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# Real-Time Energy Consumption Optimization Using AI-Based Home Energy Management: A Comparative Study

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***Abstract*: With the growing demand for sustainable and efficient energy use, there is an urgent need for advanced technologies that can manage home energy consumption. In this paper, The Design and Development of an Artificial Intelligence-Based Home Energy Management System (AI-HEMS), the system was proposed to optimize energy usage and reduce energy waste. The system utilizes machine learning algorithms to predict energy consumption patterns and optimize energy usage in real-time. The AI-HEMS consists of several components, including sensors, and actuators, to monitor and control the energy consumption of different household appliances. To test the validity on the claim that AI-HEMS are more reliable and effective in achieving Energy management and cost reduction in comparison to non-AI HEMS, Data was derived from three systems across a given time by the researcher from the same household using the same appliances. The first data set was from a traditional home system without HEMS, the second data set was from with the use of non-AI HEMS, the third data set was derived with the use of AI-HEMS. As seen by this research the AI-HEMS made a substantial reduction in the cost of energy Consumption and energy wastage when compared to other systems. The results of this research can provide valuable insights for the development of future energy management systems and contribute to the sustainable use of energy resources.**

***Keywords*: Artificial Intelligence, Household, Home Energy Management System, Appliances, Consumption.**

## 1. Introduction

In recent times, energy management and consumption has been a major point of discussion in different global fora. The popularity of this subject in recent times can be attributed to the rise of the population, especially in a “technology-dependent” society which feeds high on energy.

With the development of electric cars like Tesla that run on rechargeable batteries, to automated doors and escalators in Supermarkets and Malls which run on energy. The demand for energy is ever-increasing on a daily basis, this makes it clear that without having an effective solution for energy management, the government and society will not be able to meet the demand for energy supply at this time.

The home remains a vital part of society as most human activities take place in the home. A home is also a major place where energy is consumed with the use of high energy appliances like Water Heaters, Air Conditioners, Electric Cookers, Lightning etc. It is imperative that the home deploys an effective energy management system to help manage energy wastes and optimize the available energy supply.

Home energy management systems (HEMS) integrate power generation, electricity consumption, and energy storage devices into a single system for management and control. Hence, it can improve the efficiency of household renewable energy and save electricity bills for customers.

This research seeks to design a Home Energy Management System which utilizes Artificial Intelligence (AI) technology to manage energy usage by studying human patterns to predict and automate the control of home appliances.

This research has a wide range of importance, from the reduction in energy consumption in homes, to the reduction in energy cost when the design is implemented. The significance of this research cannot be overemphasized as it will also impact the longevity of home appliances. The control of these devices will be managed by an intelligent system which will ensure that appliances are well utilized.

## 2. Literature Review

An artificial intelligence-based home energy management system (AI-HEMS) is a system that uses artificial intelligence (AI) techniques to optimize energy consumption in a home. AI-HEMS systems can examine energy consumption patterns, find solutions to use less energy, and offer advice to the homeowner (Rochd et al, 2021). A number of AI-HEMS systems can even automate the control of electronics and appliances to save energy. Using an AI-HEMS could have a number of advantages, one of such advantages is that by lowering energy use, it can assist homeowners in saving money on their energy costs. By encouraging more resource-effective use, an AI-HEMS can also assist lessen the negative effects of energy use on the environment. Additionally, by offering suggestions and notifications regarding energy-saving options, an AI-HEMS can help households better manage their energy usage, this research will explore other advantages later on. First, let us

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understand the concept of Artificial Intelligence and Home Energy Management System.

The replication of human intelligence functions by machines, particularly computer systems, is known as artificial intelligence (AI). According to Burns, expert systems, natural language processing, speech recognition, and machine vision are some examples of specific AI applications (2022).

Historically, Ancient Greece was where this concept of "a machine that thinks" first appeared. However, significant occasions and turning points brought about the development of artificial intelligence since the invention of electronic computing (IBM). The following events,

In 1950, Alan Turing released Computing Machinery and Intelligence. Turing, who gained notoriety during World War II for cracking the Nazi ENIGMA code, proposes in the paper to address the question of "Can machines think?" and introduces the Turing Test to ascertain whether a computer can exhibit the same intelligence (or the outcomes of the same intelligence) as a human. Since then, people have argued over the Turing test's usefulness. Subsequently in 1956, John McCarthy first used the term "artificial intelligence." and the first-ever AI conference was held at Dartmouth College. McCarthy later created the Lisp language. Allen Newell, J.C. Shaw, and Herbert Simon develop the Logic Theorist later that year, which is the first functioning AI software ever. Frank Rosenblatt created the Mark 1 Perceptron in 1967, the first machine based on a neural network that "learned" by making mistakes. Perceptrons, written by Marvin Minsky and Seymour Papert, was published just a year later. It quickly establishes itself as a classic work on neural networks while also serving as, at least temporarily, a counterargument to further neural network research. In the 1980s, neural networks that train themselves via a backpropagation algorithm found widespread use in AI applications and in 1997 during a chess match, IBM's Deep Blue (AI) defeated former world Chess champion Garry Kasparov (IBM, 2023).

For the most part, AI systems function by consuming enormous quantities of labeled training data, searching the data for correlations and patterns, and then using these patterns to forecast future states. In this way, an image recognition program can learn to recognize and characterize objects in photographs by looking at millions of examples, much as a chatbot can learn to make lifelike dialogues with people by being fed examples of text chats.

AI programming focuses on these three cognitive abilities; learning, reasoning, and self-correction (Burns, 2022). According to Burns (2022), the AI process of learning focuses on gathering data and developing rules for how to transform the data into useful knowledge. These procedures, also known as algorithms, give computing devices detailed instructions on how to carry out a certain activity. The reasoning techniques of AI focuses on selecting the best algorithm to achieve a particular result while the Self-correcting mechanisms feature of AI programming focuses on improving algorithms to make sure they deliver the most accurate results.

## 3. Materials and Method

To achieve the said objective, the system's design, and the performance outcomes, these strategies were blended beginning with the design phase. Using carefully selected components and software implementation, the complete system that can be seen in the finished building is run. The system design process is thoroughly covered, including the theoretical analysis, choice of values and components, calculations, simulations, and computations.

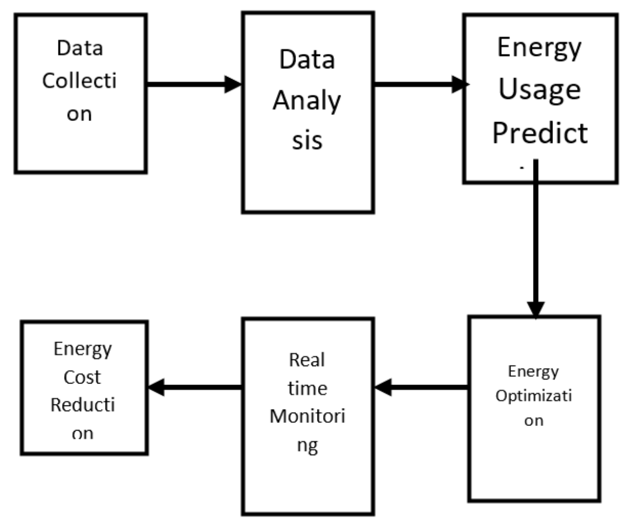


Fig. 1. Block diagram showing the sequence of steps for the implementation of the AI-based HEMS

The sequence of steps as shown in figure 1 is explained below:

i. *Data Collection*: The first step in the design of a HEMS is to collect data about the energy consumption patterns of your home. This can is done by installing sensors and smart meters that measure the energy consumption of various appliances and device in the home, such as HVAC systems, lighting, and electronic devices. This data is then stored in a database for further analysis.
ii. *Data Analysis*: Once the data has been collected, it needs to be analyzed to identify energy consumption patterns and trends. This is where AI and machine learning algorithms come into play. These algorithms can analyze the data and identify patterns that would be difficult or impossible for a human to detect. The analysis can also help to identify the most energy-intensive appliances in your home and the times when energy consumption is at its highest.
iii. *Energy Usage Prediction*: With the data analysis complete, the next step is to use the insights gained from the analysis to predict future energy usage patterns. This is also done using AI and machine learning algorithms. The predictions help plan for future energy needs and identify opportunities for energy saving.
iv. *Energy Optimization*: Once the most energy-intensive appliances have been identified and have predicted

future energy usage patterns. Energy usage can be optimized. This involves a range of strategies, including turning off appliances when they are not in use, setting the thermostat to an optimal temperature, and scheduling energy-intensive tasks for times when energy usage is at its lowest. The goal is to reduce overall energy consumption while still meeting energy needs.

v. *Real-time Monitoring*: To ensure that energy optimization strategies are working as intended, we will need to monitor the energy usage in real-time. This can be done using a dashboard that displays real-time energy usage data and alerts the user to any unusual spikes in energy usage. Real-time monitoring can help to identify issues quickly and adjust as needed.

vi. *Energy Cost Reduction*: Finally, the ultimate goal is to reduce your energy costs. By collecting and analyzing data about energy usage patterns, predicting future energy needs, optimizing energy usage, and monitoring energy consumption in real-time, one can identify opportunities for energy savings and ultimately reduce energy costs.

Implementation of a Model to Reduce Energy Wastage through Detection of Standby Appliance

To implement a model for reducing energy wastage through the detection of appliances left in standby mode, the process is mainly in two parts:

i. *Appliance Priority*: Depending on the hour of the day, appliances are either high priority (H) or low priority (L) in terms of their priority. A high priority appliance is one that must be turned on at a specific time and remain in the "on" mode to continue operating. For instance, the light bulb is categorized as a high priority appliance. Conversely, if a low priority appliance is discovered to be in use, it must be switched off. These are devices that the user may not be using at a particular time.

ii. *Demand Limit*: In this sense, the demand limit at a given hour is the power consumption limit at that hour. The total consumption of all high priority appliances at any given hour constitutes the allowable consumption cap for that hour. A low priority appliance is likely to be triggered if this limit is surpassed, and the suggested energy management system responds by adjusting the consumption level by turning off the low priority appliances. Additionally, the energy management system makes sure that all standby appliances (on, Low and High) are "off"'. This it does by monitoring the time use of that particular appliance. It is clear that the demand limit setting and the appliance's priority are related.

The flowchart in figure 2, gives a step by step process of how the system detects appliances on standby mode and reduce energy wastage.

The flow chart process of reducing energy wastage through the detection of appliances left in standby mode ix explained below:

i. *Identify Appliances*: In this step, data is collected and analyzed and one identifies which appliances are in standby mode and consuming energy unnecessarily.

ii. *Schedule Appliances*: Appliances are then scheduled in relation to the user's preference and those operating outside the schedule are detected. If the appliance is on standby, the appliance is automatically switched off. If the appliance is not on.

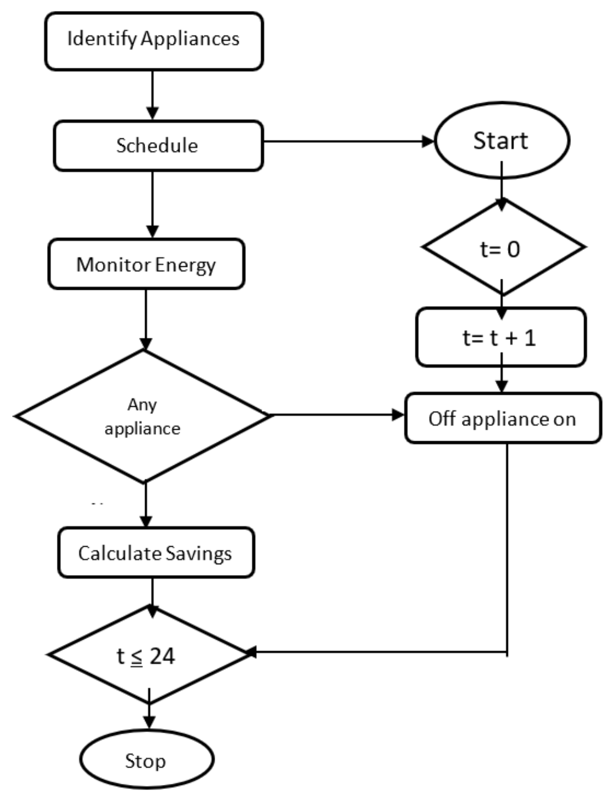


Fig. 2. Flow chart to show the process of reducing energy wastage through the detection of appliances left in standby mode

i. Standby, the system continues to monitor the energy usage.

ii. *Monitor Energy Usage*: In this step, the energy consumption of each appliance is monitored to measure the impact of the solution and determine if it is effectively reducing energy wastage.

i. *Calculate Savings*: Savings in energy consumption is then calculated.

In identifying and scheduling appliances, we check the wattage rating and standby power rating. This is important as the number and specifications of appliances vary across several homes due to differences in the manufacturer's design and the home's requirement.

Table 1 gives a list of appliances in the home, showing the appliance wattage and standby power. This data will help us in implementing an algorithm to control devices on standby.

Algorithm to Detect appliances on Standby Mode This code simulates the usage of appliances in a three-bedroom apartment; and calculates the energy savings after turning off

Table 1
The appliance rating in the house and the standby power

| | Appliances Power Ratings | |
|---|---|---|
| **Appliances** | **Appliance Wattage (W)** | **Appliances Standby Power (W)** |
| Entertainment | | |
| 43 inches LED TV | 58 | 0.3 |
| Thermal Comfort | | |
| Air conditioner | 1000 | 1.5 |
| Fan | 60 | 0 |
| Freezer | 220 | 0 |
| Electric Kettle | 1200 | 0 |
| Microwave | 600 | 3 |
| Pressing Iron | 1200 | 0 |
| Other Appliances | | |
| Phone Charging | 4 | 0.2 |
| Laptop Charging | 50 | 2.5 |
| Washing Machine | 500 | 1 |
| Blender | 450 | 0 |
| Lightning System | | |
| Panel lamps | 12 | 0 |
| LED Energy Saving Bulbs | 10 | 0 |
| Security Light | 50 | 0 |

the appliances in standby mode. The before list represents the appliances and their standby power consumption before turning off any appliances. The after list is a copy of before with the appliances that have been turned off in standby mode.

```python
import time

# define appliance power ratings
appliance_ratings = {
    'TV': {'active': 58, 'standby': 0.3},
    'DVD Player': {'active': 26, 'standby': 0.2},
    'Radio': {'active': 5, 'standby': 0.1},
    'AC': {'active': 1000, 'standby': 1.5},
    'Microwave': {'active': 600, 'standby': 3},
    'Phone Charging': {'active': 4, 'standby': 0.2},
    'Laptop Charging': {'active': 50, 'standby': 2.5},
    'Washing Machine': {'active': 500, 'standby': 1}
}

# define the decision tree to turn off appliances
def turn_off_appliances(standby_appliances):
    for appliance in standby_appliances:
        print("Turning off appliance:", appliance)
        # code to turn off the appliance goes here

# detect standby appliances and calculate energy savings
def detect_standby_appliances():
    standby_appliances = []
    energy_savings = 0

    # code to collect sensor/power data goes here
    # assume we have collected the data in a list called "sensor_data"

    for data in sensor_data:
        for appliance, ratings in appliance_ratings.items():
            if data[appliance] > ratings['active']:
                # appliance is in use
                break
        else:
            # no appliance is in use
            for appliance, ratings in appliance_ratings.items():
                if data[appliance] > ratings['standby']:
                    # appliance is in standby mode
                    standby_appliances.append(appliance)
                    energy_savings += ratings['active'] - ratings['standby']

    # turn off appliances in standby mode
    if standby_appliances:
        turn_off_appliances(standby_appliances)

    # return energy savings
    return energy_savings

# run the algorithm every 5 minutes
while True:
    energy_savings = detect_standby_appliances()
    print("Energy savings:", energy_savings, "W")
    time.sleep(300)  # sleep for 5 minutes
```

Fig. 3. Python code algorithm to detect appliances on standby mode

The "calculate energy savings" function takes the before and after lists as arguments, calculates the total wattage before and after turning off appliances, and displays the energy savings.

The "detect standby appliances" function is called to detect appliances in standby mode and turn them off. It takes the power data as input, detects which appliances are in standby mode based on their power consumption, and turns them off. The function returns the total energy savings in watts. The main loop of the algorithm reads the power data, detects standby appliances, and calculates the energy savings.

### *A. Simulation of an Intelligent Control Strategy for Home Users*

This aims at simulating an intelligent control strategy for home users as a tool for energy management. It involves using AI algorithms. The goal of the simulation is to demonstrate how the system can be used to improve energy efficiency and reduce energy waste in a typical household. The simulation would provide insights into how the system can be used to optimize energy consumption and provide a more sustainable solution for home energy management.

*The simulation involves several steps, including*:

i. *Data collection*: Collecting data on the usage patterns of devices, such as lights, HVAC systems, and appliances, as well as occupancy patterns, weather conditions, and energy consumption.
ii. *Algorithm development*: Developing AI algorithms that can analyze the collected data and predict energy consumption patterns.
iii. *Simulation*: Using python, we test and evaluate the performance of the control strategy. This include analyzing the results of the simulation to determine the effectiveness of the strategy in reducing energy waste and improving energy efficiency.
iv. *Optimization*: Refining the control strategy based on the results of the simulation, until the optimal solution is reached.

There are several approaches used for simulating intelligent control strategies such as Rule-based control strategy, Model-based control, Reinforcement learning etc. For the purpose of this project, we will be using the Rule- based control strategy.

### *B. Rule-based Control Strategy*

A rule-based control strategy is based on a set of predefined rules that determine the behavior of the system. It is a simple and straightforward approach to simulating an intelligent control strategy. It consists of a set of rules that dictate the behavior of the system based on specific conditions. For example, a rule might state that if the temperature in the room is above a certain threshold, the air conditioning should turn on

*Based on data, the AI predicts these set of rules*:

i. If the ambient temperature is above 23oCelcius, turn on the air conditioning.
ii. If the ambient temperature is below 23oCelcius, turn off the air conditioning.
iii. If the time is between 12 AM and 5 AM, turn off the lights.
iv. If the occupancy sensor detects a person in the room, turn on the lights.
v. If the motion sensor doesn't detect motion for about 30 minutes, turn off the lights.
vi. If the humidity inside the home is above 50% turn on the dehumidifier.

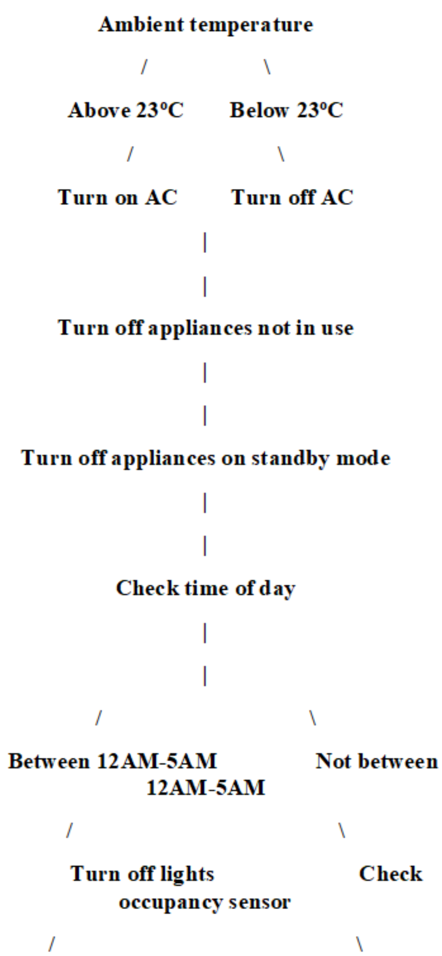


Fig. 4. Decision tree for the rule-based control strategy algorithm

vii. If the time is between 6:30 PM and 6:30 AM turn on the security lights.
viii. Turn off appliances when not in use.
ix. Turn off appliances on standby mode

### *C. Decision Tree*

A decision tree is a type of machine learning algorithm that is used to model decisions or decisions based on certain conditions. It is a tree-like graph that represents a series of decisions or conditions and their possible outcomes. It can be used to predict the outcome of a set of rules, based on the values of certain variables.

The tree consists of nodes and branches. Each node represents a test on a variable, and each branch represents the outcome of the test. The final leaves of the tree represent the predicted outcome, which can be a class label or a predicted value. The structure of the tree is determined based on the relationships between the variables and the target variable, as well as the algorithm used to build the tree.

In the case of this AI algorithm, the decision tree has nodes that test the values of the ambient temperature, the time, the occupancy sensor, the motion sensor, the humidity inside the home, and the state of the appliances.

Based on the results of these tests, the tree determines which actions to take, such as turning on or off the air conditioning, lights, dehumidifier, or security lights. The decision tree also has additional branches or nodes that consider turning off appliances when not in use or turning off appliances on standby mode. These branches are based on the state of the appliances and would determine if it is necessary to turn off any of the appliances based on whether they are in use or on standby. The decision tree is shown in figure 4.

The code is implemented using Python Programming. In writing, we first define the functions and with the rules, write the program to control devices in this apartment. This rule-based control function takes in the current state of the environment, such as temperature, time, occupancy, motion, humidity, and appliance states, and returns a dictionary of actions to be taken based on the rules.

The function checks each rule one by one, and if a rule applies, it adds an action to the dictionary. Finally, the function returns the dictionary of actions to be taken.

Note that I assumed the appliance states are represented as a dictionary with keys being the appliance names and values being the states of the appliances, which can be either "on", "off", or "standby". The program is given below in figure 5.

```python
# Define device control functions
def turn_on_air_conditioning():
    print("Turning on the air conditioning.")

def turn_off_air_conditioning():
    print("Turning off the air conditioning.")

def turn_on_lights():
    print("Turning on the lights.")

def turn_off_lights():
    print("Turning off the lights.")

def turn_on_dehumidifier():
    print("Turning on the dehumidifier.")

def turn_off_dehumidifier():
    print("Turning off the dehumidifier.")

def turn_on_security_lights():
    print("Turning on the security lights.")

def turn_off_security_lights():
    print("Turning off the security lights.")
```

```python
def turn_on_appliance(appliance_name):
    if appliance_name == "oven":
        print("Turning on the oven.")
        global oven_in_use
        oven_in_use = True
        global oven_on_standby
        oven_on_standby = False
    elif appliance_name == "washing_machine":
        print("Turning on the washing machine.")
        global washing_machine_in_use
        washing_machine_in_use = True
        global washing_machine_on_standby
        washing_machine_on_standby = False

def turn_off_appliance(appliance_name):
    if appliance_name == "oven":
        print("Turning off the oven.")
        global oven_in_use
        oven_in_use = False
        global oven_on_standby
        oven_on_standby = True
    elif appliance_name == "washing_machine":
        print("Turning off the washing machine.")
        global washing_machine_in_use
        washing_machine_in_use = False
        global washing_machine_on_standby
        washing_machine_on_standby = True
```

Fig. 5. Python algorithm to achieve control of appliances

As seen in figure 5, the main loop repeatedly reads the current state of the environment, calls the rule- based control function to get the actions to be taken, and then sends those actions to the appropriate devices. It also waits for a certain amount of time before reading the environment state again, in order to avoid constantly querying the sensors and devices.

An AI HEMS system typically consists of a central control unit that communicates with a variety of smart devices and appliances in the home. These devices can include smart thermostats, lighting systems, and appliances like washing machines, microwave, etc. The central control unit collects data from these devices and analyzes it using AI algorithms to determine the best way to manage energy consumption in the home. In this design, a homeowner recently installed an AI HEMS system in her home. On a typical weekday morning, she wakes up and starts getting ready for work. As she moves around the house, the AI HEMS system detects her presence and turns on the lights in the bathroom and kitchen and other places of utility. At the same time, the system adjusts the temperature in this house to her preferred setting. When she leaves for work, the AI HEMS system detects that she is no longer in the house and turns off the lights and adjusts the temperature to a more energy-efficient setting. The system also automatically turns off appliances and devices that are not in use, such as the television and the coffee maker. During the day, the AI HEMS system continues to monitor and optimize energy consumption in the home. In the evening, when the house owner returns home, the AI HEMS system detects her presence and adjusts the temperature and lighting in the house to her preferred settings. By constantly monitoring and optimizing energy consumption in the home, the AI HEMS system helps her save money on her utility bills and reduces her carbon footprint. Additionally, the system provides valuable insights into her energy consumption patterns, helping her make informed decisions about how to use energy more efficiently in the future.

### *D. Optimizing Energy Consumption*

From the proposed control strategy and standby detection approach, Energy will be greatly optimized as energy waste sources are eradicated.

Total Energy Consumption

$$E = P \, x \, t / 1000 \tag{1}$$

Where:

- E is the total energy consumption in Kilowatt- hour
- P is the power unit in Watts
- T is the time over which energy was consumed in hours

A full data analysis of the system is done to ascertain energy consumption for three cases: with implementation of AI HEMS, with implementation of a non-AI HEMS, and without any Energy Management system.

Cost of Energy will be calculated and reduced as Energy consumption reduces. To find the energy cost for this user, we find the category of the house according to PHED grouping.

This house falls under the Band B customers according to the PHED grouping. On an average, they have 16 hours of Power supply.

Table 2
The total appliance rating in the home

| | **Appliances Power Ratings** | |
|---|---|---|
| **Appliances** | **Appliance Wattage (W)** | **Appliances Standby Power (W)** |
| Entertainment | | |
| 43 inches LED TV | 58 | 0.3 |
| Thermal Comfort | | |
| Air conditioner | 1000 | 1.5 |
| Fan | 60 | 0 |
| Freezer | 220 | 0 |
| Electric Kettle | 1200 | 0 |
| Microwave | 600 | 3 |
| Pressing Iron | 1200 | 0 |
| Other Appliances | | |
| Phone Charging | 4 | 0.2 |
| Laptop Charging | 50 | 2.5 |
| Washing Machine | 500 | 1 |
| Blender | 450 | 0 |
| Lightning System | | |
| Panel lamps | 12 | 0 |
| LED Energy Saving Bulbs | 10 | 0 |
| Security Light | 50 | 0 |
| Total | 5414W= 5.414KW | 8.5W= 0.0085KW |

Table 3
Dataset of Energy consumption across several home appliances with AI-HEMS, Non-AI Hems and without HEMS for One Month

| Appliances | Appliance Wattage (in Watts) | Standby Power (in KW) | Quantity of Appliance | Total Wattage (in Watts) | Total Wattage (in KW) | Monthly Runtime with AI HEMS (in hrs.) | Monthly Runtime without HEMS (in hrs.) | Monthly Runtime for non- AI HEMS (in hrs.) | Standby Runtime (in hrs.) | Monthly Power consumption in Standby Mode (in KWH) | Monthly Power Consumption for AI HEMS (in KWH) | Monthly Power Consumption without AI HEMS (in KWH) | Monthly power consumption for non-AI HEMS (in KWH) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Television** | 58 | 0.0003 | 1 | 58 | 0.058 | 150 | 240 | 180 | 30 | 0.009 | 8.7 | 13.929 | 10.44 |
| **Air Conditioner** | 1000 | 0.0015 | 1 | 1000 | 1 | 120 | 250 | 150 | 15 | 0.0225 | 120 | 250.023 | 150 |
| **Fan** | 60 | 0 | 2 | 120 | 0.12 | 240 | 300 | 270 | 0 | 0 | 28.8 | 36 | 32.4 |
| **Freezer** | 220 | 0 | 1 | 220 | 0.22 | 300 | 480 | 380 | 0 | 0 | 66 | 105.6 | 83.6 |
| **Electric Kettle** | 1200 | 0 | 1 | 1200 | 1.2 | 2.5 | 3.5 | 3 | 0 | 0 | 3 | 4.2 | 3.6 |
| **Microwave** | 600 | 0.003 | 1 | 600 | 0.6 | 5 | 8 | 6 | 2.5 | 0.0075 | 3 | 4.8075 | 3.6 |
| **Pressing Iron** | 1200 | 0 | 1 | 1200 | 1.2 | 5 | 9 | 8 | 0 | 0 | 6 | 10.8 | 9.6 |
| **Phone Charging** | 4 | 0.0004 | 2 | 8 | 0.008 | 90 | 95 | 92 | 15 | 0.006 | 0.72 | 0.766 | 0.736 |
| **Laptop Charging** | 50 | 0.0025 | 1 | 50 | 0.05 | 60 | 80 | 65 | 15 | 0.0375 | 3 | 4.0375 | 3.25 |
| **Washing Machine** | 500 | 0.001 | 1 | 500 | 0.5 | 8 | 10 | 9.5 | 2 | 0.002 | 4 | 5.002 | 4.75 |
| **Blender** | 450 | 0 | 1 | 450 | 0.45 | 1 | 2 | 1.5 | 0 | 0 | 0.45 | 0.9 | 0.675 |
| **Panel Lamps** | 12 | 0 | 2 | 24 | 0.024 | 180 | 270 | 220 | 0 | 0 | 4.32 | 6.48 | 5.28 |
| **LED Energy Saving Bulbs** | 10 | 0 | 14 | 140 | 0.14 | 300 | 480 | 380 | 0 | 0 | 42 | 67.2 | 53.2 |
| **Security Light** | 50 | 0 | 2 | 100 | 0.1 | 360 | 480 | 420 | 0 | 0 | 36 | 48 | 42 |
| **Total** | | | | | | | | | | | **325.99** | **557.745** | **403.131** |

As at June, 2022, the tariff for band B user was increased from ₦49.72/kWh to ₦54.13/kWh (PUNCH, 2022)

Therefore, the average electricity bill for this apartment is given as:

$$Energy\ Consumption\ x\ Tariff\ (₦\ per\ KWh)$$

The reduction in cost will be seen when we calculate the electricity cost for three cases: with implementation of AI HEMS, with implementation of a non- AI HEMS, and without any Energy Management system.

The circuit diagram for the design is as shown in figure 6.

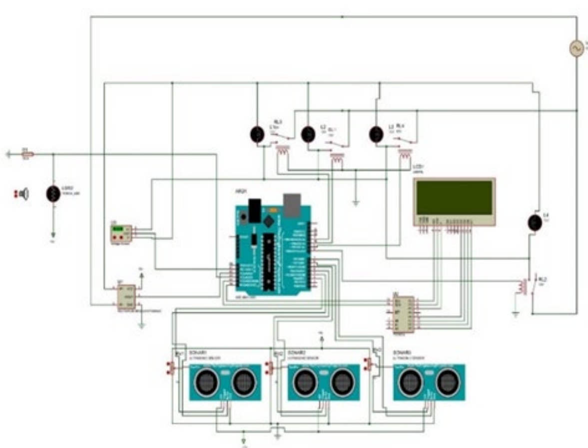

Fig. 6. Circuit diagram of the AI HEMS

## 4. Discussion

The dataset for the simulation process is as displayed in *Table 3* below. The first and second column gives the Appliance Wattage and standby power. The number count of appliances is recorded in column three and total wattage is gotten by multiplying the quantity by the appliance wattage and converting to kilowatt. The algorithm uses this data to simulate the daily hourly consumption of each appliance, the working status of the appliance and the total hourly consumption in a month. The monthly run time in each case is recorded, as well as the standby run time. The monthly Energy consumption for each case is gotten by multiplying the total wattage by the monthly run time for each appliance. The total Energy consumption of the home is recorded as a sum of energy consumptions of the individual appliances.

## 5. Conclusion

The energy consumption of the individual appliances in the home is clearly shown. In the three cases, the energy consumption varies across the appliance. The Energy consumption is highest when there is no Home Energy Management System; it is considerably lower with the implementation of Non- AI Home Energy Management System and it is lowest at impact of AI- based systems is that it can be programmed to respond to changes in energy usage in real-time, optimizing energy usage and reducing energy waste. Non-AI systems, on the other hand, often rely on manual inputs or pre-programmed settings that may not be as responsive or efficient as AI-based system. This work has been able to effectively reduce energy consumption and cost to a great extent and the model can be deployed and improved on for better results.

## 6. Recommendation

Further supportive research is required as there are limited related work on this subject. In future works, data can be collected electronically and simulation done over a minimum period of six (6) months for better predictions and analysis. The point where there is implementation of the proposed AI- based Home Energy Management System.

AI-based Home Energy management Systems tend to be more sophisticated and effective than traditional non-AI systems, due to the ability of AI algorithms to process large amounts of data and make complex decisions, allowing for more efficient energy management. The outstanding.

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