Wind Turbine Kit 24 /48V 600W</u>**

- Varying Blade Pitch Wind Turbine 24/48V (Class II) 5 Blade with overspeed protection
- Charge Unit
- Divert Resistor
- Deep Cycle Battery
- Voltage Limiter
- Cabling / plug in type cables, battery terminals
- Portable Workstation complete with fixed or configurable didactic components.
- System includes instrumentation & probes to measure various parameters such as DC / AC voltage, current & Wind Speed at various points throughout the system

<u>Optional:</u>

- 12m Mast for outdoor use (Collapsible / Fixed Type)
- Industrial Speed controlled Fan Unit for Indoor use to drive blades.

RENEWABLE ENERGIES

DL WIND-L

Wind Energy

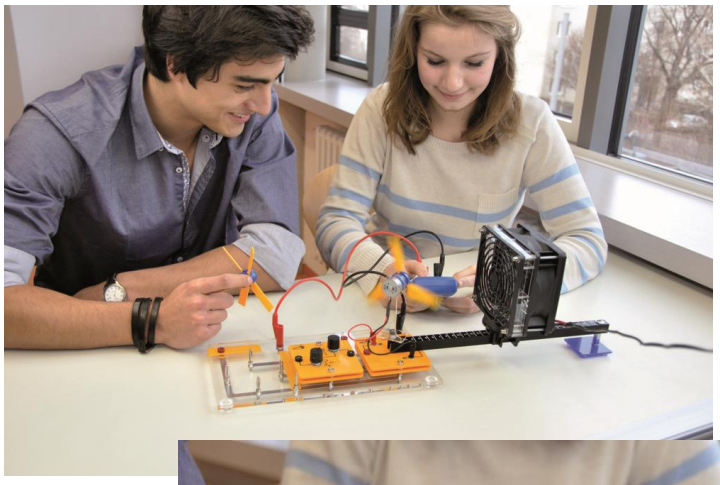
This system provides you with all the answers you need concerning the basics of using wind energy. It discusses different topics, which are necessary for understanding the functions of wind power plants.

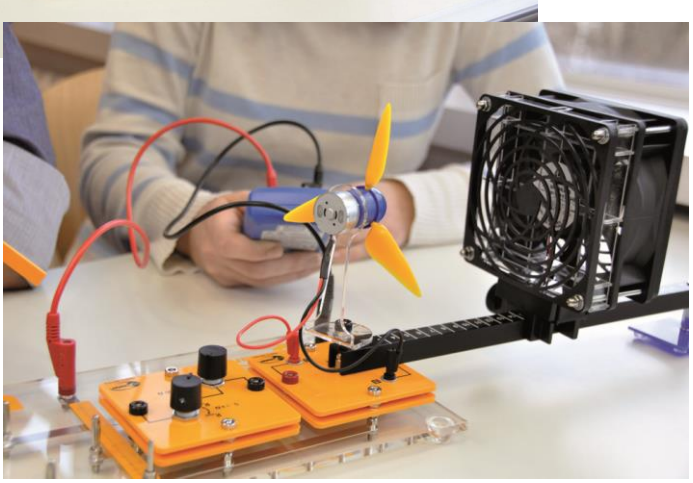
The study of how wind force, wind direction or rotor type influences the power output are only some examples of possible experiments.

Both qualitative and quantitative experiments are described in detail in the manual provided with the kit.

COMPONENTS

- Plastic box with hard foam insert
- Wind machine module
- Base
- Potentiometer module
- Wind generator module
- LED-module
- Capacitor module
- Resistance module
- Set of wind turbines (2, 3 and 4 blades)
- Savonius rotor
- Buzzer module
- Light bulb module
- Motor module without gear
- Color disc
- Lid for tray
- 1 AV module
- 1 power supply
- CD with teacher and student manuals
- 2 leads - black 25 cm
- 2 leads - red 25 cm





RENEWABLE ENERGIES

MICRO-GRID WIND TURBINE TRAINER

DL WIND-WT

Modular trainer for the theoretical and practical study of the electric energy generation from a wind turbine.

The system is composed of laboratory didactic panels installed on a vertical frame and a three-phase wind turbine to be installed on the rooftop.

With the Micro-Grid Wind Turbine Trainer, it is possible to perform experiments to study the conversion from wind energy into electrical energy, and measure the system parameters such as wind speed, turbine speed, electrical power and efficiency on a real wind turbine installed outdoor.

TRAINING OBJECTIVES

- Identification of wind turbine components
- Wind turbine installation and testing
- Anemometer installation and testing
- Operating the wind turbine and anemometer
- Operating the wind turbine breaker
- Measuring wind power
- Measuring wind turbine electrical power
- Wind speed vs rpm
- Wind speed vs power
- Calculating wind turbine power coefficient Cp
- Using the wind turbine to charge the Battery
- Study of the wind turbine with load.

The Micro-grid Wind Turbine Trainer is supplied with a software developed in LabVIEW that communicates with the main components of the modular system via RS485 serial communication using Modbus RTU protocol to perform data acquisition and processing.

TECHNICAL SPECIFICATIONS

Laboratory equipment

- Three phase rectifier bridge module
- Battery 100 Ah complete with battery protection module
- Wind turbine charge controller with brake
- Active DC load used in the renewable energies laboratories configurable as constant resistance or constant current.
- Multifunction measurement module: wind speed (m/s), wind direction (degrees), wind turbine speed (rpm), 2 AC power meters (512Vac, 20Aac, 1000W).
- AC and DC power meter: (0-750 Vac/dc, 0-20Aac/dc, 0-1000W).

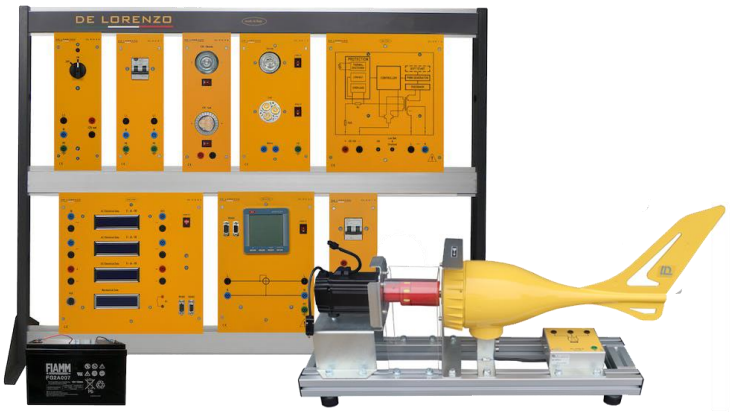
Rooftop Wind Turbine equipment

- Three phase wind turbine (400 W, 12 Vac)
- A cylindrical 5 meters-tall pole with a base plate with complete kit for permanent outdoor installation.
- 10 meters three phase cable
- Anemometer with wind direction sensor

RENEWABLE ENERGIES

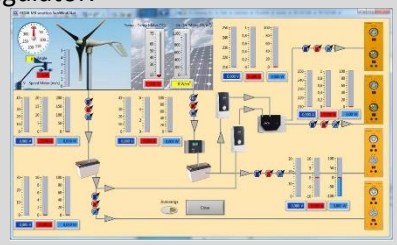
WIND ENERGY TRAINER

WITH BATTERY CHARGE REGULATOR AND BATTERY



DL WIND-OG

Modular trainer for the theoretical and practical study of the electrical installations with wind energy.
With the wind trainer it is possible to perform experiments to determine the characteristics of a wind generator and study their off-grid operation with a battery charge regulator.



Complete with connecting cables, experiment manual and **software for data acquisition and processing.**

DIDACTIC EXPERIENCE

STUDY OF WIND TURBINE
- Identification of wind turbine components
- Operating the Wind Turbine Breaker
- Calculating wind power

STUDY OF OFF-GRID WIND SYSTEM
- Dimensioning of an off-grid wind system.
- Battery regulating and charging
- Supplying DC load with wind power stored in a battery
- Supplying AC load with wind power and a battery.
- Calculating the system autonomy with different loads

TECHNICAL SPECIFICATIONS
- Battery protection module
- DC load module. It includes a 20W dichroic lamp and 3W LED lamps, with independent switches.
- AC load module. It includes a dichroic lamp and LED lamps, with independent switches.
- Motor/generator group for the simulation of a wind turbine. Composed of a brushless motor and a DC permanent magnet generator.
- Control module for brushless motor drive
- Anemometer
- 100Ah battery
- Off-grid inverter module
- Multifunction measurement module for wind applications: It includes four separate instruments to measure all fundamental parameters for the study of a wind-system.
- Wind turbine charge controller with brake system,
- Support frame for modules

Average hours of training:8h

DELORENZO WIND POWER PLANT

DL WPP

This trainer allows the students to study the functions and operations of a modern wind power plant simulating the effects of the wind force and their effects on the plant.
This system operates through a brushless machine and the simulation software and the double-feed asynchronous machine allows a practical and effective approach to this trainer.

The trainer has a modular structure that will grant teachers and students extreme flexibility during the study of the related topics and the performance of the experiments.
An interactive multimedia software is also available to allow performing the experiments set-up as well as the visualization and management of the collected data through PC.

The control unit of this trainer allows controlling and operating a speed-variable double-feed asynchronous generator. Thanks to this control unit it is possible to simulate and investigate the operating principles of this topic.

This control unit allows approaching and theoretically in depth analyzing the following topics:

- Operation of the double-feed asynchronous generator;
- Integrated power switch for switching the generator on line;
- Reactive and active power, frequency and voltage control;
- Mains synchronization.

This trainer is complete with the relevant software that can control and set the several operations of the system; with this software it is possible to adjust the wind speed and profile and to examine the effects on the operating functions of a real wind power plant. Another important feature of this software is related to the possibility to control, parameterize and visualize the obtained data.

In particular, with this software it is possible to perform the following activities:

- Measurement, calculation and graphic representation of many mechanical and electrical operating parameters.
- Selection of the set-point values for reactive and active power.
- Definition and simulation of wind power and profiles.
- Interactive experiments set-up.
- Values and graphs can be stored.
- Experiments instructions can be viewed directly from the software.
- Possibility to print documents for easy hardcopy printing of experiments instructions with solutions.

With this wind power plant trainer it is possible to perform the following experiments:

- Study of functions and operations of a modern wind power plant.
- Relationships between a pitch control system and the wind.
- Analysis of the mechanical parameters within an induction generator.
- Analysis of the electrical parameters within an induction generator.
- Starting method of a wind system
- DFIG – doubly fed induction generator.

CONFIGURATIONS

DL WPP

DL 2108T26	BRUSHLESS CONTROLLER WITH MOTOR	1
DL 2108T26BR	BRAKING RESISTANCE	1
DL 1022P4	SLIP RING THREE-PHASE ASYNCHRONOUS MOTOR	1
DL 1013A	BASE	1
DL 2108TAL-CP	THREE PHASE SUPPLY UNIT	1
DL 2109T29	THREE-PHASE POWER METER	1
DL 2108T29	BACK TO BACK INVERTER	1
DL 2108T02	POWER CIRCUIT BREAKER	3
DL HUBRS485F	MODBUS COMMUNICATION HUB	1
DL WINDSIM	WIND SIMULATOR	1
DL SCADA-WEB	SOFTWARE SCADA	1
DL 1155WPP	KIT OF CONNECTING LEADS	1
DL 2100-3M-AS	FRAME	1
DL PCGRID	ALL-IN-ONE PERSONAL COMPUTER	1
SOCKET-MAINS	THREE-PHASE SOCKETS HOLDER	1
DL 1001-1-AS	WORKBENCH	1
DL 2600TT	THREE-PHASE TRANSFORMER	1

OPTIONS FOR THE FAULT RIDE THROUGH

DL 7901TT	LINE MODEL	1
DL 2108T18	MULTIFUNCTION THREE-PHASE OVERVOLTAGE/UNDERVOLTAGE RELAY	1
DL 1017R	RESISTIVE LOAD	1
DL 2108T02	POWER CIRCUIT BREAKER	1
DL 2100-3M-AS	FRAME	1

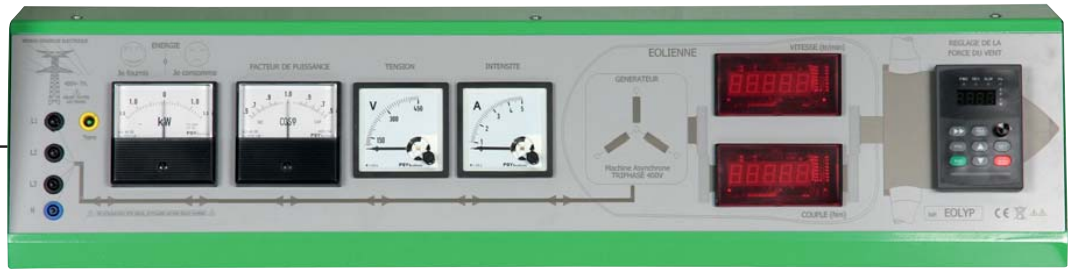
WIND TURBINE SIMULATOR - NETWORK INJECTION

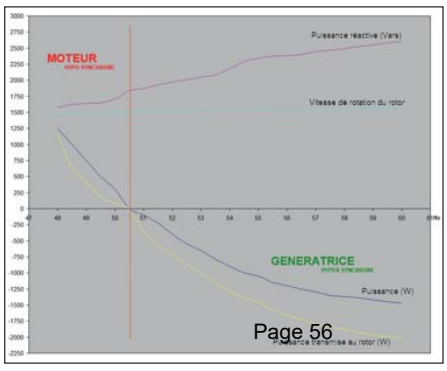
EOLYP is a test bench dealing with the study of the hyper synchronous activity of a wind turbine for its electricity production aspects, excluding the mechanical aspects.
Due to noise pollution and draughts, which are incompatible with a classroom environment, the propeller has been replaced by a variable speed drive motor.

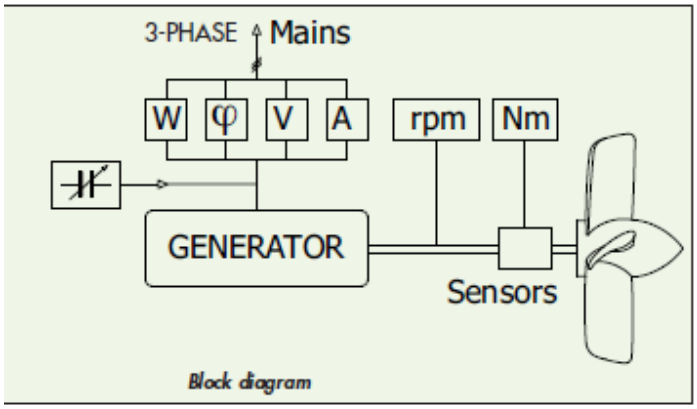
The functional diagram presents the operating principle. The safety components placed in the electrical cabinet are not represented to simplify reading. The propeller, for which the operator adjusts the speed, drives the generator from 0 to 1800 rpm. Two sensors placed on the shaft, returns rotation speed and torque information to the console which displays this information. The generator is coupled to the public three-phase network, through an electrical measurement bench indicating the:

- active power injected into the network.
- voltage between phases
- current
- power factor.

The central-zero wattmeter shows that depending on the drive speed, the generator consumes or produces energy highlighting the hypersynchronous and hyposynchronous operations. The voltage/current distortion also changes with the rotation speed as indicated by the central-zero power factor meter. The adjustable capacitors battery is used to adjust the power factor to around 1 depending on the speed and power produced.







Block diagram

EDUCATIONAL OBJECTIVES

- **Understanding the mechanical & electrical principles of a wind turbine.**
- **Studying the hypo-synchronous and hyper-synchronous operating modes of an asynchronous motor.**
- **Studying the synchronization of the electrical network.**
- **Calculating the efficiency of the energy production system.**
- **Using a clamp-on Ammeter.**

TEACHING RESOURCES STUDENT & TEACHER

Proposed Practical Works

- Reminders on the wind turbine functioning.
- Synchronization procedure on the electrical network.
- Raising the power factor by a capacitors bank and study the results.
- Plotting the electrical characteristics of the energy production system.
- Calculating the overall efficiency.
- Studying of the functioning in an isolated site.

COMPRISES

- 1 frame on casters, dim. 1200x750mm height : 1820mm. Weight: 143kg.
- 1 asynchronous motor 1.5 kVA
- 1 generator
- 1 DC tachogenerator / 1 torque sensor
- 1 command console
- 1 electrical cabinet
- 1 network coupling unit

GENERATOR FEATURES

- Generator: 3 x 400VAC Asynchronous motor.
- Active power injected into the network: 0 to 1.2kVA
- Generator efficiency: 78%
- Speed variation: 0 to 1800 rpm

ELECTRICAL CABINET FEATURES

Inside

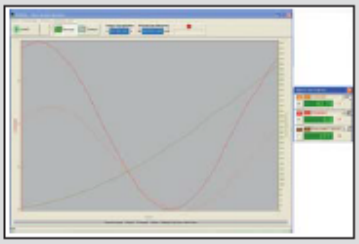
- 30 mA circuit breakers & thermal-magnetic and thermal circuit breakers.
- 2.2kVA speed controller with control unit on the console.
- stepped capacitors battery

On the front

- 1 emergency stop circuit breaker
- 1 switch disconnector
- 1 stop/Start button with push button
- 4 switches triggering the capacitors to rectify the cosϕ
- 2 indicator lights show a thermal fault on the motor and generator

ACQUISITION PACK

ref. EOL-COM2



EOL-COM2 is an option for EOLYP and EOLYP-ECO. This option allows recording and plotting on PC the electrical values as voltage, current and power provided to the Electrical network. The software supplied displays these electrical values in real time and collects them in Excel format.

During the acquisition, the values of U/I/P are displayed at the same time as curves and numerical values. Connection on PC by a USB cable of 2m (supplied). Mains supply: 230Vac – 50/60Hz

DISPLAY

By two displays 2000 pts and one display 2000 pts with LEDS.

INPUTS

Voltage inputs: Three floating potential voltage terminals, situated at the rear of the apparatus allowing either the application of an alternating, continuous or composite voltage, or a balanced three phase voltage. These inputs are electronically protected against over voltages. Max. voltage: 400Vrms single phase, 700Vrms three phase

Current inputs: Two floating potential current terminals, situated at the rear of the apparatus allowing the application of an alternating, continuous or composite current. Imax = 20A. The current input is protected by a delay fuse, allowing measurements on starting up a motor

RECOPY OUTPUTS

Voltage output: 0 to 10V DC signal for 0 to 1000Vrms entering.
Current output: 0 to 10V DC signal for 0 to 20Arms entering.
Power output: 0 to 10V DC for 0 to 0.2kW - 0 to 2kW - 0 to 20kW; these three ratings are switched automatically.
Important: these three outputs are insulated from the voltage and currents applied to the input terminals of the apparatus.

OTHER CHARACTERISTICS

Dimensions of each case : 375 x 80 x 275mm. Weight : 5kg.

Function	U	I	W
Ranges	400Vrms single-phase 700Vrms 3-phase	20Arms	0.2 - 2 - 20kW
Accuracy in % of reading	1% from 0 to 70kHz	2% 0 – 20kHz 3% 20 – 70kHz	2% 0 – 20kHz 3% 20 – 30kHz 5% 30 – 70kHz
Protection	Electronic breaker	20A delayed fuse	
Impedance	1.5MΩ	<5mΩ	
Recopy outputs	10VDC/1000Vrms	10VDC/20Arms	10VDC/ 0,2kW - 2kW - 20kW

THREE-PHASE WIND TURBINE - 400W

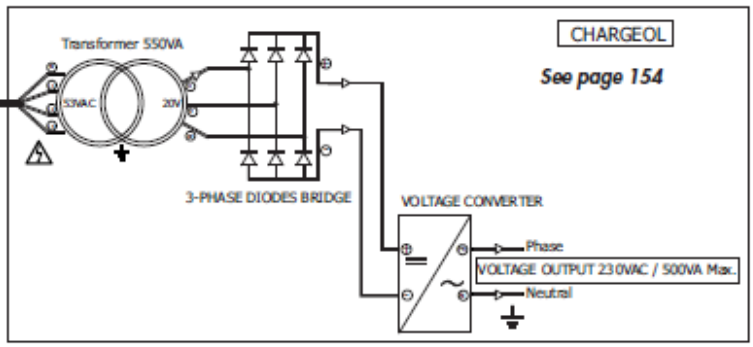
EOLYS-500 is a three-phase wind turbine 400W belt-linked to a driven motor that simulates the wind strength. This system is suited to class room conditions. It perfectly simulates wind turbine operation without noise or draughts since there is no fan. Protected by a transparent cover, the wind turbine can be seen with no risk of direct contact. EOLYS-500 is more than a simulator because it rotates a true three-phase generator and short blades.

EDUCATIONAL OBJECTIVES

- Understanding the different elements of a wind turbine.
- Make the measurements of electrical parameters (3-phase and continuous).
- Analyzing and interpreting results.
- Studying the efficiency and impacts related to the wind force.
- Studying the chain of wind energy (production, storage, consumption, energetic behavior).
- Control and set a speed variator from a PC.

DELIVERED WITH TESTS & PRACTICAL WORKS

EXAMPLE OF COMPATIBLE LOAD



CHARGEOL

See page 154

ref. EOLYS-500

Wind turbine features

- Three-phase output 3 x 53V AC - 400W at 370 rpm on safety terminals.
- Direct current output 90V DC - 400W at 370 rpm on safety terminals.
- Selection of these outputs by using an included rectifier or by direct connection.

Features of the wind simulation

- Squirrel-cage three-phase asynchronous motor.
- Speed controller simulating wind turbine speed 0-400 rpm.
- Using the supplied SOMOVE software, the PC operations are:
  - Acceleration of the wind speed.
  - Deceleration of the wind speed.

General features

- Wheeled frame with brakes
- Overall dimensions: 750 x 670 x (h) 1500 mm
- Top cover made with aluminium frame and Lexan sides (translucent and unbreakable).
- Power supply 2P+N+E 230V AC - 50/60 Hz (5m lead with mains plug)
- Supplied with: Practical assignments in the form of measurements/tests; RJ45-USB cable for linking between the speed controller and the PC. **Schneider® SoMove software.**

Supplied with SoMove

THREE-PHASE WIND TURBINE - 400W

EDUCATIONAL OBJECTIVES

- Understanding the different parts of a wind turbine.
- Make the measurements of electrical parameters.
- Analyzing and interpreting results.
- Studying the efficiency and impacts related to the wind force.
- Study the chain of wind energy (production, storage, consumption, energetic behavior).
- Wiring of a wind turbine installation.

TEACHING RESOURCES STUDENT & TEACHER

Proposed practical works

- Studying and reading of the electrical features of the wind turbine.
- Calculate the system's efficiency.
- Realization of the diagram and wiring for the energy injection on the electrical network.
- Realization of a diagram & wiring for the energy use in an isolated site.

1. WIND TURBINE 400W

- SEE opposite EOLYS-500

2. ELECTRICAL CABINET

Standard technical cabinet on wheeled frame.
Dimensions: 810 x 600 x 1890mm base included.

Comprises

- 2 disconnectors
- 1 500mA -30A RC device
- 1 30mA RC device
- 1 lightning arrester + fuses
- 3 100Wh resolution meters
- 1 Mushroom head emergency stop
- 1 source inverter
- 1 charging controller 12/24VDC-20A
- 2 batteries 12V-12Ah
- 1 set of photovoltaic connectors
- 1 500W inverter for network synchronisation
- 1 Voltage converter 24VDC/230VAC-200W

Reference EOL-1

Each reference includes:
1 turbine (Ref. EOLYS-500) + 1 specific electrical cabinet + 1 link cable

Ref	Features
EOL1	Operation with partial and total resale + at isolated site
EOL2	Partial or total resale operation only
EOL3	Operation at isolated site only

PARTIAL OR TOTAL RESALE OPERATION

In the cabinet, a DC/AC inverter converts the DC current from the turbine into alternating current 220VAC 50Hz and feeds it into the grid in synchronism. This inverter is protected against any polarity reversal and any overload on the DC or AC side.

When the turbine is stopped, the inverter consumes no current

INVERTER	VOLTAGE	Max current	Power
INPUT	65~125VDC	8A	
OUTPUT	230VAC-50Hz	2,25A	400VA

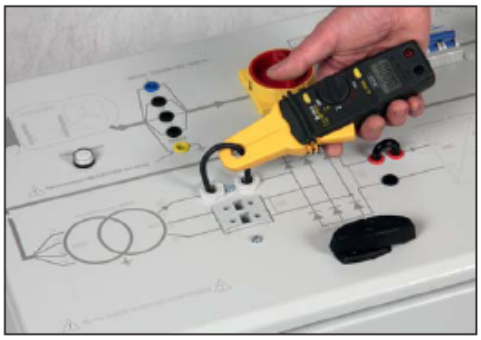
OPERATION AT ISOLATED SITE

The turbine current charges two 12V sealed batteries cabled in series through a charging controller. This DC voltage is either available on safety terminals at the rear of the cabinet, or transformed into 250VAC 50Hz voltage by a 200W voltage converter.

Technical characteristics for the isolated site converter

VOLTAGE CONVERTER	Voltage	Max Current	Power
INPUT	20~32 VDC	11A	210W
OUTPUT	230VAC 50Hz	1.5A	300VA

STUDYING THE CONVERSION OF RENEWABLE ENERGY



ref. CONVERTYS

ref. CHARGEOL

EDUCATIONAL OBJECTIVES

- **Study of the conversion of the electrical energy from 3-phase to single-phase.**
- **Make some measurements with a clamp-on ammeter.**

TEACHING RESOURCES STUDENT & TEACHER

Proposed Practical Works

- Understanding of the wiring diagram.
- Sizing of the electrical components related to the voltage and the power.
- Reading of currents and voltage in different points of the circuit.
- Calculation of powers.
- Calculation of electrical efficiencies.

These converters operate on the same principle as an industrial model.
They treat the electrical power supplied by a wind turbine.
The output cannot be synchronized with the network
but can be used in isolated site.

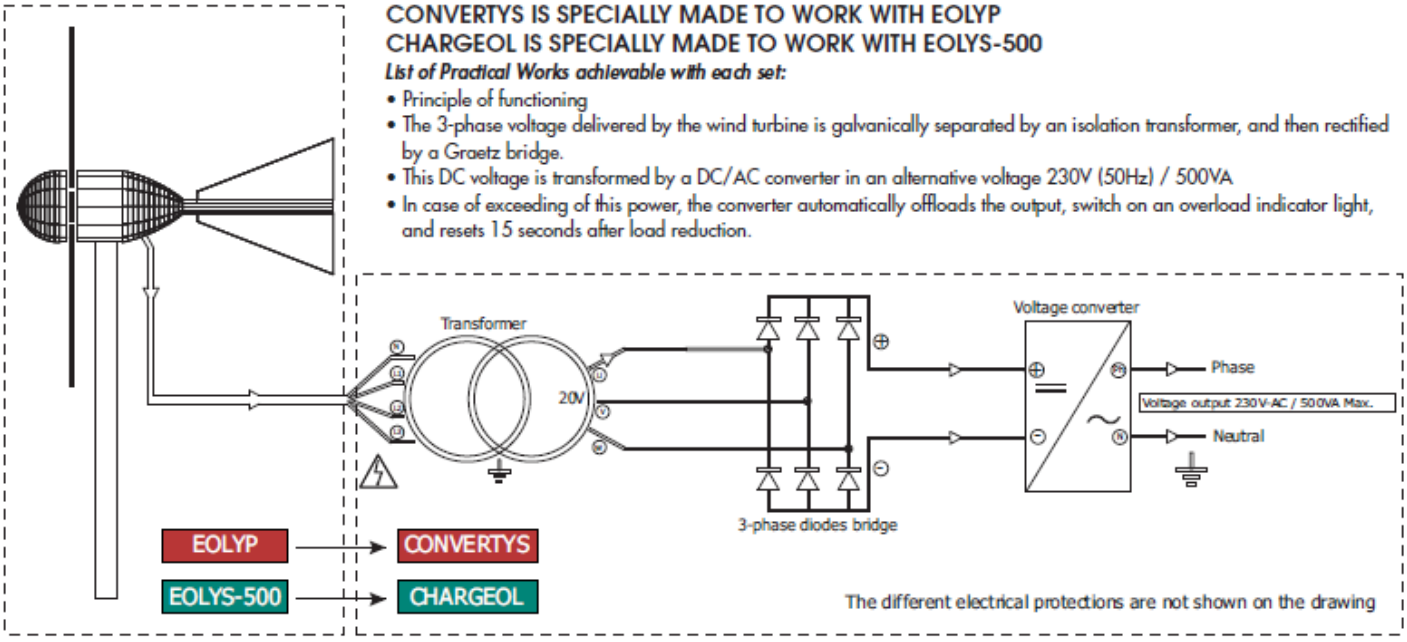
TECHNICAL CHARACTERISTICS

- The converter's synoptic, printed on the front, facilitates location of the components and measurement points.
- The three-phase voltage from the wind turbine is applied to CONVERTYS or CHARGEOL through 4 safety terminals 4mm dia. The wind turbine-to-converter interconnection is made using laboratory leads.
  CONVERTYS : Inputs between 375 and 460V three-phase.
  CHARGEOL : Inputs between 80 and 120V three-phase.
- A main switch located on the top of the box, starts and stops the converter's power supply.
- Safety terminals 4mm diam. located between each component enable the voltages and currents to be measured at each conversion step.
- A thermal-magnetic circuit-breaker protects the transformer primary against any overload.
- Output converter 500W/230V.
- A differential circuit-breaker 30mA protects the output to the use network cabled according to neutral system TT.
- Unit on casters dimensions: 600 x 450mm. Height 530mm

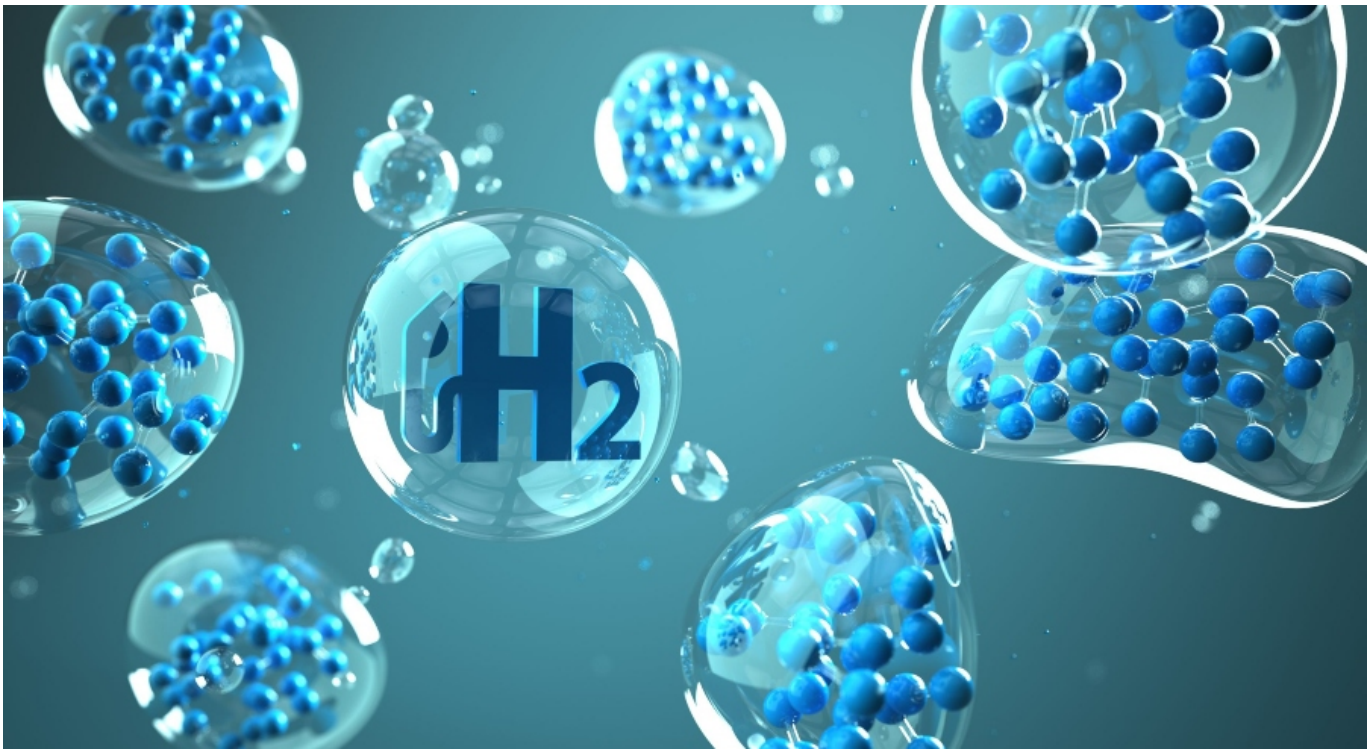
CONVERTYS IS SPECIALLY MADE TO WORK WITH EOLYP
CHARGEOL IS SPECIALLY MADE TO WORK WITH EOLYS-500

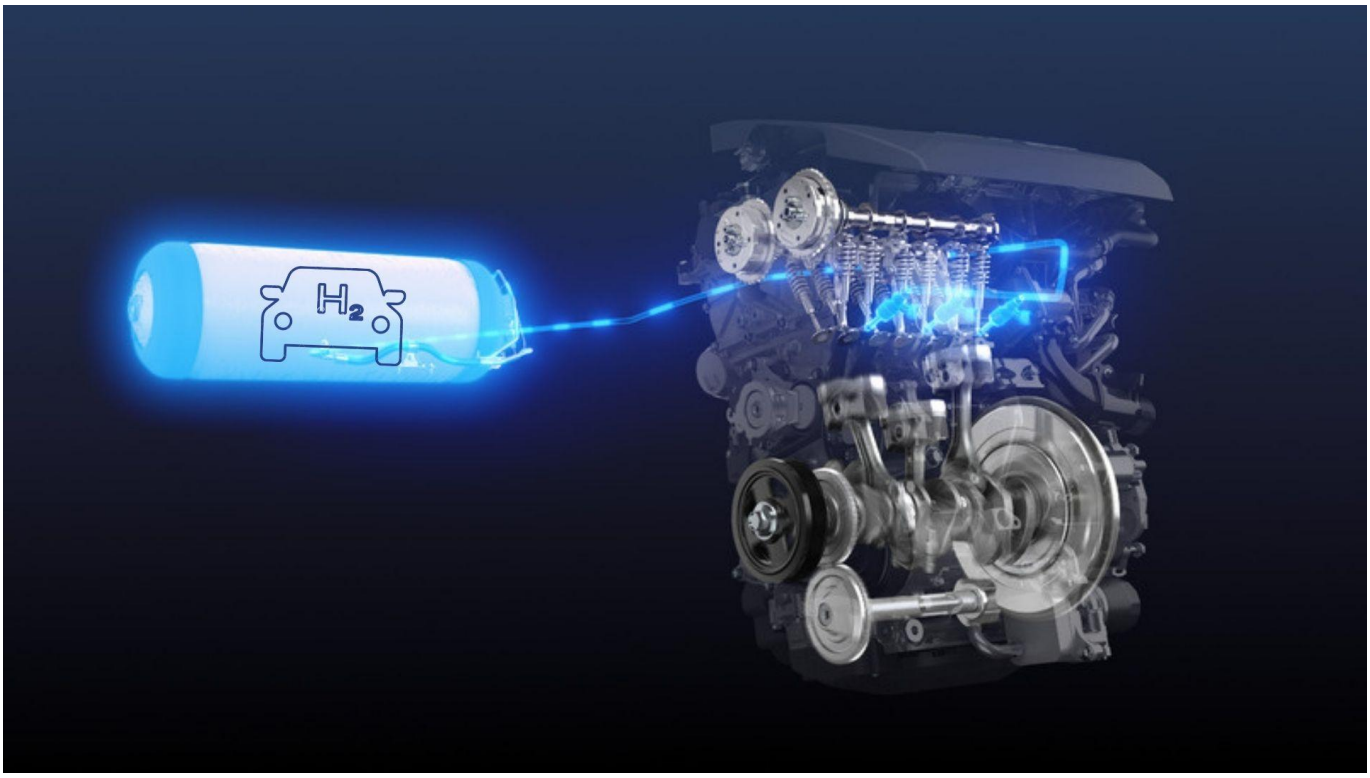
List of Practical Works achievable with each set:

- Principle of functioning
- The 3-phase voltage delivered by the wind turbine is galvanically separated by an isolation transformer, and then rectified by a Graetz bridge.
- This DC voltage is transformed by a DC/AC converter in an alternative voltage 230V (50Hz) / 500VA
- In case of exceeding of this power, the converter automatically offloads the output, switch on an overload indicator light, and resets 15 seconds after load reduction.



AMTEC HYDROGEN ENERGY





RENEWABLE ENERGIES

DL HYDROGEN-L

H2 energy

This kit allows studying the principles and the operation of an electrolyser and proton exchange membrane (PEM) fuel cells. It can be used in physics and chemistry classes as well as in technology classes.

With the electrical loads (like a motor or a lamp) clear and practical experiments are possible. High-quality, didactic manuals complete this product.

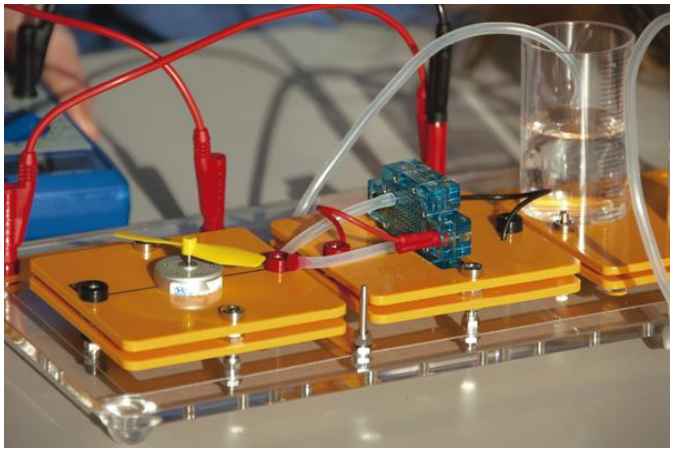
MAIN EXPERIMENTS

- Characteristics and operation of an electrolyser, of a PEM-Fuel cell
- Faraday and energy efficiency of the electrolyser and of the PEM-fuel cell.

MAIN OBJECTIVES

- Understanding the physical principles of electrolysis and fuel cells
- Basic quantitative experiments with reversible fuel cells
- High-quality, didactic manuals

MAIN COMPONENTS

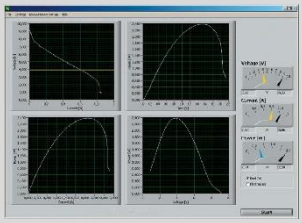


- Base
- PEM-Fuel cell module
- Electrolyzer module
- Potentiometer module
- Motor module
- Solar module
- Gas storage module
- Propeller
- Lamp
- Test leads
- AV module
- Power supply module
- Complete with CD with manual

RENEWABLE ENERGIES

HYDROGEN FUEL CELLS TRAINER

Trainer for the theoretical-practical study of the hydrogen based fuel cells energy.



Complete with connecting cables, experiment manual and **software for data acquisition and display**.

DL HYDROGEN-A

TRAINING OBJECTIVES

- Study of a fuel cell stack up to ten cells
- Producing and storing hydrogen
- Determining characteristic curve of solar panel
- Voltage controlled automatic measurements
- Determining characteristic curve of electrolyser
- Learning about Faraday's laws
- Determining characteristic curves of fuel cell
- Determining fuel cell efficiency
- Determining decomposition voltage of water
- Long-term measurements at your own PC
- Fixing the output at different operating points of the fuel cell stack
- Monitoring single cell stack voltages at your PC
- Power-controlled automatic measurements

Average training hours: 5h
Approx. packing dimensions: 1.03 x 0.50 x 0.97 m.
Net weight: 35 kg.

TECHNICAL SPECIFICATIONS

The trainer includes: PEM fuel cell stack 10 (ten cells), electrolyser, power supply, fuel cell monitor software, hydrogen storage tank, electric load (lamp), fan, solar module and 2 modules with lamps for the solar panel.

Specifications:

- Electrolyser: 15 W
- Fuel cell
- Power per cell: 200 mW
- Power (10 cells): 2 W
- Solar module: 4 V / 3,3 A
- Gas storage: 80 cm^3
- Lamp: 4.4 W
- Power supply: 6 Vdc / 3 A
- Monitoring software

The following accessories are also included: water bottle (with distilled water), protective goggles, silicone tubing and textbook.

RENEWABLE ENERGIES

FUEL CELLS SYSTEMS TRAINER

DL HYDROGEN-B

This trainer has been designed for the study of fuel cell systems. It teaches their engineering principles and it allows performing a set of experiments for educational purposes.
It is safe and easy to be operated.

Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

TRAINING OBJECTIVES

The trainer is very flexible, modular and suitable for the understanding of basic principles as well as more complex technology concepts.
It allows performing the following experiments:

- Familiarize yourself with the trainer
- Performance of the PEM Fuel Cell with fixed loads, without DC/DC converter
- Performance of the PEM Fuel Cell with fixed loads, with DC/DC Converter
- Recording of the current/voltage characteristic curve of the PEM Fuel Cell with variable load
- Calculation of the energy efficiency of the PEM Fuel Cell

Average training hours: 8h.
Approx. packing dimensions: 1.21 x 0.62 x 0.82 m.
Net weight: 35 kg.

Option:
DL HYGEN: Hydrogen generator, for filling the hydride storage canister

TECHNICAL SPECIFICATIONS

The trainer includes the following modules:

- 100 W PEM fuel cell. Performance: 14 V at 7.2 A. Consumption of H_2: 1.4 l/min. it includes the electronic controller.
- 225 Nl aluminum storage canister
- DC/DC converter, output 12 V, 8 A
- Load, with one halogen lamp, 12 V, 50 W, and one LED lamp, 12 V, 3 x 1 W
- Variable logarithmic rheostat, 1.5 Ohm ÷ 17 Ohm, 100 W, Imax = 8 A
- Battery
- Instruments module, containing 4 multifunction meters and 4 LCD displays

RENEWABLE ENERGIES

HYDROGEN GENERATOR
DL HYGEN

The hydrogen generator is designed to produce Hydrogen for laboratory use and must comply with the limits for a class B digital device, pursuant to part 15 of the Federal Communications Commissions (FCC) rules.

It produces pure Hydrogen (and Oxygen as a by-product) by the electrolysis of water. The key element is an electrochemical cell assembly which contains a solid polymer electrolyte filled by deionized or pure distilled water, and no free acids or alkaline are used. The conductivity of the water used in the generator must not exceed 2µS/cm.

It must be placed on a flat level with vibration and shock-free surface. It should not be in contact with any other objects on any side, and the air inlet must not be blocked. 30 cm of free space at the rear side must be left for ventilation.

Pure dry Hydrogen at regulated pressure is available at the Hydrogen outlet port at the rear of the generator. The pressure at this port is adjusted and shown on the display. The Hydrogen relief port and the Hydrogen vent at the rear of the unit can be connected to an exhaust hood or another venting system.

On the front side, it is equipped with a water level indicator.

It has an LCD display to provide the final user all the important information to manage the unit in a simple and safe mode, and the following parameters can be also configured:

- To set the clock
- To set low pressure
- To set pressure rise
- To set pressure drop delay
- To set Auto start
- To set the beeper
- To set pre alarms
- To set pressure unit
- To set temperature unit
- To set volume unit
- To set the lock keyboard
- To set default values.

and tests such as internal and external leak tests, flow test, and complete system test.

The hydrogen generator has the following technical specifications:

- Hydrogen flowrates at STP (Standard Temperature and Pressure) (20°C, 1barg): 0 ÷ 100cc/min,
- Max. Outlet pressure: 11bar (160psi),
- Purity: 99.9999%,
- Power consumption: 130W,
- Weight dry: 13kg,
- Input voltage: 100 ÷ 240V/50 ÷ 60Hz,
- Fuse: 4A,
- Pressure accuracy: 0.1bar (± 0.5%),
- µProcessor controlled display: graphic display, 128x64pixels,
- Index of protection: IP2x,
- Operating conditions:
  - Temperature: 15°C to 40°C,
  - Relative humidity (non-condensing): 0 ÷ 80%,
- Over voltage category: II,
- Noise level: 46dB (A),
- Pollution degree: 2.

It is supplied with the following elements:

- Instruction USB key,
- Deionizer triangle bag,
- Water drain with flexible tubing,
- Power cable,
- USB cable.

and a detailed manual in English language.

SMART GRID

INTRODUCTION

WHY A SMART GRID?

Since the early 21st century, opportunities to take advantage of improvements in electronic communication technology to resolve the limitations and costs of the electrical grid have become apparent.

Technological limitations on metering no longer force peak power prices to be averaged out and passed on to all consumers equally.

In parallel, growing concerns over environmental damage from fossil fuel-fired power stations has led to a desire to use large amounts of renewable energy.

Dominant forms such as wind power and solar power are highly variable, and so the need for more sophisticated control systems became apparent, to facilitate the connection of sources to the otherwise highly controllable grid. Power from photovoltaic cells (and to a lesser extent wind turbines) has also, significantly, called into question the imperative for large, centralised power stations.

The rapidly falling costs point to a major change from the centralised grid topology to one that is highly distributed, with power being both generated and consumed right at the limits of the grid.

Finally, growing concern over terrorist attack in some countries has led to calls for a more robust energy grid that is less dependent on centralised power stations that were perceived to be potential attack targets.

SMART GRID

WHAT IS A SMART GRID?

The Smart Grid is a system for an "intelligent distribution" of electricity, able to know the consumption of the various end users and to manage the generation and distribution of electricity according to demand.

Simply put, if in a given area we have a potential overload of energy, the excess energy can be redistributed to other areas that need it, based on the actual requests from end users.

Furthermore, the software that runs the Smart Grid monitors the electrical flow of the system, integrates renewable energy into the network and activates / suspends the industrial or domestic processes during periods when electricity costs less / more.

The smart grid knows our requirement of power consumption. When the demand for electricity is at its maximum, the smart grid automatically adapts to the demand by picking up excess energy from many sources to avoid overload problems or interruptions of power.

It has, therefore, the function of sharing the electricity that is generated from various sources, both public and private, traditional and renewable, and ensuring that electrical devices use electricity as efficiently as possible.

WHAT IS A SCADA SOFTWARE?

The **SCADA** (Supervisory Control And Data Acquisition) is an industrial control system that performs the following functions:

- acquisition of the physical quantities that are needed for the control and the supervision of the system;
- control, by means of actuators, of its operation;
- supervision, to visually monitor, through the so termed synoptic diagrams, the operating status of the system, the alarms, etc., also in remote control.

SCADA systems supervise, control, optimize and manage the systems for the generation and transmission of electrical energy as well as the distribution networks.
They allow to collect, store and analyze data from hundreds of thousands of data points in national or regional networks, to model networks, to simulate operations, highlight faults, prevent them and finally participate in the energy markets.
They are a vital part of modern networks and enable the development of the smart grids that must handle enormous amounts of energy from renewable sources produced by generators of large and small scale, to maintain stability in the network despite the intermittency of these sources and the bidirectionality of the energy flow.

SMART GRID

DE LORENZO SOLUTION

The smart grid system developed by De Lorenzo can be organized in **eight subsystems**, each comprised of several modules. The first four subsystems are simulations of energy sources; the first one is the main power supply of the grid with a three-phase supply unit that represents a coal plant.

The other three subsystems correspond to alternative sources of energy: wind, hydroelectric and solar. The wind plant simulation is made with a three-phase induction motor acting as a generator while the hydroelectric plant simulation is made with a three-phase synchronous machine, additionally with a generator synchronizing relay module to make possible the connection to the grid. Finally, the solar energy part of the system is generated with a solar panel and four dimmable lamps simulating the sun, which is connected to an inverter module that allows the energy generated to be transferred to the grid.

A fifth subsystem in the smart grid consists of modules for fault protection; the modules are a feeder manager relay that measures in real time voltages and currents to detect faults in the grid and four power circuit breakers controlled by the previous module to disconnect faulty lines.

The sixth subsystem refers to modules for measuring; it has three maximum demand meters that measure AC voltages, currents, frequencies, active power, reactive power, apparent power, power factor and THD for each of the three available phases in the grid and two electrical power digital measuring units that, besides measuring the same as the previous module, make measurements of DC voltage, current, power and energy.

The seventh subsystem is for power factor control with 2 modules, the first one is a switchable capacitor battery with four different values of capacitors and the second one is a reactive power controller that activates the capacitors of the previous module to make a power factor correction.

The last subsystem is composed of passive elements; three modules with different kind of loads (capacitive, inductive, resistive) that simulate the loads in a house or factory and two modules with impedances simulating the losses generated in transmission lines, specifically in lines of 10 and 100 km length.

A **SCADA** software provides to the acquisition and storage of the data coming from the measurement instruments and to the control of the actuators for an “intelligent” management of the whole electrical system. The SCADA software can also be supplied on request in an OPEN version, so that the teacher can implement his own project and select modes and procedure for visualizing the parameters and controlling the actuators.

The system described above represents the basic configuration of our laboratory (DL SGWD).

Optionally, it is also possible to add an additional wind energy small scale generation system, with a real wind turbine connected to an inverter module to make possible the connection to the grid.

SMART GRID

Special configuration prepared for the Worlddidac Exhibition

TRAINING OBJECTIVES

The Smart Grid trainer can be considered a **multidisciplinary laboratory**, because it allows studying and exercising different technical subjects, that are then integrated in a full Smart Grid system setup.

Actually, the Smart Grid trainer is an integrated laboratory that can be useful for a huge number of undergraduate and graduate courses in the engineering school. The laboratory equipment can be configured to create different exercises, which reinforce basic and advanced concepts in electric energy. The equipment can be interconnected to form **a full smart grid system**. However, as you can see from the list of experiments in the next paragraph, conventional topics, such as electric machines, distribution systems and so on could be covered by the Smart Grid trainer; this innovative laboratory can include class demonstrations and laboratory experiments under regular laboratory classes.

There are fundamental topics that are needed for understanding the smart grid concept and they have to be connected with real life situations, yet a set of different topics could be added in order to get a special curricula. The **core topics** include: electric circuits, electric machinery, hydroelectricity, wind energy, photovoltaic solar energy, renewable energies, power transmission, power distribution.

Furthermore, **additional courses** can benefit from the smart grid trainer, such as, for example: power system engineering & analysis, electric machines, linear control systems, electrical distribution engineering and smart grids automation, power generation operation and control, power electronics, cost and construction of electrical supply, power system stability, optimization methods, stochastic processes, embedded systems.

The smart grid system can be used by mechanical and electrical engineering students as a longtime project as it comprises enough elements to cover most of the topics listed above.

SMART GRID

LIST OF MODULES

DL 2108T26	BRUSHLESS CONTROLLER WITH MOTOR	2
DL 1021/4	THREE-PHASE ASYNCHRONOUS MOTOR	1
DL 1013A	BASE	2
DL 1026P4	THREE-PHASE SYNCHRONOUS MACHINE	1
DL 1017R	RESISTIVE LOAD	1
DL 1017L	INDUCTIVE LOAD	1
DL 1017C	CAPACITIVE LOAD	1
DL 2108TAL-CP	THREE PHASE SUPPLY UNIT	1
DL 1067S	MOTOR DRIVEN POWER SUPPLY	1
DL 7901TT	OVERHEAD LINE MODEL – 360 KM	1
DL 7901TTS	OVERHEAD LINE MODEL – 110 KM	1
DL 10065N	ELECTRICAL POWER DIGITAL MEASURING UNIT	2
DL 2109T29	THREE-PHASE POWER METER	3
DL 2108T25	GENERATOR SYNCHRONIZING RELAY	1
DL 2108T23	FEEDER MANAGER RELAY	1
DL 2108T02	POWER CIRCUIT BREAKER	3
DL 2108T02A	POWER CIRCUIT BREAKER	1
DL 2108T19	REACTIVE POWER CONTROLLER	1
DL 2108T20	SWITCHABLE CAPACITOR BATTERY	1
DL 9031	CIRCUIT BREAKER	1
DL 9013G	INVERTER GRID	1
PFS-85	PHOTOVOLTAIC SOLAR PANEL	1
DL SIMSUN	LAMPS FOR THE PHOTOVOLTAIC SOLAR PANEL	1
DL WINDSIM	WIND SIMULATOR	1
DL HUBRS485F	MODBUS COMMUNICATION HUB	1
DL SCADA-WEB	SOFTWARE SCADA	1
DL 1080TT	THREE-PHASE TRANSFORMER	3
DL 1155SGWD	KIT OF CONNECTING LEADS	1
DL 1001-1-AS	WORKBENCH	2
DL 2100-3M-AS2	FRAME	1
DL PCGRID	ALL-IN-ONE PERSONAL COMPUTER	1
SOCKET-MAIN	MAIN SOCKETS	1
SOCKET-EXT	SOCKET EXTENSION	1
DL 2100TT	THREE-PHASE TRANSFORMER	1

Options:

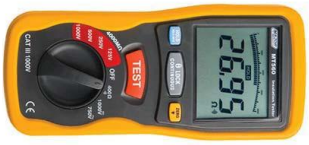
- **Wind energy grid connection.** It allows adding a wind energy system in parallel to the photovoltaic solar system in the utilization section of the system **– ordering code:**
  DL SGWD-W (which includes the DL SGWD and the DL WIND-A1G option).

AMTEC MEASURING INSTRUMENTS

Multimeter

Insulation tester

Digital Loop & PSC tester



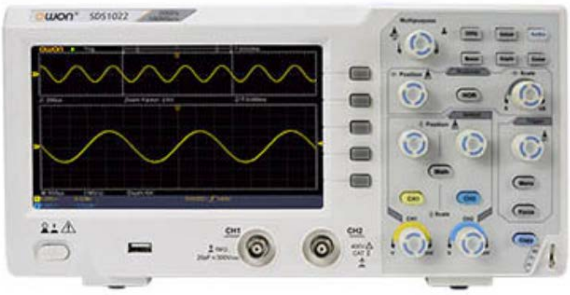
Phase rotation meter

Voltage Detector

Clamp meter

Earth Leakage tester

Digital and Analog Oscilloscope



LUX Meter

Sound level meter

Earth Resistance tester

Power meter

Line and Voltage Detector

AMTEC DVD LIST

Amtec Techniquip has training DVDs and manuals available for common processes in the various Engineering workshop teaching various principles from safety in the workplace to various machines.

We have the following DVD's available for the Engineering Workshop.

DVD Description	PART NO	COURSE
AC & DC MACHINES DVD + 2 MANUALS	AMTECDVD001	Electrical
AC INDUCTION MOTORS DVD + 2 MANUALS	AMTECDVD002	Electrical
AIR CONDITIONING & REFRIGERATION DVD + 2 MANUALS	AMTECDVD003	AC
ANALOGUE OSCILLOSCOPE DVD + 1 MANUAL	AMTECDVD004	Electronics
AUTO ELECTRICAL TESTING DVD + 1 MANUAL	AMTECDVD005	Auto Electrical
AUTOMATIC PROCESS CONTROL DVD + 2 MANUALS	AMTECDVD006	Instrumentation
AUTOMOTIVE ELECTRICAL MAINTENANCE DVD + 1 MANUAL	AMTECDVD007	Auto Electrical
BASIC BEARING MAINTENANCE DVD + 2 MANUALS	AMTECDVD008	Mechanical
BASIC CENTRIFUGAL PUMPS DVD + 2 MANUALS	AMTECDVD009	Mechanical
BASIC HAND TOOLS DVD + 2 MANUALS	AMTECDVD010	Various
BASIC HYDRAULIC MAINTENANCE DVD + 2 MANUALS	AMTECDVD011	Mechanical
BELT AND CHAIN DRIVES DVD + 1 MANUAL	AMTECDVD012	Mechanical
BRAZING AND BRAZE WELDING DVD + 2 MANUALS	AMTECDVD013	Mechanical
COMPOUND MITRE SAW DVD + 1 MANUAL	AMTECDVD014	Mechanical
COMPRESSED AIR SYSTEMS DVD + 2 MANUALS	AMTECDVD015	Mechanical
CONFINED SPACES DVD + 2 MANUALS	AMTECDVD016	Various
DRILLING TAPPING AND THREADING DVD + 2 MANUALS	AMTECDVD017	Mechanical
ELECTRICAL ANGLE GRINDER DVD + 2 MANUALS	AMTECDVD018	Mechanical
ELECTRICAL CONSTRUCTION OPERATOR DVD + 2 MANUALS	AMTECDVD019	Electrical
ELECTRICAL TEST EQUIPMENT DVD + 2 MANUALS	AMTECDVD020	Electrical
ELECTRICITY IN THE WORKPLACE DVD + 2 MANUALS	AMTECDVD021	Electrical
ESSENTIAL KNOWLEDGE FOR WELDERS DVD + 1 MANUAL	AMTECDVD022	Welding
FIRE SAFETY SERIES DVD + 1 MANUAL	AMTECDVD023	Various
FIRE SAFETY FOR OFFICES DVD - NO MANUALS	AMTECDVD024	Various
FORKLIFT OPERATOR TRAINING 2 DVDs + CD ROM	AMTECDVD025	Fork Lift
GAS HAZARD AWARENESS DVD + 1 MANUAL	AMTECDVD026	Welding
GAS METAL ARC WELDING DVD + 1 MANUAL	AMTECDVD027	Welding
GAS SAFETY - PORTABLE CYLINDER HANDLING DVD + 1 MANUAL	AMTECDVD028	Welding
GEARED REDUCTION UNITS DVD + 1 MANUAL	AMTECDVD029	Mechanical
GENERAL SAFETY IN THE WORKPLACE 2 DVDs + CDROM	AMTECDVD030	Various
GENERAL WELDING SAFETY DVD + 1 MANUAL	AMTECDVD031	Welding
GRINDING MACHINES DVD + 2 MANUALS	AMTECDVD032	Mechanical
LEAD ACID BATTERIES DVD + 2 MANUALS	AMTECDVD033	Electrical
LIGHT DUTY HAND SOLDERING DVD + 1 MANUALS	AMTECDVD034	Electrical
LIGHT VOLTAGE JOINTS DVD + 1 MANUAL & EVJ MANUAL	AMTECDVD035	Electrical
LUBRICATION DVD + 1 MANUAL	AMTECDVD036	Mechanical
MEASURING & MARKING (BASIC ENG SKILLS) DVD + 1 MAN	AMTECDVD037	Mechanical
MECHANICAL COUPLING ALIGNMENT DVD + 2 MANUALS	AMTECDVD038	Mechanical
MECHANICAL THREADED FASTENERS DVD + 1 MANUAL	AMTECDVD039	Mechanical
MEDIUM VOLTAGE JOINTS 2 DVDs - NO MANUALS	AMTECDVD040	Electrical
OXY/ACETYLENE EQUIPMENT DVD + 2 MANUALS	AMTECDVD041	Welding
OXY/ACETYLENE PROCESS DVD + 2 MANUALS	AMTECDVD042	Welding
PRECISION MEASURING INSTRUMENTS DVD + 2 MANUALS	AMTECDVD043	Welding
PRESSURE VESSEL TESTING DVD + 1 MANUAL	AMTECDVD044	Mechanical
PROGRAMMABLE LOGIC CONTROLLERS DVD + 2 MANUALS	AMTECDVD045	Electrical
SAFE LIFTING & MOVING 2 DVDs + CD ROM	AMTECDVD046	Various
SEALS & GASKETS DVD + 2 MANUALS	AMTECDVD047	Various
SHIELDED METAL ARC WELDING DVD + 2 MANUALS	AMTECDVD048	Welding
TUNGSTEN INERT GAS WELDING DVD + 2 MANUALS	AMTECDVD049	Welding
VALVES AND VALVE MAINTENANCE DVD + 2 MANUALS	AMTECDVD050	Mechanical
WORKING WITH PORTABLE LADDERS DVD + 2 MANUALS	AMTECDVD051	Mechanical

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