# DESIGN AND IMPLEMENTATION OF HOME ASSISTANT BASED ON RASPBERRY PI FOR HOME ENERGY MANAGEMENT

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

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# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.). The members of the supervisory committee are as follow:

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# ABSTRAK

Automasi rumah merupakan penyelesaian terkenal untuk aktiviti harian di rumah yang mungkin dikendalikan oleh pembangunan Internet Perkara (Internet of Things, IoT) untuk menghubungkan teknologi antara manusia dan perkakas rumah. Disebabkan oleh situasi pandemic Covid-19 semasa dan perubahan iklim yang berlaku di negara, situasi ini telah membawa kepada peningkatan mendadak penggunaan tenaga daripada isi rumah dan seterusnya mendorong pelaksanaan projek ini untuk menambah baik pengurusan tenaga rumah. Untuk melaksanakan pelaksanaan projek, objektif yang telah dikenalpasti adalah untuk mengenal pasti integrasi skrip yang sesuai untuk aktiviti rumah yang boleh diperkenalkan dalam Home Assistant sebagai hab automasi rumah, perekaan bentuk dan pelaksanaan Home Assistant berdasarkan Raspberry Pi untuk pengurusan tenaga rumah, dan terakhirnya adalah untuk menganalisis ketepatan Home Assistant dalam memantau penggunaan tenaga dan mengawal peranti pintar. Untuk pelaksanaan projek ini, pengekodan Python telah dipilih sebagai skrip untuk menyepadukan sistem manakala Linux dipilih sebagai sistem pengendalian. Selain itu, Raspberry Pi 4 Model B, Amazon Alexa, sensor jarak, jambatan RF, suis Sonoff dan Shelly EM telah dipilih sebagai peralatan untuk melaksanakan projek bagi tugasan dan permintaan. Untuk projek ini, Home Assistant telah digunakan sebagai perisian sumber terbuka untuk menjalankan skrip bagi sistem automasi rumah. Pada masa yang sama, papan pemuka tenaga Home Assistant digunakan untuk menganalisis penggunaan tenaga serta penyepadukan Shelly 3EM ke dalam kotak agihan dan seterusnya membandingkan analisis dengan bacaan daripada meter kuasa pintar di dalam rumah. Sebagai kesimpulannya, semua objektif telah dicapai tetapi prestasi projek mengenai analisis Home Assistant dalam memantau penggunaan tenaga dan mengawal peranti pintar boleh dipertingkatkan untuk pembangunan selanjutnya.

# ABSTRACT

Home automation is a well-known solution for home daily activities that might be operated by the development of Internet of Things (IoT) to connect the technology between human and the home appliances. Due to the current Covid-19 pandemic situation and the climate change that happened in the country, these situations had led to a surge in the energy consumption from the household and hence motivated the project implementation to improve the home energy management. To carry out the project implementation, the objectives that had been identified were to identify the suitable script integration for the home activities that can be introduced in the Home Assistant as a home automation hub, to design and implement the Home Assistant based on Raspberry Pi for home energy management, and lastly to analyse the Home Assistant accuracy on monitoring energy consumption and controlling smart devices. For the implementation, Python coding was chosen as the script to integrate the system while Linux was selected as the operating system. Besides, Raspberry Pi 4 Model B, Amazon Alexa, proximity sensor, RF bridge, Sonoff switch, and Shelly 3EM were chosen as the hardware to implement the project in order to perform the task and the demand. For this project, Home Assistant was used as the open-source software to run the script for the home automation system for the house. At the same time, energy dashboard of the Home Assistant was used to analyse the energy usage as well as integrating Shelly 3EM into the distribution box and hence compare the analysis with the readings from the smart meter in the site. For the conclusion, all the objectives were achieved but the performance of the project on the analysis of Home Assistant on monitoring the energy consumption and controlling the smart devices can be enhanced for further development.

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# DEDICATION

Only

my beloved father, Ooi Eng Leong

my appreciated mother, Teoh Mooi Im

my adored sisters, Xiang Piang, Shen Ling, Shen Yi and Xuan Huan

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AI | - | Artificial Intelligence |
| API | - | Application Programming Interface |
| ASR | - | Automatic Speech Recognition |
| AWS | - | Amazon Web Service |
| BE | - | Basic Entrepreneurship |
| CCTV | - | Closed-circuit Television |
| $CO_2$ | - | Carbon dioxide |
| CT | - | Current Transformer |
| DNS | - | Domain Name System |
| GPIO | - | General-purpose Input/Output |
| HASS | - | Home Assistant Operating System |
| HoG | - | Histogram of Gradient |
| IFTTT | - | If This Then That |
| IoT | - | Internet of Things |
| IP | - | Internet Protocol |
| kWh | - | Kilowatt Hour |
| LLL | - | Lifelong Learning |
| MQTT | - | Message Queue Telemetry Transport |
| NLU | - | Natural Language Understanding |
| PIR | - | Passive Infrared |
| SSL | - | Secure Socket Layer |
| SVM | - | Support Vector Machine |
| VPAs | - | Virtual Personal Assistants |
| VPN | - | Virtual Private Network |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

In this technology era, technology has a tremendous impact on our life that plays a crucial role in everyday life no matter in living, working or relaxing. As the technology has evolved, people have witnessed how technology is beneficial and useful in terms of improving and make the life easier and more convenient.

With the advance technology has been developed, the artificial intelligence (AI) and internet of things (IoT) have been developed as well as in creating improvement and connecting the technology within human and the device. For instance, according to Lobaccaro et al. (2016), home automation is currently a well-known solution for home daily activities which operate together with the combination of technology of electronics and information technology.

Generally, the home automation which is also the smart home technology which has been developed in many houses nowadays. Sisavath & Yu, (2021) defined that the smart home is enabled on the Internet of Things (IoT) which develops with the widespread use of modern electronic technology in everyday life at home. The advent of smart home technology brings convenient to life as well as connecting the smart devices such as smartphones with the smart home application to remote control home appliances. By few simple steps, the smart home system can be operated efficiently as in monitor and control the home appliances and systems efficiently and effectively such as air-conditioner, lighting, gate and so on. These smart devices and appliances utilize the internet to connect to operate normally with the automating actions to

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accommodate the users for their demand and preference. Consequently, the smart home technology is obviously beneficial for many parties include kids, adults and even elders, providing the owners to achieve a secured home, control the home for its comfortable, safety, convenience, efficiency, save cost and of course the energy management.

Home Assistant is one of the open-source software that run for home automation system in today's market. According to Baat (2021), Home Assistant has a vast user base with one purpose in mind that the home automation system could priorities the local control and also the privacy. Home Assistant is an application based as Python scripting that a managed operating system, Hass.io will be introduced to use it with Raspberry Pi. Besides, Home Assistant is able to connect to Amazon Alexa while the users able to access it via the website or the application on a smartphone.

In particular, home automation could make a home to be intelligent in the way it operates. However, with the environmental issue which the world is facing a climate crisis, Home Assistant does have an add-on support for home energy management. The energy management in the houses can be achieved when the Home Assistant is installed which it could be a better platform in this issue. With the implementation of Home Assistant with the home appliances in home, it could make people's life easier, as simple as possible, in understanding the energy consumption in a house with few simple steps.

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Overall, this project aims to design and implement a home energy management by using Home Assistant that runs on the Raspberry Pi. With the technology available, users could utilize it effectively and efficiently in tracking and controlling energy usage in their home.

## 1.2 Problem Statement

Energy management and energy consumption are always the topics to be discussed in an organization which is to track and reduce energy consumption throughout the daily life.

Relating to the current situation which is the COVID-19 pandemic, Movement Control Order (MCO) was implemented not only in Malaysia but also around the world in order to encourage people to stay at home to curb the spread of the virus. By now, most of the company employees and students are urged to work from home and study from home which implies a surge in household energy consumption and demand. According to the research, the most notable impact on home and living appliances is the significant rise in hourly use of nearly 12 appliances per day during MCO, particularly Wi-Fi routers, lighting and fans (Institute of Energy Policy and Research, 2021). Besides, from the news reported in Malaysiakini, the minister has claimed that the electricity usage in residential area during MCO has increased with 23% ("Residential Electricity Usage Soars 23 Pct during MCO – Minister," 2020). This is due to the people spent more time and stayed at home during that period. This indicates that the energy consumption and demand are high during the period when most of the people stay at home for their work and study. However, the usage of energy of each device is still not able to be tracked and monitored. Hence, the implementation of the project is able to monitor and control the home energy consumption in daily life.

On the other hand, the role of energy efficiency is critical when climate change happened in the country. According to research Lamb et al., (2021) ~~Oladokun & Odesola, (2015)~~, the increase of greenhouse gasses emission such as carbon dioxide ($CO_2$) in the atmosphere contributes to the change of climate. The greenhouse gas is always accumulated from the human activities as in industries, commercial, transportation and residential. Sulphur hexafluoride is one kind of the greenhouse gas emissions from the residential sector which is generally from the electric utilities transmission and systems which means the greenhouse gas emissions are linked to the energy usage. As a cycle, there will be a significant rise on the electricity energy consumption and hence the temperature rises which will lead to a rise in fan and air-conditioning usage in the houses or offices. When the problem is solved by an efficient way by monitoring the energy usage in a household as in transiting to a sustainable energy and save the cost in another way.

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In short, the reasons as mentioned above are motivating this project implementation. This implementation will review the implementation on Home Assistant based on Raspberry Pi as well in improving the home energy management.

## 1.3 Objectives

There are several objectives of the project which are:

1. To program the suitable script integration for the home activities that is introduced in the Home Assistant as a Home Automation Hub.
2. To design and implement the Home Assistant based on Raspberry Pi for Home Energy Management.
3. To analyse the Home Assistant accuracy on monitoring energy consumption and controlling smart devices.

## 1.4 Scopes

This project is studied to design and implement the home energy management using Home Assistant by integrating it with some home appliances. The home energy management is implemented in such a way of utilizing the Raspberry Pi in order to accomplish the task and the objectives of the project. Therefore, this project pays attention to:

1. Conduct research on the energy usage of some home activities that involve the energy consumption of the devices at home by analysing the daily tasks that have been carried out in a house. It does not include the energy consumption of the other areas such as commercial, industrial and transportation.

2. Carry out the design and implementation of an energy management system in the houses by using Home Assistant to assess the efficiency of energy usage.

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3. Utilize the technology of microcomputer of Raspberry Pi to build this project. The technology of Home Assistant is developed to connect with some home appliances and control the environment.

4. Integrate and configure the home appliances in the Home Assistant via supported virtual assistant includes Amazon Alexa, Sonoff Switches, and Shelly 3EM.

5. Optimize the coding in implementation stage in order to communicate with the appliances and modify based on the rule set.

## 1.5 Significance of Study

Home automation technology has the potential and benefit to the current households and the users in improving their quality of life. By implementing home automation systems, the technology and knowledge of energy management has been studied. There are some potential benefits that can be achieved by the users.

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After completion of the study, it has important implications for the users to improve household energy efficiency in achieving sustainable energy by applying the concept of home automation. With the change of the climate change, it has significantly influenced the users on their demand for energy in the houses when the temperature changes. As a result, climate change could result in high increases in electricity and a high increase in need for cooling, of course the adoption of air conditioning. Automation technology could ever improve the home in such a smart way that the users could reduce the energy consumption which could bring a positive impact on the environment as it reduces pollution of the emission of greenhouse gases from the home appliances when the household energy is under control and managed.

With the implementation of home automation technology, one of the importance is to provide the users a solution to monitor the energy usage then schedule the energy usage depending on their demand with the technology throughout their daily life. Home Assistant is

one of the solutions for energy efficiency and cost saving. The users are able to automate appliances to do daily house activities with just a tap on the smartphones at anywhere and anytime. Therefore, home automation could be more cost-efficient to operate and aid in saving cost on energy bills for the long term by approaching the implementation of smart home solutions.

Furthermore, one of the significances is to improve quality of life with the convenient and user-friendly smart appliances in the houses. The users are able to control any appliances or systems which are connected with a common network in the house from their smartphone. For instance, a programmable smart thermostat is convenient as it will learn the set schedule and temperature preferences and then suggest the most energy efficient settings throughout the day, giving a more accurate control over the situation of the home. The lights can also be programmed to switch to the appropriate lighting mode automatically when entering or leaving the room, ensuring that there is no waste energy. As a result, the quality of their life will be improved with the adoption of home automation systems.

Lastly, the users are able to understand their energy usage as well as to understand the energy usage per hour and the sources of energy used at home from the dashboard of applications such as Home Assistant. It indicates that the users can plan their home energy usage according to the graph during the period especially under travel restrictions in which the people are asked to stay at home. Hence, the users could integrate Home Assistant to plan their energy usage on the home appliances such as lights, fans or air conditioners for a better home energy management.

Ultimately, linking the home appliances and devices with the automation technology will increase the efficiency and overall upgrade the lifestyle to a more convenient and enjoyable life.

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## 1.6 Organization of Report

As for the overall project, the report consists of a total of five chapters, each of which contains comprehensive information regarding the implementation of the project. The organization of the report is as follows:

Chapter One is the introduction of the study, discussing the background of the study, problem statement, project objectives, project scope and significant of study. In the background of the project, the details of the implementation of the project for home energy management are described as well as the characteristics of the product and component utilized in the project implementation. The problems regarding the home automation system are analysed as it clearly provides an insight to the situation encountered during some home activities. This is continued with the project objectives to be achieved within a set of project scope. From this, the significance of the study is briefly introduced. Finally, the report provides a short summary as an overview of the chapter for this project.

Chapter Two is about the literature review regarding the related topic. This chapter reviews the related work as well as the fundamental theory and knowledge that are applied as references in completing the project. This is followed by the reviews on the implementation of Home Assistant for home energy management on controlling the smart devices in the houses. Lastly, the previous studies on various home automation systems have also been summarized.

Chapter Three discusses the methodology applied that aids in accomplishing the project. This chapter goes into the details of implementation of the home automation system and the suitable script applied in this project. This chapter will provide a clear overview of the process throughout the study.

Chapter Four comprises the results achieved from the system, including its development and implementation stages throughout the integration. Discussion will be made concerning the results and overall performance of the system as well.

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