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Energy Efficiency in Smart Homes: A Case Study of Home Automation Technologies

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A B S T R A C T

The increasing integration of smart home technologies has sparked popular interest, with an increased emphasis on energy efficiency as a crucial component of sustainable living. This research paper provides an in-depth examination of "Energy Efficiency in Smart Homes" via a targeted case study that examines the influence of home automation technologies. The study's goal is to provide useful insights into the dynamics of energy use in smart homes and to evaluate the efficacy of automation in promoting sustainability.

The problem statement emphasises the existing vacuum in the literature as well as the critical need to address energy usage in the fast-changing landscape of smart homes. The research objectives chart the course for comprehending, analysing, and improving energy efficiency through home automation technologies.

Keywords: Houses that are smart, Automation in the home, Energy conservation, Living in a sustainable manner, The Internet of Things (IoT), Case Study on Artificial Intelligence, Patterns of energy usage, Technologies for smart homes, User encounter, Design with a focus on the human being, Environmental consequences, Privacy and security, Integration of IoT, Social ramifications, A cost-benefit analysis is performed, Health and happiness, Technology that is environmentally friendly, Conserving energy, Methods of data collection.

1. Introduction

The modern residential landscape has seen a tremendous boom in the incorporation of smart home technologies, revolutionizing the way people interact with their living surroundings. Homes are developing into intelligent ecosystems that provide unprecedented convenience, security, and control as a result of the proliferation of networked gadgets and creative automation solutions. This section presents a brief but informative review of the increasing prominence of smart home technology, laying the groundwork for further investigation into their implications for energy efficiency.

With a plethora of gadgets and systems aimed to improve the overall quality of life for residents, the spread of smart home technologies signifies a paradigm shift in domestic living. These technologies, which range from smart thermostats and lighting systems to intelligent security solutions, provide a seamless integration of digital innovations into the fabric of daily life. The pervasiveness of smartphones and the Internet of Things (IoT) has accelerated the adoption of these technologies, resulting in houses that intelligently respond to user preferences and environmental conditions.

The use of sensors, actuators, and networked devices has resulted in homes that can learn, adapt, and automate numerous functions. This transition not only brings exceptional convenience, but it also provides the groundwork for optimising resource use, with a focus on energy efficiency. As houses become more networked, the potential for intelligent automation to reduce energy usage and environmental effect becomes more apparent.

2. Importance of Energy Efficiency in the Context of Smart Homes

In the middle of the fast adoption of smart home devices, energy efficiency arises as a critical consideration. The traditional paradigm of household energy use is being rewritten as smart homes provide options for dynamic control and optimisation. In this setting, energy efficiency goes beyond simple cost savings; it connects with broader environmental sustainability goals and addresses climate change problems.

The role of smart homes in contributing to energy efficiency is becoming more important as people become more conscious of environmental challenges and the need for responsible resource management. Energy efficiency not only lowers power expenses for homeowners, but it also reduces the ecological imprint associated with residential life. Understanding and optimising the energy efficiency of smart homes is becoming increasingly important as these disruptive technologies gain traction. This study aims to dive into the complicated interaction between smart home technology and energy efficiency, revealing the challenges and opportunities that exist at the crossroads of intelligent living and sustainable practices.

3. Internet of Things (IOT)

The Internet of objects (IoT) connects various devices, including computers, tablets, and smartphones, to the internet and enables new forms of communication between objects and people.

IoT enables successful data transmission over networks for any object with a "IP address". The internet allows for remote device connectivity, providing solutions to many difficulties. The Internet of Things increases quality of life through innovative concepts. IoT will transform industries such as automation, transportation, healthcare, energy, and housing.

This study explores the usage of Wi-Fi technology as an Internet of Things. Wi-Fi is a popular wireless networking technology that employs radio waves to provide fast internet. Wi-Fi is sometimes confused with wireless fidelity; however, it actually refers to IEEE 802.11x standards. The Wi-Fi alliance defines Wi-Fi as any wireless LAN (WLAN) device based on IEEE 802.11 specifications. The organisation owns the registered trademark. Wi-Fi versions are based on IEEE 802.11 protocol standards, with varying radio technology impacting range, bands, and speeds.

4. Evaluation of systems

The Smart home automation system uses ESP8266 Wi-Fi technology to control 230V and 5A appliances in users' homes. Sensors such as PIR, temperature, humidity, and flame sensors, coupled with GPS and GSM modules, are used for home safety and security to detect fires, short circuits, and other incidents. Figure shows the block diagram for the hardware implementation of Smart home automation system.

4.1 Tables

Table 1 – COMPONENT LIST

Components	**Voltage V (*t*)**	**Current i (*t*)**
Power Supply	12V	1A
Voltage Regulator	5V	1A
Extension Board	230V	5A
ESP8266 (NodeMCU)	3.3V	0.5A
Temperature & Humidity sensor	5V	0.5A
Relay	12V	5A
LED	12V	1.5A

4.2 Characterization of components.

4.2.1 Power Supply

A power supply provides power to a load. A power supply powers a load by converting current from the source to the appropriate current, frequency, and voltage. Some power supplies are separate components, while others are integrated into equipment to power loads. The suggested system uses two different power supplies: 12V/1A for GSM and GPS modules and 12V/2A for ESP8266-01 and ESP12 Wi-Fi modules. Figure illustrates a circuit for a 12V/1A power supply.

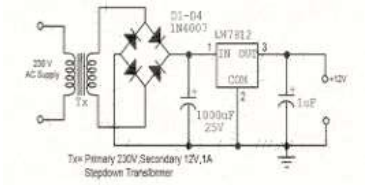

Figure 1(POWER SUPPLY)

4.2.2 Relay

A relay is a switch that operates electrically. Relays employ electromagnets to operate switches, however solid-state relays can also be used.

Relays are used to monitor circuits using low-power signals or to manage several circuits with a single signal. The ESP12 Wi-Fi Module receives a 5V supply from four relay input pins and can support up to 10A at 250V.

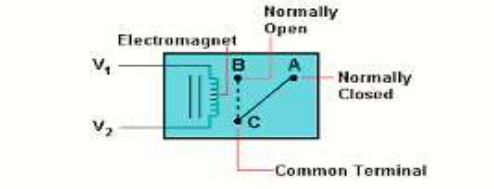

Figure 2(relay)

4.2.3 Temperature and Humidity sensor

The created system uses a DHT11 Temperature and Humidity Sensor. The digital output signal is calibrated and can detect temperature and humidity. The device features a 5 V supply voltage, a temperature range of 0-50°C with an error of ±2°C, and a humidity range of 20-90% RH with an error of ±5%.

Figure 3(temperature sensor)

4.2.4 Voltage Regulator

This system uses a voltage regulator to automatically maintain a fixed voltage level. Voltage regulators can utilize negative feedback or feed-forward designs. It may use electronic or electromechanical mechanisms. The design allows for operation of several AC or DC voltages.

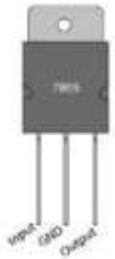

Figure 4(ic 7805)

4.2.5 ESP8266 (NodeMCU)

NodeMCU is open-source firmware available for open-source prototyping board designs. The name "NodeMCU" is a combination of "node" and "MCU" (microcontroller unit). The term "NodeMCU" strictly refers to the firmware rather than the associated development kit. The firmware uses the Lua scripting language. The firmware is based on the eLua project and is based on the Espressif Non-OS SDK for ESP8266. We use many open-source projects such as lua-cjson and SPIFFS. Due to resource constraints, users need to select modules relevant to their project and create firmware to suit their needs. 32-bit ESP32 support has also been implemented. The commonly used prototyping hardware is a board that acts as a dual in-line package (DIP) and integrates a USB controller into a small surface mount board that includes the MCU and antenna. Choosing the DIP format allows easy prototyping on a breadboard. This design was originally based on his ESP-12 module for ESP8266. This module is a Wi-Fi SoC integrated with Tensilica Xtensa LX106 core and widely used in IoT applications.

Figure 1(NodeMCU ESP8266)

Table 2 – Pin Config NodeMCU

Pin No.	Pin Names	Usage
D0	GPIO16	USED TO WAKE UP FROM DEEP SLEEP
D1	GPIO5	USED FOR SCL(I2C)
D2	GPIO4	USED FOR SCL(I2C)
D3	GPIO0	CONNECTED TO FLASH BUTTON
D4	GPIO2	CONNECTED TO ONBOARD LED
D5	GPIO14	SCLK
D6	GPIO12	MISO
D7	GPIO13	MOSI
D8	GPIO15	CS
Rx	GPIO3	Rx PIN
Tx	GPIO1	Tx PIN
A0	ACD0	ANALOG INPUT

4.3 SOFTWARE CONFIGURATION

The described system uses several software for programming and operating Smart Home Automation. IDE (integrated development environment) is an open-source software for developing and uploading code to Arduino and ESP8266 Wi-Fi Modules. An application entitled "Smart Home Automation" is made utilizing ESP8266 and blynk app which provides a platform for controlling purpose. This requires a Wi-Fi connection to function properly.

4.4 Implementation Setup

The Smart Home Automation system analysis is implemented using hardware. The Smart Home Automation system analysis uses hardware modules connected via ESP8266 Wi-Fi and Arduino microcontrollers to regulate home appliances and prevent accidents like fires and short circuits. To charge a mobile device using an AC adapter, relay, Wi-Fi module, and mobile app. The hardware arrangement is divided into three cases. In the first scenario, home automation with ESP8266 Wi-Fi is demonstrated. In the second scenario, temperature and humidity readings using IOT are shown.

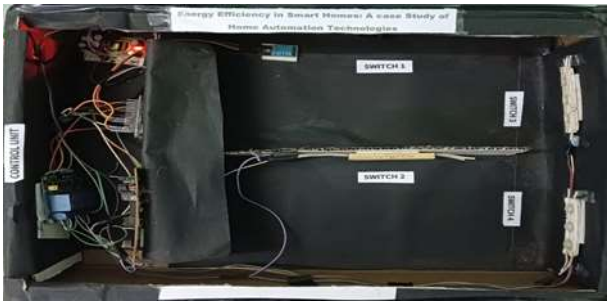

Figure 6(project setup)

Figure 7(circuit overview)

5. Result and Discussion

An Energy Efficiency in Smart Homes: A Case Study of Home Automation Technologies project using NodeMCU and Blynk has been successfully implemented, enabling remote control and monitoring of various devices in the home. The following results and observations were obtained during the testing and evaluation of the system.

1. Functions and controls:

- The system effectively controlled connected devices such as lights, fans, and appliances through the Blynk app interface.

- Blynk widgets, including buttons and sliders, provided users with convenient control options to turn the device on/off and adjust settings. - Real-time feedback in the Blynk app shows device status and gives users instant visual confirmation of commands.

2. Sensor integration and monitoring:

- Sensors integrated in NodeMCU. B. Temperature and humidity sensors. Accurately measure your data and send it to the Blynk app.

- Users can remotely monitor environmental conditions in their home to ensure comfort and enable informed decision making.

3. Mobile App UI:

- The Blynk App's interface is intuitive and customizable, allowing users to arrange and style their panels exactly how they want.

- Widgets were responsive and provided a seamless user experience, allowing users to easily control their devices.

4. Reliability and stability:

– The system showed reliable performance with stable Wi-Fi connection and consistent communication between NodeMCU and Blynk app.

- Commands sent by the app are reliably executed by her NodeMCU, ensuring consistent device control.

5. Scalability and extensibility:

- The modular nature of the project facilitated expansion and integration of additional devices and sensors.

- The code structure and virtual pin mapping in the NodeMCU code allowed us to integrate new features without major changes.

6. CONCLUSION

The system is running well with the Nodemcu ESP8266 and internet access via mobile phones and tablets. The system not only controls home appliances, but also monitors them using sensors for safety and security. This paper offers a prototype and implementation of Wi-Fi-based automation for mobile devices, laptops, and tablets. This system can be expanded to control additional home appliances using an app and an ESP8266 Wi-Fi module. Data collected from sensors can also be used for monitoring and safety purposes, and analysed online for future improvements..

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