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Ecometer: Live Co_2 Footprint and Tree Indicator for Campus

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Abstract: Ecometer an IoT-based system designed to provide insight for people to understand the amount of electricity used in a campus and how it affects the environment. Many students and staff use electricity every day but do not know how much CO_2 is released at power generation side. Measuring energy use in real time, the Ecometer converts this into a clear CO_2 footprint and tree-equivalent value at consumer side .This device features an ESP32 microcontroller and a PZEM-004T sensor to accomplish accurate voltage, current, power, and energy measurements. The ESP32 then calculates the total energy in kWh and multiplies it by a carbon factor of 0.82 kg CO_2 per kWh to show how much CO_2 is produced at the power plant. It makes the environmental impact simple to understand.This system also converts CO_2 into the "Number of Trees Needed" to absorb that amount of carbon. The results appear both on a 16×2 LCD and on a web dashboard hosted by the ESP32. Anyone connected to the Wi-Fi can see the live energy use, CO_2 output, and tree count. This promotes awareness, reduces wastage, and aids campus sustainability.

Keywords: *IoT, ESP32, PZEM004T, CO_2 Footprint, Tree Indicator, Sustainability, Energy Monitoring.*

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I. INTRODUCTION

Electricity is used everywhere in a college campus: in classrooms, labs, hostels, offices, and libraries. But most people have no idea how much electricity they are using, or how much CO_2 was released when that electricity was produced. Because of this, many lights, fans, and devices stay ON when they are not needed, thereby wasting energy and harming the environment.To solve this problem, we created the Ecometer, a simple IoT device that displays the real environmental impact from the use of electricity. The Ecometer measures how much power is in use with the help of a PZEM-004T energy meter and an ESP32 microcontroller. These components read voltage, current, power, and energy in real time.The special feature of the Ecometer is that it immediately converts the energy used into CO_2 footprint. It tells us how much carbon dioxide is released at the power plant when we use electricity. The system uses a standard carbon emission factor of 0.82 kg CO_2/kWh, and thus we can easily and fairly precisely estimate the level of pollution.To make the idea even clearer, the Ecometer also shows the Tree Equivalent Value, which basically means how many trees are needed to absorb the CO_2 produced by the electricity used. This simple comparison helps students and staff easily understand the environmental cost of using electrical appliances.All the results-energy, CO_2, and tree count-get displayed on a 16×2 LCD screen and also on the web dashboard created by the ESP32. Live data can be viewed by anyone connected to the device through Wi-Fi.The main purpose of the Ecometer is to create awareness, reduce electricity wastage, and support a cleaner and greener campus. By showing environmental impact in simple numbers, the Ecometer motivates everyone to use electricity wisely.

II. METHODOLOGY AND WORKING

First, the Ecometer checks how much electricity is being used.Then, the ESP32 reads this information from the PZEM sensor.The value of electricity is then changed to CO_2 and tree numbers.Finally, all the results are shown on the LCD and the web page by the device.

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➢ *Block Diagram*

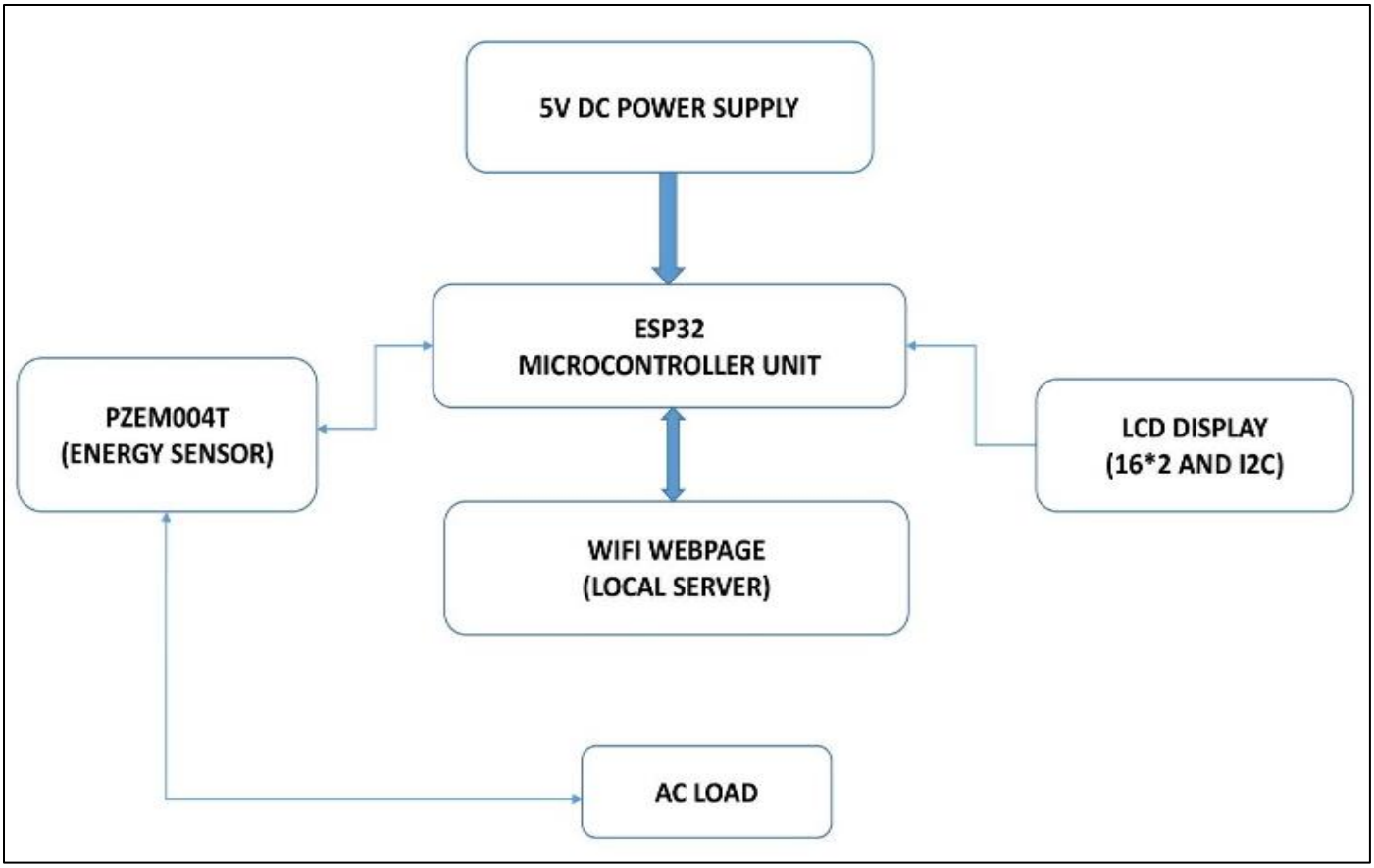

Fig 1 Block Diagram of Ecometer System

➢ *Circuit Diagram*

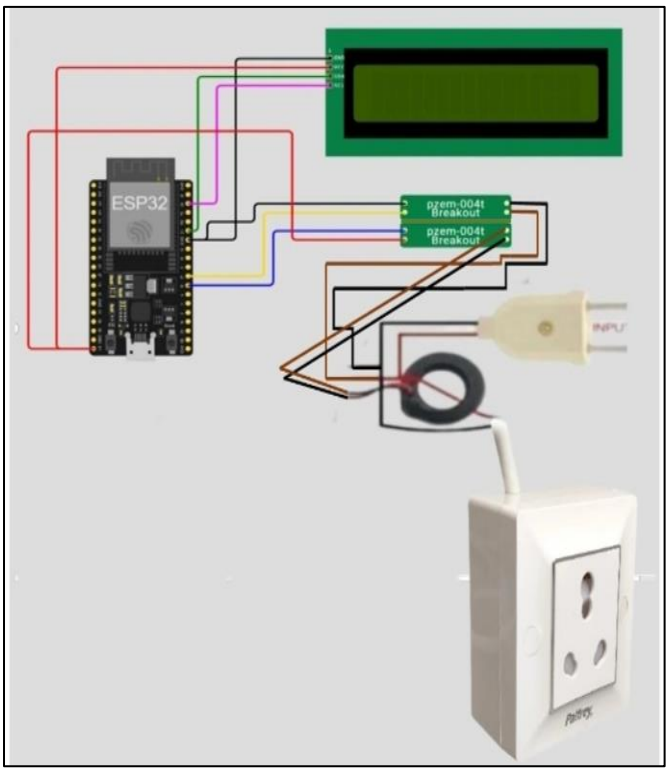

Fig 2 Circuit Diagram of Ecometer System

➢ *Working Principle*

- *Data Acquisition*

The PZEM-004T module measures voltage, current, power, frequency, and energy (kWh). A CT clamp is used to safely measure current without direct contact.

- *Processing Unit*

The ESP32 reads sensor values and computes:

✓ CO_2 (kg) = kWh × 0.82
✓ Trees Equivalent = CO_2 / 100kg

- *Display and Dashboard*

✓ Local LCD shows instant readings.
✓ ESP32 Wi-Fi dashboard provides full data visualization.

- *IoT Communication*

Users connect to the ESP32 Wi-Fi network and access the live dashboard via smartphone or PC.

➢ *Components Used*

Components of the Ecometer System:

- ESP32 Development Board
- PZEM-004T v3.0 Sensor
- 16×2 LCD (I2C)

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- 5V DC Adapter
- AC Load (Fan/Lamp)
- Jumper Wires & AC Wires
- Socket

➢ *Experimantal Setup and Result*

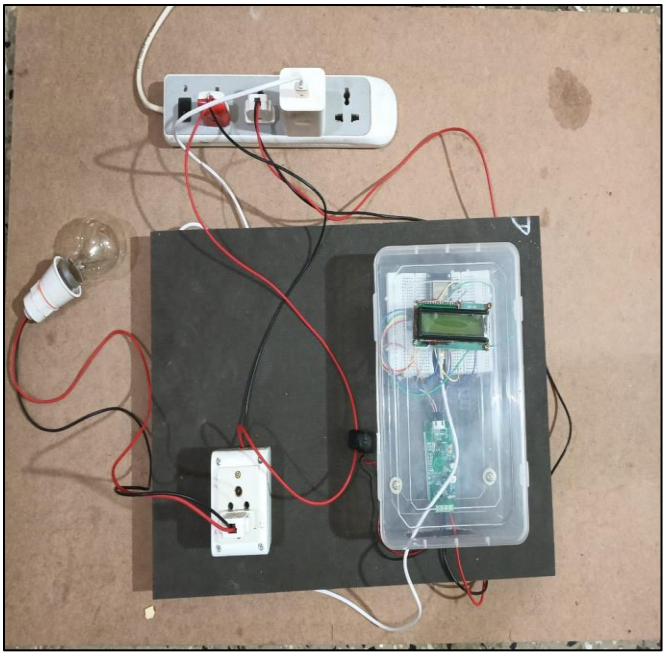

Fig 3 Experimental Setup

III. RESULTS

Expected results show that the Ecometer is doing very well in improving campus sustainability. Real-time information is provided: the CO_2 emissions, at every instant, are clearly depicted on the LCD, making it easy to understand how much pollution every electricity use creates. Since the readings from PZEM-004T and ESP32 are very accurate, with an error less than 1%, the CO_2 values presented can be trusted.

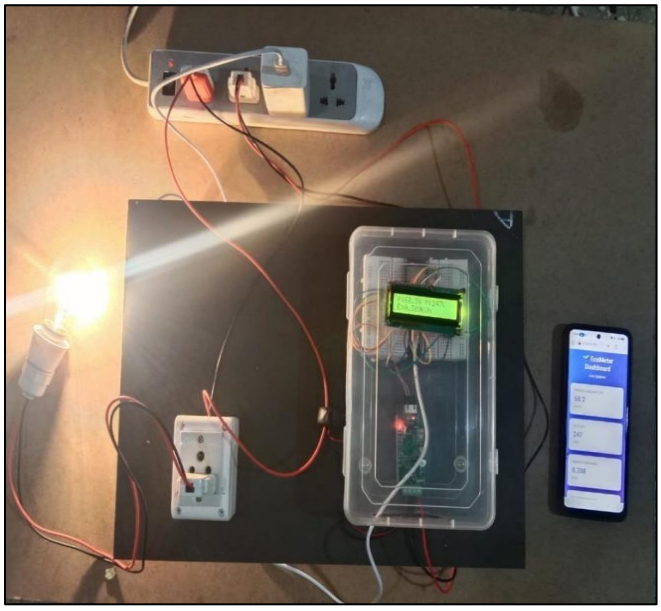

Fig 4 Results of Project

IV. CONCLUSION

The Ecometer is a device that simply and effectively helps human beings understand how their use of electricity affects the environment. It uses the PZEM-004T sensor and ESP32 to measure power, then shows how much CO_2 is produced because of that electricity. It further states how many trees are needed to absorb such CO_2.Clearly showing this information on a 16×2 LCD and on a web page, Ecometer makes people more aware of energy wastage. It allows students and staff to clearly see how their actions, like keeping lights, fans, or chargers ON, increase pollution. This will make them more careful and responsible.This project proves that even a small IoT system can bring a big change in thinking. When people can "see" their CO_2 footprint in real time, they understand the environmental impact better. This leads to better habits of turning off appliances when not needed and using electricity judiciously.Overall, the Ecometer is not just an energy meter; it is a green awareness tool. It motivates people to save electricity, reduce CO_2 emissions, and help make the campus cleaner and more sustainable. This project illustrates that technology can be applied in a very simple way to support environmental protection and stimulate eco-friendly behaviour.

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