A PRODUCT DESIGN FOR : SMART HOME ENERGY MANAGEMENT

CMP 441 Human Computer Interface

Course Project - 2023/2024 Session

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Topic: Smart Home Energy Management App

INTRODUCTION

Problem Statement:
The problem this project aims to address are the difficulties homeowners face in accurately monitoring their energy consumption and forming strategies for efficiency and cost savings. Despite the availability of solutions, such as energy monitoring systems, they often face challenges due to complex interfaces and limited real-time insights into individual appliances' energy usage. This makes it arduous for homeowners to make informed decisions about managing their energy consumption effectively.

Proposed Solution:
Develop a smart home energy management app that provides homeowners with the tools and information needed to monitor, analyze, and optimize their energy consumption.
The application will feature:
    I. The ability to track and visualize energy usage in real-time,
    II. Indicate energy consumption patterns over time,
    III. Suggest actionable tips to reduce energy consumption.
    IV. Estimate energy costs based on usage and local utility rates.
    V. Alert users to unusual energy usage situations.

Users:
Homeowners: Individuals or families looking to manage their energy consumption.
Environment-conscious users: Individuals interested in reducing their environmental impact by reducing their electricity consumption.
Budget-Conscious Consumers: Homeowners looking to cut down energy costs.

Data Collection Methods:
The development of the application will require insights into users' expectations for the app and common energy usage patterns of homeowners. This includes understanding current practices, challenges faced, and desired features. This information will be gathered using the following survey tools:
Questionnaire: Gather insights into users' current energy consumption habits and expectations for a home energy management application.

Observation: Observe potential users making use of existing solutions to meet their energy consumption management goals in order to discover their challenges, and , and identify opportunities for improvement in their current practices.

The questions to be used in the questionnaire will be:

I. Are you a homeowner?

II. On average, how much money do you spend on electricity costs?

III. How often do you think about your energy consumption habits?

IV. Do you currently use any tools or apps to monitor or manage your home energy consumption? If yes, please specify.

V. What challenges, if any, do you face in managing your home energy consumption effectively?

VI. How interested are you in incorporating smart home technology to monitor and optimize your energy usage?

VII. What features do you expect in a home energy management application?

VIII. Would you be willing to adopt a new home energy management app if it proves to be effective and user-friendly?

Google forms will be used to send out the questionnaire among target audience (Homeowners)

Observation:

The observation will take place in a controlled environment and feature finding a small group of homeowners who are using any kind of technology, to monitor or manage your home energy consumption and observing their energy consumption management routine for set amount of time. The goal of this is to answer the questions:

What solutions are people currently using?

Who is using the technology at any particular time?

What are they doing with it?

Are they pleased with the existing solutions?

Does the technology aid the homeowners to meet their optimal energy consumption goals?

Over the course of the observation period, do existing solutions help homeowners get detailed insights into their energy consumption?

Notes will be taken to record daily observations of the activities of the sample of homeowners over the course of the observation period

Pilot Test Results

Questionnaire:

The participants responded positively to the questionnaire. They were able to answer all the questions without any issues and had no complaints about the questions themselves. Based on the reactions of the participants we believe the questionnaire may need minimal or no modifications before it is used for the actual data collection among our target audience.

Observation:

The subjects were willing to participate in the observation and understood the conditions required by the activity. However , the subjects were unable to accurately keep track of their power consumption because they had not previously made use of any detailed method of monitoring how much power they consumed. The subjects tried to perform the required activity during the observation but we were unable to get any usable data from the observation. This leads us to the conclusion that the observation conditions will need to be reworked before the actual data collection.

COMPLETED DATA COLLECTION

Questionnaire:

	A	B	C	D	E	F	G	H	I
1	Times	I. Are yc	I. On average, how r	How often do you	Do you currently us	What challenges, ii	What features do yc	Would yo	Would you p
2	1/5/20	No	0₦ - 10,000₦	Sometimes	No	Remembering to tu	Access to everythin	Yes	Mobile
3	1/5/20	No	11,000₦ - 50,000₦	Rarely	nope	funds	anywher anyplace c	Yes	Mobile
4	1/5/20	Yes	51,000₦ - 100,000₦	Sometimes	No	Not having a sumn	Energy consumptior	Yes	Mobile
5	1/5/20	Yes	11,000₦ - 50,000₦	Sometimes				Yes	Mobile
6	1/5/20	No	0₦ - 10,000₦	Sometimes	No		1. Estimated energy 2. Ability to pay to b 3. A wallet system v	Yes	Mobile
7	1/5/20	No	0₦ - 10,000₦	Rarely			kW used, amount in	Yes	Mobile
8	1/5/20	No	11,000₦ - 50,000₦	Often	No	Unexplained light u	Monitor each applia	Yes	Mobile
9	1/5/20	No	11,000₦ - 50,000₦	Sometimes				Yes	Mobile
10	1/5/20	No	0₦ - 10,000₦	Rarely	no	not knowing energy	Mobile alert on ener	Yes	Mobile
11	1/5/20	No	0₦ - 10,000₦	Often	No	None		Yes	Mobile
12	1/5/20	No	0₦ - 10,000₦	Often	No		Detailed per day inf	Yes	Mobile
13	1/5/20	Yes	11,000₦ - 50,000₦	Sometimes				Yes	Mobile
14	1/6/20	No	0₦ - 10,000₦	Rarely			I would like a featur	Yes	Mobile
15	1/6/20	Yes	51,000₦ - 100,000₦	Often	No	Leaving electrical a	I expect easy, efficie	Yes	Mobile
16	1/6/20	No	11,000₦ - 50,000₦	Sometimes	No	None	Statistics on energy	Yes	Mobile
17	1/6/20	No	0₦ - 10,000₦	Often	A Meter	Interrupted Power supply		Yes	Mobile
18	1/6/20	No	0₦ - 10,000₦	Rarely	No		An indicator or an a	Yes	Mobile
19	1/6/20	No	0₦ - 10,000₦	Rarely	No	Nothing really	Ability to monitor it	Yes	Mobile
20	1/6/20	No	0₦ - 10,000₦	Sometimes	No		No	Yes	Mobile
21	1/6/20	Yes	11,000₦ - 50,000₦	Often	no		to onow what takes	Yes	Mobile
22	1/6/20	Yes	11,000₦ - 50,000₦	Often				Yes	Mobile
23	1/6/20	Yes	11,000₦ - 50,000₦	Sometimes	No			Yes	Mobile
24	1/6/20	Yes	51,000₦ - 100,000₦	Often		None		Yes	Mobile
25	1/6/20	Yes	11,000₦ - 50,000₦	Often	No			Yes	Mobile

	Times	I. Are yo	I. On average, how	How often do you	Do you currently us	What challenges, if	What features do yo	Would yo	Would you pre
30	1/8/20	Yes	11,000₦ - 50,000₦	Often	No	Over use	Daily consumption l	Yes	Mobile
31	1/8/20	Yes	0₦ - 10,000₦	Rarely	No	Reloading whenev	I don't understand	Yes	Mobile
32	1/8/20	Yes	0₦ - 10,000₦	Often	No. Except the har	How to minimize c	A regulator to monit	Yes	Mobile
33	1/8/20	Yes	11,000₦ - 50,000₦	Sometimes	I don't know of any	Paying bill of what	Supervisory control	Yes	Desktop
34	1/8/20	Yes	0₦ - 10,000₦	Often	No	No control meter	Control meter	Yes	Mobile
35	1/8/20	Yes	11,000₦ - 50,000₦	Often	No			Yes	Mobile
36	1/8/20	No	0₦ - 10,000₦	Rarely	The meter monitor	Children and spous	Proper education	Yes	Mobile
37	1/8/20	Yes	11,000₦ - 50,000₦	Sometimes	No	Use of some equip	* Put off security ligh * Put off water pump	Yes	Mobile
38	1/8/20	Yes	11,000₦ - 50,000₦	Often	No	Nothing	Less power consum	Yes	Mobile
39	1/8/20	Yes	11,000₦ - 50,000₦	Sometimes	none	unaware of applian	detailed appliance p	Yes	Mobile
40	1/8/20	Yes	11,000₦ - 50,000₦	Often	Meter box		An alert system for	Yes	Mobile
41	1/8/20	Yes	0₦ - 10,000₦	Often	No	Having challenges	Metering devices	Yes	Mobile
42	1/8/20	Yes	0₦ - 10,000₦	Often	No			Yes	Mobile
43	1/8/20	Yes	51,000₦ - 100,000₦	Sometimes	No	Lack of regulation	Regular supply	Yes	Mobile
44	1/8/20		0₦ - 10,000₦		No			Yes	Mobile
45	1/8/20	Yes	0₦ - 10,000₦	Sometimes	No	No light	Constant light	Yes	Mobile
46	1/8/20	No	11,000₦ - 50,000₦	Often	NO	The use of pressin	Any user friendly fe	Yes	Mobile
47	1/8/20	No	11,000₦ - 50,000₦	Often	No			Yes	Desktop
48	1/8/20	Yes	11,000₦ - 50,000₦	Often	no	none	daily updates on en	Yes	Mobile
49	1/8/20	No	0₦ - 10,000₦	Often	None	Don't have a smart	Easy navigation	Yes	Mobile
50	1/8/20	No	0₦ - 10,000₦	Sometimes	Iron hi	Lack frequent electric ki		Yes	Mobile
51	1/8/20	No	0₦ - 10,000₦	Never	Nope	None	Not sure	Yes	Mobile
52	1/8/20	No	0₦ - 10,000₦	Rarely	Prepaid meter	Non	A feature that show	Yes	Mobile
53	1/8/20	No	51,000₦ - 100,000₦	Sometimes	No			Yes	Mobile
54	1/8/20	Yes	0₦ - 10,000₦	Often	No	Constant hike in er	Let the exact energy	Yes	Mobile

Observation:

CMP 441-HCI Assignment

CMP 441-HCI Assignment

Data Collection Observation Notes

Participants were instructed to use an electricity meter to evaluate their average electricity consumption over a specified 3-day period.

Following this assessment, participants will actively engage in endeavors to reduce this calculated average over the subsequent 3 days.

Throughout the reduction phase, participants were encouraged to document specific activities or behaviors contributing to heightened electricity consumption.

The objective was to pinpoint aspects of the energy management process that could be made more efficient using our proposed application to simplify and optimizing energy consumption practices.

This experiment involved five participants, and we derived the following insights from their engagement :

1. Subjects observed a decrease in their average power consumption by the conclusion of the observation period.
2. Subjects expressed difficulty in calculating their energy usage using an electricity meter, finding the process to be tedious.
3. Participants reported a tendency to refrain from using certain appliances, including electric kettles, TVs, electric fences, etc., during the observation period.

The observations revealed challenges participants faced in the activity, giving insights into features needed for the application to optimize energy management.

DATA ANALYSIS

Qualitative Analysis:

From our survey we had the following qualitative questions:

- What challenges, if any, do you face in managing your home energy consumption effectively?
- What features do you expect in a home energy management application?

To analyze our responses we make use of a deductive analysis method by categorizing the responses.

I.   What challenges, if any, do you face in managing your home energy consumption effectively?

From 36 responses, challenges faced by participants in managing home energy can be categorized into 3 sections.

Ignorance of appliance energy consumption	Lack of discipline to routinely turn off appliances	Miscellaneous
19	8	9

II. What features do you expect in a home energy management application?

From 39 responses, features expected by participants can be categorized into 3 sections

| Energy usage tracking/monitoring	Ability to control applications from the application	Miscellaneous
19	14	6

From our observation:

I.   Participants verbalized difficulty uncovering the energy consumption of electrical appliances

II. Participants verbalized difficulty tracking savings made at the end of the experiment.

Quantitative analysis:

From our survey we had the following quantitative results from certain questions:

I. Are you a homeowner?

57 responses

- Yes
- No

49.1%

50.9%
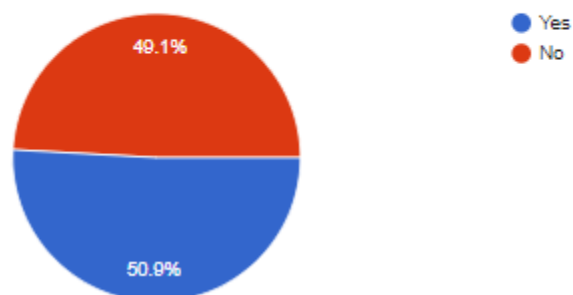
I. On average, how much money do you spend on electricity costs in a month?

58 responses

- 0₦ - 10,000₦
- 11,000₦ - 50,000₦
- 51,000₦ - 100,000₦
- More than 100,000₦

44.8%
8.6%
46.6%
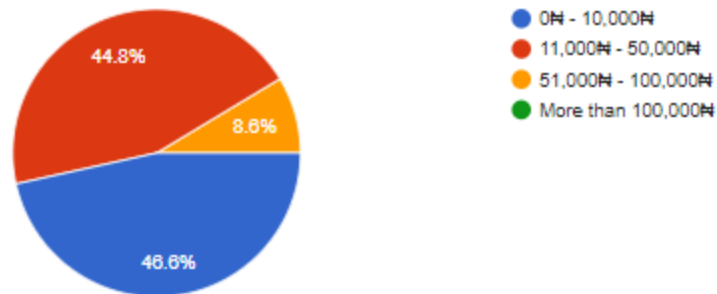
How often do you think about your energy consumption rate?

57 responses
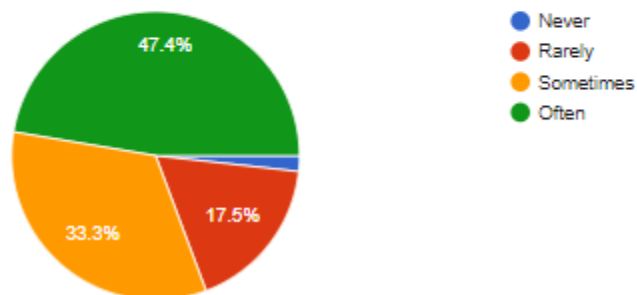
- Never
- Rarely
- Sometimes
- Often

47.4%
33.3%
17.5%

Would you be willing to adopt a new home energy management app if it proves to be effective and user-friendly?

57 responses

- Yes
- No

100%
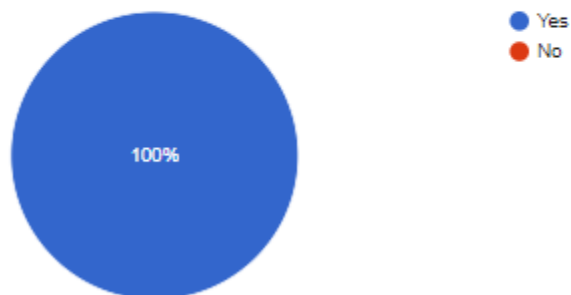
Would you prefer this App be a mobile application or a desktop application?

58 responses

- Mobile
- Desktop

96.6%

PRODUCT REQUIREMENTS

Question	Requirement ascertained from responses
What challenges, if any, do you face in managing your home energy consumption effectively?	Challenges faced by users suggest that the app design should assist users to identify what appliances cause high energy consumption and assist them in remaining budget-conscious of energy consumption Thus app design will require: A display of the detailed energy consumption of specific appliances A reminders/notification system
What features do you expect in a home energy management application?	The responses of the features expected by users indicate the app design should include features for effortlessly tracking appliance energy consumption. It should also assist user to gain a mindful conservative lifestyle, and offer control options for switching appliances on and off.. Thus app design will require: A display of energy consumption over specific periods of time. A device control dashboard
Observation scenario: Participants tried to reduce and track energy consumption over a time period	Challenges faced by users suggest that the app design should assist users to perceive significant positive changes resulting from its utilization. Thus app design will require: A feature to track cost-effectiveness gained from using app

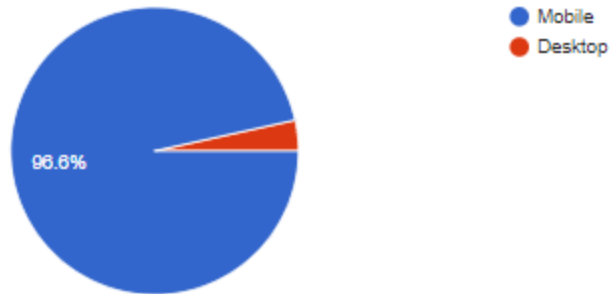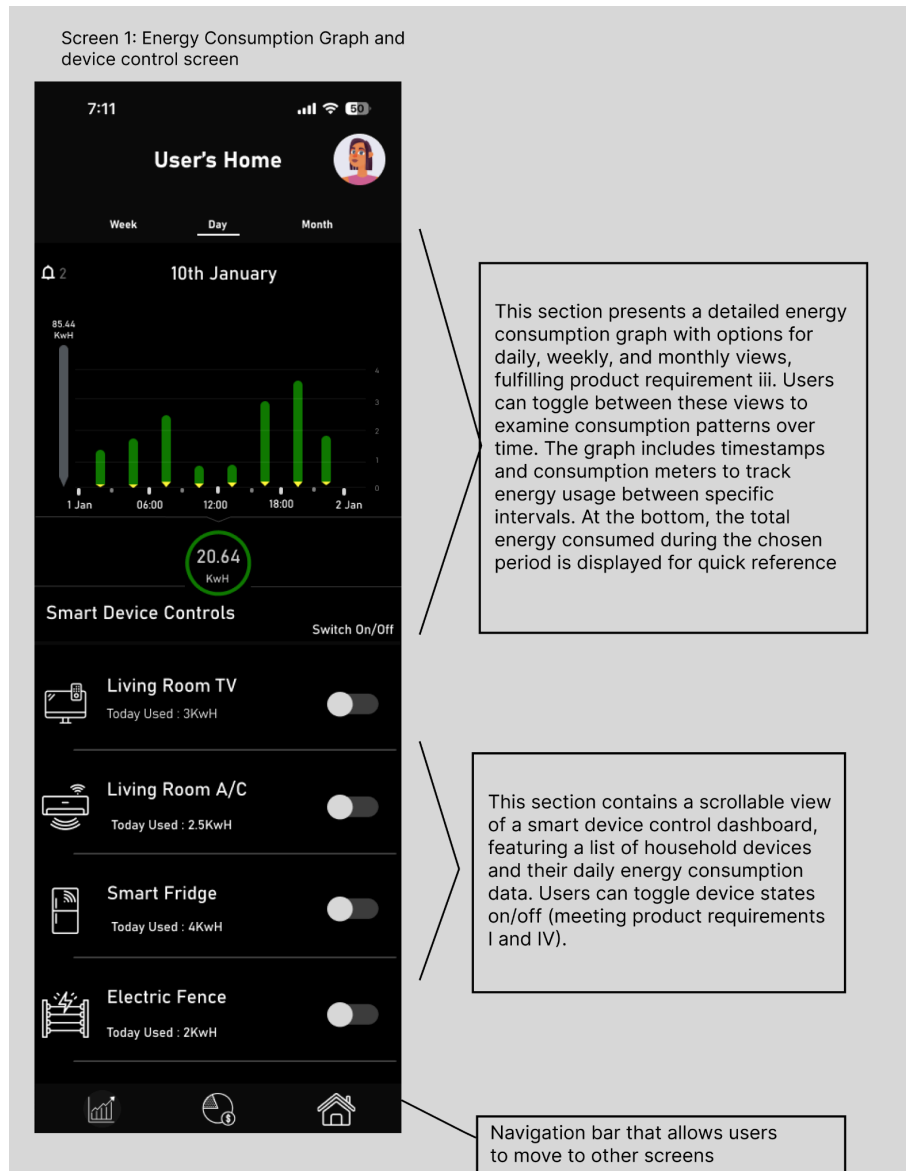|	
Are you a homeowner?	Responses indicate design will need to be tailored towards homeowners thus the design will require: A profile page to display profile of user's home
On average how much do you spend on electricity costs in a month?	For this app designed to address energy consumption issues, responses indicate the design will require: Ability to track costs paid for electricity over a term (monthly)
How often do you think about your energy consumption rate?	Responses indicate app design will require: Feature that provides reminders about energy consumption (I.e notifications)
Would you be willing to adopt a new home energy management app if it proves to be effective and user-friendly?	Responses indicate app design will need to be effective, user-friendly and intuitive to retain user's willingness to adopt app as a solution
Would you prefer this App be a mobile application or a desktop application?	Responses indicate users will prefer app to be a mobile application thus the app will be designed for mobile devices

Product requirement list:
- I. A display of the detailed energy consumption of specific appliances
- II. A reminders/notification system
- III. A display of energy consumption over specific periods of time.
- IV. A device control dashboard
- V. A feature to track cost-effectiveness gained from using app
- VI. A profile page to display profile of user's home
- VII. Ability to track costs paid for electricity over a term (monthly)
- VIII. Feature that provides reminders about energy consumption (i.e notifications)
- IX. User-friendly interface
- X. Designed for mobile device.

PRODUCT DESIGN

Screen 1: Energy Consumption Graph and device control screen

7:11

User's Home

Week   **Day**   Month

🔔 2   10th January

85.44 KwH

1 Jan   06:00   12:00   18:00   2 Jan

20.64 KwH

Smart Device Controls

Switch On/Off

Living Room TV
Today Used : 3KwH

Living Room A/C
Today Used : 2.5KwH

Smart Fridge
Today Used : 4KwH

Electric Fence
Today Used : 2KwH

This section presents a detailed energy consumption graph with options for daily, weekly, and monthly views, fulfilling product requirement iii. Users can toggle between these views to examine consumption patterns over time. The graph includes timestamps and consumption meters to track energy usage between specific intervals. At the bottom, the total energy consumed during the chosen period is displayed for quick reference

This section contains a scrollable view of a smart device control dashboard, featuring a list of household devices and their daily energy consumption data. Users can toggle device states on/off (meeting product requirements I and IV).

Navigation bar that allows users to move to other screens

Screen 1

Feedback Design Principle:

The device control tab design incorporates toggles which displays device state changes for user feedback: This ensures that users receive immediate feedback on the actions they perform. For example, when a user toggles a setting or activates a feature on Screen 1, the interface responds by clearly indicating the change in the device's state.
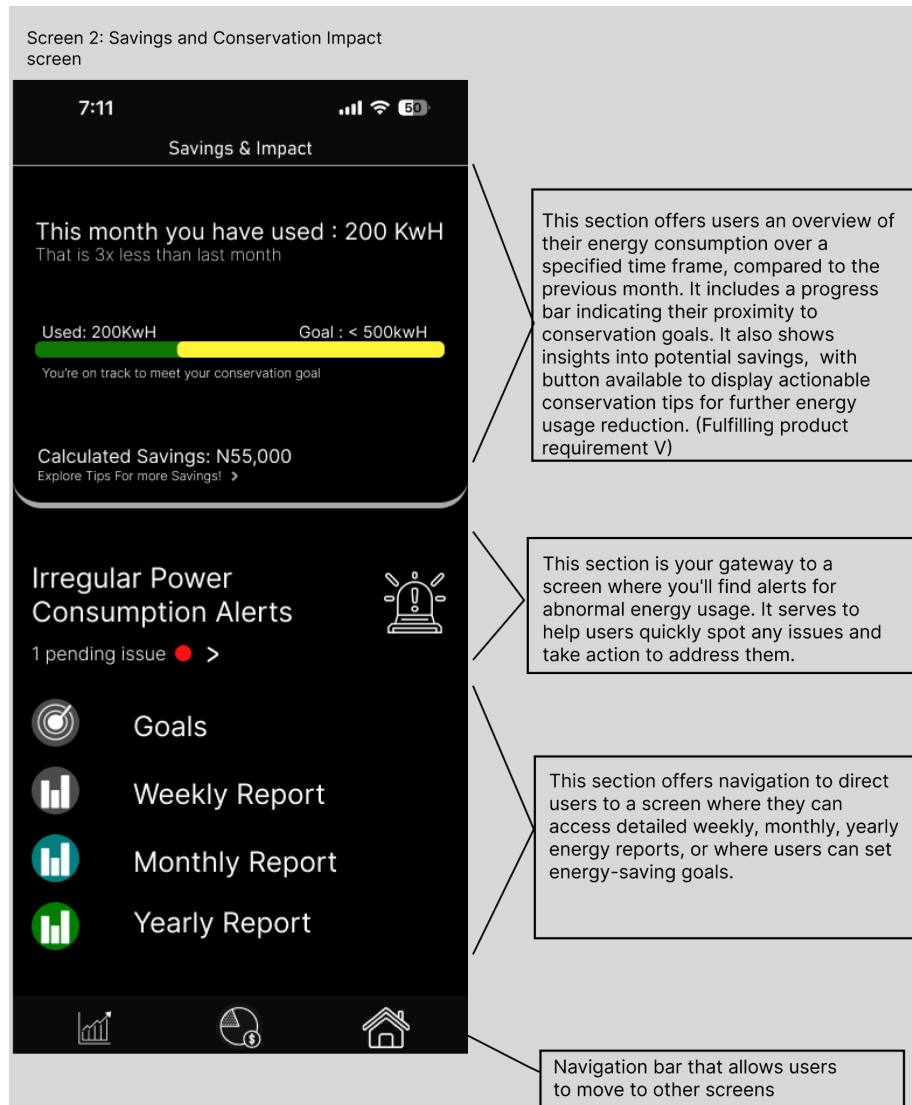
Navigability Design Principle:

The implementation of a navigation bar on Screen 1 adheres to the navigability design principle by facilitating effortless exploration and transition between different screens within the application. By organizing and presenting navigation options, users can intuitively navigate to

desired destinations without confusion or disorientation, thereby enhancing the overall user experience.

Findability Design Principle:

Essential information, like actual energy usage, is readily accessible on-screen: This design principle emphasizes the importance of making crucial information easily discoverable for users. On Screen 1, essential details such as real-time energy usage are prominently displayed, ensuring users can quickly locate and access relevant data without undue effort

Screen 2

Navigability Design Principle:

Screen 2 upholds the navigability design principle by incorporating a streamlined navigation system comprising a navigation bar and intuitive buttons. This design choice enables users to seamlessly navigate between different sections or screens within the application, fostering a smooth and intuitive user experience.

Findability Design Principle:

Key information, like calculated savings and conservation details, is displayed with clarity and priority in adherence to the findability design principle. By displaying these crucial data points, the interface ensures that users can easily locate and access relevant information, facilitating informed decision-making and enhancing user satisfaction.

Clarity Design Principle:

By minimizing unnecessary clutter and presenting information in a clear and straightforward manner, the interface enhances user comprehension and engagement. This ensures that users can quickly grasp the content without distraction or confusion.

Screen 4 : Alerts

7:11

Alerts

Navigation button that allows users to move to previous screen

Extended Energy Usage Alert:
10 Jan, 10 : 45
A device has been running for an extended period, this could lead to unnecessary energy consumption

High Energy Usage Alert
8 Jan, 14 : 21
A device energy consumption has spiked significantly, indicating potential wastage.

Extended Energy Usage Alert:
6 Jan, 10 : 45
A device has been running for an extended period, this could lead to unnecessary energy consumption

This section presents users with an overview of irregular energy usage alerts, complete with timestamps. These alerts may indicate either prolonged usage or high energy consumption, allowing users to monitor and optimize their energy usage effectively.

Extended Energy Usage Alert:
1 Jan, 12 : 58
A device has been running for an extended period, this could lead to unnecessary energy consumption

High Energy Usage Alert
1 Jan, 13 : 47
A device energy consumption has spiked significantly, indicating potential wastage.

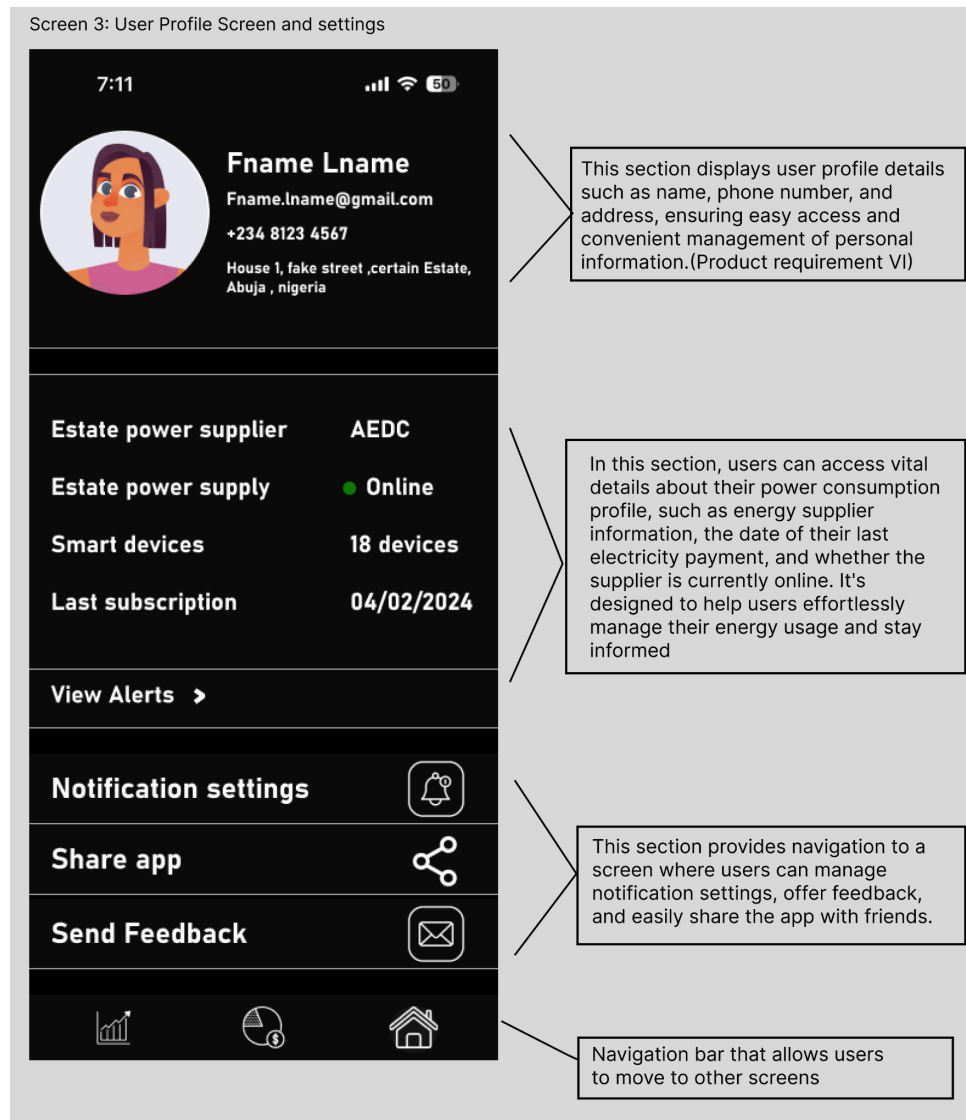Screen 3

Findability Design Principle:
Usage alerts are prominently displayed for quick identification: This principle ensures that energy usage alerts are prominently showcased on the interface, enabling users to swiftly identify and address any issues or anomalies.

Visibility Design Principle:
Screen 3 adheres to this principle by ensuring that critical information, such as the cause of abnormal energy alerts and the time noticed, is presented in a clearly. Enhancing the visibility of key details, enables users to quickly grasp pertinent information and make informed decisions.

Navigability Design Principle:
The navigability design principle is upheld in Screen 3 through the inclusion of a button that facilitates easy navigation back to the previous screen.

Screen 3: User Profile Screen and settings

7:11

Fname Lname
Fname.lname@gmail.com
+234 8123 4567
House 1, fake street ,certain Estate, Abuja , nigeria

This section displays user profile details such as name, phone number, and address, ensuring easy access and convenient management of personal information.(Product requirement VI)

Estate power supplier   AEDC
Estate power supply   ● Online
Smart devices   18 devices
Last subscription   04/02/2024

View Alerts ›

In this section, users can access vital details about their power consumption profile, such as energy supplier information, the date of their last electricity payment, and whether the supplier is currently online. It's designed to help users effortlessly manage their energy usage and stay informed

Notification settings

Share app

Send Feedback

This section provides navigation to a screen where users can manage notification settings, offer feedback, and easily share the app with friends.

Navigation bar that allows users to move to other screens

Screen 4

Visibility Design Principle:
Screen 4 prioritizes the visibility of profile information, ensuring that essential details are prominently displayed and easily accessible to users. By making profile information readily visible, the interface enhances user awareness and facilitates quick access to important personal data, thereby improving overall usability and user satisfaction.

Clarity Design Principle:
Screen 4 emphasizes simplicity and conciseness in presenting profile information. By avoiding unnecessary clutter and extraneous elements, the interface ensures that users can focus on essential profile details without distraction, enhancing comprehension and usability.

Consistency Design Principle:
Screen 4 maintains consistency by logically grouping specific parts of the interface together based on their functionality or significance. By organizing related elements in a cohesive manner, the interface enhances user understanding and navigational predictability, fostering a consistent and intuitive user experience across different sections of the application.

PRODUCT DESIGN EVALUATION

The evaluation method employed for this product design is a cognitive walkthrough, a comprehensive approach that enables us to simulate how individuals navigate problem-solving processes at each step of a human-computer interaction while predicting users' problems without doing user testing.

Cognitive walkthrough activities:

Step 1

Identifying typical users:

- Homeowners who want to reduce energy consumption costs.

Identifying typical tasks:

- Tracking device energy usage at specific times.
- Tracking cost savings gained by using application.

Step 2

We play the role of the evaluators performing a cognitive walkthrough to determine the user's perspective

Step 3 (Determining the primary action of users)

The first action will probably be to open the app and monitor the user's energy usage for that day.

Q: Will users know what to do?

A: Yes. They want to monitor energy usage, and the usage chart is located on the main page

Q: Will they see how to do it?

A: Yes. From the chart they can see timestamps that show how much energy is being used at a certain time.

Q: Will they understand from the feedback provided how much energy is being consumed?

A: Yes. The chart is easily understood with the usage rate corresponding to an indicated amount used at a certain time.

Step 4 (Determining the secondary action of users)

The secondary action will probably be to use other functions within the app i.e Using smart device controls, viewing energy usage alerts and assessing effectiveness of using the app.

Q: Will users know what to do?

A: Yes. The smart device control section is visible, as well as the navigation bar that leads to other screens with other features.

Q: What feedback will they receive by interacting with other components?

A: The users can see that they have toggled device state on the control section. From the other sections they can see the savings and effectiveness of using the app or the user's profile.

Q:After the action is performed, will users see that progress is made toward the goal?

A: Yes. There are visible components that help users visualize the returns of using the application