مسابقة الإمارات للتكنولوجيا والابتكار
EMIRATES TECHNOLOGY & INNOVATION COMPETITION

Renewable Energy Category
Briefing Document

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Introduction to Renewable Energy

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Traditional Power Systems Components

Consist of

- Generation (Power Plants)
- Transformers
- Transmission Lines
- Distribution Networks
- Loads/consumers

Conventional Power Plants

Thermal Power Plants

The oldest type of plants

Water is heated by burning fossil fuel such as natural gas, petroleum or coal.

Steam produced from heated water drives a steam turbine to generate electricity.

Source for air pollution.

Acts as the base power.

Dispatchable.

Mohave Thermal Generating Station, USA
Author: Kjkolb
Source:
https://en.wikipedia.org/wiki/Thermal_power_station#/media/File:Mohave_Generating_Station_1.jpg
https://creativecommons.org/licenses/by/2.5/

Conventional Power Plants

Nuclear Power Plants

A clean source of energy

It is a thermal power station but the heat is generated from nuclear reactors.

Steam produced from heated water drives a steam turbine to generate electricity.

Acts as the base power.

Dispatchable.

Grafenrheinfeld Nuclear Power Plant, Germany.
Author: Avda
Source:
https://en.wikipedia.org/wiki/Nuclear_power_plant#/media/File:Kernkraftwerk_Grafenrheinfeld_-_2013.jpg
https://creativecommons.org/licenses/by-sa/3.0/

Conventional Power Plants

Hydro Power Plants

A renewable source of energy

Use a dam to store water in a large reservoir. Water is released as needed passing through ducts and flows through hydroelectric turbines.

Turbines are then driven by the flow of water and generate electricity.

Non-emitting source

Sites limited by rivers location.

Acts as the base power.

Dispatchable.

The Three Gorges Dam, China
Author: Le Grand Portage
Source:
https://en.wikipedia.org/wiki/Hydroelectricity#/media/File:ThreeGorgesDam-China2009.jpg
https://creativecommons.org/licenses/by/2.0/

Wind Power Plants

A renewable source of energy

Converts wind energy into mechanical energy using the air flow through the blades of wind turbines to drive electrical generators and generate electricity.

Non-emitting source

Non-Dispatchable.

Also known as wind farms.

Small-scale or individual units are normally connected to distribution networks.

Wind power stations, China
Author: Chris Lim **Source:**
https://en.wikipedia.org/wiki/Wind_power#/media/File:Wind_power_plants_in_Xinjiang,_China.jpg
https://creativecommons.org/licenses/by-sa/2.0/

Photovoltaic Power Plants

A renewable source of energy

Use photovoltaic modules to convert light into electricity.

Non-emitting source

Non-Dispatchable.

Also known as solar farms, solar ranches, or solar parks.

Small-scale or individual units are normally connected to distribution networks.

Waldpolenz Solar Park, Germany
Author: JUWI Group
Source:
https://en.wikipedia.org/wiki/Photovoltaic_power_station#/media/File:Juwi_PV_Field.jpg https://creativecommons.org/licenses/by-sa/3.0/

Concentrated Solar Power (CSP) Plants

A renewable source of energy

Use mirrors to reflect and concentrate sunlight (solar energy) on a small area that is converted to heat.

Generated heat is used to produce steam that drives steam turbines to generate electricity.

Non-emitting source

Non-Dispatchable.

Capable of generating power after sunset.

Crescent Dunes concentrated solar power plant, USA
Author: Amble
Source:
https://en.wikipedia.org/wiki/Concentrated_solar_power#/media/File:Crescent_Dunes_Solar_December_2014.JPG

Geothermal Power Plants

A renewable source of energy

Use heat extracted from earth (steam) to drive steam turbines to generate electricity.

Almost non-emitting source

Dispatchable.

Could also be used in space heating.

A geothermal power station, Philippines.
Author: Mike Gonzalez
Source: https://en.wikipedia.org/wiki/Geothermal_power#/media/File:Puhagan_geothermal_plant.jpg

Renewable Power Plants

Run-of-the-River Hydro Plants

A renewable source of energy

Similar to large hydro plants but on a smaller scale.

Could use small size reservoirs.

Non-emitting source

Dispatchable/Non-Dispatchable.

Sites limited by rivers location.

Normally connected to distribution networks

Saint Marys Falls – run-of-the-river plant, .
Author: Chris857
Source: https://en.wikipedia.org/wiki/Run-of-the-river_hydroelectricity#/media/File:Edison_Sault_hydroelectric_power_plant.JPG

Tidal Power Plants

A renewable source of energy

Use potential and/or kinetic energy associated with tides to drive marine turbines to generate electricity.

Non-emitting source

Non-Dispatchable.

More predictable than wind and solar (PV) power.

Not widely used.

First grid connected tidal stream generator, Ireland.
Author: Fundy
Source:
https://en.wikipedia.org/wiki/Tidal_power#/media/File:SeaGen_installed.jpg

Renewable Power Plants

Tidal Power Plants

Stream Generator
Source:
http://www.gettyimages.ae/license/126703030

Tidal Barrage
Source:
http://www.gettyimages.ae/license/75489443

Renewable Energy Kit

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Renewable Kit and Components

The main electrical components to be used in the competition are provided in the Horizon Science and Educational Kits as follows;

Renewable Energy Science Educational Kit: this kit includes education models for the horizontal axis wind turbine, Photovoltaic panel, Fuel Cell and electric loads such as fan and lights.

http://www.horizonfuelcellshop.com/europe/product/renewable-energy-science-kit/?added-to-cart=63

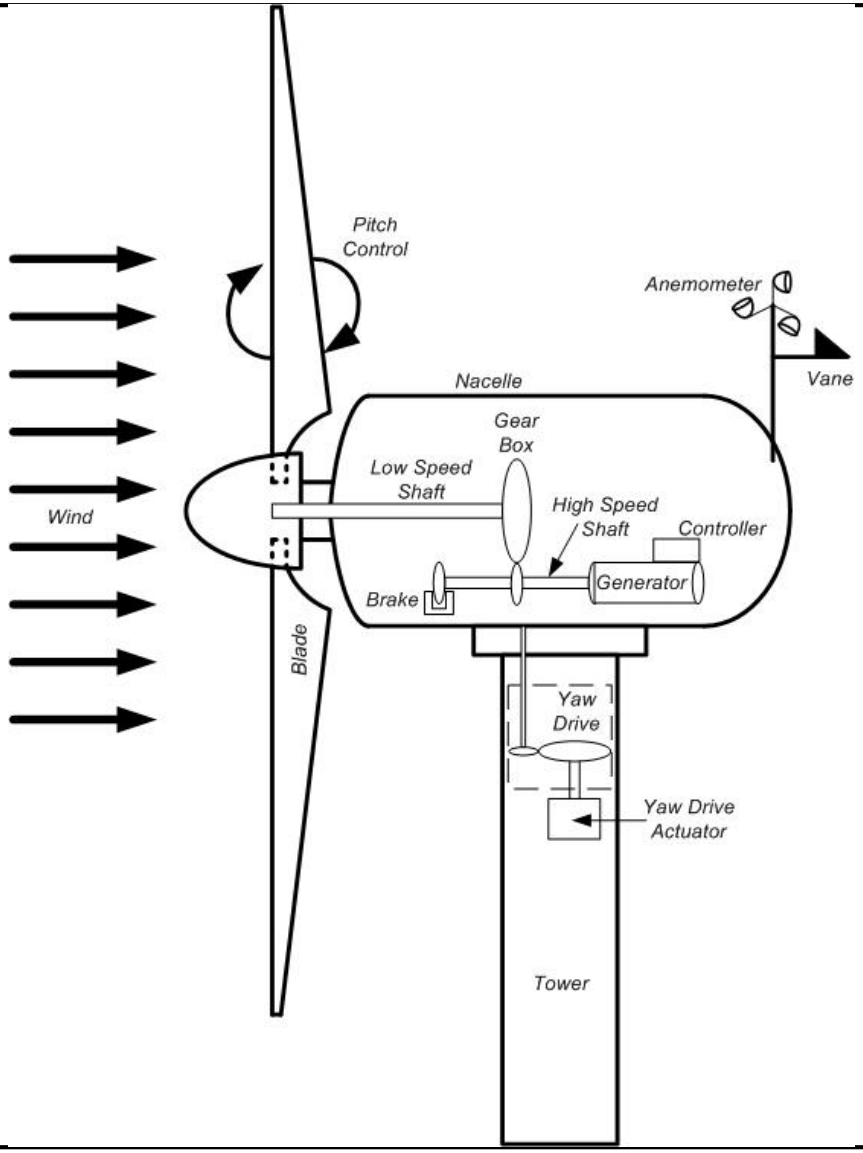
Renewable Energy Monitor: To measure the electrical parameters (voltage, current, and power).

http://www.horizonfuelcellshop.com/europe/product/horizon-energy-monitor/

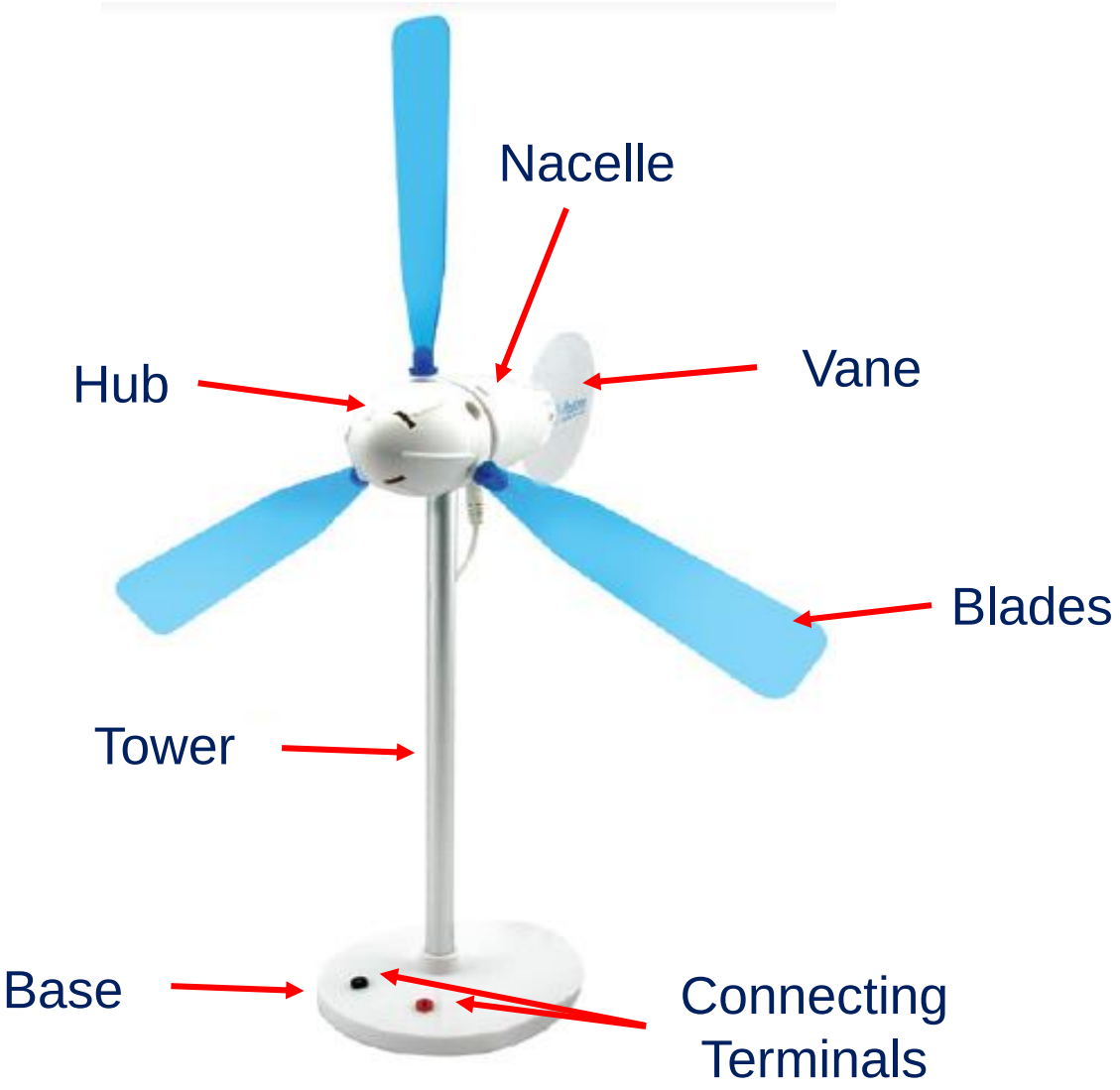
Renewable Kit and Components

Additional components would also be provided, such as various types of electric loads, together with the necessary tools to create and design the desired renewable powered systems.

Horizontal Axis Wind Turbine Main Components



Horizontal Axis Wind Turbine Kit



Horizontal Axis Wind Turbine Kit

Produces a DC voltage across its terminals when driven by incident wind.

- ***Blades:*** Capture Energy from incident winds and convert it to mechanical energy to rotate the turbine shaft.
- ***Hub:*** Connects the blades. Main rotating element of the turbine. Connected to the horizontal rotating shaft.
- ***Nacelle:*** Hosts the Generator (DC generator) and the horizontal rotating shaft.

Horizontal Axis Wind Turbine Kit

- ***Vane:*** Align the turbine to face the incident wind.
- ***Tower:*** Holds the whole structure and carry the connecting conductors/wires from the generator terminals to the base.
- ***Base:*** Include the connecting output terminals.

Horizontal Axis Wind Turbine Kit

Factors affecting generated wind power

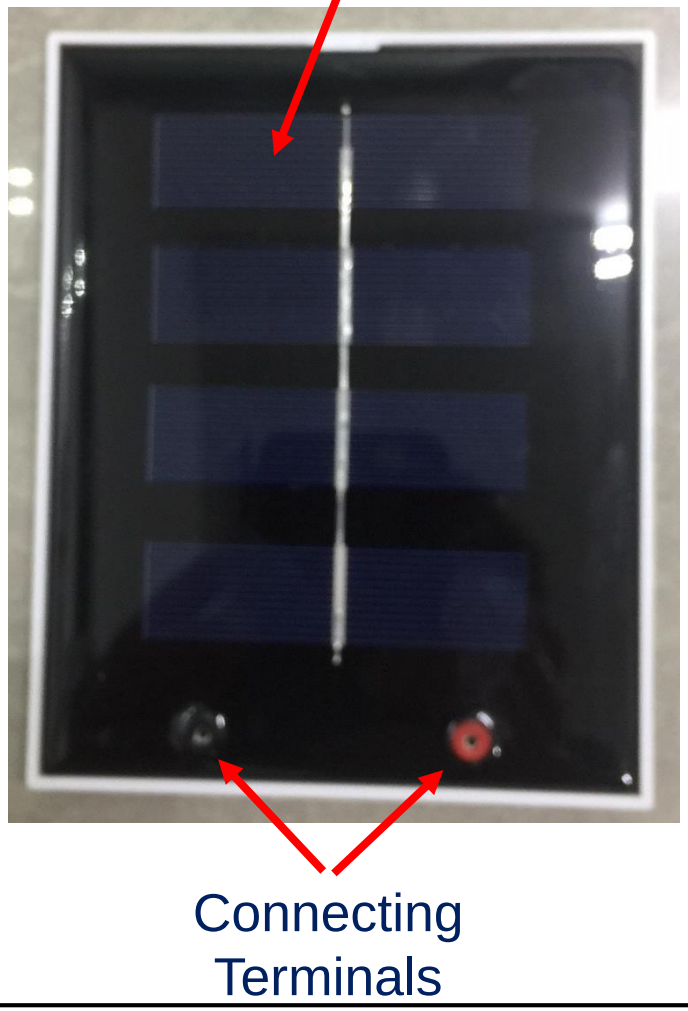
- Wind speed magnitude.
- Wind distribution over the blades
- Pitch control of the blades.

Due to absence of wind sources in the competition room, an external portable fan will be used as wind source.

Note: Assembly is required (follow the manual)

Photovoltaic (PV) Solar Panel

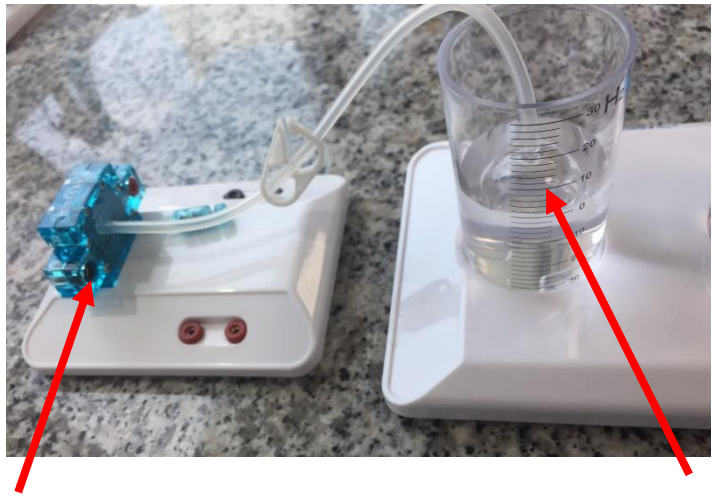
- Produces a DC voltage across its terminals when exposed to sun light.
- Due to absence of sun light in the competition room, an external portable light source will be used.

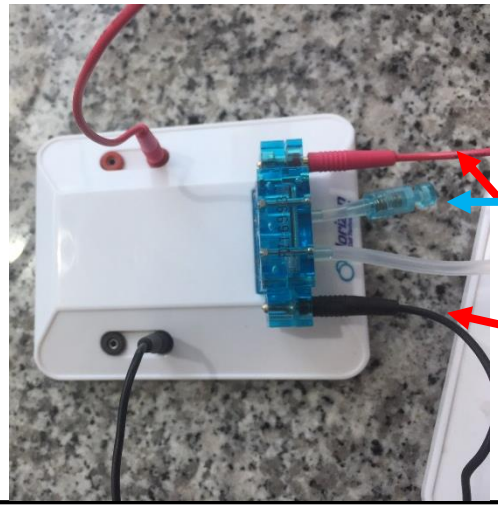


PEM Fuel Cell (FC)

- Produces a DC voltage across its terminals via internal chemical reaction combining Hydrogen (2H2) with Oxygen (O2) to produce water (2H2O) plus flow of electrons (current).
- Hydrogen is the fuel source.

Note: Assembly is required (follow the manual)





Water Electrolysis Unit

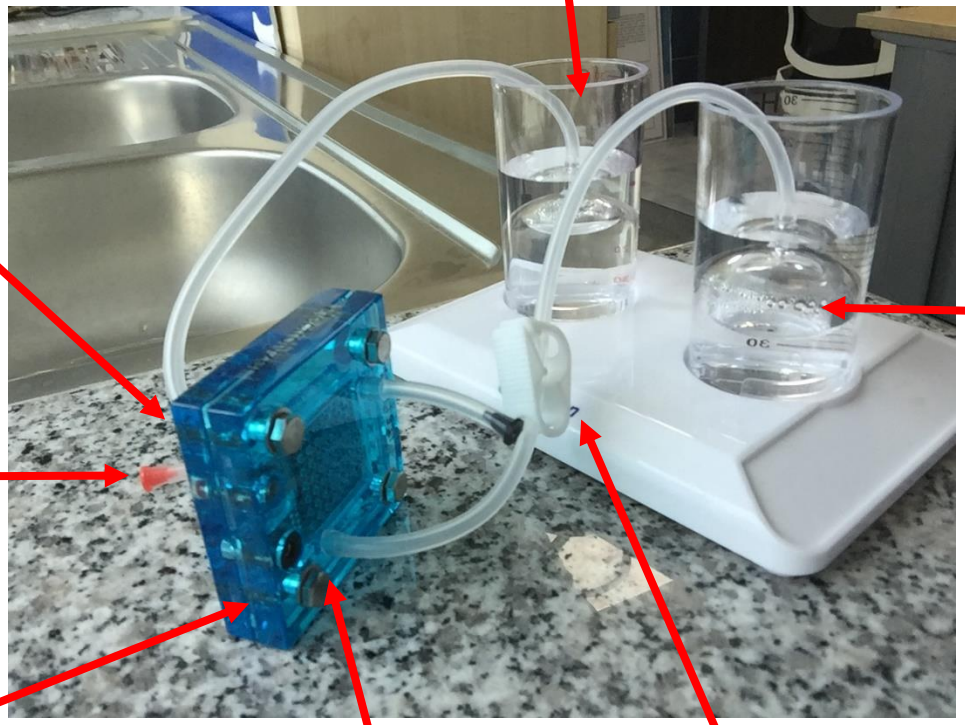
- Hydrogen required for the PEM Fuel Cell is generated via electrolysis of Water.
- Hydrogen is collected and stored in the Hydrogen tank.
- A clip is used to prevent stored Hydrogen from escaping to the surrounding after finishing the electrolysis process and while the tank being moved and connected to the PEM FC.
- The end of the Hydrogen storing process is identified when bubbles are generated in the Hydrogen tank.
- Only distilled water must be used for the electrolysis process.

Water Electrolysis Unit

- The Electrolysis unit and the FC need to be filled with distilled water and left for 3 mins before starting the process.
- Filling Terminals must be blocked during the electrolysis process.

Note: Assembly is required (follow the manual)

Water Electrolysis Unit

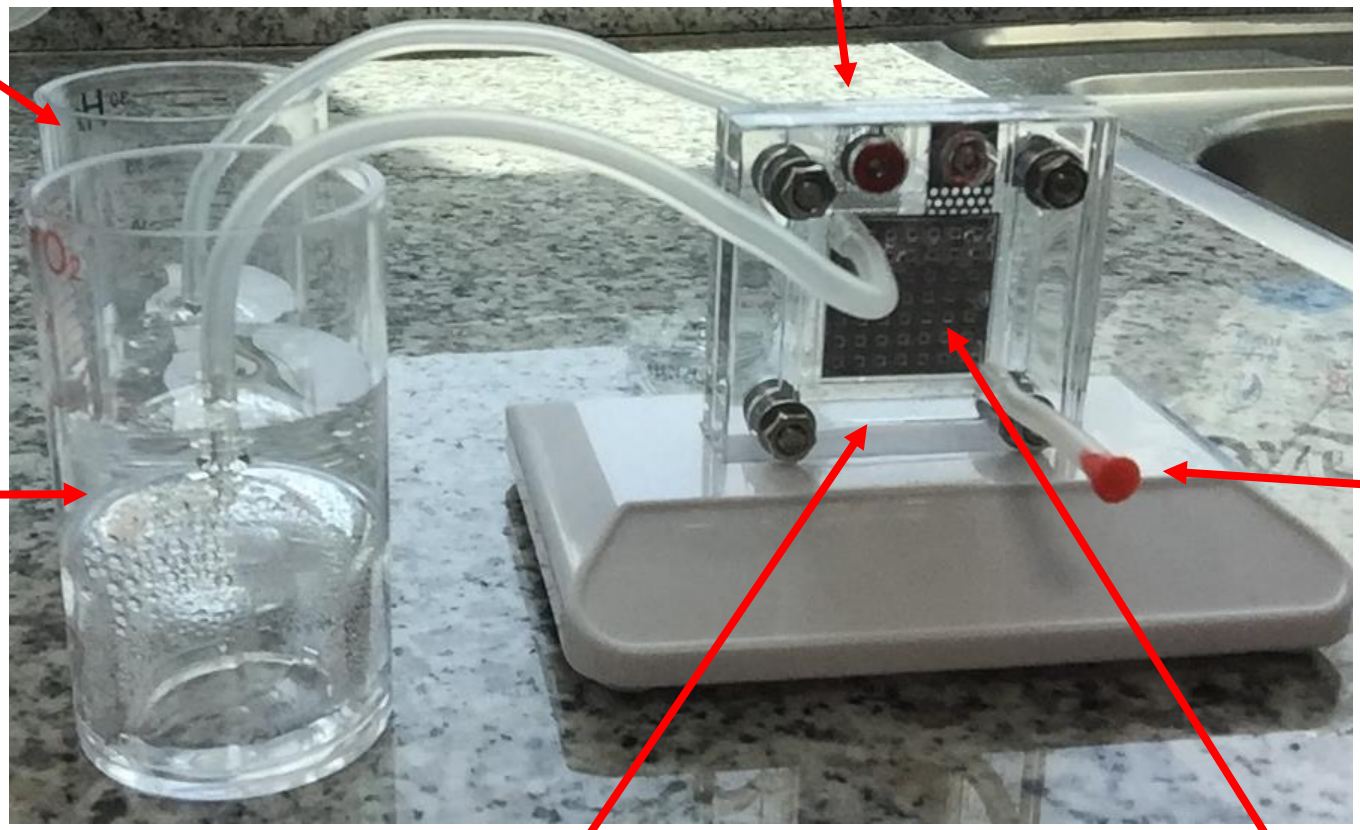


Reversible PEM Fuel Cell

- The Reversible unit can perform both the electrolysis process and the electricity generation using one unit only. There is no need to disconnect and reconnect the Hydrogen tank.
- Hydrogen is collected and stored in the Hydrogen tank.
- The end of the Hydrogen storing process is identified when bubbles are generated in the Hydrogen tank.
- Only distilled Water must be used for the electrolysis process.
- The Reversible FC need to be filled with distilled water and left for 3 mins before starting the process.
- Filling Terminals must be blocked during the electrolysis process

Note: Assembly is required (follow the manual)

Reversible PEM Fuel Cell

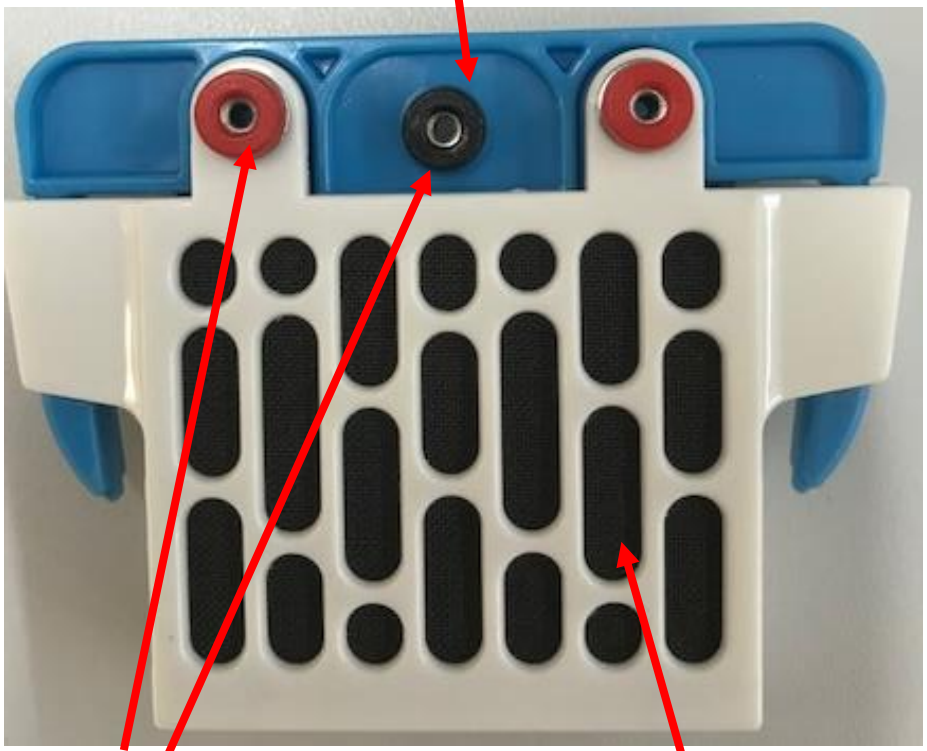


Salt Water Fuel Cell

- The Salt-water Fuel Cell combines a saltwater electrolyte with magnesium plates to generate electrical energy.
- Uses hot/warm salt-water

Magnesium Plate

Magnesium Plate Holder



Terminals

Salt FC

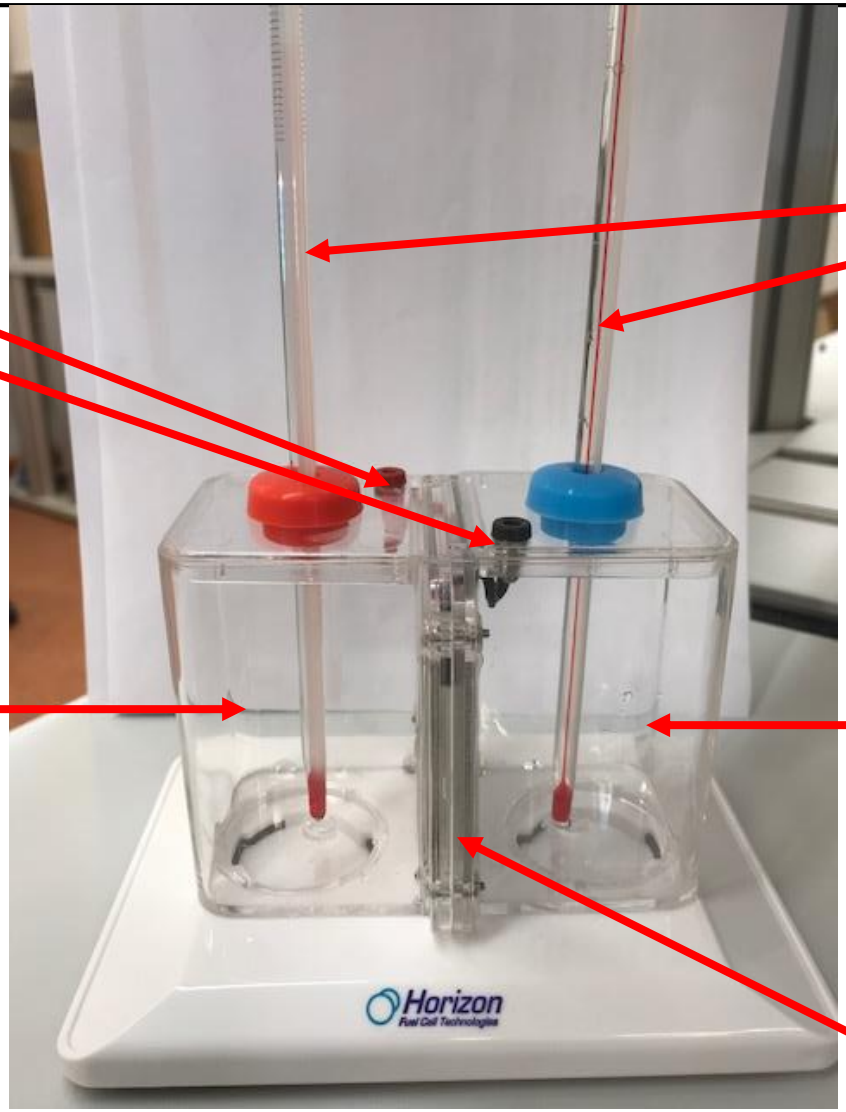
Note: Assembly is required (follow the manual)

Thermal Power Kit

- Generates electricity by combining hot and cold water with a special thermal power conversion cell (heat exchange).
- The output power reduces as the temperature difference between the two containers of water reduces.

Note: Assembly is required (follow the manual)

Thermal Power Kit



Terminals

Thermometers

Hot Water Tank

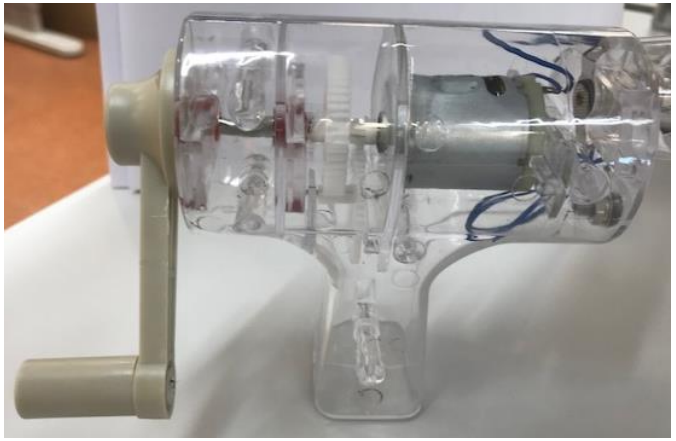
Cold Water Tank

Thermal Cell

Super Capacitor Kit

Supper Capacitor & its Stand

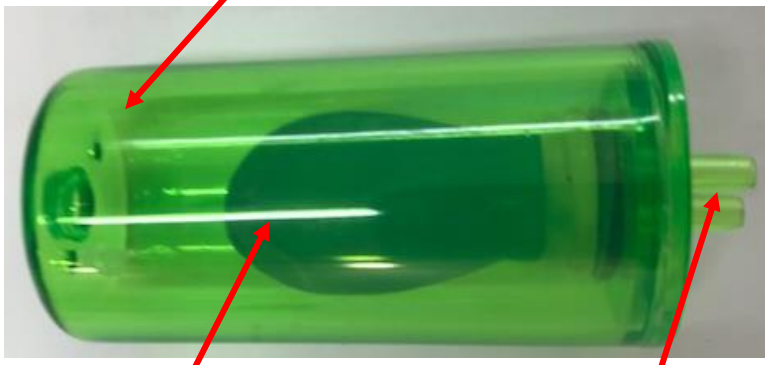
Charge Level Indicator



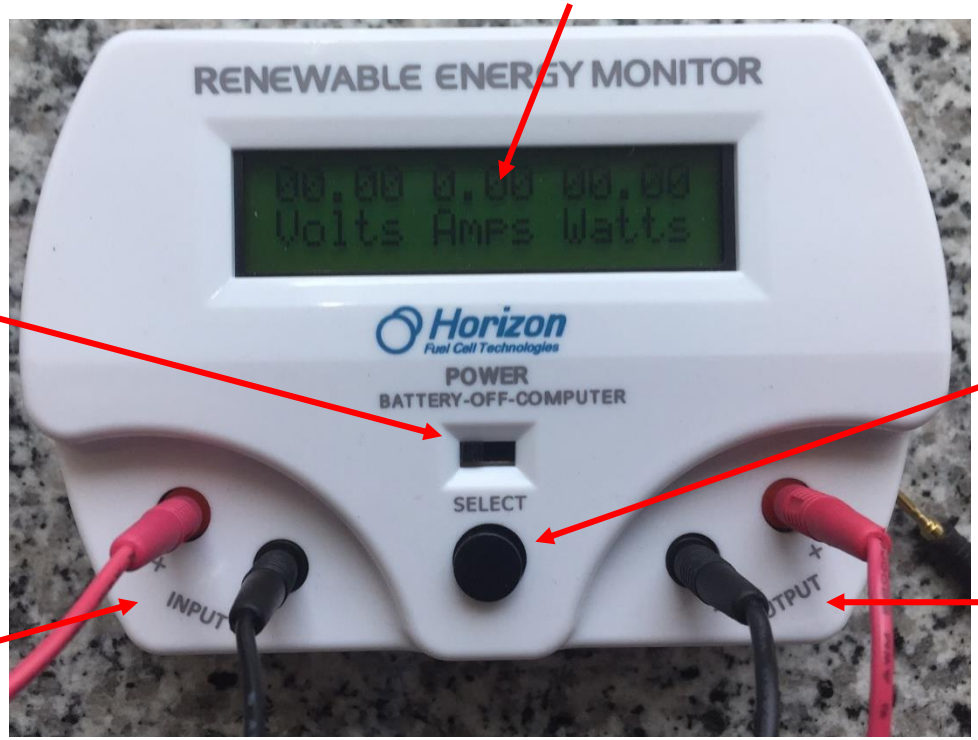
Hand Crank DC Generator

Hydrogen Storage

- Can be used to store limited volume of hydrogen.
- Need to be clipped to prevent stored Hydrogen from escaping to the surroundings .



Renewable Energy Monitor



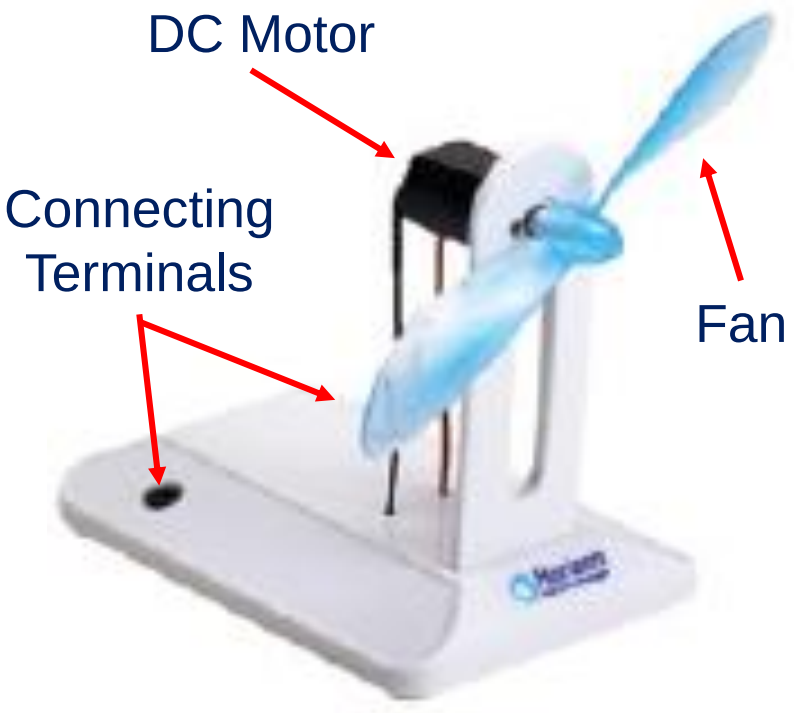
Renewable Energy Monitor

- Measures voltage, current, power, energy resistance and rotational speed.
- Four measuring ranges/selections are available, use the **SELECT** push button to switch between them.
  - Volts, Amps, Watts
  - Volts, Amps, Ohms
  - mV, mA, mW
  - Watts, Joules, RPM

- Input terminal are connected to the sources.
- Output terminals are connected to the load.
- If input terminals are used alone, the monitor will measure the terminal voltage only.

DC Fan

- Converts electrical energy into mechanical energy (fan rotation).
- The fan is driven by a coupled DC motor.

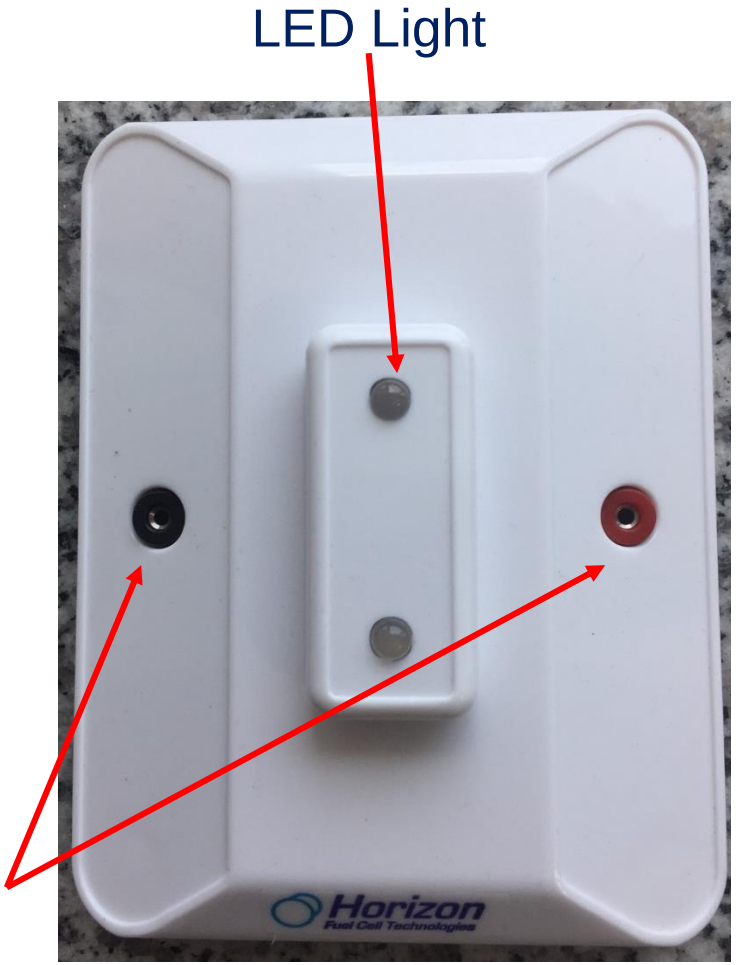


Variable Resistor

- Converts electrical energy into heat dissipated into the resistance (light heat).
- Range: 0 – 100 Ω.

LED Lights

- Converts electrical energy into light.
- Flashing LED lights that can be used as a load to test system connections and flow of electrical power.

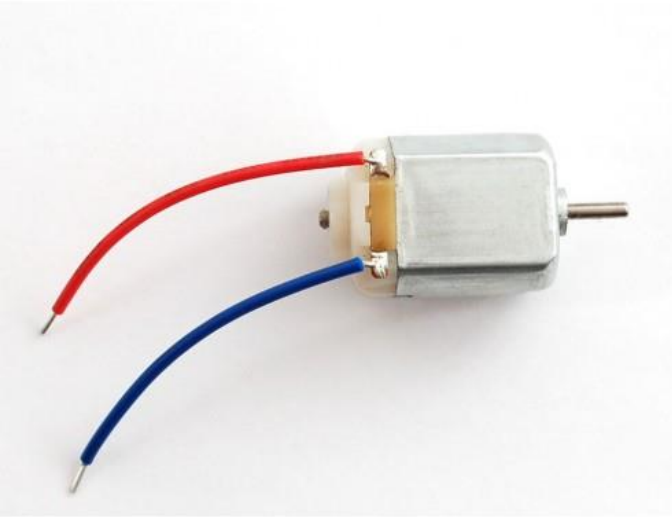


Connection Blocks

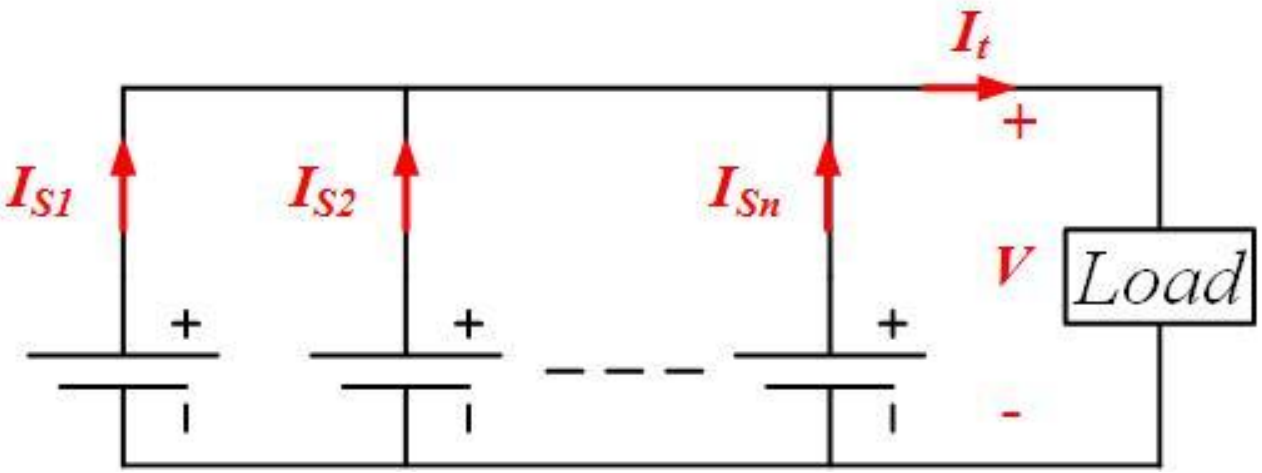
- Provide a common connection for selected elements to be connected in parallel.
- Provide one common +ve terminal and one common –ve terminal for multiple elements.

DC Motor

- Converts electrical energy into mechanical energy (rotation of the motor shaft).
- Could be used to drive mechanical loads such as fans, car models or DC water pumps.
- Reversing the polarity of the applied DC voltage to its terminal will reverse the direction of rotation of the motor.
  - In some applications this is not feasible, such as water pumps.



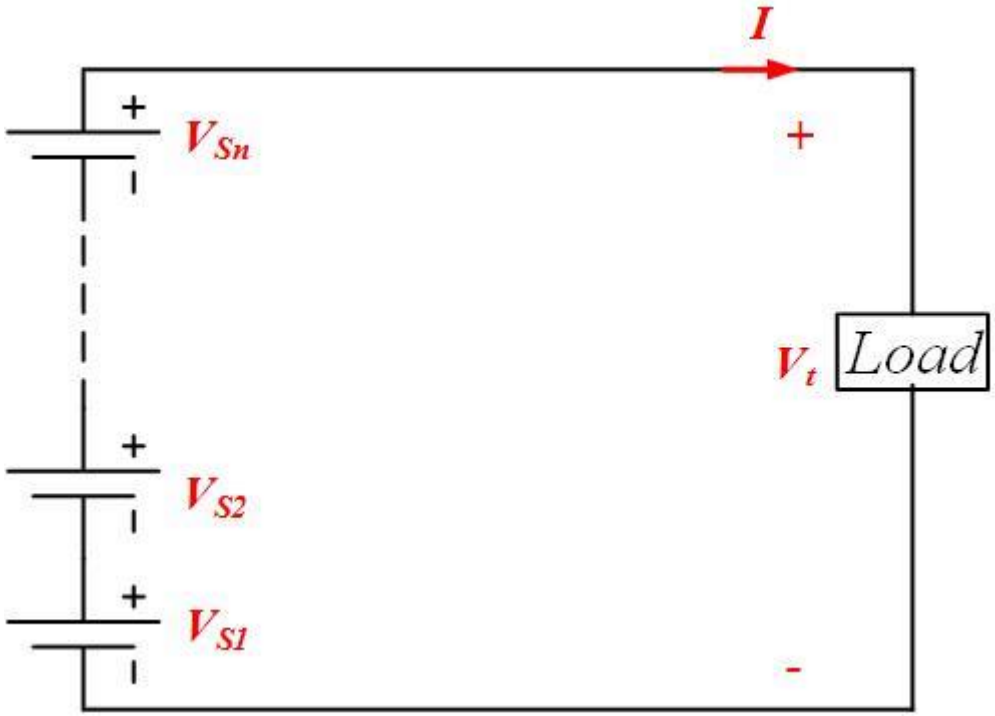
Parallel Connections of Sources



$$I_t = I_{s1} + I_{s2} + \ldots\ldots + I_{sn}$$

V is the same for all sources and the load

Series Connections of Sources



$$V_t = V_{s1} + V_{s2} + \ldots\ldots + V_{sn}$$

I is the same for all sources and the load

General Recommendations

- Be aware of the moving parts, fans' blades, wind turbine's blades and keep safe distance.
- Follow color code while connecting the wires, i.e. use red wires for +ve terminal connections and black wires for –ve connections.

Use to connect external motors

Terminal Clamp

Use to connect kit's elements

General Remarks

- Not all presented kits/components in this briefing or associated documents will be used during the competition.
- **ONLY** components and equipment needed for fulfilling tasks and competitions will be provided by the organizers.
- The participants will **ONLY** use the components supplied by the competition organizers. No outside components are allowed

References

- Horizon Fuel Cell Shop http://www.horizonfuelcellshop.com/europe/product/renewable-energy-science-kit/?added-to-cart=63
- Godfrey Boyle, *Renewable Energy: Power For A Sustainable Future*, 3rd edition, OXFORD, 2012, ISBN: 978- 01-19-954533-9.
- Tarek. H.M. El-Fouly, *Wind Power Production: Control and Prediction*, PhD Dissertation, University OF Waterloo, Canada, 2007.

Thank You !