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DESIGN OF SMART ENERGY MANAGEMENT SYSTEM USING ARDUINO

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ABSTRACT

The world's four most populated regions—the US, EU, China, and Russia—consume more than 61% of all the electricity produced. In certain developing nations, consumption rose dramatically between 2001 and 2012: in China, 2.2 times; in India; and in Brazil, 1.6 times. The majority of the energy utilised is produced from non-renewable resources, which may be a factor in the planet's present global warming. People are progressively installing several equipment in their houses that are left on all day because they are seeking more comfort and are uninformed of the dangers of energy waste. They also occasionally leave the house while turning on light bulbs, heaters, TVs, and other appliances. In this thesis, we suggest creating and implementing a smart energy management system that allows appliances to continuously collect data on their energy usage. This thesis aims to design and implement an energy management system that gives users detailed information about their energy consumption and permits sensing, control, and smart algorithms to use renewable energy as a source of residential-grade electricity in Pakistan's micro grids. The solution already exists on the market. In many economic and political discussions in Pakistan, renewable energy is becoming increasingly crucial.

Keywords: Arduino, Energy Management, Smart Grid.

I. INTRODUCTION

Modernising the power infrastructure is necessary due to the growth of the renewable energy industry and the rise of new uses for electricity. Existing uses like heaters and air conditioners have been significantly expanded, and new uses like heat pumps and hybrid electric vehicles are emerging and consuming more electricity [1]. Due to variations in electricity consumption—more electricity is used in the winter than in the summer, resulting in daily peaks and troughs—these changes are necessitating control of the power system. Due to the intermittent usage of renewable energy sources, there is also a growing change in how electricity is produced. The last justification is that a significant event has resulted from advancement in the distributed generation. Consequently, allowing grids to communicate is a key component of making them smart [2]. Transport networks are already instrumented at this time, particularly for supply-chain security-related reasons. However, because there are so many factories (stations, lines, etc.) and consumers connected to these networks, the distribution network's communication technology is subpar. As a result, the distribution network is where the smart grid faces its biggest challenge. The benefits of smart grids over conventional grids are displayed in Table 1 below. In contrast to the current grid, the smart grid has stronger two-way communication, manages the electricity system according to use, and includes consumers as participants as well. Using the STEEPLE Analysis, marketing plans can be created [3]. STEEPLE is a more complicated analysis since it takes into account the external components of the macro environment. It provides a comprehensive breakdown of the many external domains. The initials for STEEPLE Analysis stand for Society, Technology, Economy, Environment, Politics, Law, and Ethics. The study offers useful knowledge on each of the aforementioned problems that could affect your business. The STEEPLE study expands on the PEST analysis by taking legal, ethical, and environmental factors into account [4].

This thesis' main objective is to monitor and control the use and production of home appliances and renewable energy sources. The objective of this thesis is to construct an effective smart energy management system that makes use of renewable energy sources. This study examines the viability of creating a SEMS in a micro-grid setting using renewable energy in Pakistan's residential sector.

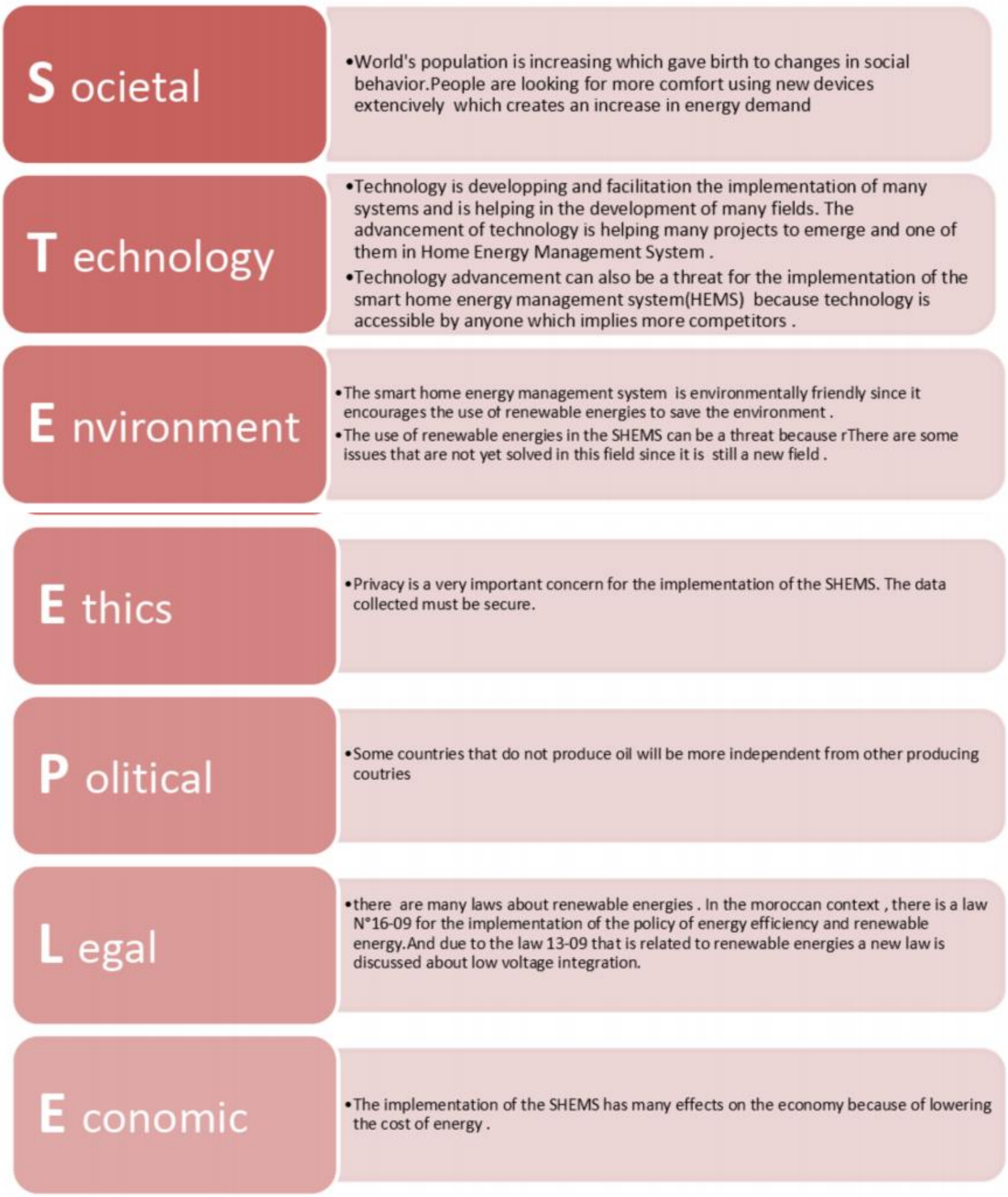

Figure 1: Steeple analysis steps

II. LITERATURE REVIEW

As a result of economic growth, the world's energy demand is expected to double between 2010 and 2030. Global carbon dioxide emissions are expected to increase more quickly than global energy consumption at the same time. The main source of CO2 is the creation of electrical energy, which has a huge impact on climate change. To fix this issue, numerous adjustments to the current electrical system are required.

Electricity is a flexible and widely used kind of energy, with a rising global need. Currently, the sole primary source of carbon dioxide emissions is the production of electrical energy, which has a substantial impact on climate change. To reduce the effects of climate change, the current electrical systems must undergo significant adjustments.

The electrical power system distributes electrical energy to industry, commercial, and residential consumers to meet the ever-increasing demand. Fossil fuels account for the majority of today's generation capacity, which contributes significantly to the increase of carbon dioxide in the atmosphere and has detrimental effects on both society and the environment [5].

Renewable energy sources including solar, wind, and fuel cells should be used to meet the growing need for energy. Rethinking the infrastructure and architecture of the conventional power system can help solve many of the problems associated with integrating renewable energy sources into the grid. The traditional power system ought to be more dependable, ecologically friendly, and intelligent than current systems. [6]

Throughout this project, we will use photovoltaic as a renewable energy source for the micro-grid. Using semiconducting substances that exhibit the photovoltaic effect, such as silicon or silicon that has been thinly covered with metal, photovoltaic solar energy is produced by converting sunlight into electricity. These photosensitive materials have the capacity to liberate their electrons when subjected to external energy [7]. The photovoltaic effect is the term used to describe this. When photons, which are part of light, collide with electrons, they release the electrons and create an electric current. This DC Micro-power, measured in watt peak (Wp), may be converted into alternating current by an inverter [8].

III. METHODOLOGY

The present Energy Management system concentrated on managing appliances and reducing the risks associated with electrical faults. None of the research developed an energy-saving strategy that involved keeping an eye on environmental factors and modifying the appliances utilised accordingly. We have therefore developed an energy management system using environmental sensors like temperature and light intensity sensors and communicating the readings to an Arduino as a result of the development of Machine to Machine and IoT connection. Based on the collected data, the Arduino is set up to control the appliances that are used. In addition to controlling appliance consumption, Hall Sensors determine the amount of current drawn by each appliance and transmit that information wirelessly to a Raspberry Pi 3 via a WiFi module.

The entire power usage of each appliance is computed and graphed on a regular basis. A cloud server receives the graphic data on power usage vs. time for all appliances under various climatic conditions. The data flow diagram for the energy management system is shown in Figure 2.

The Arduino reads the temperature and humidity from the DHT11 sensor using code. The Arduino then controls the fan and light according to the temperature, humidity, and light intensity. Based on the data gathered, the Arduino will modify the voltage that must be supplied to the appliance using a transistor. The Arduino will get information from the Hall sensor about how much current is being supplied to the appliance. The Arduino's used current will then be transferred to the Raspberry Pi. The Raspberry Pi will calculate the amount of power used, obtain the current used, and upload the data.

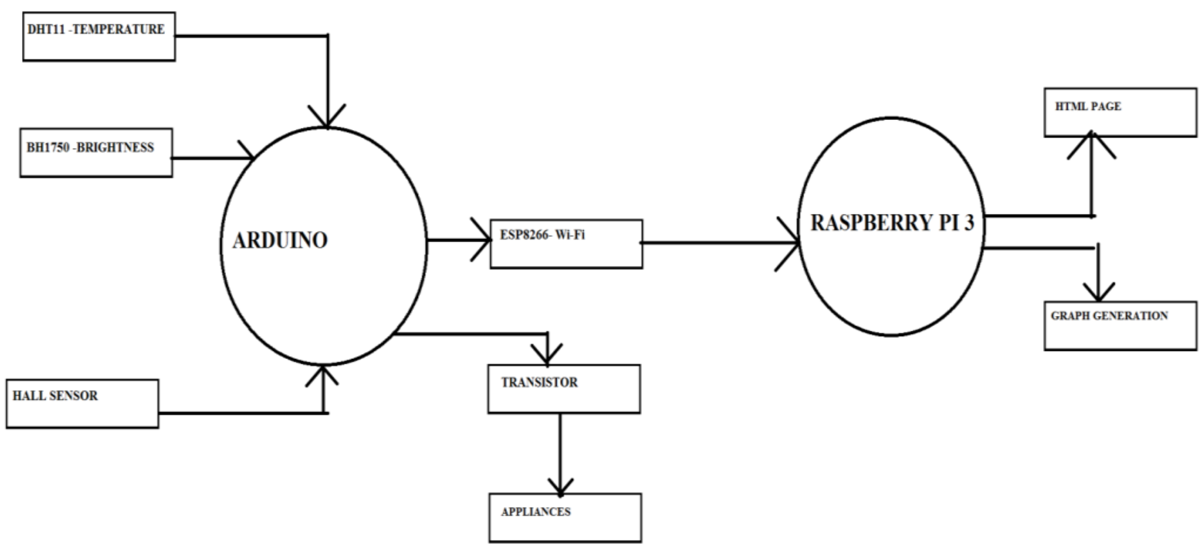

Figure 2: Data flow diagram for EMS

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The Arduino UNO and Raspberry Pi were used as the microcontroller and processing unit in the Smart Energy Management System to advance it. The light, temperature, and humidity sensors are all placed and connected to the Arduino. Then, in order to communicate with the Raspberry Pi, the Arduino linked to WiFi.

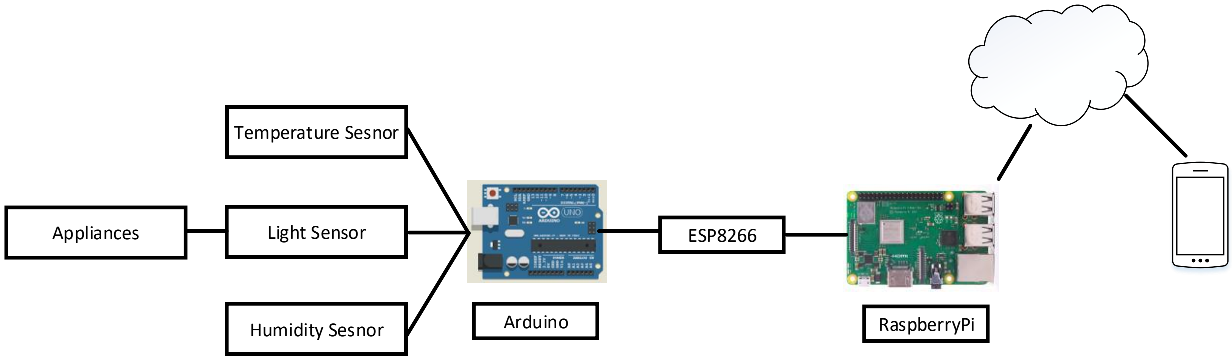

Figure 3: Proposed system architecture for smart energy management system

IV. RESULTS AND DISCUSSION

Using Arduino and Raspberry Pi3 as microcontrollers and computer devices, respectively, the whole hardware prototype of an Energy Management system was built. Additionally fitted and attached to an Arduino microcontroller were temperature and light sensors. Additionally, the Arduino unit and Pi 3 were linked via a Wi-Fi module to exchange the current drawn by each device in order to calculate the overall amount of power consumed and display the findings as a graph. The outcomes have been updated as an HTML webpage on the cloud server. Figure 4 depicts the complete Energy Management System Prototype, complete with all sensors and connections.

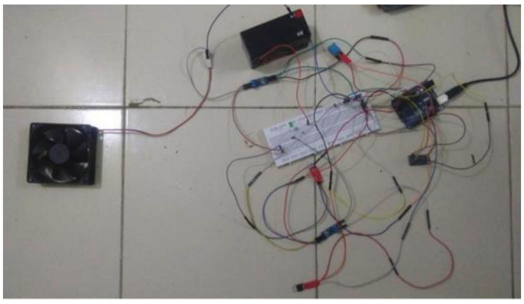

Figure 4: Energy management system hardware prototype

Energy Efficiency:

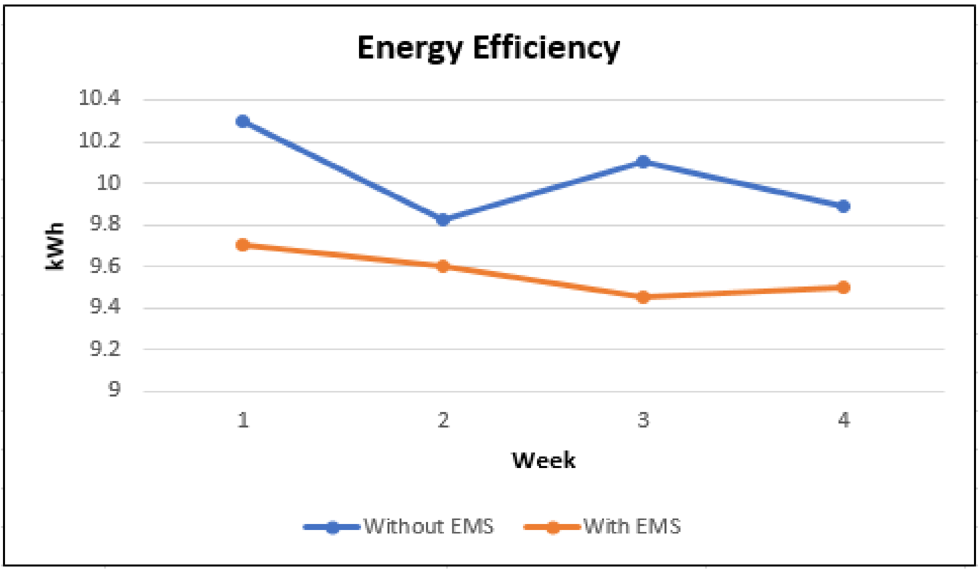

Figure 5: Energy Efficiency

V. CONCLUSION

An energy management system's main goals when operating in a micro-grid are to maximise energy return on investment, boost the usage of renewable energy, and, in the end, lessen dependency on utility power. The primary objective of the capstone project has been met. This project produced actual hardware prototypes in addition to theoretical models of the SHEMS's components.

Some of the project's constraints are as follows: first, the system's expensive implementation costs. The delay in the control part is the second problem. The current sensor's lack of accuracy is another issue, as is the absence of a voltage sensor and other sensors in the lab like those for motion, humidity, and gas. Last but not least, the lab's Lux metre was missing.

VI. REFERENCES

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