Southern University and A&M College
College of Sciences and Engineering
Department of Electrical and Computer Engineering

Green Energy Kit Experimental Report

Faculty Advisor

Dr. Yasser Ismail

Submitted By

Darius Taylor

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Abstract

This report provides a comprehensive overview of the hands-on experiments conducted using the Renewable Energy Education Kit. The kit is designed to teach the principles of renewable energy through practical, modular components that allow users to construct and test solar, wind, and hydrogen fuel cell systems. Over the course of this project, all experiments outlined in the instruction manual were completed. These experiments included solar photovoltaic generation, wind turbine power generation, hydrogen electrolysis, hydrogen fuel cell energy conversion, and hybrid systems that demonstrate combined energy storage and use. The report documents each experiment, the purpose behind each setup, and observations of energy generation and utilization. Finally, a proposed project using the kit components is described, aiming to build a smart renewable load-balancing microgrid. This project simulates real-world scenarios by actively switching between solar, wind, and hydrogen sources to maintain stable power output based on availability, offering a more dynamic and decentralized solution compared to conventional load balancing.

Table of Contents

List of Figures

Introduction

The growing emphasis on sustainable energy has highlighted the need for educational tools that make renewable energy accessible and understandable. The Green Energy Kit serves this educational purpose by offering a collection of components that represent key technologies in the renewable energy sector. The kit includes solar panels, a wind turbine, an electrolyzer, hydrogen storage containers, and a reversible fuel cell. These modules allow learners to explore how sunlight and wind can be converted into electrical energy, how excess energy can be stored via hydrogen gas, and how stored hydrogen can be used to generate electricity on demand. This report outlines the work done with the kit, breaking down each set of experiments by type and function. The emphasis is on understanding how the energy transitions occur and how each module supports the broader goal of clean energy generation and storage. The report also proposes a future project leveraging the kit's components to design a smart renewable load-balancing microgrid system that automatically selects the best energy source based on current availability.

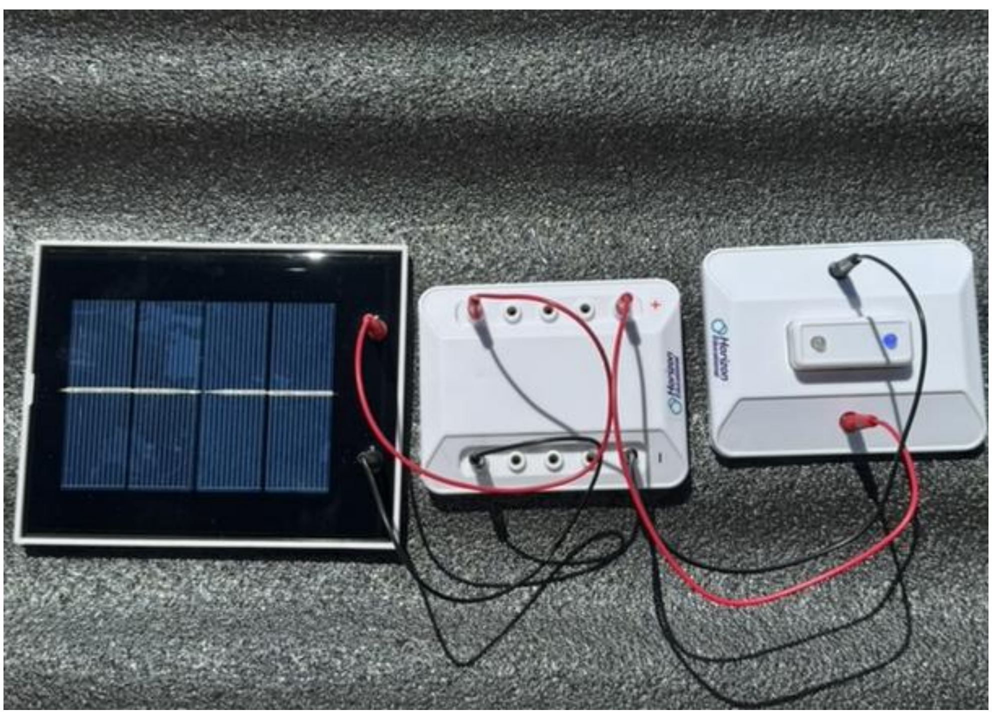
Experiments Overview

The following section details each experiment completed using the Green Energy Kit in sequential order. Each experiment is introduced with its goal, method, and observed outcomes. Figures are provided to support each setup and illustrate the results.

Experiment 1: Powering an LED with a Solar Panel

This experiment served as an essential introduction to photovoltaic electricity and its immediate application. It reinforced how sunlight can be harnessed and applied in real-time, without the need for intermediate storage systems or additional conversion steps. This concept is a critical foundation in renewable energy systems, especially for low-load applications like lighting in solar-powered buildings.

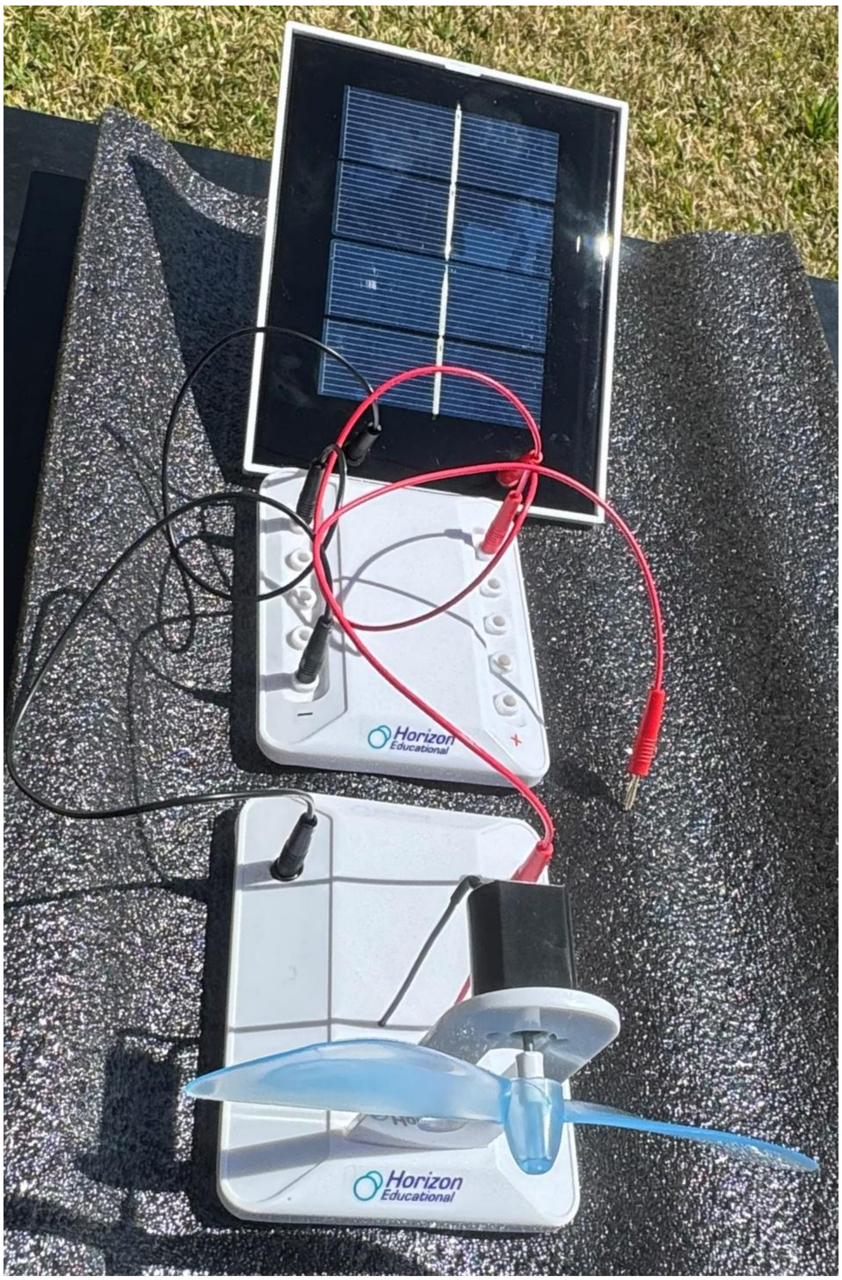
Figure 1: Solar panel powering LED module



Experiment 2: Powering a Fan or Wheel Motor Using Solar Energy

This experiment built on the principles learned in Experiment 1 by demonstrating that solar panels can also power electromechanical devices. The performance variability introduced by inconsistent sunlight highlighted the importance of both energy management and system sizing in real-world renewable installations.

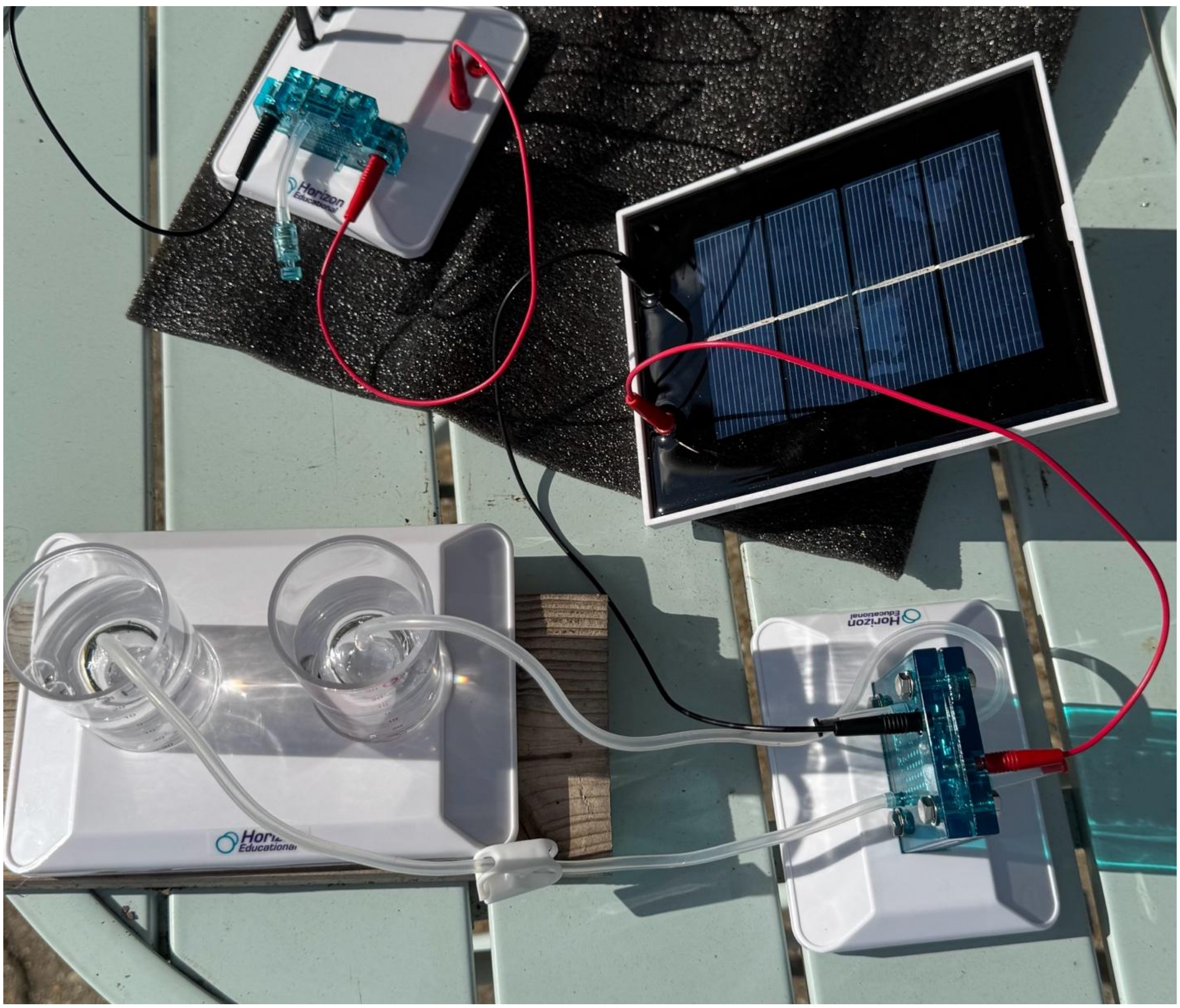
Figure 2: Solar panel powering motorized module



Experiment 3: Preparation of the Electrolyzer Module and Solar-Powered Hydrogen Production

This experiment emphasized the importance of energy storage, converting solar power into hydrogen fuel—a storable and portable energy carrier. The setup served as a critical bridge between renewable energy generation and fuel cell utilization. Observing the actual gas production offered a compelling view of how intermittent energy can be buffered for future use.

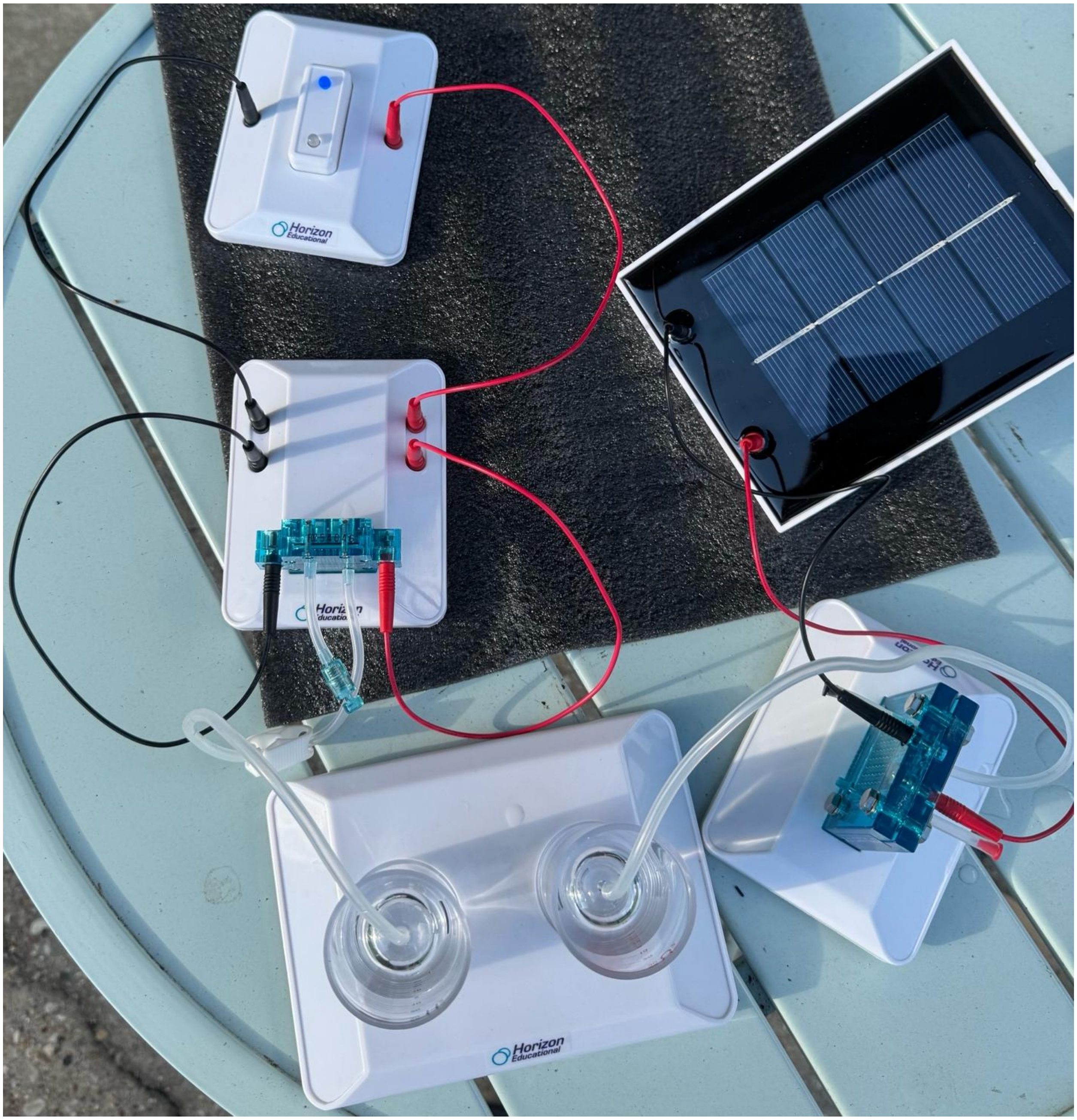
Figure 3: Solar-powered electrolysis setup and gas collection



Experiment 4: Using a PEM Fuel Cell to Power the LED Module

This experiment illustrated the closed-loop nature of hydrogen-based systems, where previously stored hydrogen was now supplying power. The successful operation of the LED signified not just energy conversion but also system reversibility and sustainability.

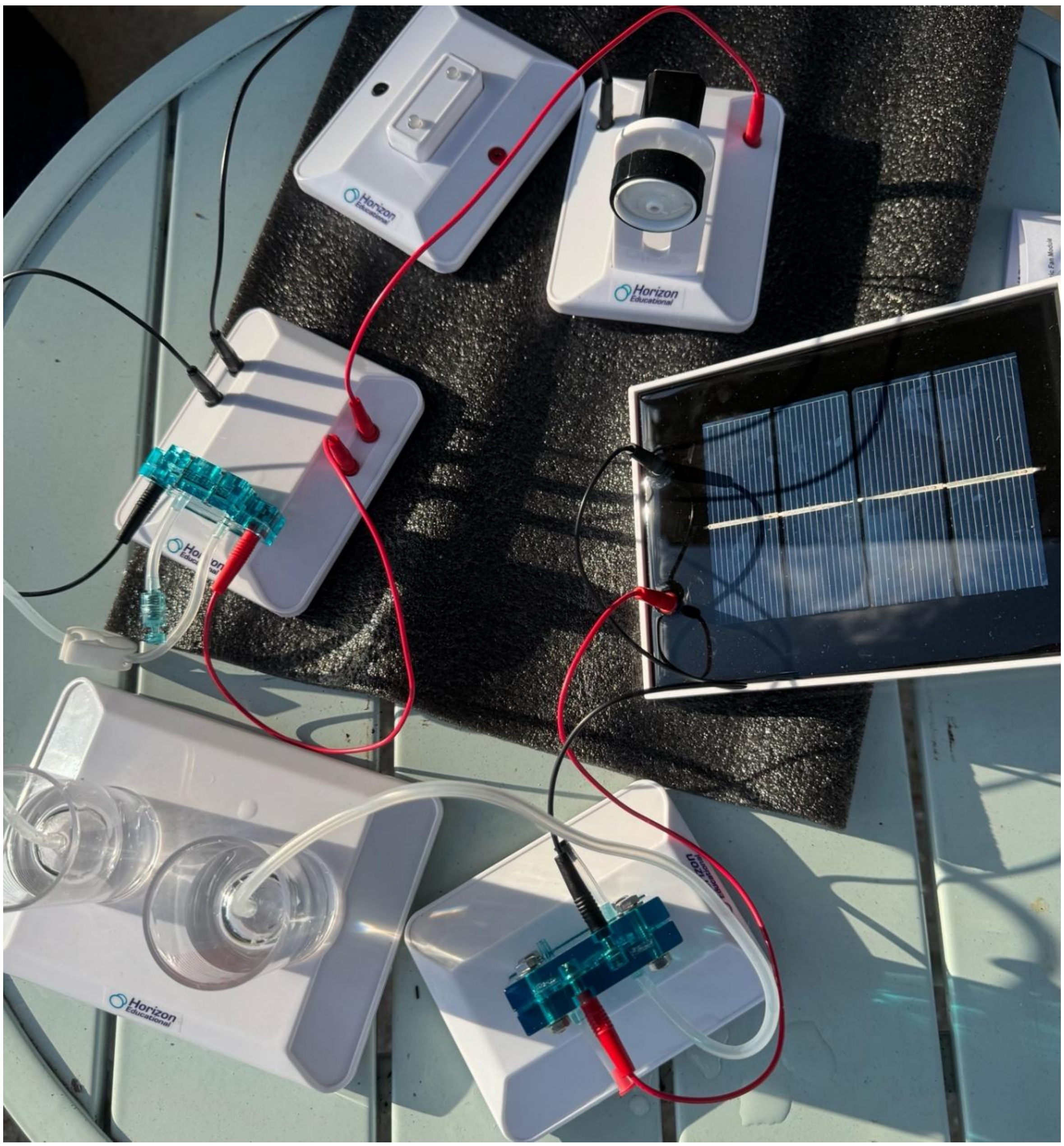
Figure 4: LED powered by hydrogen fuel cell



Experiments 5 & 6: Using a PEM Fuel Cell to Power the Small Electric Fan and Car Wheel Modules

This activity served as an intermediate test of fuel cell output under a slightly higher mechanical load. It reinforced that hydrogen can reliably support motion-based applications, provided the energy requirements are aligned with available fuel volume and cell efficiency.

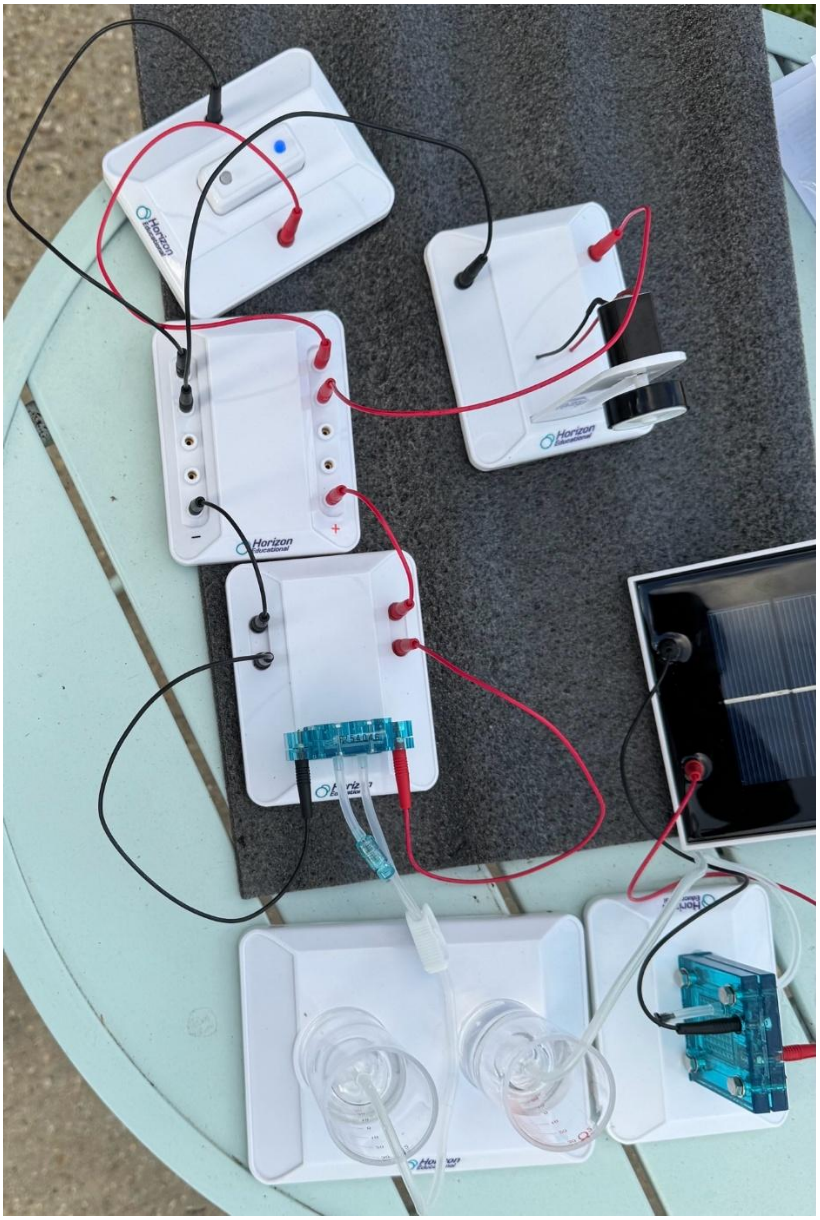
Figure 5: Hydrogen fuel cell powering wheel module



Experiment 7: Using a PEM Fuel Cell to Power the Small Fan/Wheel Motor Module and the LED Module in Parallel

The parallel configuration demonstrated the fuel cell's ability to support multiple loads simultaneously, offering a glimpse into real-life circuit design and power management. The distribution of energy between two endpoints illustrated the importance of circuit planning and load prioritization.

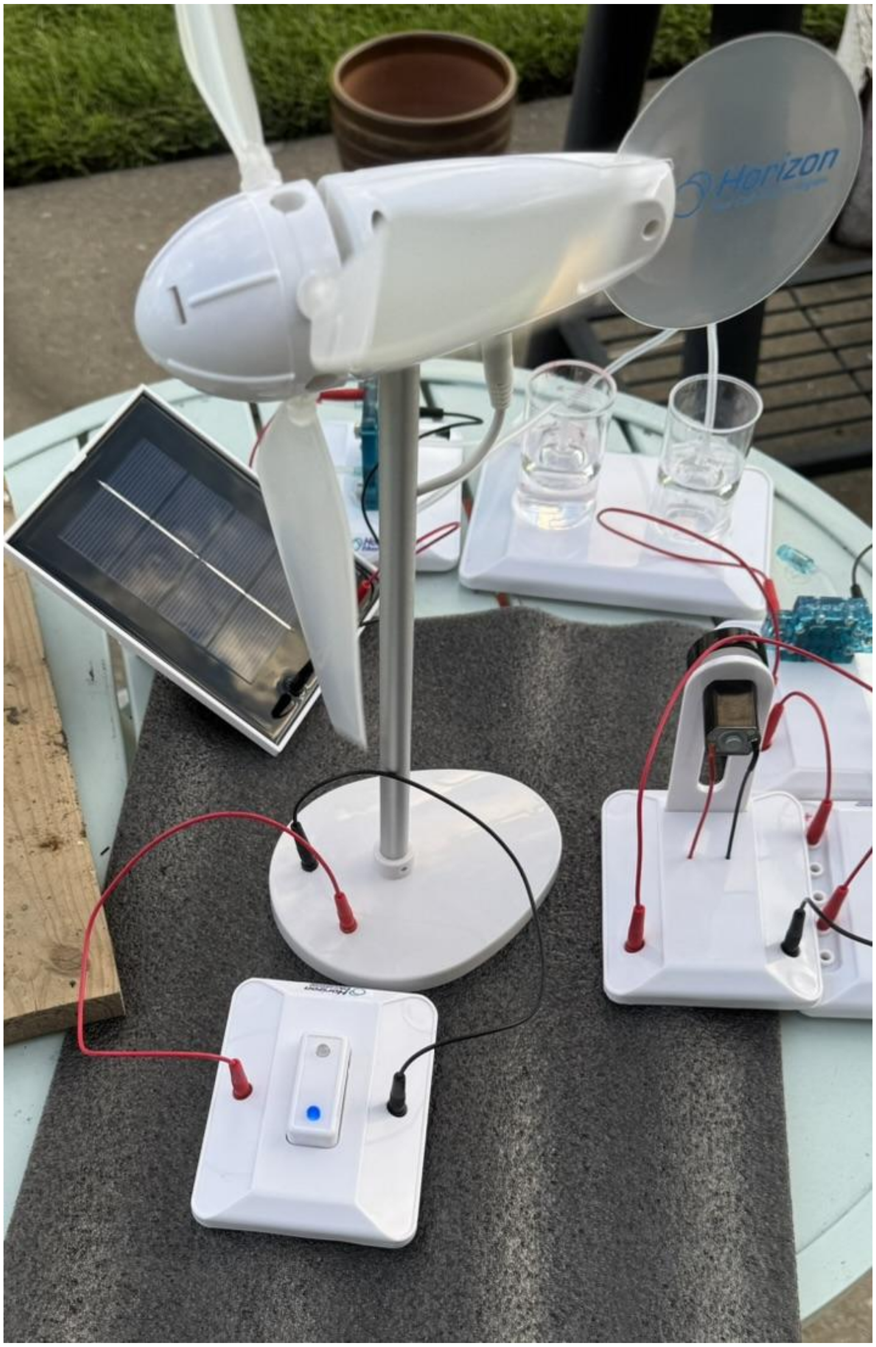
Figure 6: Fuel cell powering fan/wheel and LED in parallel



Experiment 8: Using a Wind Turbine to Power the LED Module

The experiment provided a hands-on example of how wind energy can generate electricity in real time. It emphasized the variability and unpredictability of wind as a power source and showed the importance of wind speed and turbine placement.

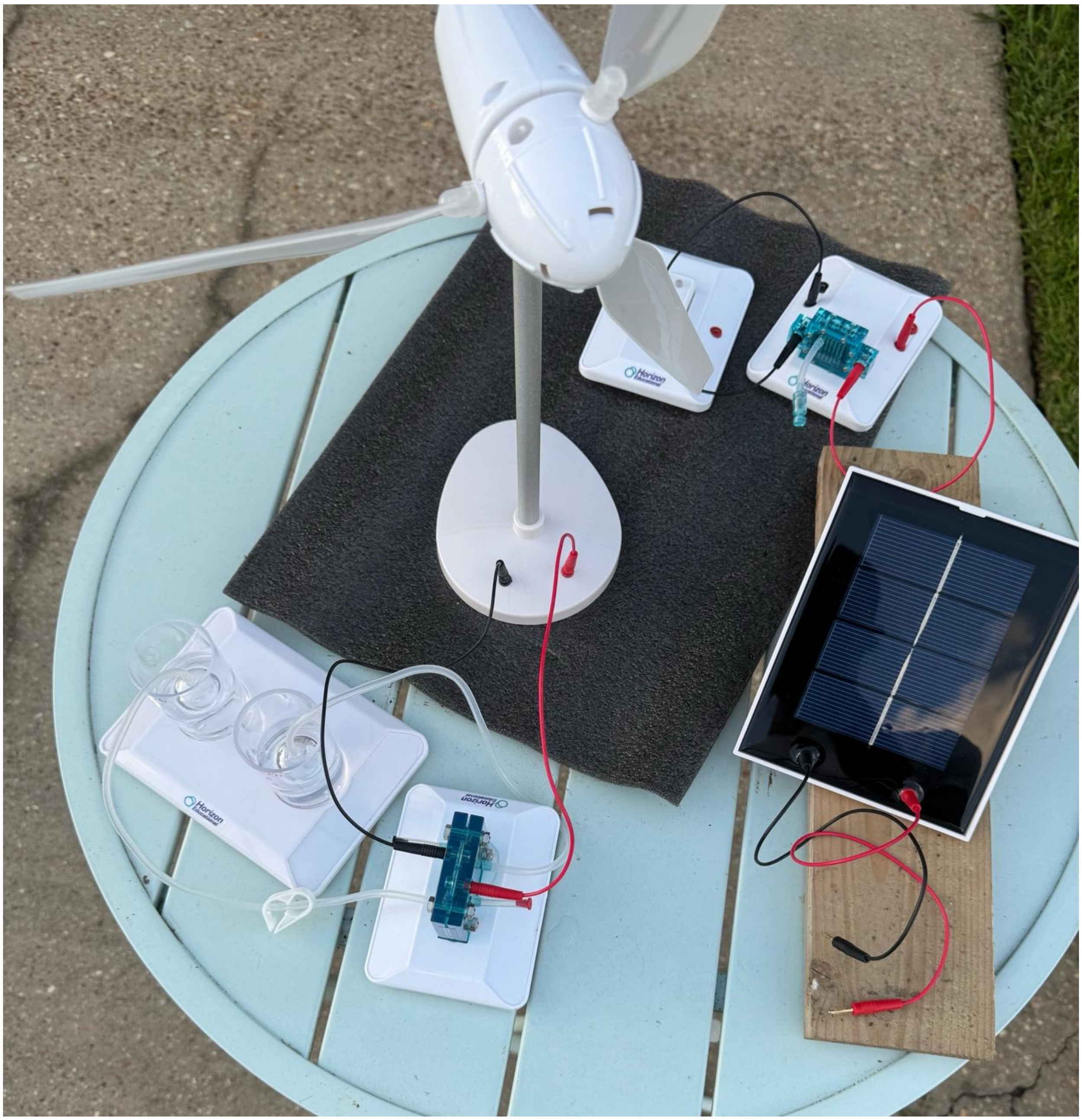
Figure 7: Wind turbine powering LED module



Experiment 9: Preparation of the Electrolyzer Module and Wind-Powered Hydrogen Production

Though slower than solar, this method effectively demonstrated how wind can be used not just for immediate power needs, but also for storing energy in hydrogen form. The flexibility of the electrolyzer to work with different inputs added to the system's educational value.

Figure 8: Wind-powered electrolysis setup and gas storage



Experiment 10: Using the Battery Pack to Perform Electrolysis (Alternate Method)

This final experiment provided an alternative power source for electrolysis using a battery pack. The battery provided stable and continuous voltage to the electrolyzer, allowing for predictable and consistent gas generation. This method was especially useful on days with insufficient sunlight or wind. No photos were taken during this experiment, but it confirmed that battery backup systems can maintain hydrogen production when renewable sources are unavailable.

Proposed Future Project: Smart Renewable Load-Balancing Microgrid

Building on the previous experiments, this proposed project involves designing a smart renewable energy microgrid that can perform load balancing using solar, wind, and hydrogen-based sources. Unlike traditional load-balancing systems that draw from fixed, centralized sources such as fossil fuel-powered grids, this microgrid will dynamically select from multiple renewable inputs based on real-time energy availability and storage conditions. The system will be powered by solar and wind energy when available, and it will use an electrolyzer to convert surplus power into hydrogen for later use in a fuel cell.

A key component of this project is the inclusion of an Arduino or Raspberry Pi controller that can read sensor data—including voltage, current, and hydrogen storage levels—and make decisions about which energy source should be used to power the load. For example, the controller could prioritize solar energy during peak daylight hours and shift to wind power when solar input is insufficient. If both sources drop below a defined threshold, the system would automatically switch to the fuel cell to maintain continuous operation.

This renewable microgrid will be outfitted with current sensors and voltage monitors on each input and load path to log and analyze source usage over time. Metrics such as uptime, source switching frequency, and power contribution percentages will help evaluate the system's efficiency and responsiveness. The final prototype would include a small LCD or Wi-Fi-based dashboard to visualize energy flow and system status in real time.

By integrating intelligent control with multiple renewable sources and hydrogen storage, this project offers a more adaptable and educational alternative to conventional load-balancing models.

Conclusion

The FCJJ-37 kit offers a practical and intuitive way to understand renewable energy systems. Each experiment provided hands-on insight into a specific type of energy conversion or storage. Together, they formed a complete cycle—from sunlight and wind to hydrogen generation, storage, and reuse through fuel cells. The proposed future project builds on these foundations and points toward more integrated and intelligent energy solutions.