INSTITUTO SUPERIOR DE ENGENHARIA DE LISBOA
Department of Electronic, Telecommunications and Computers Engineering

Home Energy Management System

Paulo Miguel Monteiro Rodrigues | 47118

Carlos Miguel Freire Santos | 45938

Advisor | Professor Rui António Policarpo Duarte

Initial Report for the Curricular Unit of Final Course Project of Bachelor's Degree in Electronic, Telecommunications and Computers Engineering

February 2024

Table of Contents

1. Introduction

In the current context of seeking sustainable and efficient solutions in the energy sector, European energy cooperatives promote efficiency through the implementation of innovative systems.

With this thought in mind, comes the need to optimize energy consumptions at home, using systems capable of controlling home appliances to operate during periods of greater energy availability.

The project aims to create a residential system incorporating sensors to track energy consumption, offering users insightful feedback, making it possible for users to make informed decisions regarding energy usage, thereby minimizing waste, as well as cutting down on electricity costs.

1.1. Motivation

The primary motivation of this project is to furnish users with a sophisticated system capable of delivering insights into their household electricity consumption. The aim is to empower users with information, enabling them to make well-informed decisions regarding their electrical usage and to maximize the integration of renewable energy sources.

With the escalating concerns surrounding climate change and the environmental ramifications of energy consumption, there is an increasing call for a more sustainable and conscientious approach to energy use. The implementation of an energy monitoring system serves as a valuable tool for homeowners, offering real-time data on their energy utilization. This data empowers them to pinpoint areas of high energy consumption, facilitating informed choices to curtail energy waste.

Furthermore, the project is poised to assist homeowners in optimizing the efficiency of renewable energy sources, such as solar panels, by closely monitoring their performance and gauging their contribution to overall energy production.

1.2. Objectives

The aim of the project is to implement an embedded circuit, named "cofy-cookie", designed for analysing the energy consumption of each section within a household. This initiative seeks to effectively reduce electricity usage.

The data collected by the integrated circuit in each section of the house is transmitted to an application called "Home Assistant", deployed on a Raspberry Pi image, which will be referred as “cofy-box” throughout the report. This application facilitates the analysis of each monitored section, providing insights into the consumption of individual components. The "cofy-cookie" system enables a granular examination of energy usage, allowing for informed decision-making and strategies to optimize electricity consumption in various areas of the house.

1.3. System Requirements

- Analyse the current and voltage flowing in an electrical device using the PZEM-004T V3 sensor.

- Using an ESP32 microcontroller, transmit the data obtained from the sensor via Wi-Fi to the "Home Assistant" application.

- In the application, installed on a Raspberry Pi image, it is possible to analyse the data sent from different areas under study.

- From the application, send a message back to the desired microcontroller to turn the respective device on or off.

- Connected to the microcontroller is also a Solid-State Relay (SSR) that implements the instruction given to the ESP32 (MCU) by "Home Assistant."

2. Related Works

By searching on the internet, comes the conclusion that this theme has been widely researched in the last few years. A paper with great contribute to this project is the “Smart Building Ecosystem for Energy Communities” by REScoop. It’s focused on the description of the cofy-box and uses a range of existing open-source technologies to integrate and control legacy and new appliances into a smart building ecosystem.

Helps understanding the Hardware behind the final product as well as real life options to use the device. It also explains, in depth, the solution proposed, the testing of the system and how to implement it.

3. Work Plan

This project has the predicted duration of 14 weeks, which are divided in 6 main tasks, that will guide the work process. Figure 1 represents the predicted distribution of the primary tasks along the full extent of the project.

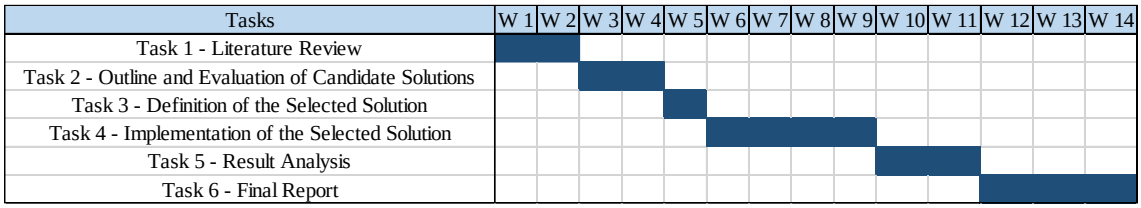

Figure 1. *Work Plan*

Throughout the planning stages, task division will not be implemented. Both group members share the same schedule, and all the work will be jointly undertaken by both individuals. The only exception lies in the Software/Hardware division, with Paulo concentrating on the software aspect and Carlos directing his focus towards the hardware component of the project. All other aspects will be realized by both members.

3.1. Scientific Research and Comparison of Previews Works

The analysis will be performed by both members of the group, by defining keywords and searching them in public databases, such as Google Scholar. The findings will then be filtered and studied in order to choose the ones that better relate to the present study.

3.2. Outline and Evaluation of Candidate Solutions

After analysing previous reports, there is an evaluation of possible solutions in order to outline the best course of action.

3.3. Definition of the Selected Solution

Having investigated all viable alternatives, the best possible solution for the project is traced.

3.4. Implementation of the Selected Solution

During this stage, the proposed solution is put into action through programming and configuration of the system. The focus is on turning theoretical concepts into functional solutions, ensuring that the benefits and outcomes are realized effectively. The project involves both software and hardware components. On the software side, there's a need to make a way to integrate both the cofy-box and cofy-cookie, to gather essential information for determining the optimal times to activate home appliances. This integration comes with the use of the application, where the project is based, Home Assistant. Regarding the hardware aspect, the sensors will continually provide information about the environment, such as light and energy levels, along with current and voltage meter. All these meters transmit information via wi-fi to the server running, providing users with the necessary data to decide the best time to activate home appliances.

3.5. Comparison of Results

This process involves evaluating the effectiveness and efficiency of different approaches, comparing the results to what was previously intended. The comparison of results is a vital phase, where the outcomes achieved are analysed and studied, allowing the optimization of future projects.

To ensure the proper functioning of the project various tests must be carried out. Each sensor must be checked in terms of energy needed as well as if the internet connection is stable and there's clear communication with the server. The server consisting of a Raspberry Pi and running the Home Assistant application, needs to be evaluated in terms of knowing, whether runs smoothly enough for the user as well as if the commands needed to make the system work, are always working properly. Lastly, the cofy-cookie component must be verified to ensure it works as the user's specifications. All these components need to be assessed in terms of energy needed and consumed, and careful attention should be given to the energy supply itself.

3.6. Final Report

The final report provides an overview of the project's objectives, proposed solutions, results and conclusions. It translates what was made in the past 11 weeks in a condensed presentation that summarizes the work undertaken and provides a critical analysis of the achieved results.

4. Conclusion

This report indicates the suggested solution for the project at hands. In a world increasingly focused on efficiency, especially in the technological industry, comes the growing demand for solutions that enhance environmental sustainability and improve people's lives. The proposed solution comes handy to make this goal come true.

To initiate the implementation of this project, it will be necessary to conduct a survey of the required hardware specifications and define specific milestones to achieve the goal. Then proceed to the implementation of the server and establish connections between the server and other components of the project, considering energy efficiency.

The system then needs to be tested, to verify the connectivity and communication between the server and each component. There's also the need to conduct tests to ensure the accuracy of measurement readings, and if the cofy-cookie is actively doing what the user wants it to do.

The expectation is that, ultimately, there's a prototype tested and verified, to make this possible.