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Energy Efficient IoT Home Monitoring and Automation System (EE-HMA)

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***Abstract:** The paper focuses on using ICT tools for smart home applications. It presents the design and implementation of a system to monitor and analyze the energy consumption, utilize lights when needed, program the temperature by identifying inhabitants' absence and setting the temperature appropriately high or low. The system also uses colored LEDs to alert inhabitants of different parameters, to turn their loads on and off based on the cost of electricity use as well as to enable them to control some of their home appliances usage through a mobile application to reduce electricity usage and minimize energy waste.*

***Keywords:** mobile application, ICT tools*

I. INTRODUCTION

The use of energy has been a key in the development of the human society by helping to adapt to the environment. Energy is the main source of income in Saudi Arabia, and the world relies heavily on oil as a major source of energy. The consumption of energy has led to major threats to climate change, environmental pollution, and human health. Electricity is mostly generated by burning coal which is highly polluting. Carbon dioxide emission has skyrocketed in the current century, therefor it is the leading cause of smog, acid rain, and global warming. The increasing use of energy threatens the volume of oil exports, for that reason diversifying the energy sources and developing alternative and non-renewable sources of energy, including solar, wind and other forms of renewable energy should be taken into consideration. However, the improvement in the efficiency and rationalization of consumption remains one of the most important factors affecting the energy future in Saudi Arabia and the world. The Residential sector in Saudi Arabia consumes roughly equivalent to half of the country's electricity consumption, as shown in Figure 1.

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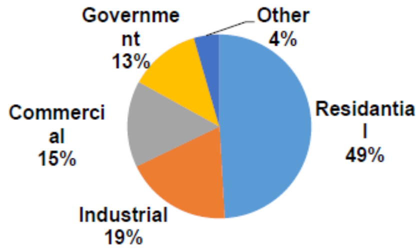


Figure 1 Distribution of consumption in Saudi Arabia

Utility companies are struggling to meet the demand and they are pursuing solutions thanks to the IoT. IoT is making energy use more efficient, which should help relieve some of the stress on energy demand. Hence, it is important to adopt the concept of smart home technology, which is all about the automation, management of daily life and -most of all- the enhancement of energy-efficiency. In this scene, the paper presents a smart home system that represents the most suitable solution to meet the contribution to energy savings, and provide minimize development costs.

The consumption of petroleum products has increased significantly in Saudi Arabia as a result of the increase in the population and the increase in the demand for electricity particularly in the summer. As shown in Figure 2, Saudi Arabia's oil consumption has risen 369% since 1980 to approximately three million barrels per day, exhausting its oil exports 2.

The electricity sector is the main consuming sector of oil 3. Saudi Arabia's primary energy consumption is based on oil and natural gas. As shown in Figure 3, Saudi Arabia uses oil to generate the majority of its electricity, with crude oil accounting for 29% of electricity production in 2013 (ECRA, 2014).

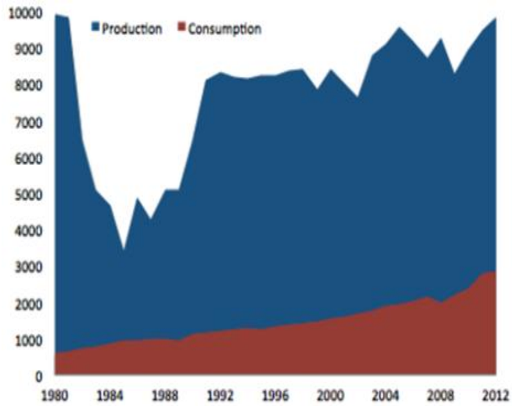


Figure 2 Saudi Arabian Oil Production vs Consumption (thousand bbl/day) 2

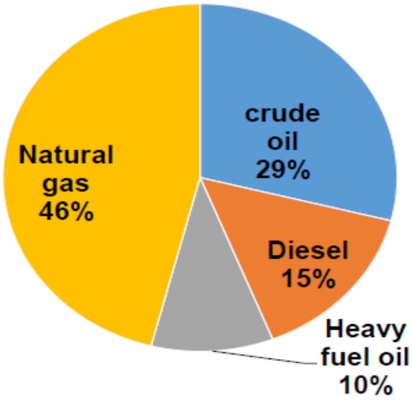


Figure 3 Saudi Arabia Power Generation Mix Source: Electricity & Cogeneration Regulatory Authority (ECRA) (2014)

Oil and natural gas are the kingdom's wealth. Therefore, preserving them is important. The high rate of energy consumption in a country indicates that the country is in an advanced standard of living, and therefore there is intense use of vehicles, air conditioners and electrical appliances. Since energy costs are more related to the amount of time the device is on than to how much current the device draws, it was estimated by the EIA that in peak summer months, the electricity consumption reaches its highest due to electricity demand for air conditioning.

Saudi Arabia has encountered a great economic growth in oil and gas resources in the past decades, and if domestic consumption rates continue in their current pathways, it is expected that there will be a decrease in oil exports, which in turn affects the oil revenues, which negatively affect the Saudi Arabia's ability in the future to maintain the current high levels of spending in

both investment and consumption 2.

The paper will present a system to help monitor energy consumption and minimize electricity bill costs. It will create a Home automation system that manages the energy by controlling different home appliances that are connected to the monitoring devices. This system will control lights, adjust temperature and will mainly focus on monitoring air conditioners, since they are the most energy consuming devices in Saudi Arabia. In addition this system will help provide information on the energy consumption of different appliances; these monitors will help consumers understand where and when the most energy is used, in order to allow developing strategies to reduce energy use and costs. The paper will present the related state of the art in section II. It will then present the related user and system requirements in section IV, followed by the mobile App design and development methodology in section V. Section VI will show the mobile App verification and testing and, finally, section VII will conclude the paper.

II. RELATED SOLUTIONS

Home automation refers to the application of computer and information technology for automatically control of home functions and features 4, or sometimes remotely control from users. The controlling can be done through interaction with the mobile application, by touching buttons or over voice control to turn lights on/off for example 5. There are various types of home automation applications that aim to provide convenience in such a way that the user does not need to struggle when he needs to switch on or off a device, which is very helpful for people with disabilities. Home automation reduces energy consumption and minimizes energy wastage. It also may result in safety benefits leading to improved quality of life as securing the home at anytime from anywhere, using motion sensors and cameras 4; each one of these types has its own benefits to the individual and society.

Homeowners do not want to have their smart home built from the ground up. Homeowners are interested in adding a bit of automation to their existing appliances by using a few plug-in modules and household electricity wiring to a wireless system then program it over the internet 6.

Measuring or monitoring household consumption is as simple as comparing and looking at bills in different times, but that will not help much due to belated information so user do not have the chance to get the idea that their consumption increased and so on.

The way to provide the user with an immediate information about their consumption is by using energy meter plugged in into appliances that shows the consumption in a current time, the feedback of consumption can be viewed through display monitors or mobile application. The Smart Metering Working Group estimated that energy meters offer more information to users, which could help reduce household consumption of energy with other potential benefits 7.

An experimental study analysis of electricity conservation demonstrated that both prompting and feedback techniques were effective in reducing daily electricity consumption, so with encouraging people to save electricity alongside with monitoring could make a change 8.

An old research has indicated that frequent feedback could reduce residential electricity consumption by 10% to 15 % 9. Back then feedback was primarily given in written form, this procedure might not be practical so if the form were replaced with electronic forms displayed through a mobile app as mentioned before then there is a big chance for reducing more than 15% on these days.

An IoT solution is a product (or set of products) combined with services that help in improving the efficiency of energy consumption; either by automation for all the appliances or by monitoring and keeping the user updated of each change in his daily (or any period) routine; because when things get measured then they can be managed.

Automation can be applied with a help of data received from simple (or complex) sensors and a program analyses them to automate actuators in an efficient way while ensuring comfort for users. Those systems take into account other parameters such as outside weather and real-time energy cost to lower the bills and save more energy 10. Each country follow different electricity pricing.Mentoring can be managed by doing comparison between the current usage and previous period's usage. The products that will be presented below have only services that monitor homes but have their benefits in saving more energy and lowering the bills.

The following subsection reviews most known smart home and other energy monitor products in the market that are most related to our proposed system with a table to compare their respective features.

Elan 11: Provides a detailed history of energy consumption, enabling the monitoring of usage and taking informed decisions without opening a single utility bill.

RTI 12: That system can controlled through mobile app or remote controls. It can provide home automation, for things like turning on/off lights. One switch can control up to five lights.

MONI Smart Security 13: They provide a scenario of using the system for their potential user in their website by showing the features and when to use it. They use smart thermostats that learn consumer habits and adjust automatically over time, and let them create schedules.

Creston 14: For luxury lifestyle, they have their own smart thermostat and light switches like others. User can set up scene (like turn-off all the light and level down the climate by 5 degrees by just one click) or customize the system by user's own schedule.

Control4 15: It have control over the lights and climate to either let the user use wired switch or wireless to control the appliances. Light can adjusted all at once or room by room.

Savant 16: As with the previously mentioned solutions, it has energy monitoring tools to keep track of electricity usage.

ADT Plus 17: Automate lights and thermostats that are connected to home system to limit energy waste. Notifications can be customized for anything the user want; via an app.

Vivint 18: Their thermostat can save $50 each month on electricity. Adjusting automation to the preferred settings for homeowners when they are at home or when they are away. Automatically changes the home temperatures when no one at home to slash energy costs, using geolocation, in-home sensors, and information about local climate.

URC 19: Their lights and thermostat are automated, they report energy savings every month, and it set schedules for temperature and lights based on different times (day, year, etc.).

Frontpoint 20: It maintains a history of the sensor readings in system logs and stores a complete historical home sensor data inventory.

Nest Thermostat 21: More than one system from the previous subsections use nest the smart thermostat for good automation over energy. It determines when energy costs are highest in user's particular area or time and adapts usage during those periods; to help homeowners save money and use less energy.

Sense 22: Home Energy Monitor, a small box that connects to home's electric panel and a smartphone application. It requires no connected devices.

The following table (Table 1) shows comparison between related works and the solution proposed in the paper (EE-HMA).

There are two classifications of the used appliances in homes:

1. Strict appliances: Strict appliances are appliances that the user does not want any automatic adjustments or schedule on it. Such as refrigerators, heating systems, air conditioners, entertainment devices, etc. 23.

2. Flexible appliance: Flexible appliances can be given a schedule time and run it at different times all day long. Such as washing machines, dishwashers or phone chargers, which are appliances needs to be run but stick to be used within a known timeframe sometimes (such as dishwasher needs to be used every day after 12 PM) 23.

Therefore the system will not be able to control the strict appliances against user's will. Monitoring strict appliances and alerting the user when exceeding a certain limit is enough. Nevertheless, for the flexible appliance, monitoring with automation will be more helpful since it will not affect the needs of the end-user. Each class of them has appliances that are classified as the most electricity consuming appliance, but that is different from one place to another or from one time to another (winter, summer, etc.). This project is going to focus on Saudi Arabia, due to the weather it has. Air conditioners come to be the most electricity consuming appliances in Saudi Arabia, as it consume 60% of total electricity consumption in the residential sector 24. Two approaches are employed to reduce residential energy consumption. Informational strategy which is based on providing information, and aims to alter an individual's knowledge or habits 25.

Table I. Comparison between related works

System	Mobile App	Scheduling	Energy Management	Home & Away Modes	Comments
RTI	Available	Available	Available	Available	Control the comfort, efficiency and safety of homes.
MONI	Available	Available	Available	Available	Handle lights and door locks, very good for security but just good for energy efficient.
Elan	Available	Available	Available	Available	Provides you with a history of the home's energy use.
Creston	Available	Available	Available	Available	The best in the market, but it has the largest hardware
Control4	Available	Available	Available	Available	Has a mobile app with a user interface that is identical to that on its touchscreen controllers.
Savant	Available	Available	Available	Available	Has energy monitoring tools so you can keep track of how much electricity the home uses
ADT Plus	Available	Available	Available	Available	User can turn off the system or turn on notifications of alerts, as they want.
Vivint	Available	Available	Available	Available	-
URC	Available	Available	Available	Available	URC's focus is on home comfort and controlling the finer things in homeowner's life.
Front point	Available	Not Available	Available	Not Available	-
Nest	Available	Available	Available	Available	Has auto-scheduling by learning technology
Sense	Available	Not Available	Not Available	Not Available	Figure out which devices in the home are drawing the most power automatically instead of the user getting an ammeter and manually measure the draw on each circuit.
EE-HMA (proposed solution)	Available	In progress	Available	Available	Not using smart meter that work outside the country and replace it with a system that help the people who lives in Saudi Arabia in particular by using electricity Saudi company levels to show the user their consumption of electricity on real time application.

It is assumed that mental changes will ultimately affect consumption behavior 26. The second strategy is the Structural strategies, which address the context of energy consumption (by providing incentives, for example) - effectively making the conservation or efficient use of energy more appealing to the individual 26. Informational Strategies keeps homeowners aware of their total energy that they are using at any time, which will gave them better response to that usage and take control of their costs.

The system is going to use colored LEDs to alert homeowners to different parameters, as well as the option to turn loads on and off based on the cost of electricity use. Homeowners can keep tabs on that information via smartphone. Structural strategies, in contrast is going to be obtained by monitoring and automating the appliance that are connected to the monitoring device. Sensor will monitor the energy usage in real time and sends that data wirelessly to the specified devices at home, including the monitor. This system is going to be based on a real-time application. The main heart of the system that does all data processing and decision making is a Raspberry Pi. It acquires data from the sensors and then actuate the devices such as LEDs and AC accordingly. The system is going to monitor energy consumption on the appliances that are colored in blue in the following Figure 4 that shows a Home Model Prototype of the system. Feedback on consumption is necessary for saving energy.

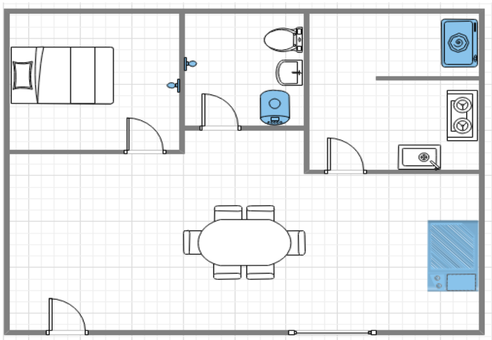


Figure 4 Home Model Prototype

A. Air Conditioner

A programmable thermostat helps regulate a home temperature at any time during any season whether the user is at home, asleep, or away. This system is going to offer the following settings:

- Setting the thermostat according to family schedule to automatically adjust the temperature at each of these times.
- Setting the temperature to drop by 8 degrees when users are away and sleeping in the winter. In the summer, set the temperature to go up by 7 degrees when users are away and 4 degree when they are sleeping. Turning the temperature way up or down won't help heat or cool the home any faster but it will make the system work overtime and can improve the energy bill 27.
- Making note of users' absence as to keep the temperature set at the energy savings set-points for long periods of time (at least seven or eight hours), can help consume unnecessary amounts of energy while away from home for several hours.

B. Lights

This system is going to offer the following settings:

- Turning lights off remotely.
- Turning outdoor-use lights off automatically at daylight such as pathway lights and porch lights.
- Turning outdoor-use lights off automatically based on users' presence in the home, such as pathway lights, step lights and porch lights.

C. Water Heaters

This system is going to offer the following settings:

- Adjusting the water heater thermostat at a convenient degree.
- Set water heater thermostat at 120ºF, which is also useful for slowing mineral buildup and corrosion in the water heater and pipes 28. Although some manufacturers set water heater thermostats at 140ºF, most households usually require less than that amount. Water heated at 140ºF also poses a safety hazard—scalding. 28

III. COLLECTION OF USER REQUIREMENTS

The purpose of the requirement and data gathering phase is to create an early well defined tasks to carry out the project, define its functionality, its input and output data.

In this phase, the method that will be used to collect information about the system is the Questionnaire. The questionnaire of this system was created using Google Forms services. It was designed to begin with a brief introduction about the proposed project and an explanation of the purpose of information collected followed by an approximate time on how long filling the whole questionnaire would take. The questionnaires were conducted to collect constitutive and qualitative data.

The data for the questionnaire was collected from 526 visually impaired persons in both genders. It was spread using social media sites and applications. Their ages range from 21 or less up to over 50 years old.

Figure 5 shows age of the majority of respondent range from 21 or less up to over 50 years old. And only 13% of people are 51 years old or older.

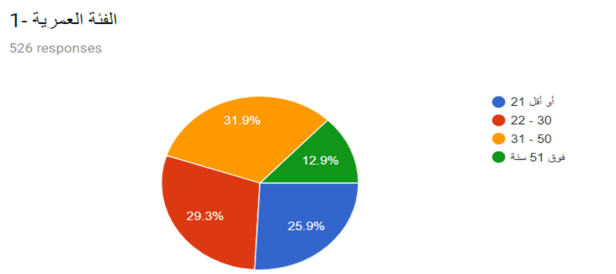


Figure 5 Pie Chart of Residents' Age

Figure 6 shows wither the respondents are living in a villa, apartment or other and half of the respondents are living in an apartment. That indicates the system should be able to work correctly in different residential building types, especially apartments.

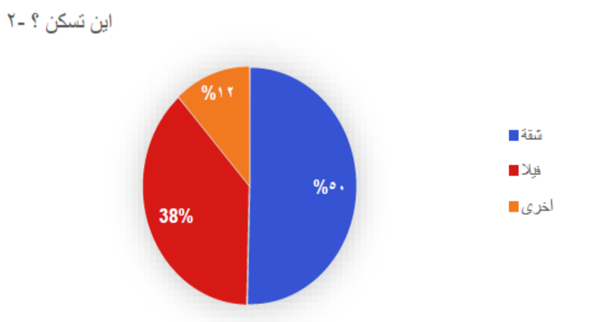


Figure 6 Pie Chart of Residents Living In Different Building Types

Figure 7 shows 77.4% of respondents find turning their lights on/off annoying when they are away from the light switch which indicate that the system should add the property of controlling the lights through an app.

Figure 7 Pie Chart of Controlling Lights Manually

Figure 8 shows that majority of respondents sometimes remember turning off outdoor-use lights (pathway lights, step lights and porch lights…etc.) before leaving home. This indicates that automation will improve efficiency for almost 50% of people. Therefore, the system should have the ability to turn outdoor-use lights off automatically at daylight.

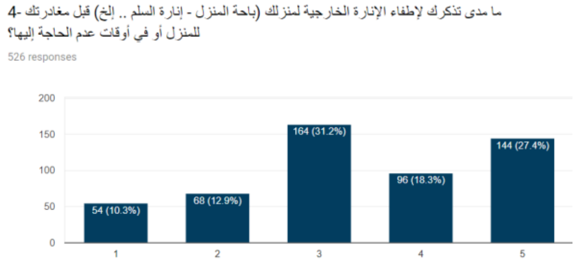


Figure 8 Pie Chart of Controlling Lights Manually

There are many types of air conditioners, split unit air conditioner and central unit air conditioner. Both units have thermostat unlike window air unit; this means the system have to add chips to the window air unit to add inelegance.

Figure 9 shows roughly half of residents have both of split unit air conditioner and window air conditioner. This indicates that the system should be able to work on both types of air conditioner system.

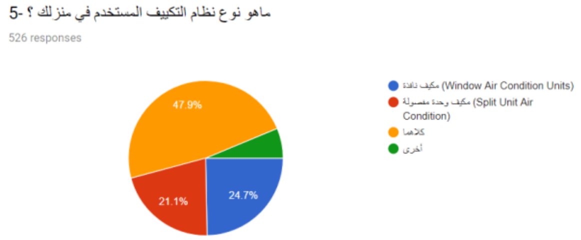


Figure 9 Pie Chart of Different ACs Type

Based on the above discussed literature review, the most consumed percentage of electricity and bill is the air conditioners. For that reason Figure 10 shows the approximate time of air conditioning that operates in a day. Nearly half of the residents turn their ACs on for 12 hours or more. This means the system is going to target air conditioners to lower electricity bill and do something about this excessive use.

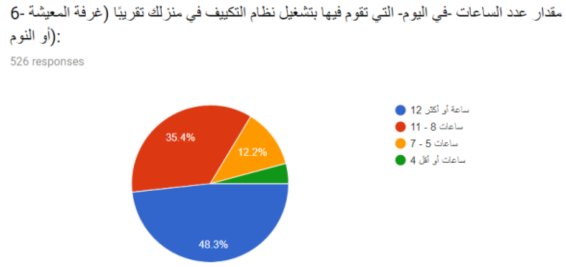


Figure 10 Pie Chart of Rate of ACs Working During Hours In Per Day

Figure 11 shows whether the residents are interested in the existence of a mobile application that allows them to control home appliances such as lights and air-conditioner, from outside or inside the house. It shows that 90% of residents are interested and this gives great encouragement to the system to build it.

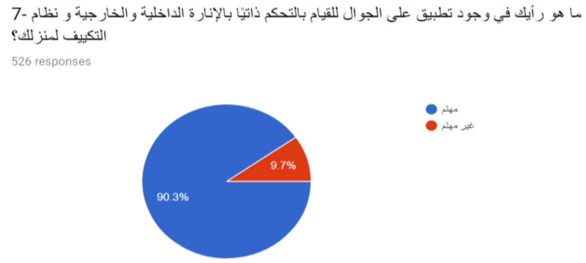


Figure 11 Pie Chart of Residents Impression on Automation System Existence

People need a motive to use a thing. To measure the motive for this system the following question was asked in Figure 12. It shows how much residents rate their house bill. If it is very high, high, normal or low. Almost half of the residents consider their home bill high. This gives indication that residents are going to have a motive to use the system.

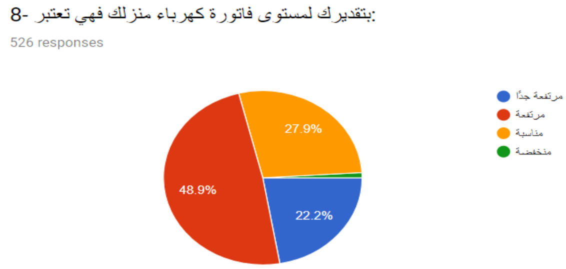


Figure 12 Pie Chart of Bill Home Rate

Figure 13 shows if the residents wish to have a system that could help them minimize their home cost bill. It shows that most of them wish to have it which gives great encouragement to the system to build it.

Figure 13 Pie Chart of Residents Impression on Lowering Home Bill Cost

Based on the literature review's research, mentoring help reduce the electricity bill. For that reason, the question in Figure 14 was asked. It shows if residents think that if they are aware of the total energy they consume at any time will it gave them better response to that usage and take control of their costs.The responses result supported these researches whereas 71% of residents agree. This indicates that the system is going to alert homeowners to different parameters

Figure 14 Pie Chart of Residents Impression on Monitoring

There was also a question in the questionnaire asking the residents how they can improve electricity consumption in their opinion. Most of the responses believe that if there was a system that could monitor and automate some appliances in their house via an app it could definitely help in improving the electricity consumption. A lot of responses mentioned the use of solar energy. One of the response also said that it would be very helpful if the system could send notifications every once in a while to tell the current status of home electricity. Some responses also mentioned that it would be very helpful if the system provides awareness about electricity consumption.

IV. SYSTEM REQUIREMENTS

This section defines the functional and system requirements of the proposed system. Functional requirements describe the main functional and nonfunctional requirements in the system. System requirements contain software and hardware requirements that should be considered in order to achieve the system goals. Functional requirements are gathered and specified by using the data gathering methods illustrated in the previous section. The identification of the users who are expected to utilize the system is as follows:

- Homeowner: A person who owns a home.
- User: A person who lives in a home but does not have access to all features.

The functional requirements for this system are divided into three categories:

A. Server functional requirements

- The system should be able to display the consumption information and alert the user when he exceeds different parameters.
- The system should be able to sum the measurements that come from the meter in every minute and store it.
- The system should be able to sum the minutes of measurement to create one hour measurement and store it in the database.
- The system should be able to sum the measurements of 24 hours and make it into one measurement and store it in the database as one day measurement.
- The system should turn outside lights off on daylight.
- The system should turning outdoor-use lights off automatically at daylight such as pathway lights and porch lights. The system should turning outdoor-use lights off automatically based on users' presence in the home, such as pathway lights, step lights and porch lights.

B. User functional requirements

- The user should be able to log in into the app.
- The user should be able to view all energy meters information.
- The user should be able to make a query about hourly consumption and view it as a graph.
- The user should be able to make a query about monthly consumption and view it as a graph.
- The user should be able to control the light (turn on or off) via mobile app.
- The user should be able to turn on/off consumption tips.

C. Admin functional requirements

- The admin should be able to log in into the app.
- The admin should be able to set the levels of consumptions.
- The admin should be able to add consumption tips

D. Non-functional requirements

- Response time: gives results to the user in a certain minimum time in such way that when the user want to know the energy consumption in specific time the result doesn't take longer than three second to appear.
- Availability: measures the amount of time that a server is running and available to respond to users, the server side must be running all the time to collect data of consumption from the sensors so no wrong results will appear.
- Usability: System's interface must be user-friendly, easy to interact with and clear for all users. It must show the consumptions data in a way that is clear to the user.

E. Data requirements

- Consumption date
- Hourly consumption data
- Monthly consumption data
- The maximum target or limit of energy consumption

The following use case diagram demonstrates the system functional requirements and the actors who can perform these functions. Figure 15 shows the use case diagram for the system. The user and the system administrator are the two actors for the system. The user can login then view daily consumption or monthly consumption, control lights and turn it on/off, turn on/off automation and view consumption tips. The system administrator can login with administrator account and set consumption targets.

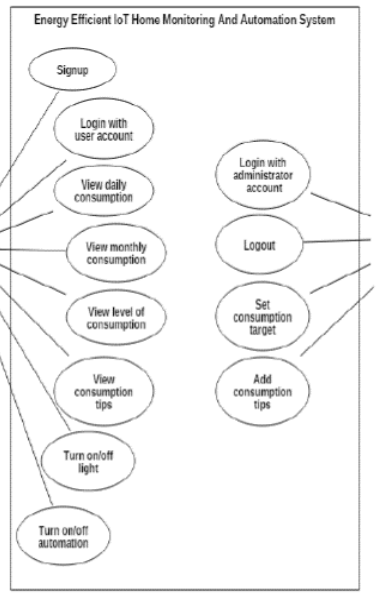


Figure 15 High-Level Architecture Diagram

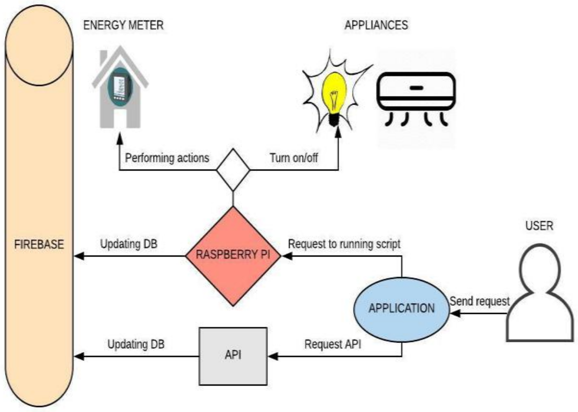


Figure 16 High-Level Architecture Diagram

V. SYSTEM DESIGN AND IMPLEMENTATION

Figure 16 shows the system architecture of the proposed system. It illustrates the whole system component and procedure with user interaction.

Figure 17 shows the sequence diagram of administrator login. The administrator must login with the correct name and password otherwise; he will not be able to login. If the authentication being accepted, the admin home page will be shown on the screen.

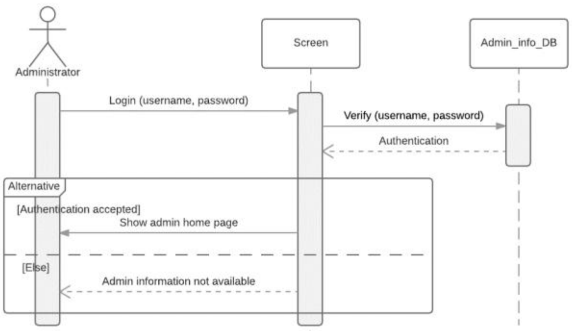


Figure 17 Administrator Login Sequence Diagram

Figure 18 shows the sequence of viewing consumption level. The user must be logged in and the registration procedures are correct. After the user request for viewing consumption level, the level of consumption will be shown in the home page screen.

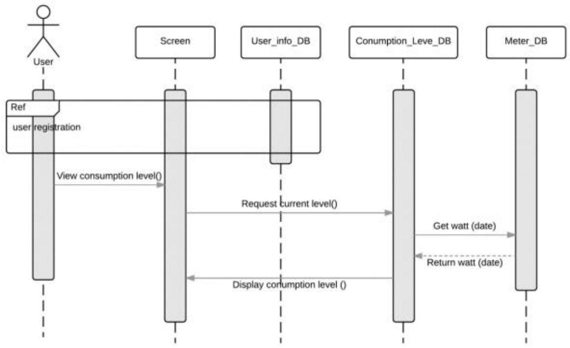


Figure 18 View Consumption Level Sequence Diagram

The remainder of the section will present the developed prototype Graphical User Interface. The home page is the first page that appears upon opening the app. As shown in Figure 19, the level of consumption is going to be displayed with an icon next to it, to guide the user to the help screen, as well as the main functions: view consumption, appliances and vies tips buttons.

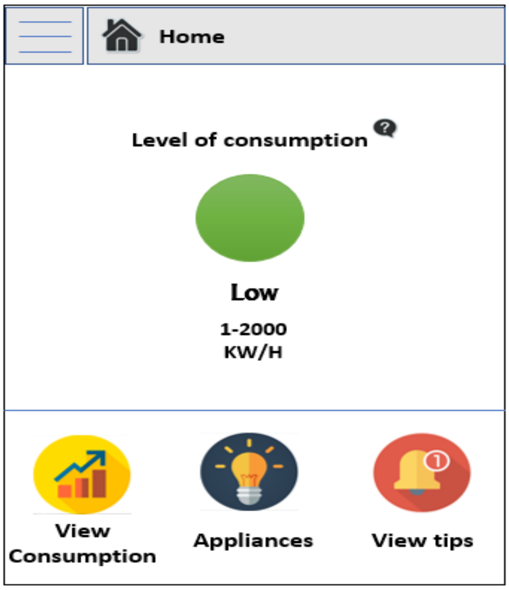


Figure 19 Home Screen Prototype

As shown in Figure 20, when the user click on (help) icon, an explanation of each level of colored consumptions levels will be shown. These levels have been developed by the Saudi Electricity Company to minimize the use of electricity in which the more user consume the more price of watt will increases. The system use colors that psychologically affect users.

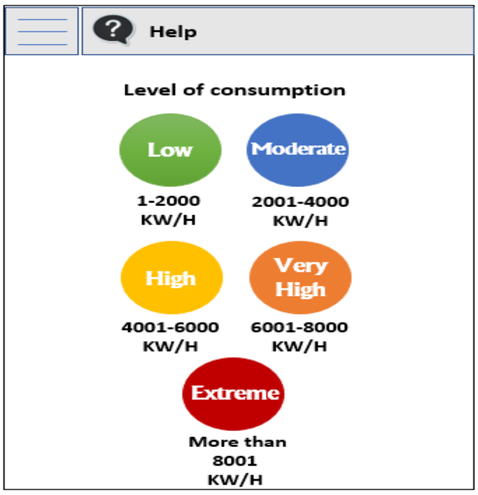


Figure 20 Help Screen Prototype

When the user click on (view consumption) button, he can either chose to view daily or monthly consumption as shown in Figure 21.

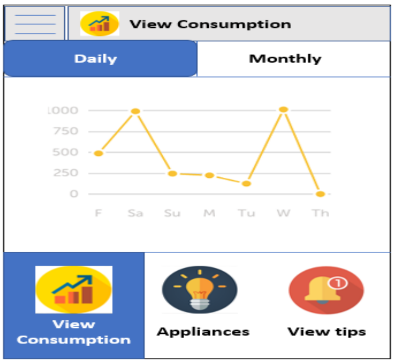


Figure 21 View Consumption Screen Prototype

When the user click on (Appliances) button, a list of appliances that can be controlled will be displayed as well as the auto control option for turning on/off automation as shown in Figure 22.

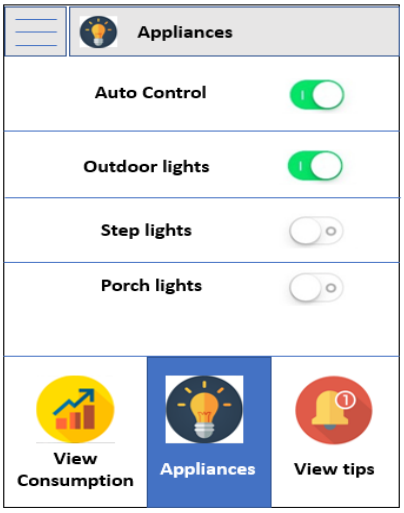


Figure 22 Appliances Screen Prototype

For the hardware platform, this system is going to use a computer running Windows operating system and it is going to use the Raspberry Pi for building the circuit. As for the software platform, it is going to use the Android studio to create the app.

The following components were considered in the prototype implementation:

- 4 Channel Relay Board

Relay board work as a mechanical switch, it can control various appliances and any equipment that requires large current, such as lights and fans.

- PIR Motion Sensor

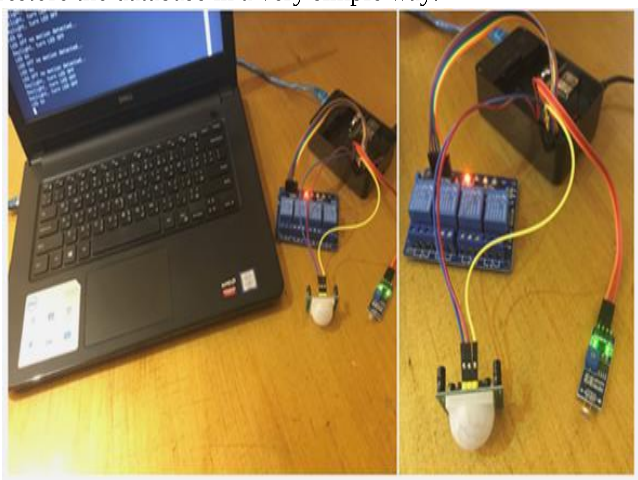
PIR motion sensors stand for passive infrared. They allow to sense motion and detect human movement within the sensors' range (about 6–7 meters).

- Light Sensor Module

The light sensor module is used to detect the intensity of light. The resistance of the sensor depends on the amount of light it is exposed to; the greater the intensity of light, the lower the resistance of LDR. The sensor has a potentiometer that can be used to adjust the sensitivity of LDR towards light.

To achieve the purpose of this system, the circuit is going to be made by connecting the module and sensors mentioned in the previous subsection (4-chanel relay board, PIR motion sensor and light module sensor) to the Raspberry Pi. Next, connecting the Raspberry Pi to the micro USB cable for powering it. After that connecting the Raspberry to the laptop via an Ethernet cable.

Figure 23 shows an overall view of the circuit connected together. For the backend design, this system is going to build a real-time app with Firebase as backend system as a service; according to its features and nature. Firebase features a real-time database, storage hosting, authentication system, push server and a lot more. Firebase is easy to use and allows to easily synchronize data between a phone app in real-time with minimal hassle. Firebase also allows to backup and restore the database in a very simple way.



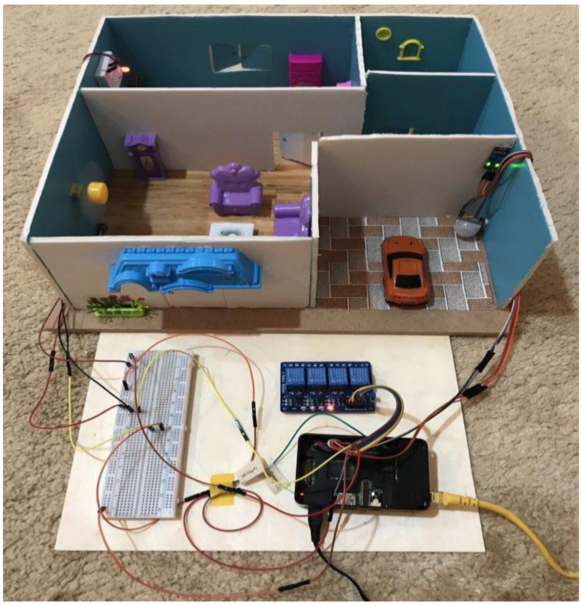


Figure 23 Interconnected prototype components

Figure 25 shows a real time database on Firebase after connecting the app with the project in the Firebase.

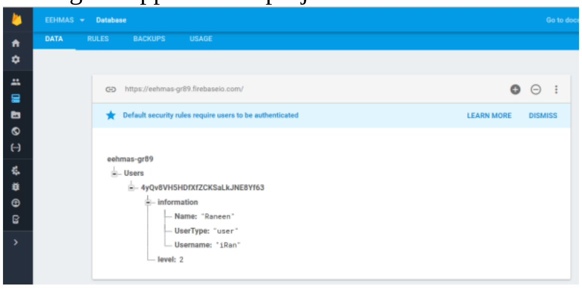


Figure 24 Real Time Database on Firebase

Figure 25 and Figure 26 show the implemented pages of the app.

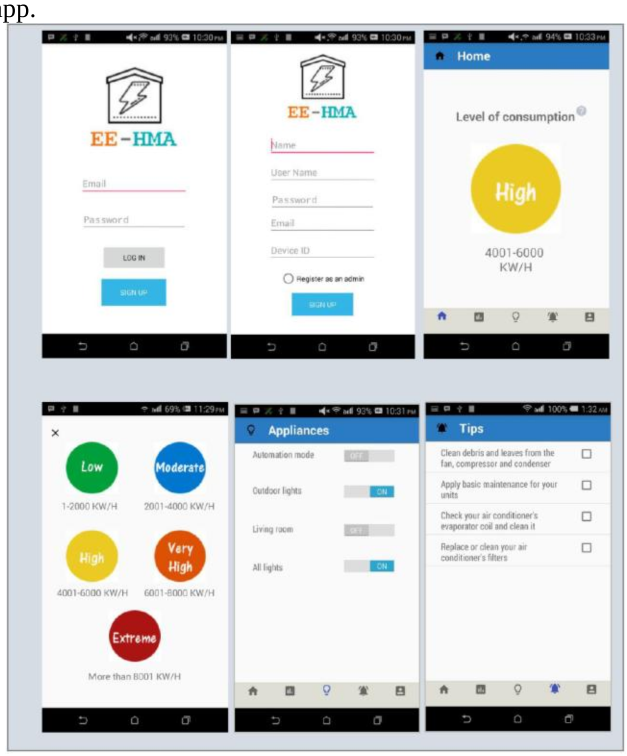


Figure 25 Implemented app pages (I)

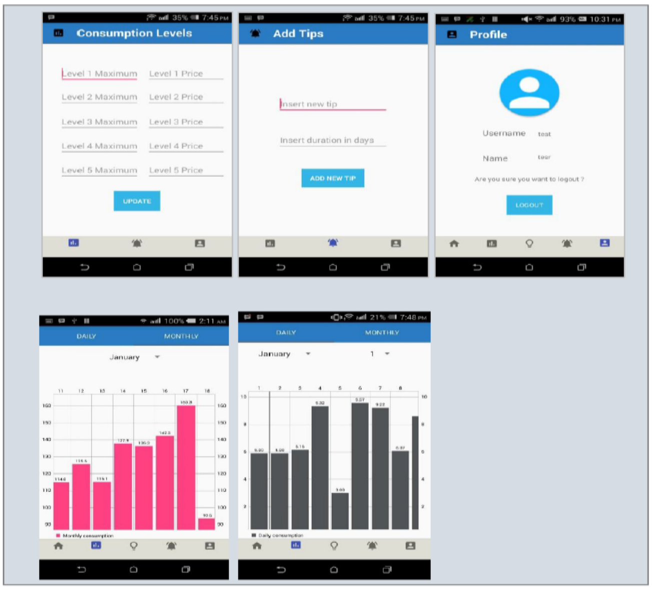


Figure 26 Implemented app pages (II)

VI. SYSTEM VERIFICATION AND TESTING

Usability test for the app has been done on Monday March 26, 2018, in King Abdulaziz University. The test aims to measure the usability of EE-HMA app interface and navigate among them. The test participants were students from King Abdulaziz University. The objective of this test is to evaluate the design of an app, if they can easily navigate through the menus.

The list of task scenarios for the main functions are divided into two type of users; admin and user.

For all the tasks, the measures we used to evaluate the performance of the tasks for the user are:

- Time for task completion.
- Repeat task.
- Number of times selecting wrong thing/error click.

There are three basic value levels to measure the time of completion, repeat task, and number of error clicks, which are:

- Excellent: means the task is easy to accomplish.
- Acceptable: means that the task is can be accomplish.
- Unacceptable: means that the task may not accomplish.

Scenario 1: You are an admin and you want to use the services of "EE-HMA" app as an admin, use these information:

- Email address: ghadii5@gmail.com
- Password: 123456

Scenario 2: The consumption level of Saudi Electricity Company has changed or the consumption level is not up to your preference. Update the consumption level in the app.

Scenario3: You have learned about a new tip that may help in reducing the energy consumption, but it is not existed in the tip page of the app. Go the tip page and add the new tip.

Scenario 4: You are a new user and you want to sign up to the "EE-HMA" app. Sign up to the app as a regular user.

Scenario 5: You want to know the state of the consumption level you have reached. Please go to the home page.
Scenario 6: You want to know the meaning of different consumption levels (colors) in the home page. Please go to the help page.
Scenario 7: You want to have a track of your daily consumption level. Please go to the daily consumption level page.
Scenario 8: You want to control your house appliances and turn on the automation mode. Pleases go to the appliances page.
Scenario 9: You want to check the tips in the app. Please go to tips page.
Scenario 10: You want to logout of the app. Please go to the profile page.
Table 2 shows the result analysis after each task. Each letter represent one of the word:
E: Excellent
A: Accepted
U: Unaccepted

Table II: Result analysis

Users\Tasks	T1	T2	T 3	T4	T 5	T6	T7	T8	T9	T10
Participant 1	E	A	E	E	E	E	E	E	E	E
Participant 2	E	E	E	E	E	E	E	A	E	E
Participant 3	E	E	E	E	E	E	E	E	E	E

The results show that the application passed the testing with encouraging results in all cases. At this stage, most of the functional requirements are fully implemented and tested.

VII CONCLUSIONS

In this paper, the EE-HMA system was presented, a system to reduce the excessive usage of electricity and lower home bill costs. In the process of creating this project, it followed the waterfall methodology. It started the system development life cycle, from phase one, planning, all the way to phase sex, testing. In the planning phase, it identified the problem, the solution for that problem and the related details, such as the goals and the objectives this system is trying to achieve, the work breakdown structure and the time table. The next phase is the analysis, it started by analyzing previous similar systems, gathering data, identifying requirements and system services. Then, came the design phase, it designed the diagrams, the interfaces, and clarified all the details needed for the next phase, implementation. In the implementation we performed all the tasks needed to produce the complete and functional prototype system. Finally, the testing phase, the system was tested against several cases, to assure its functionality and other performance metrics. In the future, EE-HMA can be extended by adding the following features:

- Provide the applications in different operating systems such as IOS; to make the system available for everyone.
- Allowing the functionality of adding the appliances or devices the homeowner wants.
- Defining the consumption of each device.

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