

# S5 GE Green Energy Kit



The **SMART:Blox S5 GE** is a set of Alternative Renewable energy practical training devices and instruments which enable the students to carry out a wide range of experiments and measurements. This laboratory set aims to train students in the operating principles and performance of **Solar, Wind, Fuel Cells** (Hydrogen and Biofuel), **Mechanical** and **Thermal energy transformations to Electrical energy**.

The Green Energy set consists of the **S5 GE** kit and 5 individual subsets, one for each of the forms of green energy under study: **S5-SL** for solar energy, **S5-WD** for wind (aeolic) energy, **S5-FC** for fuel cells energy which includes the subsets **S5-FH2** for Hydrogen cells and **S5-FBE** for Bio-fuel (Ethanol) cells, **S5-EM** for mechanical energy and **S5-TE** for electro-thermal energy.

The **S5 GE** kit is the heart for the Green energy experiments. It is a set of data acquisition, sensors, electrical loads and even output devices can be used across all of the experimental subsets of the Green Energy Resources. It offers for each Green Energy experiment or project the following devices:

S5 GE Green Energy Basic kit	Pcs
1 ARDicon controller - DAQ	1
2 RJ11 adapter universal	4
3 Capacity Sensor	1
4 Sound Buzzer	1
5 Voltmeter Dual	2
6 Ammeter Dual	2
7 Load set with:	
> 0-100 Ohm variable resistive load	1
> Fan Motor 1,5 Watt	1
> Dual LED	1
> RLC circuit	1
> Car Chassis 150mW - Optional	1

**S5 GE** kit turns each of the Renewable Energy sets to real scientific setups by providing:

- digital measurements and calculations
- digital input and output control
- measurements in a grid of renewable energy sources
- graphic results
- data tables ,analysis and statistics.

The lab-works do not just exhaust the indicative results but explore all possible parameters and relate very closely to the real engineering principles of the Renewable Energy technology, the physical laws in the energy transformations and their applications.

### S5 GE kit for all Renewable energy sets offers:

- Power measurements in real time on Input and output, under load.
- OVC and Power measurements under various loads.
- Temperature required measurements during experimentation.
- Power measurement to a grid of interconnection of renewable resources of energy: solar and wind power input to Hydrogen and Ethanol cells as loads (charging).

### S5 GE in the kit S5-WD for Wind energy also offers:

- Variable speed for wind by control of the wind drive.
- Measurement of RPM versus Power output.
- Correlation measurements to real Wind turbines.

### S5 GE in the kit S5-SL for Solar energy also offers:

- Automatic location of the maximum sunlight intensity angle and automatic turning of the solar panel.
- Light intensity level at any instant of power measurement.
- Measurement of temperature of solar panel.
- Power of serial and parallel configurations of panels, input and output.



**S5 GE** kit with the **S5-EM** for **Mechanical energy** and **S5-TE** for **Thermal energy add-on devices** covers these 2 areas of energy transformation at an insignificant additional cost, offering the same data-logging and control capabilities as in the other Renewable Energy areas of lab experimentation and applications.

## S5 SL - Solar Energy

The Solar Energy training tasks using the SMART:Blox **S5-SL** set allow the students the correlation of school physics with practical usage of the **photovoltaic cells** and **photovoltaic energy**, combined with the other green energy forms as hydrogen fuel cells, make quantitative recording and analysis of the characteristics and performance of solar cells with the use of the components of the S5 GE kit.

The S5 SL Green Energy subset with the basic set S5 GE offers unique data recording features of power transformation that non-simple kits are capable to offer. The students **control** and **record** simultaneously **parameters critical** to the Photovoltaic Power efficiency measurements as:

- **Angle of inclination** of the panel which is driven to the desired angle by a **small servo motor** via the SB S5 controller.
- **Temperature** of the photovoltaic panel.
- **Light intensity** as a variable of performance.
- Power Grid measurements to and from multiple energy sources.

### S5 SL Didactic topics

#### Photovoltaic Theory

- ◆ Electromagnetism laws - radiation.
- ◆ Power output performance of the solar cell, based on:
  - surface area
  - light intensity, angle of incidence of solar rays
  - angle of incidence of solar radiation
  - panel surface temperature
- ◆ Solar panel power output (VI) in:
  1. serial connection
  2. parallel connection
- ◆ Characteristics of performance.
- ◆ Power output - VI of photovoltaic panels.

#### Experimental work

- ✓ Transformation of Solar energy.
- ✓ Relation of Solar energy to the surface area of the solar cells.
- ✓ Relation of solar energy to the load.
- ✓ Relation of solar energy to shading.
- ✓ Relation of solar energy to the tilt angle.
- ✓ Relation of solar energy to light intensity.
- ✓ Parallel Connection.
- ✓ Serial connection.
- ✓ Power based on the area of the solar cell.
- ✓ Power based the angle of incidence.
- ✓ Power based on the level of illumination.
- ✓ Power based on the frequency of light.
- ✓ Efficiency ratio of energy conversion.
- ✓ Internal resistance of solar cells.
- ✓ Dark characteristic curve of solar cell.
- ✓ IV characteristic of solar panels under loads.
- ✓ Open circuit voltage of solar panel.
- ✓ Charging Fuel cells with solar cells.



### S5 SL kit content

A rotating (90 deg) inclined plane with base

A rotational axis with a server motor

Analog Temperature sensor

Analog Angle sensor

LDR sensor

Photovoltaic cell 1,2 Watt panel - 2 Volts, 600mA

Photovoltaic cell 0,6 Watt panel - 2Volts, 300mA

Cables and wires

Cell blocking light covers

Color filters

A light source with halogen lamp - Optional



## S5 WD - Wind - Aeolic Energy

The Wind Energy training tasks using the SMART:Blox **S5-WD** set allow the students the correlation of school physics with practical usage of the **wind turbines**, correlate the wind energy with the other forms as hydrogen fuel cells, make quantitative of the characteristics and performance of wind turbine with the use of the components of the S5 GE kit.

### S5 WD Didactic topics

#### Wind Energy theory

- ◆ Wind to electrical energy transformation principles
- ◆ Effects of the wind energy output based in: wind speeds and directions, number, position and type of wind turbine blades, blade pitch angle and structure of blade.
- ◆ Power characteristics (VI) of wind turbine under no load and under different loads.
- ◆ Green power grid: transformation and storage of electrical energy produced by wind turbine and solar photovoltaic panels into fuel cells. Principles of Energy balance, load balance and sufficiency in a green energy integrated system.

#### Experimental work

- ✓ Analysis of different prototypes of wind generation.
- ✓ Characteristics of wind generator.
- ✓ Powering LED lights with a wind turbine.
- ✓ Relationship of Open Circuit Voltage and RPM.
- ✓ Internal Resistance of the Generator.
- ✓ Electric Power of the wind turbine. VI characteristics.
- ✓ Characteristic curves of wind turbine.
- ✓ **Experimenting with blades of different curvature\***.
- ✓ **Experimenting with blade angle or pitch\***.
- ✓ Wind turbine efficiency.
- ✓ **Wind Direction - Wind Generator Performance\***.
- ✓ Dependence of the wind power plant on wind speed.
- ✓ Variation of the generated voltage produced by changing the blades on wind turbine. Blade angle and shape performance. Blade angle and pitch.
- ✓ Efficiency of wind turbine system.
- ✓ Energy conservation calculations.
- ✓ Measuring RPM.

\* These experiments need a small 3-speed air fan.

#### In conjunction with the S5 FC Fuel cell kit:

- ✓ Production of Hydrogen with Wind Turbine.
- ✓ Wind to hydrogen fuel circle.
- ✓ Wind to Ethanol.



### S5 WD kit content

Assembly of Wind generator

3 sets of different type of blades (3x14cm blades per set - total 9 pcs)

Wind-pitch angle assembly

Axial of wind generator

Base of wind generator

Anemometer

Wind driver base with motor driver

Motor-wind generator coupler

Motor wind speed dialer

RPM sensor

Power pack 12V, 1A

Allen keys (2pcs)

An auxiliary fan - Optional

The wind generator is easily assembled and disassembled for the experiments. It is a generator that can reach up to 23V OVC. The wind drive makes the most out of the generator. An auxiliary fan is available also for certain experiments as listed above. This is a 220V, 35W, air fan with tilting base and small size base.



### Wind driver

To rotate the turbine as assembly, a 3-speed domestic fan is needed. Most kits offer small wind generators and need small fans to rotate but then measurements become just very indicative. For classroom use, the S5 WD set provides an assembly of a wind driver. With this assembly, students can install the wind turbine on the wind driver base and couple it with the variable speed motor in order to vary the rotating speed of the wind and take measurements. The wind driver simulates various wind speed values so students need no wind in the classroom.

## S5 FC - Fuel Cells Energy

The Fuel cell training tasks using the SMART:Blox **S5 FC** set allow the students the correlation of school physics with practical usage of the Fuel cells. The set includes 2 subsets to conduct experiments: the **S5 FH<sub>2</sub>** Hydrogen Fuel cell kit and the **S5 FBE** Bio-Fuel (Ethanol) cell kit.

### Hydrogen Fuel cell kit

Fuel cells that convert hydrogen to electricity. Using solar and/or wind generator and/or the battery, perform Electrolysis and charge with Hydrogen a PEM fuel cell study, the characteristics of the Electrolyzer and the PEM Hydrogen fuel cell and its charging performance with the use of the components of the S5 GE kit.

### S5 FH<sub>2</sub> Didactic topics

#### Hydrogen Fuel Cell

- ◆ Fuel cell structure and specifications
- ◆ Operational principles of a fuel cell, electrolysis - charging a fuel cell, storing hydrogen in a cell
- ◆ Hydrogen/oxygen and hydrogen/air cell
- ◆ Electrolyzer: performance and efficiency
- ◆ Fuel cell: performance characteristics and efficiency

#### Experiments

- ✓ Quantitative analysis of Electrolysis products
- ✓ Minimum Voltage for Water Decomposition
- ✓ Fuel Cell Characteristic Curve
- ✓ Faraday's 1<sup>st</sup> Law Of Electrolysis
- ✓ Faraday Efficiency and Energy Efficiency
- ✓ Faraday and energy efficiency of the fuel cell
- ✓ Model hydrogen car
- ✓ Operating principle of Methanol Cell
- ✓ Functional principles and characteristics of a fuel cell and of an electrolyzer
- ✓ Solar to hydrogen circuit
- ✓ Solar and Wind power charging of Fuel cell circuit



### S5 FH<sub>2</sub> kit content

- S5-FH<sub>2</sub> Fuel cell Electrolyzer, H<sub>2</sub> and O<sub>2</sub> base
- PEM H<sub>2</sub> Fuel cell
- Electrolyzer
- O<sub>2</sub> tank
- H<sub>2</sub> tank
- Gas containers
- Rubber tubes, tube adaptors and purge valve

### Bio-Fuel cell kit - Ethanol

Fuel cells that convert Bio fuel to electricity. Using ethanol and distilled water we can produce electricity with the use of the Ethanol DEFC cell (as also from wine, beer) and with the S5 GE kit students can analyze the characteristics and the performance of this energy transformation.

### S5 FBE Didactic topics

#### Biofuel - Ethanol Fuel cell

- ✓ Fuel cell structure and specifications
- ✓ Operational principles of Bio-fuel cell
- ✓ Create electricity from ethanol and water
- ✓ Exploring polarity
- ✓ Ethanol fuel consumption
- ✓ Exploring the effect of varying fuel concentrations
- ✓ Create electricity from wine and beer
- ✓ Exploring the effects of temperature in the performance of the source

### S5 FBE kit content

- S5-F BF DEFC Fuel cell
- Rubber tubing, valve and clamp
- Biofuel storage container
- pH test paper box
- Syringe
- Plastic container tube with cap
- Plastic funnel

## S5 EM - Mechanical to electrical energy

The transformation of motion or mechanical power to electrical power is well known to everyone. Basically, we can say that **wind power is a mechanical energy transformation**. Hydropower is also a mechanical energy transformation. When mechanical forces, natural as air and hydro or steam or any input of mechanical energy, Dynamic or Kinetic, is applied and we get electrical energy as result, we can categorize it in mechanical power transformation. The bicycle dynamo that gives electricity to the bicycle light is a typical example.

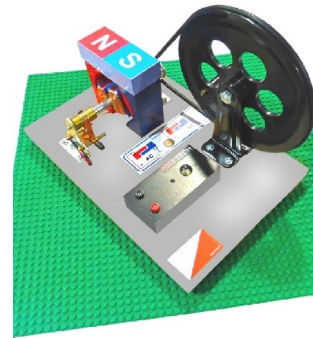
### S5 EM Didactic topics

The hand cranked generator is a low voltage power source that lets you create electrical current by simply turning a crank. This device is producing electrical energy through hands-on student effort.

Experiments include a light bulb, measuring V, I and Power by reviewing principles such as Ohm's Law and Electromagnetism laws, Ac and Dc current, electrical power produced and stored in a rechargeable capacitor/ battery, energy efficiency principles, mechanical energy transformation principles, motors and generators.

It produces approximately 300mA of usable current, which can be stored and reused. It is capable of producing up to 6 volts DC, 3 Volts AC and is also allowed to operate as DC motor, when low voltage electrical power is applied to it. When coupled with the DC motor coupler (optional), it produces a typical motor-generator apparatus and students can expand more their knowledge in such application.

### Mechanical to electrical energy set



#### S5 EM kit content

Hand Cranked generator for AC and DC current

Light bulb

Magnet

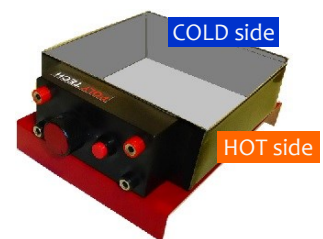
Rechargeable battery cell

Set of cables

Motor driver/coupler - Optional

## S5 TE - Thermoelectric generator TEG

Thermo-electrical energy is the electrical energy produced by heat flux. Is the **transformation of thermal energy to electrical energy**. When 2 sides of a system have a great temperature difference, they produce electrical current using a thermoelectric generator TEG.



### S5 TE Didactic topics

- ◆ Heat flux principles
- ◆ TEG principles
- ◆ The Seebeck generator
- ◆ The Peltier's effect
- ◆ Thermal conductivity of material
- ◆ Efficiency of a TEG
- ◆ Semiconductors
- ◆ PN Junction on semiconductors
- ◆ Cooling systems

### S5 TE kit content

A series of TEG Cells

Cold and Hot module

Electrical control circuit

Terminal box

Rechargeable Battery cell