GBMG

Solar energy capture, measurements, and storage

Grade 9-12

One of the environmental challenges for Canada, and indeed for the rest of the world, is the excessive consumption of fossil fuels that has resulted in global issues such as air pollution, changes in precipitation patterns, and increases in atmospheric temperatures. It is now generally accepted that the consumption of fossil fuels to generate energy must be replaced using renewable energy technologies like solar and wind generation. To achieve this replacement, there is an urgent need to educate the public in these fields and to create a renewable energy culture in our society. Students must become aware of the negative consequences of using fossil-fuel-based technologies. To this objective, GREENBMG dual-axis solar tracker aims to educate students about renewable energies like solar.
Outcome: First, students will more likely re-orientate their activities towards the use of renewable energies as they become adults and thus consume less fossil fuel. Second, they may transfer this knowledge to their families and encourage them to reduce fossil fuel consumption and switch to more renewable energy technologies.

GREENBMG Automatic Dual-Axis Solar Tracker provides practical and hands-on experience in the field of solar energy and its use can transform students' theoretical knowledge into practical and applied experience. With the help of this simple apparatus, by performing simple experiments, they will engage more closely with, and achieve a deeper understanding of, the use of renewables. It allows students to participate directly in solar experiments and thereby develop a better understanding of solar energy fundamentals. For example, through interaction with this apparatus, students will gain an understanding of changes in solar energy intensity throughout the day and the year.

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The dual-axis tracker, according to figure 1, is composed of a control panel, a chamber that contains the hardware components and supports the mechanical structure, a base, a vertical movement screw jack, and a horizontal rotational top panel. A concave mirror can be installed on the apparatus to focus the sunlight and heat the air, which operates a Stirling engine at the focal point. Alternatively, a PV panel can be installed on the apparatus to generate solar electricity at high efficiency when compared to a panel without sun tracking. The apparatus works in two modes: Remote, and automatic. It tracks the sun, or any light source located outdoors or indoors. The dual-axis tracker can hold panels or dishes up to 80 cm in diameter and 8 kg in weight. It can be used during cold Canadian winter days as an indoor training tool by installing it inside classrooms beside a window.

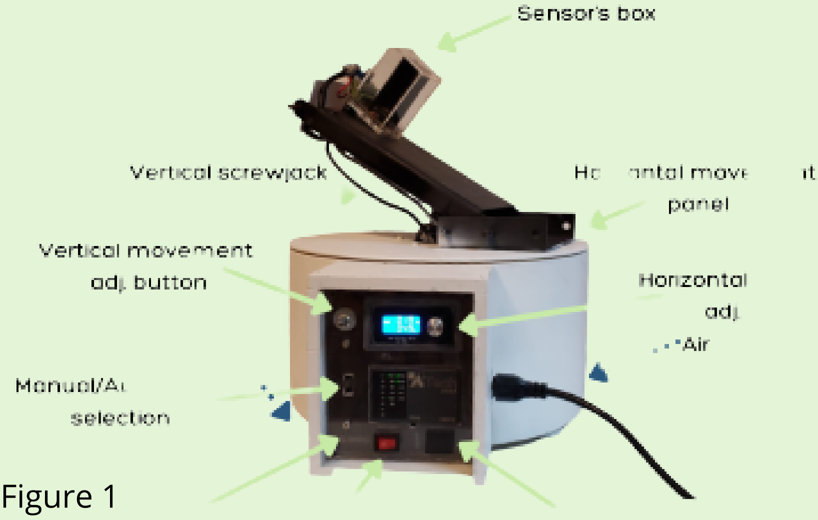

Figure 1

The following experiments are performed by two students of grades 9 to 12 with supervision:

Experiment No. 1: Dual Axis Solar Tracker experiment
Objectives: To learn about fundamentals in solar tracking, the movement of the sun in the sky relative to the time of day, the change of azimuth and elevation angles, and the change of solar intensity with date, time, and location

Experiment No. 2: Solar Stirling Engine experiment
Objectives: To learn about the harvesting of solar thermal energy, the principles of concave mirrors, the Stirling engine, and different forms of energy (thermal, mechanical, and electrical). To learn about the effects of collector surface area on the collector power.

Experiment No. 3: Boiling Water and Heating Copper Slab using Off-Centre Dish
Objectives: Measurement of collector thermal power and efficiency of solar energy collection.

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Experiment No. 4: Off-grid experiment (panel connected with charge controller, battery, and consumer)
Objectives: Measurement and monitoring of electrical energy parameters and the energy loss across various equipment: panel, charge controller, inverter, consumer, generator, flywheel

Calculations:

1. Calculate the energy output from the panel: EP=IPVP
2. Calculate the energy output from the charge controller: ECC=ICCVCC
3. Calculate the energy output from inverter: EIv=IIvVIv
4. Calculate the energy consumed by the consumer: EC=ICVC
5. Calculate the energy loss across the charge controller and inverter.
6. Calculate the energy produced by the generator: Eg=IgVg
7. Calculate the energy produced by the flywheel: Ef=m× r22