

Hybrid Renewable Energy Trainer

Wind energy, Solar energy, Hydrogen - Modular System with 5 versions



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System Overview

The Hybrid Renewable Energy Trainer is a computer-assisted training system designed for technical colleges, universities and scientific training institutions. It enables hands-on experiments covering solar energy, wind energy and hydrogen & fuel cell technology.

Training Scope

The planned activities are suitable for both **basic and advanced levels** of training and are designed with user safety in mind in compliance with current standards.

Modular Design

The system consists of individual modules that can be easily inserted or removed, depending on the type of experiment to be performed.

All components used to produce the modules are the same as those found in **real industrial equipment**, ensuring students work with industry-relevant hardware.

Main Structure

The primary workstation is built on a robust **aluminium frame**, approximately **180 cm high**, with a **110 × 60 cm work surface** and three support bars for mounting the experiment modules. The interlocking design allows quick and easy reconfiguration of the system. All connections between modules are made with the supplied cable set, keeping every connection clearly visible to the students. A separate **static storage stand** provides organised storage for modules not currently in use.

Energy Source Simulators

Solar simulation – A dedicated stand houses two 10 W monocrystalline photovoltaic panels together with an adjustable LED projector to simulate varying solar irradiance conditions in a controlled lab environment.

Wind simulation – A separate floor-standing unit contains a wind turbine driven by a 150 W DC motor with variable speed control, replicating different wind speed scenarios.

Software & System Requirements

The accompanying control and data acquisition software requires a PC (not included) meeting the following minimum specifications:

- Operating system: **Windows 10** or higher
- Memory: **4 GB RAM** minimum
- Processor: **Intel i3** class or higher

System Overview

35 Hands-on Experiments across 3 Energy Domains

The Hybrid Renewable Energy Trainer includes **35 structured experiments** across three energy domains. Each experiment is designed for progressive learning — from basic component characterisation to complete system integration.

Solar Energy Experiments

- 01 The photovoltaic panel
- 02 Open-circuit voltage measurement
- 03 Short-circuit current measurement
- 04 Current-voltage characteristic
- 05 Daily trend in panel voltage without load
- 06 Daily trend in panel voltage under load
- 07 Seasonal trend of panel voltage without load
- 08 Seasonal trend of panel voltage under load
- 09 Series-connected photovoltaic panels
- 10 Photovoltaic panels connected in parallel
- 11 Photovoltaic panel simulator
- 12 Effect of shading on photovoltaic panels
- 13 Bypass diode operation
- 14 Effect of asymmetry on photovoltaic panels
- 15 Effect of the blocking diode on photovoltaic panels
- 16 Photovoltaic panel emulator
- 17 Direct load connection of photovoltaic panels
- 18 Off-grid inverter start-up (without load)
- 19 Installation of a basic photovoltaic system (DC load)
- 20 Installation of a basic photovoltaic system (AC load)
- 21 Off-grid inverter output signal — data acquisition module
- 22 Off-grid inverter output signal — energy analysis module
- 23 Energy absorbed by the off-grid inverter
- 24 Power output and efficiency of the off-grid inverter
- 25 SCADA application of the off-grid inverter
- 26 On-grid inverter examination

Wind Energy Experiments

- 1 Turbine speed vs. output voltage (no load)
- 2 Turbine speed vs. output voltage (under load)
- 3 Effect of turbine controller on speed vs. voltage (no load)
- 4 Effect of turbine controller on speed vs. voltage (under load)
- 5 Turbine output voltage examination
- 6 Turbine output voltage — data acquisition module
- 7 Wind power system examination

Hydrogen Technology & Fuel Cell Experiments

- 1 Fuel cell output voltage — oscilloscope
- 2 Fuel cell output voltage — data acquisition

Hybrid Renewable Energy Trainer

Module Overview – 36 Components

RES-001 – RES-007

RES-001 Mobile Module Stand



The mobile module stand is the centrepiece of all experiments. Modules can be easily inserted and removed. A built-in shelf provides space for notes and working materials.

RES-002a Wind Turbine Module



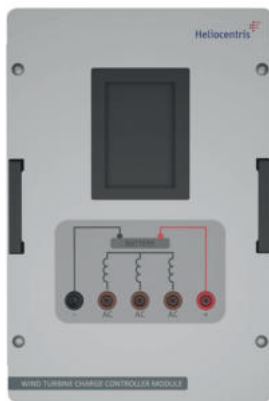
DC Motor	24V / 1400rpm
Dynamo	24V / 300W
Nom. Wind Speed	13m/s
Weight	16kg

RES-002b Wind Simulator Module



Control Power	200W
Output V	0-20V
Mode	Manual / PC
Weight	3kg

RES-002c Wind Turbine Charge Ctrl.



Battery V	12 / 24V
Brake V	15 / 30V
Weight	2,6kg

RES-003 Solar Panel (Adj. Angle)



VOC	2×23,8V
ISC	2×0,6A
LED Projector	300W / 0-36V
Weight	2,8kg

RES-004 Electronic Potentiometer



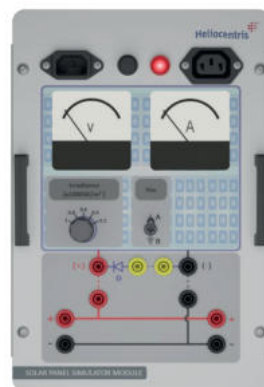
Resistance	0-1000Ω ±1Ω
Max Power	50W
Display	5" TFT
Weight	4,5kg

RES-005 Potentiometer Module



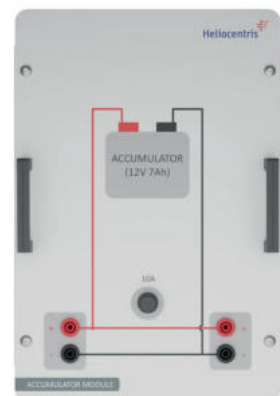
Resistance	0-1kΩ
Max Power	200W
Weight	3,1kg

RES-006 Solar Panel Simulator (2 Units)



ISC	2A
VOC	12-18V
Irradiance	5 Stage
Weight	2,9kg

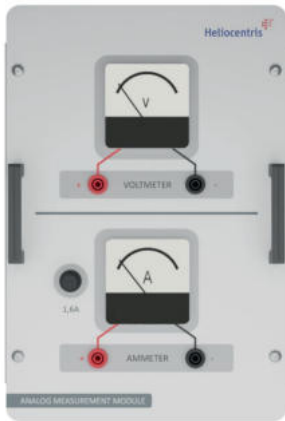
RES-007 Accumulator Module



Voltage	12V
Capacity	10Ah
BMS	Integrated
Weight	2kg

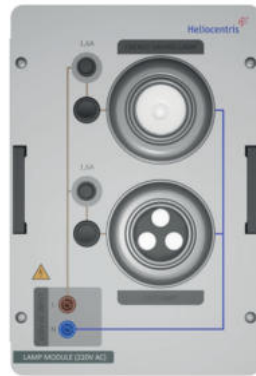
RES-008 – RES-016

RES-008 Analog Measurement



Voltmeter	0-30V
Ammeter	0-5A
Weight	3kg

RES-009 Lamp Module (220V AC)



Bulbs	Saving + LED
Socket	E27
Operating	220V / 50Hz
Weight	2,8kg

RES-010 Lamp Module (12V DC)



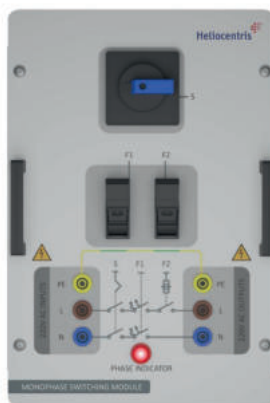
Halogen	20W
LED	2W
Operating	12VDC
Weight	2,9kg

RES-011 Isolated Measurement



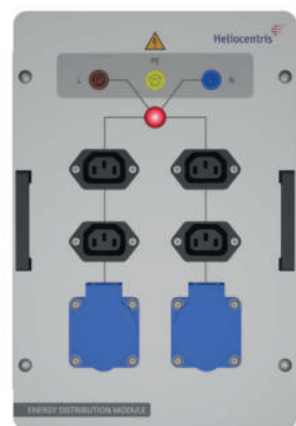
V Range	0-500V
I Range	0-5A
Channels	2
Weight	3,5kg

RES-012 Monophase Switching



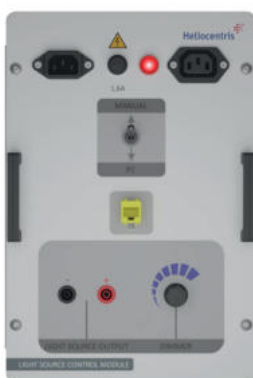
Breaker	10A
RCD Relay	25A / 30mA
Weight	3kg

RES-013 Energy Distribution



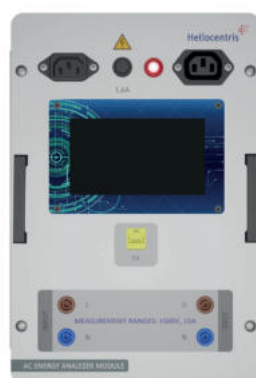
Output	4x C14; 2x CEE 7/4
Weight	2,8kg

RES-014 Light Source Control



Output Power	0-300W
Output V	0-36V
Mode	Manual / PC
Weight	3,1kg

RES-015 AC Energy Analyser



Voltage	230V
Current	5A
Accuracy	±1%
Weight	3kg

RES-016 PC Interface Module



PC	USB
Data	4x RS485 / RJ45
Analog Out	LS + WS
Weight	2,7kg

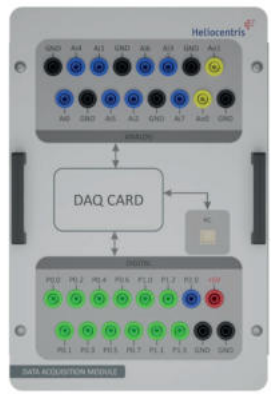
RES-017 – RES-025

RES-017 AC/DC Measurement



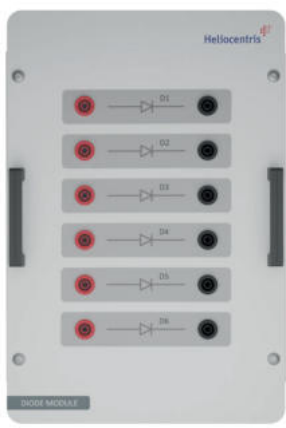
Ammeter	0-5000mA ±4mA
Voltmeter	0-500V ±400mV
Display	5" TFT
Weight	3,2kg

RES-018 Data Acquisition Module



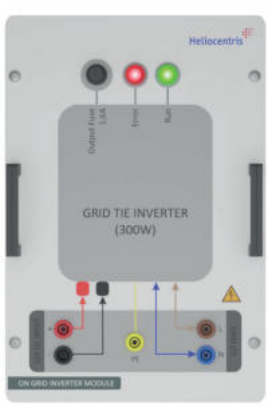
Analog In	8× (14bit, 20kS/s)
Analog Out	2× (12bit)
Digital I/O	12
Interface	USB

RES-019 Diode Module



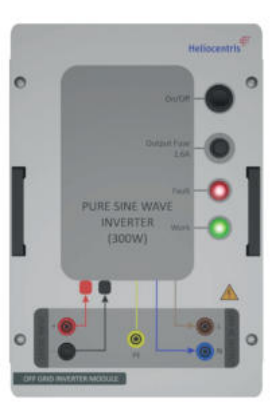
Diodes	6× Schottky
Rating	40V / 3A
Weight	2,1kg

RES-020 On-Grid Inverter



Input	11-32VDC
MPPT	15-22V
Output	230V AC
Power	Max. 330W

RES-021 Off-Grid Inverter



Input	12VDC
Output	220-240V AC ±5%
Power	300W Sine
Weight	3,5kg

RES-022 Solar Charge Regulator



System	12V / 24V Auto
Charge I	10A
Weight	2,5kg

RES-023 AC Power Module



Note **For grids ≠ 220V AC**

RES-024 LCD Monitor



Typ	LED
Size	21,5"
Weight	3,5kg

RES-025 Cable Holder



The cable holder is mounted on the side of the module stand and provides convenient storage for your cables.

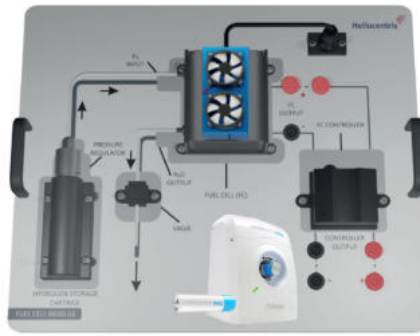
RES-026 – RES-OSC

RES-026 Cable Set (40 pcs.)



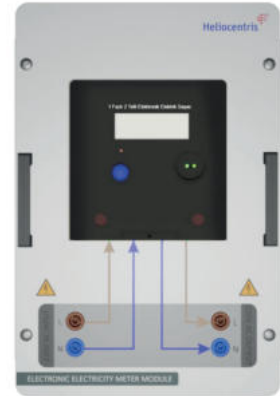
The cable set comprises 66 pieces – including banana cables in various colours and lengths, power cables, Ethernet and USB cables, as well as specialty cables and selected accessories for immediate use in all experiments.

RES-027 Fuel Cell Module



Tank Pressure	30 Bar
F.C. Input	0,4-0,55 Bar
F.C. Out	14VDC
Con. Out	11,8VDC
Weight	3kg

RES-028 Electronic Elec. Meter



Nominal V	220/230V
Ref. I	5A
Max I	100A
Display	LCD 9(6+3)

RES-029 Static Module Stand



The static module stand serves as storage for all modules not currently needed in an experiment.

RES-030 Monitor Holder



The monitor holder allows secure attachment of the display to the module stand.

RES-031 Electronic Load Module



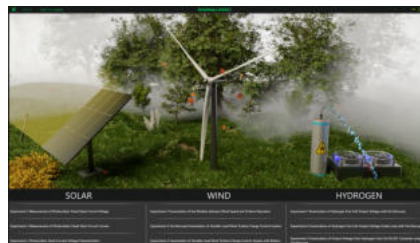
Input V	Max. 24V DC
Current	1-1000mA
Max Power	24W
Weight	3,1kg

RES-032 DC Power Supply



Output V	0-32VDC ±10mV
Output I	0-5,1A ±1mA
Power	0-160W
Weight	5kg

RES-SW Software



The intuitive experiment software is supplied on a USB stick and offers a wide range of experiments.

RES-OSC Oscilloscope (Owon)



The Owon oscilloscope enables precise display and analysis of electrical signals in real time.

Article Number	Module Description	2010 Solar Energy	2020 Wind Energy	2040 Solar + Wind	2000 Solar + Wind + H2-FC	2050 Solar + H2-FC
RES-002a	Wind Turbine Module	—	●	●	●	—
RES-002b	Wind Simulator Module	—	●	●	●	—
RES-002c	Wind Turbine Charge Ctrl.	—	●	●	●	—
RES-027	Fuel Cell Module (incl. H2-Generator & 2x H2-Storage)	—	—	—	●	●
RES-001	Mobile Module Stand	●	●	●	●	●
RES-003	Solar Panel (Adj. Angle)	●	—	●	●	●
RES-007	Accumulator Module	●	●	●	●	●
RES-009	Lamp Module (220V AC)	●	●	●	●	●
RES-010	Lamp Module (12V DC)	●	●	●	●	●
RES-013	Energy Distribution	●	●	●	●	●
RES-014	Light Source Control	●	—	●	●	●
RES-016	PC Interface Module	●	●	●	●	●
RES-017	AC/DC Measurement	●	●	●	●	●
RES-019	Diode Module	●	—	●	●	●
RES-021	Off-Grid Inverter	●	●	●	●	●
RES-022	Solar Charge Regulator	●	—	●	●	●
RES-SW	Software	●	●	●	●	●
RES-025	Cable Holder	●	●	●	●	●
RES-026	Cable Set (40 pcs.)	●	●	●	●	●
RES-031	Electronic Load Module	●	●	●	●	●
RES-004	Electronic Potentiometer	●	●	●	●	●
RES-006	Solar Panel Simulator (2 Units)	●	—	●	●	●
RES-008	Analog Measurement	●	●	●	●	●
RES-005	Potentiometer Module	●	●	●	●	●
RES-011	Isolated Measurement	●	●	●	●	●
RES-012	Monophase Switching	●	●	●	●	●
RES-015	AC Energy Analyser	●	●	●	●	●
RES-018	Data Acquisition Module	●	●	●	●	●
RES-020	On-Grid Inverter	●	●	●	●	●
RES-023	AC Power Module *	●	●	●	●	●
RES-028	Electronic Elec. Meter	●	—	●	●	●
RES-032	DC Power Supply	●	●	●	●	●
RES-029	Static Module Stand	—	—	●	●	●
RES-OSC	Oscilloscope (Owon)	●	●	●	●	●
RES-030	Monitor Holder	—	—	—	●	—
RES-024	LCD Monitor	—	—	—	●	—

● Included — Not included

* RES-023 AC Power Module: Required where grid voltage differs from 220V AC