Smart Home System

Stage 1 Report

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1.Requirements

1.1 Introduction

This document outlines the development of the Peaches Software Smart Home System, an innovative home control system for monitoring energy usage and controlling smart appliances. The system aims to promote energy consumption awareness and support efficient household energy management.

This documentation serves as a guide for the Peaches Software development team, detailing technical specifications, functional requirements, and design considerations of the system. It ensures that all team members are aligned on the system's features, architecture, and development process.

Additionally, this document is intended for review by the client, Dr. Alistair McConnell. It explains how the system will meet the client's expectations and promotes transparency in the development process.

Through clear documentation of the system requirements, design and development, we can make informed decisions and ensure the delivery of a user-friendly smart home system for all households.

1.2 Purpose

The purpose of the system is to:

- Support sustainability goals by helping users become more aware of their energy usage patterns.
- Promote energy conservation through clear data insights and energy-saving recommendations.
- Simplify smart home management by integrating robots and smart devices into a single interface.
- Enhance quality of life through automation and energy management tools.

1.3 Scope

The Smart Home System is designed to optimise energy consumption, monitor the use of robots and smart appliances, and provide insights into household energy usage. It is intended for users of all ages and will be accessible on various platforms, including mobile devices and desktops.

The development of the system, starting from requirement specification through design and implementation, will begin on the 20th of September 2024 and is scheduled to be completed by 21st of March 2025. Primary features will include:

- Real-time monitoring and management of energy usage and generation.
- Control of internet-enabled robots and smart appliances.
- Display of energy and device usage statistics.
- Automated controls and energy-saving recommendations.

The scope of the project does not include:

- Installation of the smart devices, robots or systems.
- Maintenance of third party devices or robots or software.

The system will be limited to managing energy usage within residential settings and may not be suitable for industrial or commercial use. It will focus on integrating with common smart home devices and energy metres, with the potential for future expansions.

1.4 Aims and Objectives

Aims

- To develop an innovative and user-friendly smart home control system.
- To promote energy-saving behaviour through our smart home system.
- To reduce overall energy consumption in housing.

Objectives

- Develop an easy-to-use smart home system that tracks energy generation and energy usage of smart devices.
- Enable users to monitor and control their energy usage.
- Analyze collected data on energy generation, energy usage and appliance utilisation.
- Provide users with detailed analytics on energy generation and consumption.

1.5 User Requirements

Use Case Diagram

(See Appendix A1 for the Use Case Diagram)

Activity Diagrams

(See Appendix A2, A3 and A4 for the Activity Diagrams)

1.5.1 User Functional Requirements

Table 1

Functional User Requirements

ID	Requirements	Priority
Viewing Energy Generation, Energy Usage, And Usage Time Data		
F–UR1	Users should be able to see the overall energy usage and generation data for the whole house of the current day, week, or month in the form of a graph (energy usage and generation plotted against time) and an energy profile. (average of the data, peak of the data, total of the data)	Must
F-UR2	Users should be able to see energy usage and activity (when the devices are activated and when they are not) data of the current day, week, or month for individual devices in the form of a graph (energy usage plotted against time, whilst activity is shown by the colour of the line) and a energy profile. (average of the data, peak of the data, total of the data)	Must
F-UR3	Users should be able to see energy generation data of the current day, week, or month for individual energy generation units in the form of a graph (energy generation plotted against time) and an energy profile. (average of the data, peak of the data)	Must
F-UR4	Users should be able to compare overall home energy usage data of current time periods to past time periods (current day, week, or month compared to other specified day, week, or month) on a graph. (the same on as F-UR1, F-UR2, and F-UR3)	Could
F-UR5	Users should be able to see predicted future energy usage and generation trends of the whole house of the next day, week, or month based on the current and past days, weeks, or months.	Could
F-UR6	Users should be able to see the statuses of individual devices and energy generation units.	Must
F-UR7	Privileged users should be able to view: - Net energy generation/usage. - Cost/profit estimation. - Percentage of total energy used by individual devices of the total. - Detailed energy usage and energy generation data in the form of a table. - Of the selected time period. (specified day to specified day)	Could
Device Controls		
F-UR8	Users should be able to control individual devices.	Must
F-UR9	Users should be able to create time based automations for individual devices. (triggered during specified time)	Could
F-UR10	Users should be able to create event based automations for individual devices. (triggered by controls or activities of other devices)	Could
F-UR11	Users should be able to control devices through voice commands.	Won’t
Incentives To Save Energy		
F-UR12	Users should be engaged with an optional game to encourage energy saving behaviour. A virtual garden that can be decorated and expanded with game currencies earned from net	Could

	positive energy generation in the home.	
F-UR13	Privileged users should be able to set monthly energy usage limits for the whole house and individual devices.	Could
F-UR14	Users should be able to share overall monthly usage statistics of the home to social media.	Could
Additional Quality Of Life Functionalities		
F-UR15	Users should be warned for unexpected energy generation (if it is lower than usual) or usage behaviours (unusual spikes of energy consumption) from energy generation units or devices.	Could
F-UR16	Users should receive weekly and monthly reports on energy usage and generation (total energy usage and generation, devices using the most energy), and suggestions from the system.	Could
F-UR17	Users should be able to access all notifications, warnings and suggestions in one place.	Could
F-UR18	Users should be able to access help and FAQs.	Could
Account		
F-UR19	Users should be able to create, delete and manage their accounts.	Must
F-UR20	Users should be able to login and logout of their account.	Should
F-UR21	Users should be able to recover their password.	Could
F-UR22	Users should be able to change their password.	Could
Smart Home Management		
F-UR23	Users should be able to create, delete and manage their smart homes.	Must
F-UR24	Users should be able to join and leave smart homes.	Must
F-UR25	Users should be able to see a list of smart homes they are part of.	Must
Privileged Access Controls		
F-UR26	Homeowner and Privileged users should be able to give or revoke privileged access from other users.	Must
F-UR27	Homeowner and Privileged users should be able to add or remove smart appliances.	Must

1.5.2 User Non-Functional Requirements

Table 2

User Non-Functional Requirements

Usability		
NF-UR1	The system should be easy to use with minimal training.	Must
NF-UR2	The interface should look modern and attractive.	Should
NF-UR3	The system should provide helpful guidance and clear error messages.	Must
Performance		
NF-UR4	The system should respond quickly to user actions.	Must
NF-UR5	Information should load quickly from the server.	Must
NF-UR6	The system should work well even with many users.	Must
NF-UR7	The system should work well even with many connected devices.	Should
Reliability		
NF-UR7	The system should be highly available.	Must
NF-UR8	The system should handle errors gracefully and recover quickly.	Must
Compatibility And Portability		
NF-UR9	The system should work on different devices and browsers.	Must
NF-UR10	The system should adapt to different screen sizes.	Should
Security And Privacy		
NF-UR11	Collection and analysis of data should be privacy friendly and secure.	Must
NF-UR12	Users should be able to access or remove their data if needed.	Must
NF-UR13	System should be secure from common external attacks.	Must
Legal And Compliances		
NF-UR14	The system should have strong security measures to protect user information.	Must
NF-UR15	The system should follow all relevant laws and regulations.	Must

NF-UR16	The system should clearly explain its terms and policies to users.	Should
Maintainability		
NF-UR17	The system should be easy to update and maintain.	Must
NF-UR18	The system should be able to grow as more users join.	Must
Backup And Recovery		
NF-UR19	The system should keep user data safe with regular backups.	Must

1.6 System Requirements

1.6.1 System Functional Requirement

Table 3

Functional System Requirements

ID	Requirements	Priority
F-SR 0.1	System shall collect and store energy usage and activity data from individual devices at regular intervals. (every 15 minutes)	Must
F-SR 0.2	System shall collect and store energy generation data from energy generation units at regular intervals. (every 15 minutes)	Must
F-SR 0.3	System shall compute and store the overall energy generation and energy usage data for the whole house based on the collected energy usage and energy generation data at regular intervals. (every 15 minutes)	Must
Viewing Energy Generation, Energy Usage, And Usage Time Data		
F-SR 1.1	System shall retrieve energy usage and generation data from the database for the whole house, based on the current selected time frame. (or month by default if nothing is selected yet)	Must
F-SR 1.2	System shall display the data in the form of a graph. (energy usage and generation plotted against time)	Must
F-SR 1.3	System shall compute the average of the data, the highest energy usage per lesser time period (day if week or month is selected, hour if day is selected), the total energy usage, and total energy generated, and display this data in the form of an energy profile.	Must
F-SR 1.4	System shall provide options for different time frames (day, week, month), and should re-run F-SR1.1 and F-SR1.2 if a different time frame from the current one is selected.	Must
F-SR 2.1	System shall retrieve energy usage and activity data from the database for the selected device, based on the current selected time frame. (or month by default if nothing is selected yet)	Must
F-SR 2.2	System shall display the data in the form of a graph. (energy usage plotted against time, part of the line when the device was active should be green, red if it was inactive, and grey	Must

	if the device was disconnected)	
F-SR 2.3	System shall compute the average energy usage, the highest energy usage per lesser time period (day if week or month is selected, hour if day is selected), the total energy usage, and the total active time of the device and display this data in the form of a summarised energy profile.	Must
F-SR 2.4	System shall provide options for different time frames (day, week, month), and should re-run F-SR2.1 and F-SR2.2 if a different time frame from the current one is selected.	Must
F-SR 3.1	System shall retrieve energy generation data from the database for the selected energy generation unit, based on the current selected time frame. (or month by default if nothing is selected yet)	Must
F-SR 3.2	System shall display the data in the form of a graph. (energy generation plotted against time)	Must
F-SR 3.3	System shall compute the average energy generation, the highest energy generated per lesser time period (day if week or month is selected, hour if day is selected), and the total energy generated, and display this data in the form of a summarised energy profile.	Must
F-SR 3.4	System shall provide options for different time frames (day, week, month), and should re-run F-SR3.1 and F-SR3.2 if a different time frame from the current one is selected.	Must
F-SR 4.1	System shall provide an option for users to select a time frame and a date. (must be before the current date)	Could
F-SR 4.2	System shall retrieve overall energy usage data for the whole house for the selected time frame of the current time period and the selected date.	Could
F-SR 4.3	System shall display the data in the form of a graph. (energy usage of current time period and selected date time period against time)	Could
F-SR 5.1	System shall retrieve energy usage and generation data for the whole house from the past 6 x selected time period. (day, week, or month (default))	Could
F-SR 5.2	System shall use the retrieved data to predict the energy usage and generation trend of the upcoming selected time period. (day, week, or month (default))	Could
F-SR 5.3	System shall display the predicted energy usage and generation trends on a graph. (two lines, energy usage and generation plotted against time)	Could
F-SR 5.4	System shall provide options to choose between the next day, next week, or next month.	Could
F-SR 6.1	System shall call every connected device and energy generation unit, if there is at least one client application active, every 5 seconds, keep a temporary store of their statuses. (active, inactive, disconnected), and send it to active client devices on every collection (5 seconds).	Must
F-SR 6.2	System shall display a list of connected devices and energy generation units and their status (active, inactive, disconnected), and update the displayed statuses every 5 seconds. (refer to F-SR6.1)	Must
F-SR 7.1	System shall retrieve energy generation and energy usage data within the selected time periods. (specified day to specified day, or current month if nothing is selected) System should display the following: - By default, data for the current month shall be retrieved if no specific time period is selected. - If a custom time period is selected, data shall be retrieved from the specified start	Could

	date to the specified end date.	
F-SR 7.2	System shall calculate the net energy generation or usage, and use this information to calculate a probable cost or profit. Calculate net energy usage is to subtract total energy usage from total energy generation for a specific period. To determine cost or profit: - If net balance is negative (more energy used), calculate cost based on current electricity rates. - If net balance is positive (more energy generated), calculate potential profit from selling excess energy to the grid.	Could
F-SR 7.3	The system will calculate the percentage of total household energy consumed by each connected device for a given time period, store these percentages, and use them for later display and analysis. Steps involved are: - Obtain the total energy consumed by the entire household during the specified period. - Obtain the energy consumption of each connected device within the household during the same period. - For each device, divide its energy usage by the total household energy usage and multiply by 100 to determine the percentage contribution. - Save the calculated percentages for future reference and analysis.	Could
F-SR 7.4	The system will provide a clear and concise overview of the household's energy usage and potential savings. This information will be presented in a user-friendly format, such as a summary table or dashboard. - The calculated net energy generation or usage. - The calculated cost or profit. - The list of connected devices with their percentage energy usage.	Could
F-SR 7.5	The system allows users to customise the time period for energy data analysis. Select a start and end date to focus on a specific range. The system ensures the end date is after the start date. Once a custom period is selected, the system processes energy data for that period following the steps outlined in F-SR7.1 through F-SR7.4, updating calculations, visualisations, and reports. If no custom period is selected, the current month is used by default.	Could
Device Controls		
F-SR 8.1	System shall retrieve and store the current status (on/off, mode, temperature settings, etc.) and control options for each connected device every 10 seconds. This information shall be used to populate the user interface with accurate, real-time device data.	Must
F-SR 8.2	System shall provide a user interface that displays the current status of each connected device and allows users to interact with available control options. The interface shall be updated in real-time based on the data retrieved in F-SR8.1.	Must
F-SR 8.3	Upon user interaction with a device control, the system shall immediately send the appropriate command to the respective device and update the user interface to reflect the requested change.	Must
F-SR 9.1	System shall provide a user interface for scheduling automated device actions. This will allow for the following features: - Allows users to select when actions should occur (daily, weekly, etc.) and at specific times. - Enable selection of multiple device-action pairs from dropdown menus. - Implement logic to ensure device selection precedes action selection. - Validate and save only complete device-action pairs and triggers with associated	Should

	actions. - Discard incomplete entries upon user exit from the scheduling interface.	
F-SR 9.2	System shall execute scheduled device actions: - Store valid schedules in a database. - Implement a scheduler to track and trigger actions at specified times. - Send appropriate commands to devices when scheduled times are reached. - Provide feedback to users on successful execution or any errors encountered.	Should
F-SR 9.3	System shall allow users to view, edit, and delete existing schedules: - Display a list of all current device action schedules. - Provide options to modify frequency, time, or device-action pairs for existing schedules. - Allow users to remove schedules entirely. - Update the schedule database immediately upon user modifications.	Should
F-SR 10.1	System shall provide a user interface for creating and managing device automation rules with the following features: - Allow users to specify trigger conditions. (e.g., time-based, device status changes, environmental factors) - Enable users to define actions for one or more devices. - Ensure trigger conditions are set before allowing users to define actions. - Validate and save only complete automation rules with valid trigger-action pairs. - Allow users to view, edit, and delete existing automation rules. - Execute automation rules in real-time when trigger conditions are met. - Log all automated actions and provide a history of rule executions.	Should
F-SR 10.2	System shall execute and monitor automation rules: - Continuously evaluate trigger conditions for all active automation rules. - When a trigger condition is met, execute the corresponding device actions immediately. - Log each rule execution, including the trigger condition met, actions taken, and timestamp.	Should
F-SR 10.3	System shall provide real-time notifications to users when automation rules are executed.	Should
F-SR 10.4	System shall handle multiple triggered rules simultaneously, prioritising based on user-defined importance or creation order.	Should
F-SR 10.5	System should implement error handling to manage cases where device actions cannot be completed.	Should
F-SR 10.6	System shall update the user interface to reflect the current state of devices after automation rule execution.	Should
F-SR 10.7	System should allow users to temporarily disable specific automation rules without deleting them.	Should
F-SR 10.8	System shall provide a summary of automation rule executions, including frequency and success rate, for user review.	Should
F-SR 11.1	System shall implement a voice command interface for device control and energy management.	Could
F-SR 11.2	System shall receive and process voice data sent from client devices.	Could
F-SR 11.3	System shall utilise speech-to-text technology to accurately transcribe voice commands.	Could
F-SR 11.4	System shall employ natural language processing to extract relevant keywords and intent	Could

	from transcribed text.	
F-SR 11.5	System shall match extracted keywords and intent to predefined command patterns for device control and energy management functions.	Could
F-SR 11.6	System shall execute appropriate actions based on the interpreted command. (e.g., adjust device settings, retrieve energy data)	Could
F-SR 11.7	System shall send feedback to the client device, confirming the executed action or requesting clarification if the command is ambiguous.	Could
Incentives To Save Energy		
F-SR 12.1	System should update the user's game currency daily: - During 12:00 am everyday, the system should compile all the energy usage and energy generation. - Calculate the net energy usage by using data compiled. - The total net energy usage will be converted into in-game currency. - Currency in accounts is not shareable with other accounts. - Users cannot check on other users' account currency. - Currency will be stored safely and it is protected even though there is a temporary system shutdown or network disconnection.	Could
F-SR 12.2	There is a in-game store where users can spend their in-game currency: - The stores will provide decoration for the garden if users spend their in-game currency. - The decoration in the store will be updated weekly. - The decoration will have different prices, the higher the price, the higher its value. - The decoration can be sold back to the store with prices lower than its sold value.	Could
F-SR 12.3	There will be a virtual garden display in the system: - Able to arrange their decoration freely in their virtual garden. - Able to move their decoration even after the users have placed them. - Able to see the marks of their garden by accumulating all the value of their decoration. - Able to visit the virtual garden of other users and interact with them. - The virtual garden includes a ranking board that displays energy-saving performance rankings.	Could
F-SR 13.1	System shall allow privileged users to set limits for individual devices or the whole house.	Must
F-SR13.2	System shall provide options to specify time frames for the limits. (e.g., daily, weekly, monthly)	Must
F-SR 13.3	System shall store and display a list of all set limits.	Must
F-SR13.4	System shall continuously monitor energy consumption and compare it to set limits.	Must
F-SR13.5	System shall send notifications to users when energy consumption approaches or exceeds set limits.	Must
F-SR13.6	System shall provide visual indicators in the user interface showing current consumption relative to set limits.	Must
F-SR13.7	System shall allow privileged users to modify or remove existing limits.	Must
F-SR14.1	System shall generate a shareable monthly energy usage report.	Should

F-SR 14.2	System shall compile overall monthly usage statistics for the home.	Should
F-SR 14.3	System shall create a visually appealing and concise summary suitable for social media sharing.	Should
F-SR14.4	System shall provide a user interface for selecting which platforms to share the report on.	Should
F-SR14.5	Create a visually appealing and concise summary suitable for social media sharing.	Should
F-SR 14.6	Upon user initiation, post the generated report to the selected social media platform(s)	Should
F-SR14.7	Provide feedback on successful sharing or any errors encountered.	Should
Additional Quality Of Life Functionalities		
F-SR 15	System shall track for unexpected energy generation or usage every 15 minutes.	Could
F-SR 16.1	System shall generate a weekly and monthly reports to the users including: - Total energy usage and generation for the specified period. - List of devices ranked by energy consumption. - Energy efficiency recommendations based on usage patterns and potential savings.	Could
F-SR 16.2	System should also have the options to customise the content of the report. Customization options may include report frequency (weekly, monthly, yearly), report content (cost analysis and a more detailed breakdown), and the delivery options. (email, SMS, physical mail letter to your post office).	Could
F-SR 17	System should have a centralised notification centre for all the notifications, warnings, and suggestions. This centre will display the notifications with their dates, times, descriptions. The centre also allows users to filter and sort notifications based on types, devices, and sources.	Could
F-SR 18	System should have a dedicated help centre or FAQ section available 24-7. This section contains information and troubleshooting tips, users can search for specific topics to find answers to their current problem. The system should also include an AI chatbot in assisting users to transfer to a customer support staff to provide immediate assistance.	Could
Account		
F-SR 19	System should provide a user account management functionalities that include the following: Account Creation**:** Users shall be able to create new accounts by providing necessary information. Account Deletion**:** Users shall be able to delete their accounts removing all associated data. Account Management**:** Users shall be able to manage their account settings, including: - Updating personal information. - Changing passwords. - Modifying preferences and notifications.	Must
F-SR 20.1	System should have an idle detector and a user authentication feature that includes setting session timeout durations and automatically logging users out after inactivity periods to ensure maximum security that prevents leakages.	Should
F-SR 20.2	System should allow users to: - Log in to their accounts using their login credentials. - Logout of their accounts, terminating their active session and ensuring data security.	Must

F-SR 21	System shall provide password recovery functionality. Users can initiate the password recovery process by clicking on a "Forgot Password" icon. The system will then prompt the user to provide their registered email address. Upon verification of the email address, the system will send a password reset link to the user's email address. The user is now able to login and set a new password.	Could
F-SR 22	System shall provide a password change functionality. Users can initiate a password change by accessing the "Change Password" option within the system settings. To ensure security, users will be required to input their current password before entering a new one. The system will enforce password complexity requirements (minimum length, a combination of special characters, numbers, uppercase, and lowercase letters). Additionally, the system will prompt users to re-enter their new password to confirm accuracy and prevent accidental errors.	Could
Smart Home Management		
F-SR 23.1	System shall allow homeowners to create a Smart Home and add the Smart Home into their list of “Owned Smart Homes”.	Must
F-SR 23.2	System shall allow homeowners to permanently delete an existing smart home profile. Upon deletion, all users associated with the smart home profile will be removed. Before completing the deletion, the system shall send a confirmation request to the homeowner to verify the action.	Must
F-SR 23.3	System shall allow homeowners and privileged users to manage the Smart Home by enabling them to add users to any room, remove users from a room or the Smart Home, control devices in each room, and add new devices to a room.	Must
F-SR 24	System shall allow users to join or quit a Smart Home: - Users can send a join request to Smart Home by entering the Smart Home ID or by searching nearby Smart Home. - Users who receive an invitation to join a Smart Home can complete the process by accepting the invitation through an email verification link. - Users can quit a Smart Home after confirming on confirmation.	Must
F-SR 25	System shall allow users to view a list of Smart Homes they are part of: - Smart Homes will be organised in the list based on the user's privilege level, with higher privileges displayed first. - Within each privilege level, Smart Homes will be sorted by the time the user joined, starting with the most recent.	Must
Privileged Access Controls		
F-SR 26	System shall implement a role-authority access control mechanism to manage user privileges. “Homeowner” and “Privileged User” can grant and revoke specific system functionalities access such as: - viewing detailed energy consumption data. - managing devices. - configuring system settings.	Must
F-SR 27	System shall have a “Devices Control” functionalities, that allow “Homeowner” and “Privileged User” have access to the list of smart appliances connected to the system and the ability to “Add” and “Remove” anything connected to their respective “Smart Home”.	Must

1.6.2 System Non-Functional Requirement

Table 4

Non-Functional System Requirements

Usability		
NF-SR1	90% of users should be able to complete basic tasks without assistance after a 5-minute introduction, ensuring the system is intuitive and easy to navigate.	Must
NF-SR2	The user interface should adhere to current design trends and accessibility standards (WCAG 2.1 AA compliance), ensuring a modern, clean, and visually appealing design.	Should
NF-SR3	The system should provide clear, concise, and helpful error messages and tooltips to guide users through complex tasks, with a user satisfaction rate of at least 85% for error handling and guidance.	Must
Performance		
NF-SR4	The user interface should respond to user inputs within 300 milliseconds to ensure a smooth user experience, with 95% of interactions meeting this threshold.	Must
NF-SR5	Data retrieval from the server should complete within 2 seconds for 95% of requests under normal load conditions, ensuring fast information retrieval.	Must
NF-SR6	The system should maintain performance levels with up to 10,000 concurrent users, with response times degrading no more than 20% under peak load.	Must
Reliability		
NF-SR7	The system should achieve 99.9% uptime, excluding scheduled maintenance periods, to ensure high availability.	Must
NF-SR8	In case of errors, the system should log detailed information, display user-friendly messages, and recover automatically when possible. Critical errors should be resolved within 2 hours.	Must
Compatibility And Portability		
NF-SR9	The system should function consistently across major web browsers (Chrome, Firefox, Safari, Edge) and mobile operating systems (iOS, Android), with feature parity on at least 98% of functions.	Must
NF-SR10	The application should be responsive, adapting to different screen sizes from smartphones to large desktop monitors, with all features fully functional on devices with screen sizes ranging from 320px to 2560px width.	Should
Security And Privacy		
NF-SR11	All user data should be encrypted at rest using AES-256 encryption and in transit using TLS 1.3. Regular security audits should be conducted at least quarterly.	Must
NF-SR12	Users should have the ability to export or delete their data in compliance with GDPR and other relevant data protection regulations, with data export requests fulfilled within 72 hours.	Must

NF-SR13	The system shall prioritise security by implementing strong authentication mechanisms, encrypting sensitive data, and conducting regular security audits and penetration testing.	Must
Legal And Compliances		
NF-SR14	The system should implement multi-factor authentication and role-based access control to protect sensitive information, with 100% of privileged actions requiring additional verification.	Must
NF-SR15	The system must comply with relevant energy industry standards and regulations, including data protection laws (e.g., GDPR, CCPA) and accessibility guidelines (WCAG 2.1). Compliance should be reviewed and updated quarterly.	Must
NF-SR16	Clear and concise terms of use, privacy policy, and end-user licence agreement should be easily accessible within the application and require user consent before first use. These documents should be reviewed and updated annually.	Should
Maintainability		
NF-SR17	The system architecture should follow a modular design, allowing for independent updates of components without affecting the entire system. Each module should have less than 70% coupling and a minimum of 80% cohesion.	Must
NF-SR18	The system should be designed to scale horizontally, capable of handling a 300% increase in users and devices within a 6-month period without major architectural changes.	Must
Backup And Recovery		
NF-SR19	The system should perform daily backups with a recovery point objective (RPO) of 24 hours and a recovery time objective (RTO) of 2 hours. Monthly disaster recovery drills should be conducted to ensure the effectiveness of the backup and recovery processes.	Must

2. Risk Analysis

2.1 Risk Management Approach

Our risk management approach consists of 4 steps:

1. Identification: Recognise the project, product and business risk, the likelihood and severity of the impact.
2. Analysis: Analyse in detail the cause and consequences of these risks.
3. Planning: Strategies to minimise or avoid the effects of the risks.
4. Monitoring: Monitor the risk and the effectiveness of the strategies used to manage the risks.

2.2 Risk Identification

In this stage, we identify potential risks that could impact our project. The goal is to create a comprehensive list of potential risks.

Table 5

Risk Identification

Risk ID	Risk	Risk Category	Description
R1	Time constraints	Project	Time constraints due to academic commitments.
R2	Inefficient development	Project and Product	Inefficient development due to inexperience.
R3	Staff unavailability	Project	Staff is temporarily unable to work due to illness or injury.
R4	Staff turnover	Project	Staff has left the team before the project completion.
R5	Workload underestimate	Project	Team is overwhelmed by the volume of work.
R6	Project complexity underestimate	Project and Product	Project is more difficult than it is thought to be.
R7	Unmotivated staff	Project	Staff is unmotivated to finish the project.
R8	Ineffective team collaboration	Project	Team is unable to communicate and work together effectively.
R9	Server issues	Project	Server provider is down.
R10	Requirements change	Project and Product	Changes in requirements halfway through development.

R11	Unsatisfactory product	Business	Product does not satisfy the end user's needs.
R12	Budget underestimate	Product	Estimated cost is lower than the actual costs.
R13	Database breaches	Project	Data breaches from databases, leading to unauthorised access to sensitive data.
R14	Internet connectivity dependency	Product	Dependency on internet connectivity for core functionalities.
R15	Loss of source code	Project	Source code lost due to corruption, being stolen or misplaced.
R16	Poor time management	Project and Product	Ineffective scheduling and prioritisation of tasks.

2.3 Risk Analysis

In this section, we analyse each risk to understand its potential impact and likelihood of occurrence. By categorising risks based on their severity and probability, we prioritise risks and focus our mitigation efforts on the most critical ones. We also consider the potential consequences of each risk on our project objectives, timeline, and resources. (See Appendix B for

Table 6

Risk Priority Colour Guide

Risk Priority	Colour	Definition
High		Requires immediate action.
Medium		Should be monitored closely.
Low		Can be handled with contingency plans.

Table 7

Risk Impact and Priority

Risk ID	Risk Priority Colour	Risk	Probability	Impact	Risk Priority
R1		Time constraints	Moderate	Serious	High
R2		Inefficient development	Moderate	Serious	High
R4		Staff turnover	Low	Catastrophic	High
R5		Workload underestimate	Moderate	Serious	High
R11		Unsatisfactory product	Moderate	Serious	High
R15		Loss of source code	Low	Catastrophic	High
R16		Poor time management	Moderate	Serious	Medium
R3		Staff unavailability	Moderate	Serious	Medium
R6		Project complexity underestimate	Moderate	Serious	Medium
R7		Unmotivated staff	Low	Serious	Medium
R8		Ineffective team collaboration	Low/Moderate	Serious	Medium
R9		Server issues	Low/Moderate	Serious	Medium
R10		Requirements change	Moderate	Serious	Medium
R12		Budget underestimate	Moderate	Serious	Medium
R13		Database breaches	Low	Catastrophic	Medium
R14		Internet connectivity dependency	Low	Serious	Medium

Note. See Appendix B for definition of the Probability and Impact criteria.

2.4 Risk Planning

Based on our analysis, we develop specific strategies to address each significant risk. These strategies include:

- Avoidance: Eliminating the risk by changing our approach or removing the risk source.
- Mitigation: Reducing the probability or impact of the risk.
- Transfer: Shifting the risk to a third party (e.g., through insurance or outsourcing).
- Acceptance: Acknowledging the risk and preparing contingency plans if it occurs.

Table 8

Risk Planning and Strategies

RISK ID	RISK	STRATEGIES		
		AVOIDANCE	MITIGATION	CONTINGENCY
R1	Time constraints	Avoid tight deadlines by ensuring project timelines are realistic and flexible for team members' academic schedules.	Improve time management by using scheduling tools and setting clear priorities for each team member.	Plan for buffer time in the schedule or allow for extra team members to step in if someone falls behind.
R2	Inefficient development	Assign experienced developers to critical tasks or provide training before the project begins.	Peer reviews and regular check-ups to detect inefficiencies early.	Have an expert standby to help if the project falls behind due to inefficiencies.
R3	Staff unavailability	Enforce a healthy work environment to reduce the probability of illness and burnout.	Cross-train team members so tasks can be distributed if someone is absent.	Have a backup team member or temporary resource ready to take over if needed.
R4	Staff turnover	Have clear contracts and agreements to prevent sudden departures.	Ensure knowledge sharing and proper documentation practices are in place so others can step in.	Create a plan for recruitment in case of staff loss.
R5	Workload underestimate	Avoid general scope by clearly defining the project's scope early on and managing expectations.	Break down tasks into manageable pieces and ensure the workload is balanced.	Bring in additional resources or redistribute the workload to relieve the pressure.
R6	Project complexity underestimate	Thorough research and planning in advance to avoid underestimating project difficulty.	Break down complex tasks into smaller ones.	Extend project timelines and get additional resources if difficulties arise.
R7	Unmotivated staff	Balance workloads and set reasonable deadlines.	Implement regular feedback sessions to keep the team motivated and united.	Reassign unmotivated staff to roles that better suit their strengths or bring in new team members to maintain the momentum.
R8	Ineffective team collaboration	Establish clear communication between team members.	Use collaboration tools and schedule team meetings regularly to improve communication.	Assign a project manager or coordinator to resolve conflicts if communication issues persist.

R9	Server issues	Choose a reliable server provider with a strong uptime record.	Use a secondary server when needed.	Prepare a backup server in case of downtime
R10	Requirements change	Thoroughly document and confirm requirements early on.	Use agile development methods that allow for flexibility in any changes adapted.	Set aside extra time or resources for changes if they are unavoidable.
R11	Unsatisfactory product	Involve stakeholders in every development cycle to get user feedback.	Include usability testing in each sprint.	Set aside extra time or resources for changes if they are unavoidable.
R12	Budget underestimate	Perform a thorough budget analysis at the start.	Regularly track expenses and adjust the budget throughout the project.	Set aside a financial reserve and fund to cover unexpected costs.
R13	Database breaches	Avoid storing sensitive data in vulnerable systems by using secure and encrypted databases.	Implement security measures such as firewalls, encryption and regular security audits.	Having a data recovery and incident response plan to mitigate the effects of a breach.
R14	Internet connectivity dependency	Avoid full reliance on online systems, building some offline functionality where possible.	Implement caching and backup systems to maintain limited functionality during outages.	Provide users with a way to monitor or control the system manually in case of an internet outage.
R15	Loss of source code	Avoid code loss by using a version control system with regular backups.	Automate backups and implement access control to limit who can modify, merge or access the codebase.	Have backup copies stored in multiple locations and prepare a recovery plan.
R16	Poor time management	Set realistic deadlines and include buffer time for each phase.	Review progress regularly.	Reallocate resources to focus on high-priority tasks.

2.5 Risk Monitoring

Risk monitoring involves regularly monitoring identified risks and looking for new ones to ensure minimal disruptions to our timeline and is essential to keep the project on track.

Table 9

Risk Monitoring

ID	RISK
R1	**Time constraints**
	● Regularly check the project timeline against the academic calendar. Also, schedule frequent meetings to assess the team's progress and address any issues early. ● Look for missed deadlines, lower productivity during study or exam periods, or team members requesting deadline extensions.
R2	**Inefficient development**
	● Track progress through code reviews and project milestones. Assess the complexity of tasks assigned to less experienced team members and adjust as needed. ● Attention to the time spent on tasks, more frequent errors and pull requests requiring multiple revisions.
R3	**Staff unavailability**
	● Track attendance and task assignments regularly. Monitor the wellbeing of the team, encouraging breaks to avoid burnout. ● Detecting absences, delay in task completion. ● Daily stand-ups to check on individuality availability, and workload assessments.
R4	**Staff turnover**
	● Regularly check the team's engagement and satisfaction to prevent sudden departures. Ensure that critical knowledge must be documented. ● Take note of signs of disengagement, lower productivity or lack of communication. ● Conduct team satisfaction surveys and performance reviews.
R5	**Workload underestimate**
	● Track workload distribution among team members. Compare actual workload with planned workload regularly. ● Take note of overdue tasks or complaints from the team about excessive workloads. ● Weekly workload reviews and team check-ins.
R6	**Project complexity underestimate**
	● Conduct weekly meetings to discuss current project status and difficulty. ● Keep track of the actual time taken to complete tasks and compare them to the originally expected time taken to complete the tasks. ● Frequently evaluate actual task complexity and compare them to the initial task complexity expectations.

R7	**Unmotivated staff**
	● Team leader regularly performs 1-on-1 check-ins with team members to assess the team members' level of engagement and motivation towards performing project tasks. ● Look out for decreases in productivity and task contributions from specific team members. ● Regularly assess individual task completion rates from every team member to watch out for signs of low motivation in team members.
R8	**Ineffective team collaboration**
	● Keep track of the number of task revisions and redos caused by ineffective team communication. ● Regularly monitor the effectiveness of communication tools and mediums that are currently in use. ● Watch out for noticeable delays in team members' responses and feedbacks to any questions and decreases in team members' engagements during meetings which could be signs of poor team communication.
R9	**Server issues**
	● Keep track of the server provider's uptime using independent uptime monitoring services. ● Build up regular communication with the server provider so that any updates regarding planned server maintenance or any other issues with the servers could be informed quickly.
R10	**Requirements change**
	● Regularly track and review project requirements with stakeholders to identify if there are any potential desires for changes in project requirements. ● Introduce some degree of flexibility into the project development to allow changes in requirements without having to rework significantly. ● Identify potential changes in requirements as early as possible.
R11	**Unsatisfactory product**
	● Conduct usability testings and collect user feedback regularly. ● Take into consideration the user feedback during the development process. ● Track user behaviour during user tests to identify areas where users are not satisfied.
R12	**Budget underestimate**
	● Periodically review project budgeting and financial reports to detect potential over-budgeting and take corrective measures to prevent further over-budgeting. ● Always monitor actual project expenditures and compare it to the estimated or allocated project budget to get a sense of how much are we actually spending. ● Utilise cost-tracking and budgeting tools to track actual project expenses so that areas of the project that went over budget could be identified.
R13	**Database breaches**
	● Integrate the database with strong security measures such as encryption and that only authorised users are allowed to access the database. ● Perform regular security auditings on the database. ● Regularly perform security vulnerability testings to the security of the database to identify and fix potential security vulnerabilities in the database. ● Monitor the database's accesses 24/7 to detect suspicious events such as unauthorised database access attempts and data breaches.

R14	**Internet connectivity dependency**
	● Design the system such that it must be capable of performing some degree of essential core functions even when the system is offline. ● Employ and utilise backup internet service providers in case of a complete internet connection lost from the main internet service provider.
R15	**Loss of source code**
	● Ensure code is consistently and frequently pushed to GitLab to maintain a secure and up-to-date backup of the system. ● Limit access to the repository by enforcing strict permissions and role-based access control, reducing the likelihood of unauthorised changes or loss. ● Continuously monitor GitLab activity and promptly respond to suspicious or unauthorised actions, such as repeated failed login attempts or unusual system behaviour.
R16	**Poor time management**
	● Track progress of assigned tasks regularly. ● Compare planned milestones with actual progress. ● Conduct weekly meetings to check if members need additional support.

3. Project Decision and Planning

3.1 Choice of Framework

To ensure efficiency and cost-effectiveness, we decided to leverage existing web frameworks and libraries for our project. This approach reduces development time, provides access to extensive documentation, and minimises the need for extensive code testing.

React is selected as a frontend framework because:

- It is a popular JavaScript library that is often used for building interactive interfaces.
- Its component-based structure allows for reusable UI elements.
- It integrates well with JavaScript and has a wide range of libraries.

Django is chosen as a backend framework because:

- It is a high-level Python framework with tools for data management, handling backend processing and security.
- Using the Django REST Framework, we can build APIs that allow for stable communication between the React frontend and Django backend.

3.2 Web-based Application

The system will be developed as a web application. Javascript will enhance web page functionality, making it more user-friendly and intelligible.

3.3 Version Control

Git will be used to manage concurrent system upgrades. This prevents code overwriting and ensures backups are maintained.

3.4 Communication Tools

We will use Microsoft Teams and Whatsapp to ensure team productivity and communication.

3.5 System Requirements

Upon having a meeting with our supervisor, we determined that using a dedicated web server instead of the university network would be the best option for developing and executing the product. In this setting, we will have less limitations when developing the system.

3.6 Project Management Utility

Several group members have experience with tools like draw.io, Figma, and Monday.com, and feel confident using them for planning projects of this scope. We believe these applications offer sufficient utilities, making them reliable choices for creating project diagrams and Gantt charts.

3.7 Intended Audience

The primary audience for this project includes homeowners seeking innovative and efficient solutions to manage their homes through smart technology. This includes tech-savvy individuals, busy professionals looking to automate daily tasks, families prioritising comfort and energy efficiency, and elderly homeowners seeking user-friendly systems for improved home management and safety. The project aims to design and develop a smart home system that allows homeowners to control and monitor smart appliances conveniently and securely. Key objectives include providing centralised control via web or mobile applications, incorporating automation for tasks like lighting, temperature, and security, and ensuring the system is customizable to meet individual needs. Additionally, the system will feature a user-friendly interface, reliable operation, and robust security measures to protect user data and home access. This approach ensures the smart home system aligns with homeowners' expectations for convenience, efficiency, and safety.

3.8 Risk Management

We had discussed potential dangers for the project and offered our thoughts for assessment. The hazards would be documented and classified based on their type, impact, and likelihood. In addition, we will present risk management strategies for each of the risks highlighted.

3.9 Project Costing

The project will operate on a schedule of 8 hours per day, from 9:00 AM to 5:00 PM, five days a week, over a period of three months, totaling approximately 480 working hours per team member. All the costing includes manpower, hardware, software equipment and consumables such as paper and printer ink. A comprehensive estimation of all these costs will be based on current market prices researched online, ensuring an accurate and realistic project budget.

3.10 Usability Testing Mockups

The group, consisting of eight members, will be split into two teams to conduct usability testing. Each team will perform two tests, after which we will gather and compile the results to draw conclusions that can be used to enhance the website's overall functionality and design.

3.11 Software Process

We will use the **Scrum Model** for our software process. This means that we will develop the smart home system in small, repeated cycles known as sprints, where each sprint results in an

incrementally improved and working version of the product and at the end of each sprint, we will conduct product reviews to gather user feedback and perform product testing. This approach allows us to incrementally refine and improve the product, ensuring the system aligns more closely with the user needs with each sprint.

3.12 Team Roles

Table 10.

Each Member's Roles in the Project

Team Members	**Role**
Avril Lim	Reporter and UX/UI Designer
Aisyah Nadhirah Hasrin	Frontend Developer
Tan Alan Yong Hong	Backend Developer
Chong Shing Boa	Scrum Master
Chia Zheng Rong	Technical Manager and Lead Developer
Xu Jing Yu	Frontend Developer
Mohammad Dzuhair Ahmad Hakimi	Liaison and Software Tester
Tang Yang	Operational Manager and Backend Developer

3.13 Collaboration

Code Development:

- We will use VS-Code for coding, paired with GitHub for version control and collaboration.

Evaluation and Feedback:

- Evaluation will be shared and discussed using Google Docs for real-time comments and reviews.

Documentation:

- All technical and project documentation will be handled using Google Docs.

Task Management and Tracking:

- Trello will be used for managing tasks and tracking project progress. Team members can assign responsibilities to each member for specific tasks, update the status of tasks, and

add deadlines. We can have a clear overview of the current status and upcoming deliverables this way.

3.14 Gantt Chart

Table 10

Stage 1 Gantt Chart Table

Name	Start Date	End Date	Team Member	Number of Days
Initiation				
Group Assignment	20/9/2024	20/9/2024	All	1
Communication set up	20/9/2024	20/9/2024	All	1
Group Familiarising	24/9/2024	24/9/2024	All	1
Role Allocation	24/9/2024	24/9/2024	All	1
Outline Introduction	24/9/2024	24/9/2024	All	1
Outline overall system	24/9/2024	24/9/2024	All	1
Requirements Specification				
Requirements Specification	24/9/24	8/10/24	All	15
Functional Requirements	24/9/24	1/10/24	All	8
Non-Functional Requirements	1/10/24	8/10/24	All	8
Product Manager Meeting	3/10/24	3/10/24	All + Product Manager	1
Requirement Validations	4/10/24	4/10/24	TY	1
Line Manager Meeting	7/10/24	7/10/24	All + Line Manager	1
Risk Analysis				
Risk Analysis	8/10/24	20/10/24	ZR	13
Risk Management Approach	8/10/24	8/10/24	ZR	1
Risk Identification	9/10/24	14/10/24	ZR	6
Risk Assessment	15/10/24	16/10/24	ZR	2
Risk Mitigation Strategies	17/10/24	18/10/24	ZR	2

Risk Monitoring	19/10/24	20/10/24	ZR	2
Project Decisions and Plan				
Project Decisions and Plan	31/10/24	14/11/24	All	15
Overall Project Breakdown Structure	31/10/24	12/11/24	All	13
Task Allocation	12/11/24	12/11/24	All	1
Gantt Chart	12/11/24	14/11/24	AV	3
Project Costing				
Project Costing	2/11/24	10/11/24	All	9
Costing Breakdown Structure	2/11/24	2/11/24	ZR	1
Cost Analysis	3/11/24	5/11/24	All	3
Cost Calculations	5/11/24	7/11/24	All	3
Line Manager Meeting	7/11/24	7/11/24	DZ, ZR, ST, AV	1
Revised Costing	7/11/24	10/11/24	ZR	4
Revised Requirements Specification	7/11/24	10/11/24	TY	4
Revised Project Decision and Planning	7/11/24	10/11/24	All	4
Usability Evaluation of Mock-ups				
Usability Evaluation of Mock-ups	10/11/24	14/11/24	All	5
Introduction	10/11/24	10/11/24	AS	1
Overview of study	10/11/24	10/11/24	AS	1
Mock-up Interface (Figma)	10/11/24	12/11/24	DZ, ZR	3
Usability Test Plan	13/11/24	13/11/24	BB, AL, DZ, ZR	1
Usability Test Protocol	13/11/24	13/11/24	BB, AL, DZ, ZR	1
Usability Test Results Analysis	13/11/24	13/11/24	BB, AL, DZ, ZR	1
Conclusion	14/11/24	14/11/24	All	1
Finalisation				

Finalisation	15/11/24	22/11/24	All	8
Line-Manager Meeting	15/11/24	15/11/24	DZ, ZR, AL, ST, AS, AV + Line Manager	1
Proofreading	16/11/24	22/11/24	All	7
Document Adjustment	16/11/24	22/11/24	All	7
Stage 1 Submission	22/11/24	22/11/24	All	1

Note. The table above details when tasks are done, the duration of each task as well as the members involved in each task for Stage 1.

Table 11

Stage 2 Gantt Chart Table

Name	Start Date	End Date	Team Member	Number of Days
Sprint 1				
Marketing Analysis and Strategy	13/01/25	20/01/25	All	8
General Discussion on Marketing Strategy	13/01/25	13/01/25	All	1
Review Final System Design	13/01/25	13/01/25	All	1
Review Final Interface Design	13/01/25	13/01/25	All	1
Finalise Project Requirements and Implemented Features	13/01/25	13/01/25	All	1
Market Research	14/01/25	16/01/25	All	3
Produce Marketing Materials	17/01/25	20/01/25	AV, AS, AL, BB	4
Produce Marketing Strategy	17/01/25	20/01/25	ZR, DZ, TY, ST	4
Sprint 2				
Final Application Design and Implementation	14/01/25	24/02/25	All	42
Final System Overview	14/01/25	21/01/25	All	8
Description of Final System Design	14/01/25	21/01/25	All	8
Create Dataflow, UML and Class Diagrams	14/01/25	21/01/25	All	8
Description of Final Interface Design	14/01/25	21/01/25	All	8

Description of sprint 1	21/01/25	21/01/25	AV	1
Implement Interface and Final System	22/01/25	18/02/25	All	28
System Trial Plan	19/02/25	20/02/25	All	2
System Trial	21/02/25	21/02/25	All	1
User Guide Documentation	22/02/25	24/02/25	All	3
Sprint 3				
Final Usability Evaluation	24/02/25	03/03/25	All	8
Description of sprint 2	24/02/25	24/02/25	AV	1
Define Evaluation Goals and Scope	24/02/25	24/02/25	All	1
Define Test Plan and Test Protocol	24/02/25	25/02/25	BB, AL, DZ, ZR	2
Create pre- and post-test questionnaires	26/02/25	27/02/25	BB, AL, DZ, ZR	2
Collect Data	28/02/25	28/02/25	All	1
Analyse Results	01/03/25	03/03/25	All	3
Sprint 4				
Project Evaluation	03/03/25	16/03/25	All	14
Description of sprint 3	03/03/25	03/03/25	AV	1
Group Assessment	03/03/25	05/03/25	All	3
Implementation Assessment	05/03/25	07/03/25	All	3
Product Assessment	07/03/25	09/03/25	All	3
Conclusion and Future Recommendations	09/03/25	10/03/25	All	2
Proofreading	10/03/25	16/03/25	All	7
Document Adjustment	10/03/25	16/03/25	All	7
Sprint 5				
Final Product Demonstration Preparation	16/03/25	21/03/25	All	6
Description of sprint 4	16/03/25	16/03/25	AV	1
Design Overview Document	16/03/25	18/03/25	All	3

Prepare Demonstration Plan	18/03/25	20/03/25	All	3
Demonstration Practice	20/03/25	21/03/25	All	2
Final Product Demonstration	21/03/25	21/03/25	All	1
Description of sprint 5	21/03/25	21/03/25	AV	1
Final Check	22/03/25	26/03/25	All	5
Stage 2 Submission	26/03/25	26/03/25	All	1

Note. The table above details the completion, duration and the members involved in each sprint.

Stage 1 Gantt Chart

(See Appendix C1 for Gantt Chart)

Stage 2 Gantt Chart

(See Appendix C1 and C2 for Gantt Chart)

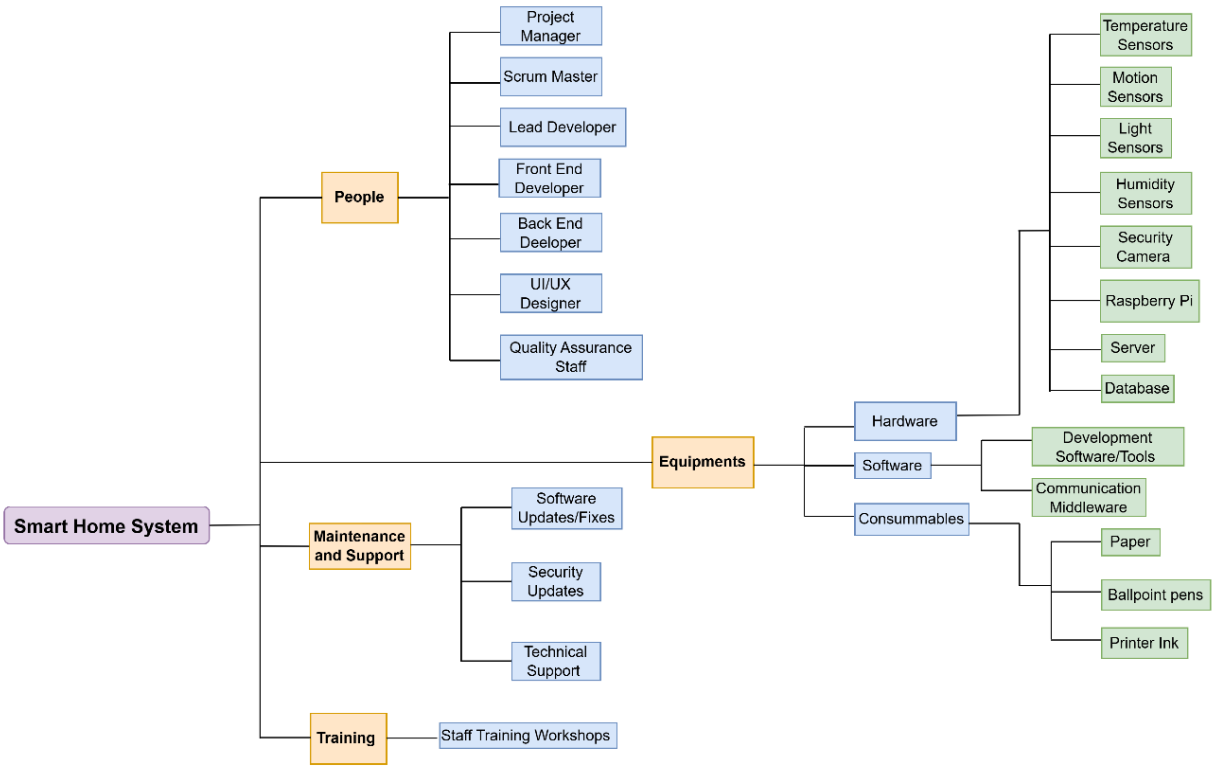
4. Project Costing

4.1 Overall budget

Breakdown of all the possible costs that have been taken into account. The cost categories and their related costs are detailed in the table below in the “Calculations” section.

Figure 1

Cost Breakdown Structure



4.2 Cost Analysis

Descriptions of the individual costs of items observed in Table 12.

1. People
    - Wage of the people involved in this project.

    1.1 Project Manager

    - Manages project schedules and timelines, coordinates the project tasks and ensures that project milestones are met accordingly.

    1.2 Scrum Master

- Ensures that scrum methodologies and agile framework is followed.

1.3 Lead Developer

- Leads and coordinates the development team and makes key development decisions.

1.4 Front End Developer

- Works in tandem with the UI/UX designer to create a visually appealing and functional application for the user.

1.5 Back End Developer

- Builds and maintains functions and mechanisms that process data and perform actions on the application.

1.6 UI/UX Designer

- Works together with the frontend developer to create a functional and visually appealing application for the user.

1.7 Quality Assurance Staff

- Perform thorough tests of the Smart Home System to identify and resolve any potential bugs and issues in the system that were overlooked during development.

2. Equipment
    - The hardware, software and consumables needed for the development and deployment for Smart Home System.

2.1 Hardware

- Includes the rental or purchase of computers, servers, databases and other hardwares needed for system development and deployment.

2.1.1 Temperature Sensors

- Detects indoor temperatures

2.1.2 Motion Sensors

- Detects movements within the smart home

2.1.3 Light Sensors

- Detects indoor lighting conditions

2.1.4 Humidity Sensors

- Detects indoor humidity levels

2.1.5 Security Devices

- Security cameras and alarms for the smart home's security

2.1.6 Raspberry Pi

- Microcontroller for controlling and processing the system

2.1.7 Servers

- For data storage and processing

2.1.8 Database

- For storing generated data while using the Smart Home System

2.2 Software

- Includes the subscription or purchase of software tools and licences that are required for this system development and deployment.

2.2.1 Development Software/Tools

- IDEs and project planning tools that are essential for the development of the Smart Home System.

2.2.2 Communication Middleware

- Facilitates efficient data transfers and exchanges between the Smart Home devices.

2.3 Consumables

- Frequently used items during the development of Smart Home System.

2.3.1 Paper

- For project planning, documenting and records.

2.3.2 Ballpoint Pens

- Used by project team members for taking notes, sketching ideas, drafting and writing documentations.

2.3.3 Printer Ink

- Used for printing project reports and documents.

3. Maintenance and Support
    - Costs related for maintenance and technical support of the Smart Home System.

3.1 Software Updates

- Feature updates and bug fixes for the Smart Home System and its devices' firmwares.

3.2 Security Updates

- Security patches to protect the system against security vulnerabilities.

3.3 Technical Support

- Providing assistance to the client for troubleshooting and resolving issues that the client may encounter when using the system.

4. Training
    - Training expenses to ensure that staff are able to develop and maintain the system safely, effectively and efficiently.

4.1 Staff Training workshops

- Workshops to train and upskill the project staff.

4.3 Cost Calculations

Table 12

Staff Cost Calculation

Employee	Total Project Hours	Number of Staff	Hourly Rate	Monthly Wage per Person	Total Cost
Project Manager	480	1	RM 53.13	RM 8,500.00	RM 25,502.40
Scrum Master	480	1	RM 75.00	RM 12,000.00	RM 36,000.00
Lead Developer	480	1	RM 59.63	RM 9,540.00	RM 28,622.40
Front End Developer	480	2	RM 40.63	RM 6,500.00	RM 39,004.80
Back End Developer	480	2	RM 40.63	RM 6,500.00	RM 39,004.80
UI/UX Designer	480	1	RM 28.13	RM 4,500.00	RM 13,502.40
Quality Assurance Staff	480	1	RM 31.25	RM 5,000.00	RM 15,000.00
				Total:	**RM 196,636.80**

Note. Assumption:

- Assume that we are working full time to develop this project for 3 months.
- The monthly wage for each position is based on the market price (See References for referenced market price).
- The staff are paid according to their project hours but not according to month, the Monthly Wage Per Person is just a reference for the hourly rate of the staff.

Calculations for:

- Total Project Hours: 8 hours/day * 5 days/week = 40 hours/week * 4 weeks = 160 hours/month * 3 months = 480 hours
- Hourly rate: Monthly wage/(Total project hours/3 months = 160 hours/month)
- Total cost: Total Project Hours * Hourly Rate * Number of Staff

Table 13

Equipment Cost Calculation

Equipment	Units	Cost per Unit	Acquisition Type (Buy/Rent)	Total Cost
Hardware				
Temperature and Humidity Sensor	5	RM 35.20	Buy	RM 176.00

Motion Sensor	7	RM 35.13	Buy	RM 245.91
Light Sensors	5	RM 14.15	Buy	RM 70.75
Security Camera	5	RM 39.00	Buy	RM 195.00
Raspberry Pi	1	RM 409.00	Buy	RM 409.00
Server (GitHub Pages, Heroku, netlify)	1	RM 0.00	N/A	RM 0.00
MySQL (MariaDB) Database	1	RM 0.00	Rent	RM 0.00
			Total:	**RM 1,096.66**
Equipment	**Units**	**Cost per Unit**	**Acquisition Type (Buy/Rent)**	**Total Cost**
Software				
Development Software/Tools (VS Code, GitHub, GitLab, Jira, Figma, Postman)	6	RM 0.00	N/A	RM 100.00
Communication Middleware (Eclipse Mosquitto, Socket.io, Express.js, Flask, Node-RED)	4	RM 0.00	N/A	RM 0.00
			Total:	**RM 100.00**
Equipment	**Units**	**Cost per Unit**	**Acquisition Type (Buy/Rent)**	**Total Cost**
Consumable				
Paper	1 carton (5 reams/carton)	RM 70.00	Buy	RM 70.00
Ballpoint pens	5 boxes (12 pens/box)	RM 18.00	Buy	RM 90.00
Printer Ink	8 cartridges	RM 116.20	Buy	RM 929.60
			Total:	**RM 1,089.60**
			Grand Total:	**RM 2,286.26**

Note. Assumptions:

- We will be using VS Code, GitHub, GitLab, Jira, Figma and Postman for Development Software/Tools, which makes them 6 units of software.
- We will be using Eclipse Mosquitto, Socket.io, Express.js or Flask and Node-RED for Communication Middlewares, which makes 4 units of software.

- We will only be using 1 of the options from [GitHub Pages, Heroku and netlify] as our software server, making only 1 hardware unit in the table.
- The hardware equipments like sensors and cameras included here are one-time purchases used solely for testing purposes. The client company should be the one responsible for sourcing and distributing/selling these devices to the smart homes of end users for commercial use.
- See References for the referenced market price.

Table 14

Maintenance and Support Cost Calculation

Maintenance and Support	Description	Length	Cost Per Month	Total Cost
Software Updates/Fixes	Updating software features and compatibility with new technologies and fixing software issues	2 Years	RM 200	RM 4,800.00
Security Updates	Applying security patches	2 Years	RM 700	RM 16,800.00
Technical Support	Assisting client company with technical issues of the system	2 Years	RM 3,500	RM 84,000.00
		Total:		**RM 105,600**

Note. We assume that we provide software maintenance and technical support services for the client for 2 years after system deployment.
Calculations for cost: Cost per month * Length

Table 15

Training Cost Calculation

Training	Length	Cost
Staff Training Workshops	21 hours	RM 13,031.36
	Total:	**RM 13,031.36**

Table 16

Summary of Cost Calculation

Summary	Cost
Staff	RM 196,636.80
Equipment	RM 2,286.26
Maintenance and Support	RM 105,600.00
Training	RM 13,031.36
Total:	**RM 317,554.42**

5. Usability Evaluation of Mock-ups

5.1 Introduction

Aims & Objectives

This document provides a detailed plan for conducting usability assessments and presents the findings obtained. The aim of this report is to guide the development of the Peaches Software Smart Home System by incorporating insights from end-user testing and feedback. The collected data is intended to identify potential errors and design flaws to ensure they are addressed before the final product release.

Overview

Test Plan

The system will be tested using a combination of observational testing, task-based scenarios, and surveys. We will gather both quantitative data (task completion rates, error counts, and time taken) and qualitative feedback (user impressions and satisfaction) from selected participants. The aim is to identify usability issues, enhance user satisfaction, and refine the design to ensure it meets user needs.

Test Protocol

Participants will complete a series of tasks that mimic real-world interactions, such as logging in, controlling devices, and setting up automation routines. We will record their success rates, completion times, and any errors they encounter. This will help us evaluate how effectively the system supports common user tasks.

Usability Results

This section will summarise findings, using quotes from user feedback and metrics like completion rates and survey scores. Demographic data will add context to the feedback, and the combined qualitative and quantitative insights will reveal the system's usability strengths and weaknesses.

Conclusions

Key takeaways from testing will be outlined, including successful aspects and areas needing improvement. We will recommend specific changes based on user feedback, focusing on enhancing clarity, performance, and any additional features users request to ensure a seamless final product experience.

5.2 Test Plan

Objectives

The test will primarily assess participants' ability to use the mock-up prototype of the *Peaches Software Smart Home System*, focusing on how easily they can complete core tasks. The aim is to gather feedback to identify areas for improvement and suggest potential changes.

Aims:

- To conduct a trial run of the front-end prototype for the smart home system.
- To collect both quantitative and qualitative data from user feedback.
- To identify any usability issues with the system's design.

Participant

This document outlines the usability testing plan for the Peaches Software Smart Home System. The goal is to incorporate insights from end-user feedback to identify and resolve design flaws before the final product release.

Table 17

Task Scenarios

No.	Tasks	Related Requirements
1.	Logging into the System	F-UR-20: Users must be able to log in and out of their account. F-UR-21: Users must be able to recover their password securely if they forget it.
2.	Registering a New User Account	F-UR-19: Users should be able to create a new user account.
3.	Navigating the Normal User Dashboard	F-UR-1: Users should be able to see the home's overall time and energy usage. F-UR-4: Display time usage, energy usage, and analysed data of connected smart appliances.
4.	Using the Privileged User Dashboard	F-UR-7: Privileged users should be able to see detailed time and energy usage over time frames. F-UR-26: Privileged users should be able to add or remove smart devices..
5.	Accessing the Homeowner Dashboard	F-UR-7: Homeowners should be able to see detailed time and energy usage over time frames. F-UR-26: Homeowners should be able to assign or change access levels for other users.

6.	Controlling Room Devices (Normal User)	F-UR-8: Users should be able to control connected smart appliances.
7.	Utilising Privileged User Functions	F-UR-7: Privileged users should be able to view detailed energy usage over time frames. F-UR-26: Privileged users should be able to assign or change access levels for other users. F-UR-27: Privileged users should be able to add or remove smart devices.
8.	Analysing Energy Data (All Users)	F-UR-1: Users should be able to view energy usage data based on day, month and year. F-UR-4: Users should be able to view energy usage and analyse data for smart devices. .

Each task will be rated on a scale of 1-5 by participants based on their experience. A rating below 3 indicates design issues.

A task will be considered "complete" when participants confirm its completion or when sufficient assistance has been provided. The investigator will also monitor any deviations from the simplest task path, as frequent deviations may indicate potential design issues.

Metrics

The following key metrics will be evaluated in the usability study:

- Task Completion Rate: Percentage of users completing tasks successfully.
- Time on Task: Average time to complete each task.
- Error Rate: Percentage of users encountering errors during tasks.
- User Satisfaction: Average satisfaction rating (Likert scale).
- Usability Score: Aggregate score based on user feedback.
- Feature Comprehension: Percentage of users understanding key features without assistance.
- Feedback and Suggestions: Qualitative data on user experience and improvement suggestions.

5.3 Test Protocol

To be completed by the supervisor

Testing Supervisor:_____ **Date:**_____

Participant No:_____ **Location:**_____

Aim of this session
You will test the key components of a smart home system during today's session. With the help of this system, you can monitor the energy generation and consumption in your home and manage the electronics in particular areas. Your suggestions are utilised to support and enhance the system, which is still in its early stages of development, as well as how it communicates with users.

Introduction
I want you to look at several UI components in a specific order, or "flow." After that, you should describe what you think each page is asking you to do before doing a few simple tasks. I will be taking notes during the exam to record your actions and any voice input you may provide at any point. Any comments or information we collect from you will remain anonymous and untraceable.

Once the test is over, I would appreciate it if you could spend a few minutes doing an anonymous survey so I can get further input on the website.

There are no correct or incorrect responses. We can improve the system's design if we understand how you perceive its presentation.

This test can be stopped at any moment. Please let the test supervisor know if you would want to do so.

5.3.1 Login page

(A diagram depicting the login page of the Smart Home System)
See Appendix E1

1. Is this page easy to navigate?

2. Are there any texts you find hard to see?

3. Do you find any options missing from this page?

5.3.2 Registration Page

(A diagram depicting the registration page of the Smart Home System)
See Appendix E2

1. On a scale of 1 to 5, please describe the user friendliness of the page?

1 **Not User Friendly**	2	3	4	5 **User Friendly**

2. Describe your process on how you would register into the system.

3. Is there any unnecessary information that you think is not needed in the registration?

5.3.3 Normal User Interface

(A diagram depicting the Normal User Interface of the Smart Home System)
See Appendix E3

1. On a scale of 1 to 5, how clear and understandable do you think are the functions and features on the normal user interface? (1 being the most unclear and 5 being the clearest)

1 **Most Unclear**	2	3	4	5 **Clearest**

2. On a scale of 1 to 5, how well do you think the interface presented the most relevant information for your needs? (1 being the poorest and 5 being the best)

1 **Poorly Presented**	2	3	4	5 **Most well presented**

3. Are there any additional features or information that you would expect to see on this interface?

5.3.4 Privileged User Interface

(A diagram depicting the Privileged User Interface of the Smart Home System)
See Appendix E4

1. Please point out and name all clickable components of the page.

All Correct	**Most Correct**	**Some Correct**	**None Correct**

None clickable pointed out

2. Can you spot the difference between this interface and the Normal User Interface that was shown to you previously?

3. On a scale of 1 to 5, how easy is it to locate the additional functions for privileged users on this interface? (1 being the hardest and 5 being the easiest)

1 **Hardest**	2	3	4	5 **Easiest**

5.3.5 Homeowner Interface

(A diagram depicting the Homeowner Interface of the Smart Home System)
See Appendix E5

1. On a scale of 1 to 5, how easy is it to track the entire home's energy usage and generation statistics on this interface? (1 being the hardest and 5 being the easiest)

1 **Hardest**	2	3	4	5 **Easiest**

2. Can you spot the difference between this interface and the Privileged User Interface that was shown to you previously?

3. Are the necessary information and features easily accessible for a homeowner when navigating this interface?

5.3.6 Functionalities For Normal Users

(Diagrams depicting the Normal User functionalities of the Smart Home System)
See Appendix E6, E7, E8

1. Indicate how you would turn on and adjust the speakers in "Room 2".

2. Please refer to the "Manage Rooms" page. Explain what you see on the page.

3. Please refer to the “Room 2” page. On a scale of 1 to 10, how would you describe the amount of information on the page?

1 **Not enough**	2	3 **Just enough**	4	5 **Too much**

5.3.7 Functionalities for Home Owners and Privileged Users

(Diagrams depicting the Privileged User functionalities of the Smart Home System)
See Appendix E9, E10, E11, E12, E13, E14

1. Are the privileged functionality easily accessible and do these privileged functionalities (like removing devices or removing users from rooms or the entire Smart Home) meet your expectations of how privileged functionalities should work in a Smart Home System?

2. On a scale of 1 to 5 how easy is it for you to set energy limits for the devices and the entire Smart Home?

1 **Hard**	2	3	4	5 **Easy**

3. Are there any additional privileged functionalities you think that would benefit the role of homeowners or privileged users in a Smart Home?

5.3.8 Functionalities for all Users

(A diagram depicting the overall functionality of the Smart Home System)
Refer to Appendix E15

1. At a first glance, are you able to see which days have the highest values?

2. On a scale of 1 to 5, how visible are the values on each diagram? (1 being least visible and 5 being most visible)

   Energy Usage

1 **Least**	2	3	4	5 **Most**

Energy Generation

1 **Least**	2	3	4	5 **Most**

Room

1 **Least**	2	3	4	5 **Most**

3. Indicate how you would check the monthly use of the living room.

5.4 Usability Test Results

Sample of Demographic

Table 18

Test Gender Demographics

Gender	
Male	6
Female	2

Table 19

Test Age Demographics

Age	
18 -20	1
21- 26	3
27 - 35	4
36 - 45	0
45 +	0

Table 20

Test Occupation Demographics

Occupation	
College Student	2
University Student	3
Employed	3
Unemployed / Seeking Work	0
Retired	0

Finding of Usability Results

Before any test can be taken, participants need to fill up a consent form (See Appendix D for full user consent form). Also, please refer to the System mockup in Appendix E, which features the entire mockup system interface. Finally, see Appendix G for the survey questions done by users.

5.4.1 Login Page

First Impressions and appearance

Most users that did the survey find that the home page is easy to navigate. The page layout is within the acceptable range of the user preferences "creative" and "fun" when describing the page.

Few user commented on the ease of navigating the page by remaking:

"Easy to understand at first glance"

However, one user believed that the creative part could be toned-down, by remarking:

"The page looks cartoonish, make it simple and show a bit of professionalism"

Font Format and Sizing

Users complain that the font used in making the login page looks unprofessional, it required fonts such as Time New Roman, Verdana, Helvetica format.

One user commented the target audience of the system:

"Is the system made for adults to monitor or for kids to play?"

Future changes/adjustments based on User's Feedback

1. Make changes to the Font format by using professional fonts such as "Time New Roman".
2. The Logo should be improved to target an older audience (25 - 50) that are seeking to buy the product.

5.4.2 Registration

User Friendliness

Based on the scaling that users voted, most users voted "5". Stating that the registration page made the obvious to the users what needed to be done on this page.The page itself is "self explanatory" in a lot of ways.

1 **Not User Friendly**	2	3	4	5 **User Friendly**
0	0	0	1	7

Thought Process

Most users have a general idea on what to write and answer them based on the screen, however, age groups within (30 - 40 +) may have difficulty signing up an account due to small font used and no ease of third-party login method (Facebook, Instagram, X). Here is a remark:

"What if my 50s parent would like to create an account, I want a fast login process instead of keying in all the information"

Future changes/adjustments based on User's Feedback

1. Make use of third-party login methods
2. Make changes to the Font format by using professional fonts such as "Time New Roman".

5.4.3 Normal User Dashboard

Ease of Understanding Function or Features

Based on the voting scale, most of the users stated that they do not know that "Manage Rooms" is clickable.

" I thought the "Manage Rooms" is just showing the total energy consumption that day."

1 **Most Unclear**	2	3	4	5 **Clearest**
2	5	0	1	0

However, all the users actually understand the “Energy Usage/Generation” features as it clearly shows what it is supposed to show the users.

Information Presentation

The voting scale indicates that users can easily access the information they need, with all users praising the clear display of details such as energy usage or generation on specific days.

1 **Poorly Presented**	2	3	4	5 **Most well presented**
0	0	0	0	8

Recommendation

Some users suggested adding a feature to show the net energy used or generated for each day.

5.4.4 Privileged User Dashboard

Ease of Use

Most users commented that the dashboard looks “easy to navigate around”. However, most users fail to understand that “Manage Rooms” and “Manage Home Users” tabs are meant to be clickable at first glance. Here is a remark by one of the user:

“I didn’t even know I could click on those at first glance”

Differences between Normal and Privileged Dashboard

All users commented that the only differences are the “Manage Home Users” and “Smart Home Monthly Energy Usage Limit” tabs are missing from the Normal User Dashboard. This implies that privileged users have extra features in controlling the users and energy limit.

Main Features for Privileged User

All users are able to tell at first glance the main functionality of what the privileged user is capable of managing residents in the building and setting energy limits and automations around the home.

1 **Hardest**	2	3	4	5 **Easiest**
0	0	0	0	8

5.4.5 Homeowner Dashboard

Ease of Use

Based on the scaling, most users are able to easily identify and access the information they need as a Homeowner authority.

1 **Hardest**	2	3	4	5 **Easiest**
0	0	0	2	6

Differences between Privileged and Homeowner Dashboard

Most of the users commented that the privileged and homeowner dashboard look identical, no differences can be spotted by comparing them side-by-side. Here is one remark:

"Are you sure this isn't a typo? So privileged and homeowners are meant to have the same dashboard? "

Main Features for Homeowners

Due to privileged Dashboard and Homeowner Dashboard sharing the same interface, all users aren't able to tell the main feature of what the Homeobert authority is.

1 **Hardest**	2	3	4	5 **Easiest**
4	2	2	0	8

5.4.6 Functionalities for Normal Users

User Friendliness

All users are able to identify the procedure on what must be needed to "Turn On/Off" and "Adjust Volume" actions. The picture shown has a clear and easy interface to show the different actions of different devices.

Feedback on "Manage Rooms"
All users came to an agreement that "Manage Rooms" is an interface that allows normal users to turn on and off smart appliances.

Information Display
Based on the scaling, most users agreed upon that the information presented in the Normal User interface is sufficient. No changes will be made.

1 **Not enough**	2	3 **Just enough**	4	5 **Too much**
0	0	6	1	1

5.4.7 Functionalities for Home Owners and Privileged Users

User Friendliness
All users agree that the privileged functionalities such as "Remove Devices", "Remove Users" and "Delete Smart Home" are the main features of the higher priority account. This shows that the privileged users are able to configure more features and functionalities than normal users.

Feedback on Energy Limit Functionalities
Based on the scaling, users are not happy with the interface. Too much information being displayed at once confused some users on what to look at. It required a tutorial on each different functionalities of what privileges users are accessed to.

1 **Hard**	2	3	4	5 **Easy**
4	3	1	0	0

Additional Feedback on Functionalities
1. Make the privileged information as a hidden pop-up, don't immediately show all information, make a tiny icon that can be interacted to show detailed information
2. Make the interface simple, re-use normal functionality dashboard, but add a pull down options bar for the other functionality of homeowners or privileged users.

5.4.8 Functionalities for all Users

User Friendliness

All users agree that the graph has clearly displayed the highest and lowest values in a single week. This implies that the system keeps track of the energy limit on a daily basis and records them into a database on each specific day to compare energy used daily.

Information Visibility

According to the scaling, most users find that the information displayed for each task is clear and concise, no confusing jargon was used to display information making it user-friendly to all ages.

Energy Usage

1 **Least**	2	3	4	5 **Most**
0	0	0	0	8

Energy Generation

1 **Least**	2	3	4	5 **Most**
0	0	0	0	8

Room

1 **Least**	2	3	4	5 **Most**
0	0	0	2	6

Report Generation Functionalities

All users are able to clearly identify the “Generate Weekly/Monthly/Yearly Energy Statistics Report” on the bottom page. This is a functionality that allows everybody to have a copy of the total energy usage and consumption made in the home that they are currently residing in. One user commented on the “usefulness” of this feature.

“This is definitely a nice feature to add, so I can show my kids how much energy we used in a day so we can save energy bills together”

5.5 Questionnaire findings

5.5.1 Summary of response

The following scale is used to evaluate users' attitudes toward the system.
Strongly Disagree - 1
Strongly Agree - 5

See Appendix D for the full questionnaire.

Table 21

Response Summary

Questions	1	2	3	4	5
The website is easy to use.	0	0	6	2	0
The website is too complicated to understand.	0	2	4	2	0
The website interface is well-designed.	0	0	0	6	2
The website has a clear and logical layout.	0	0	1	2	5
I can get information like electricity used and electricity generated easily from the website.	0	0	2	4	2
What homeowner, privilege users, and normal users can see in the interface is logical.	0	2	1	1	4
Have you ever felt lost or confused while using the app, even for a moment?	**Yes** 3			**No** 5	
Can you differentiate the privileges between homeowners and privileged users?	**Yes** 5			**No** 3	
Do you think you need any tutorial before using the website?	**Yes** 4			**No** 4	

Note. Cells highlighted yellow are the mode of the result.

5.5.2 Observations from questionnaire results

User Friendliness

Most users find the website neither too difficult nor too easy to understand or use. However, there are several recommendations to enhance the overall user experience.

Firstly, 3rd-party app integration should be implemented to enhance the login and sign-in experience. Some users mentioned that entering all their information during the login process is

frustrating. Introducing 3rd-party login options would help streamline the process and reduce redundancy.

Moreover, most of the users did not realise the 'Manage Room' and ‘Manage Home Users’ tabs are clickable. This led to confusion and difficulty in accessing its functionality. Enhancing the 'Manage Room' and ‘Manage Home Users’ tabs with clearer labelling or adding a brief tooltip could help users understand its functionality and improve ease of navigation.

In short, there is significant room for improvement to enhance the user experience. On a positive note, most users did not feel lost while using the website, indicating that it is functional. However, implementing additional features and refinements should be done in order to improve usability and satisfaction.

Visual Impression and Layout

Most users expressed positive feedback regarding the website's visual impression, which is likely attributed to its cartoonish design. The vibrant colours create a welcoming and stress-free experience for users, leaving a lasting positive impact.

In addition to the visual design, users also praised the layout of the website. They found it logical and well-structured, with clear distinctions made for homeowners, privileged users, and normal users. This thoughtful organisation ensures that each type of user can easily access relevant features, contributing to an overall smooth and enjoyable navigation experience

Information Representation

Even first-time users can easily find their target information on the website, indicating that the representation of data, such as energy usage and energy generation, is well-designed and effective.

Additionally, most users were able to differentiate between the privileges of homeowners and privileged users. However, some noted that the differences were not immediately apparent. To address this, unique features like 'Delete Smart Homes' should be clearly highlighted, helping users better understand the distinctions between them.

Tutorial

Half of the users expressed a desire for a tutorial to guide them when using the website. Providing a tutorial for first-time users would significantly enhance the user experience, allowing them to quickly and effectively access the available functions and features.

5.6 Conclusion

Through the findings from the questionnaires, we have identified both the strengths and areas for improvement of the website. While the website demonstrates strong functionality and usability, implementing certain enhancements will further refine the user experience and address user concerns effectively.

One common feedback from users was the frustration experienced during the login or sign-in process due to repetitive entry of personal information. To resolve this issue, 3rd-party login options will be integrated, streamlining the process and reducing redundancy. Additionally, tooltips will be added to the 'Manage Rooms' and 'Manage Home Users' tabs to enhance clarity and reduce confusion, enabling users to fully experience the website's functionality. Highlighting features such as the 'Delete Smart Homes' functionality will also help users better understand and utilise the platform.

While most users did not feel lost while navigating the website, 50% of participants recommended adding a tutorial to guide new users. To address this, a quick tutorial guide will be implemented, ensuring first-time users can quickly familiarise themselves with the website's features and reducing potential confusion.

By addressing these issues, we aim to provide a smooth and enjoyable experience for all users, enhancing the website's usability and functionality.

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Appendix A
Diagrams

Figure A1

Use Case Diagram

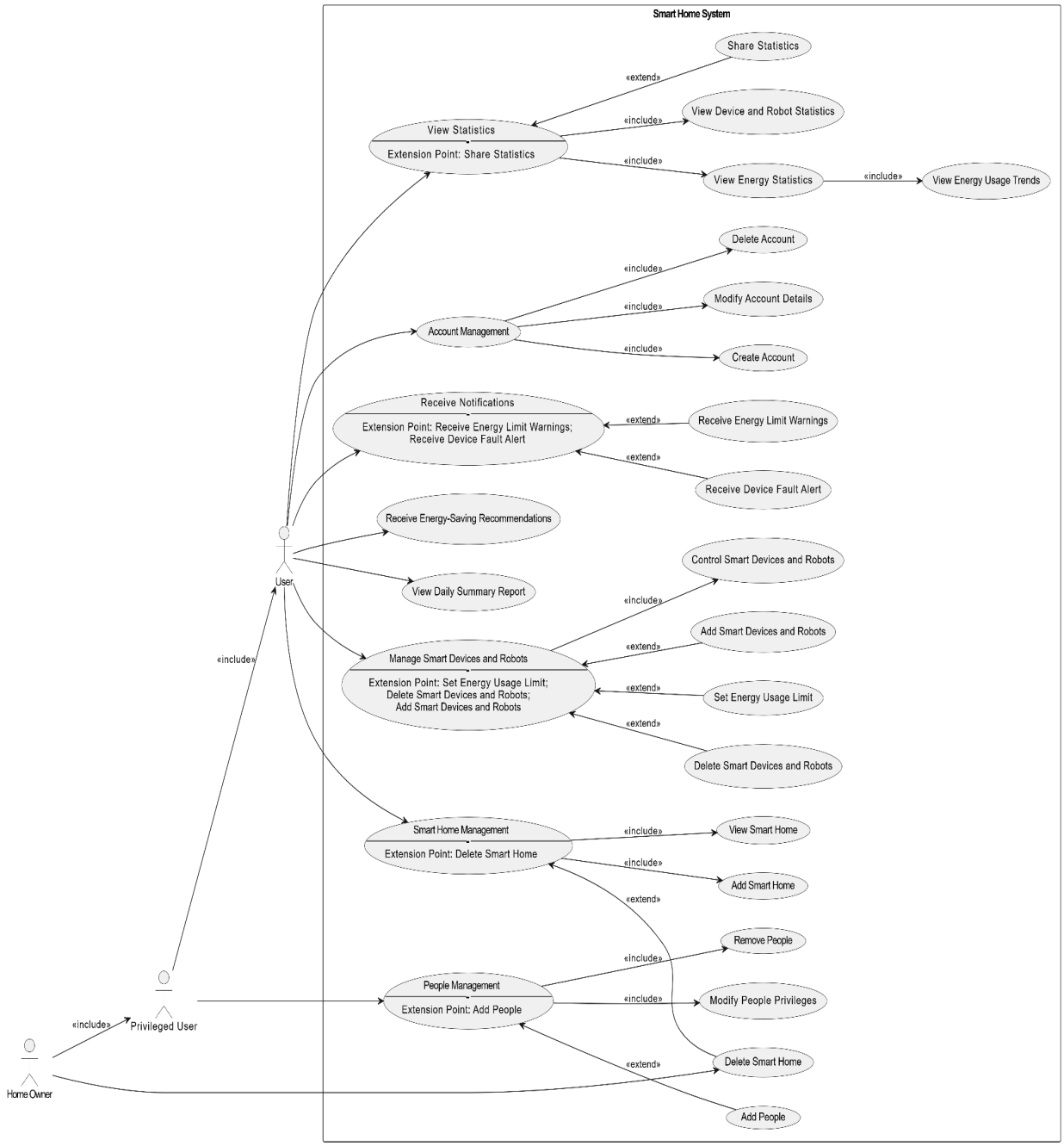


Figure A2

Activity Diagram for View Statistics Use Case

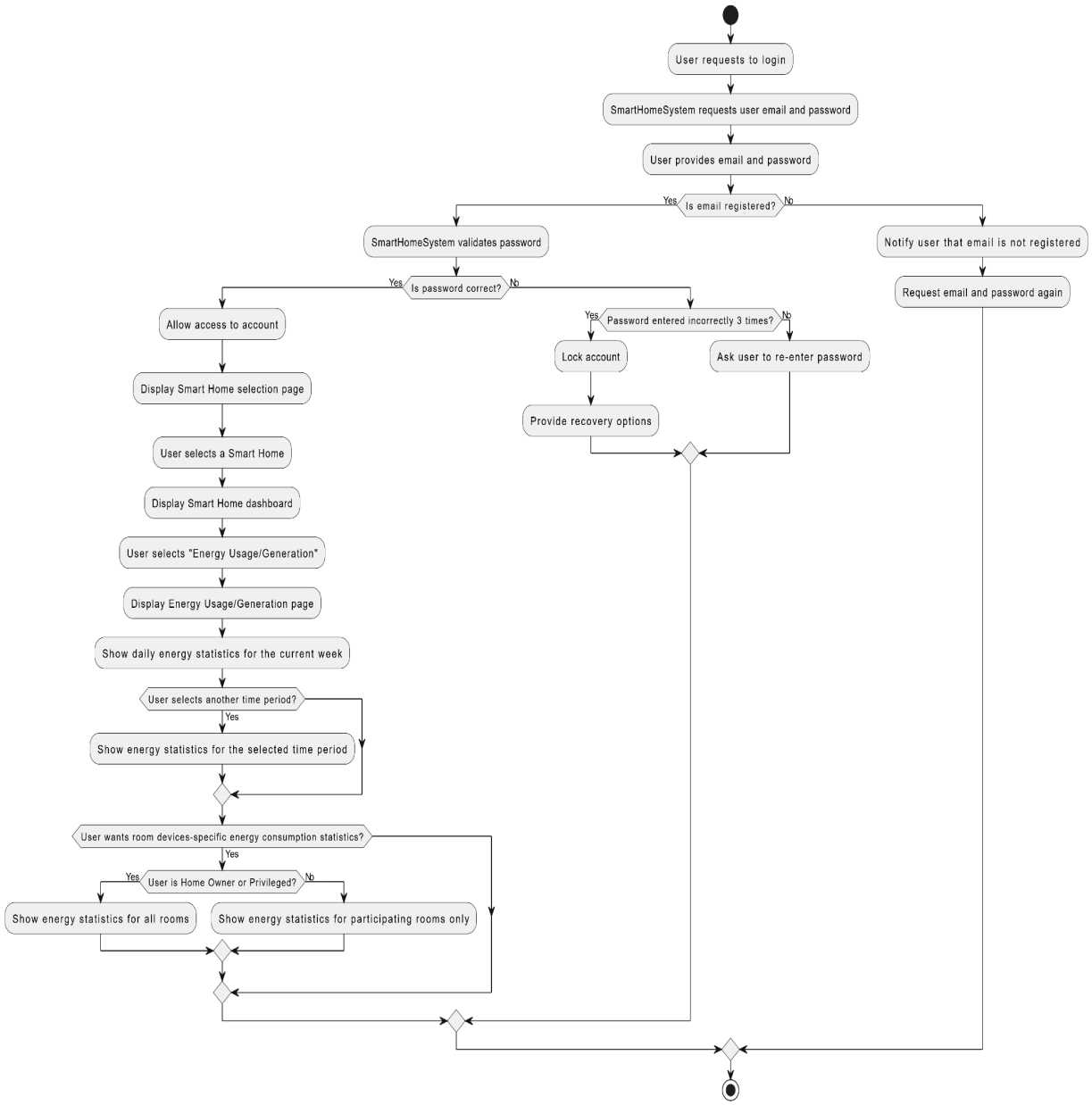


Figure A3

Activity Diagram for Manage Smart Devices and Robots Use Case

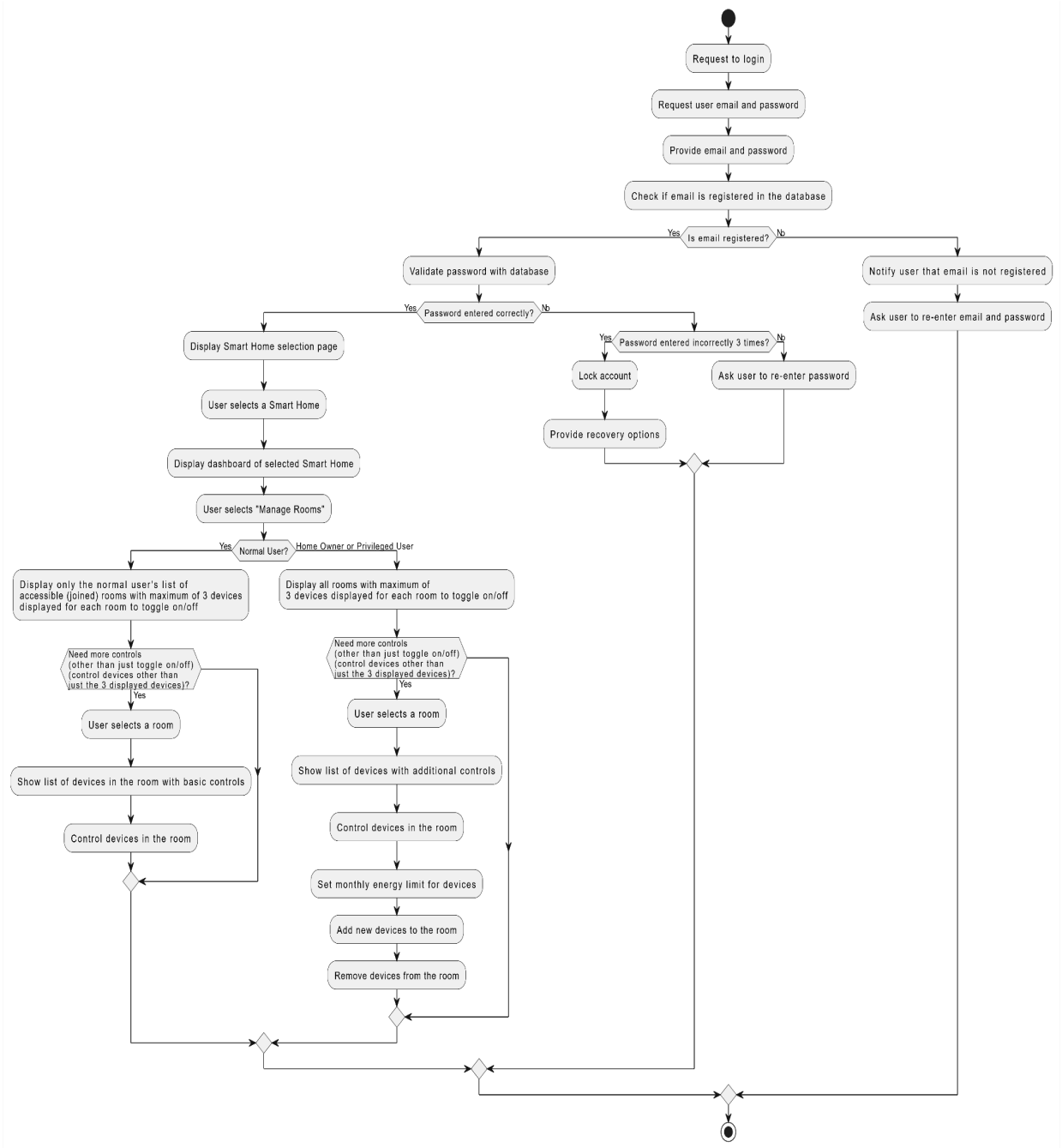
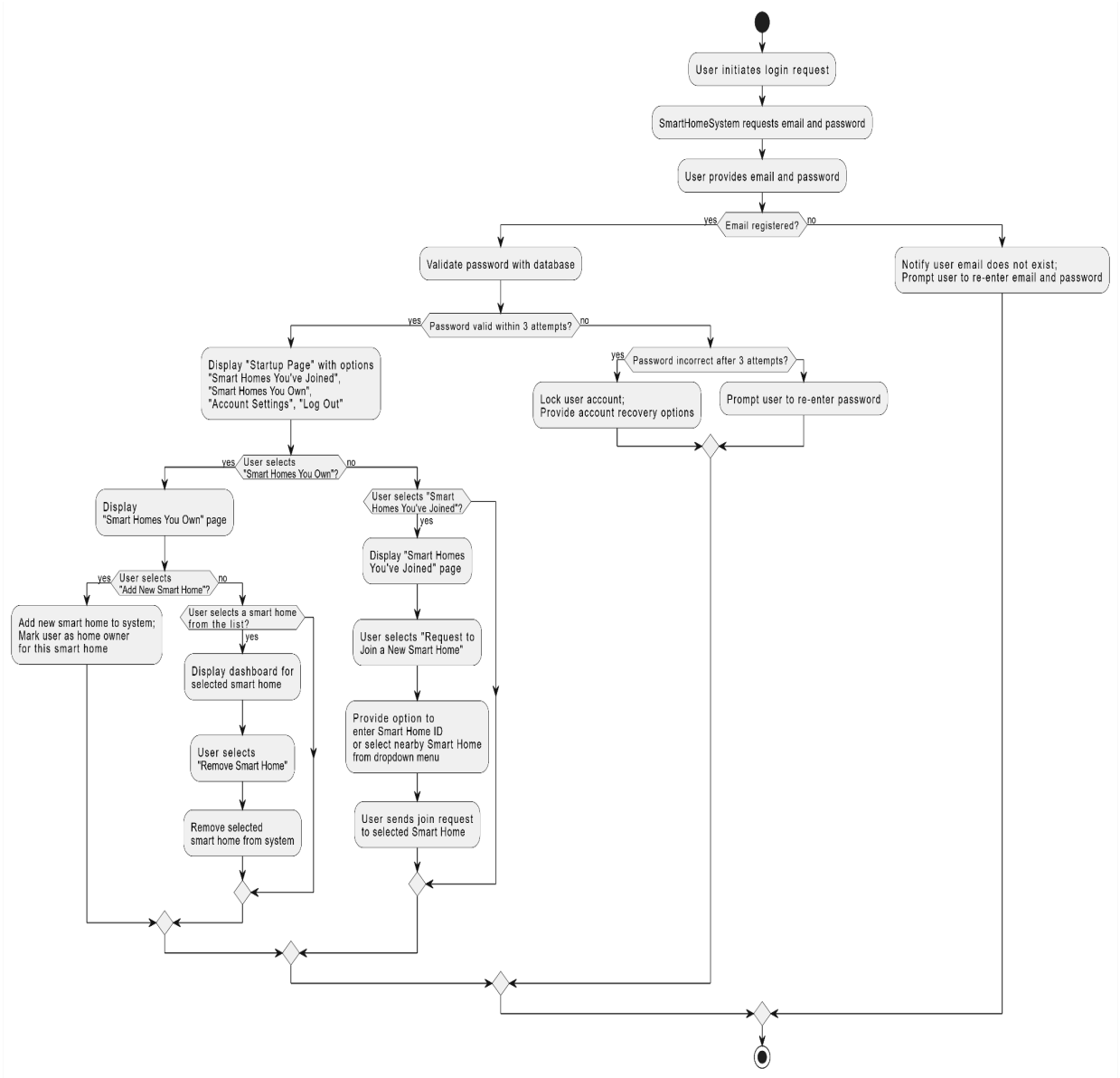


Figure A4

Activity Diagram for Smart Home Management



Appendix B
Risk Analysis Criteria Definition

Table B1.

Definition for Impact Levels

Impact of the Risk	**Description**
Catastrophic	Results in project failure
Serious	Causes serious disruption to the project timeline that may need major rework
Tolerable	Minor impact that can be managed by minor adjustments
Insignificant	Negligible impact that can be managed without affecting the project significantly

Table B2.

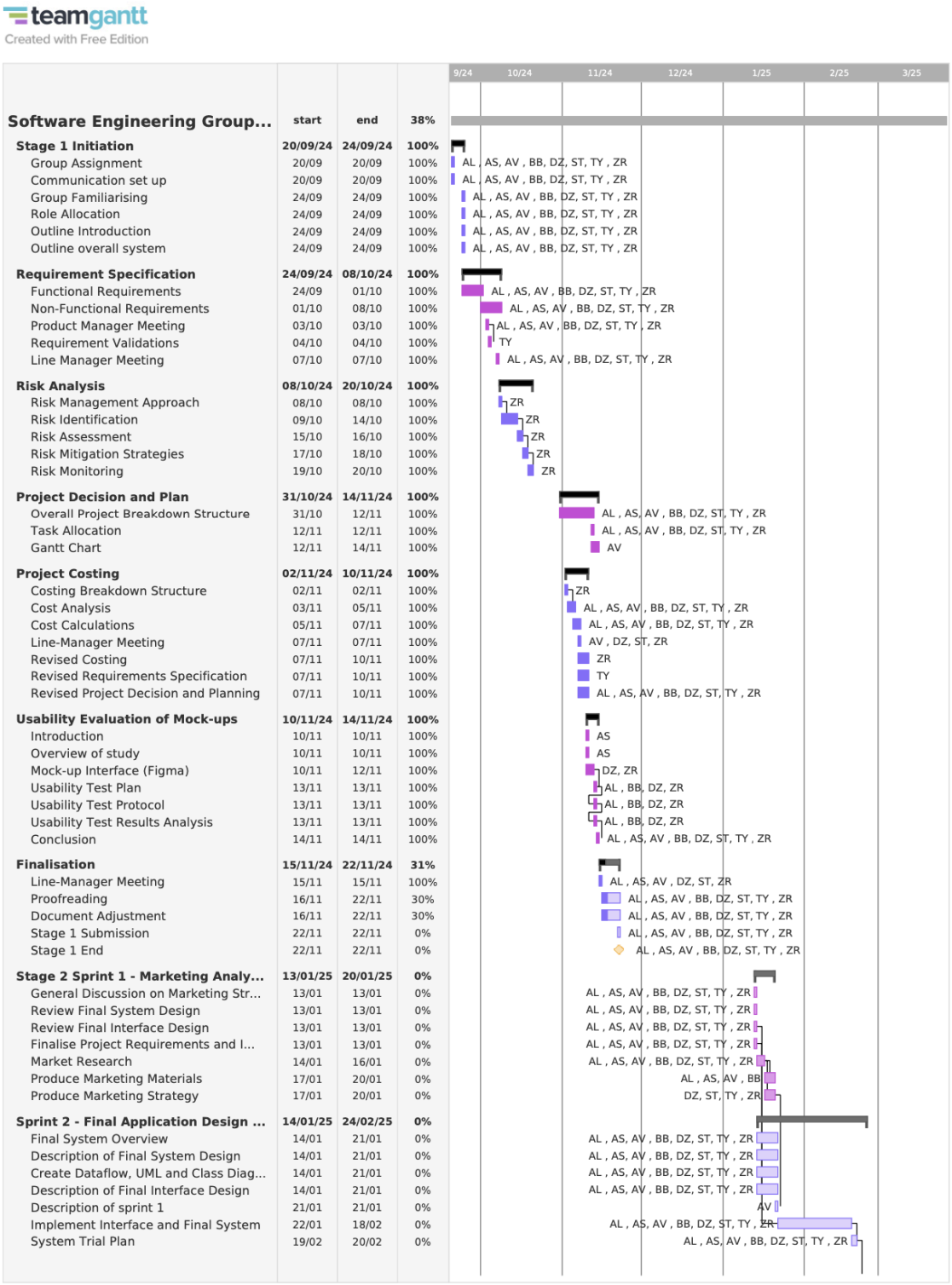
Definition for Probability Levels

Probability	**Description**
Low	Not likely to happen
Moderate	May happen
High	Likely to happen

Appendix C
Gantt Chart

Figure C1

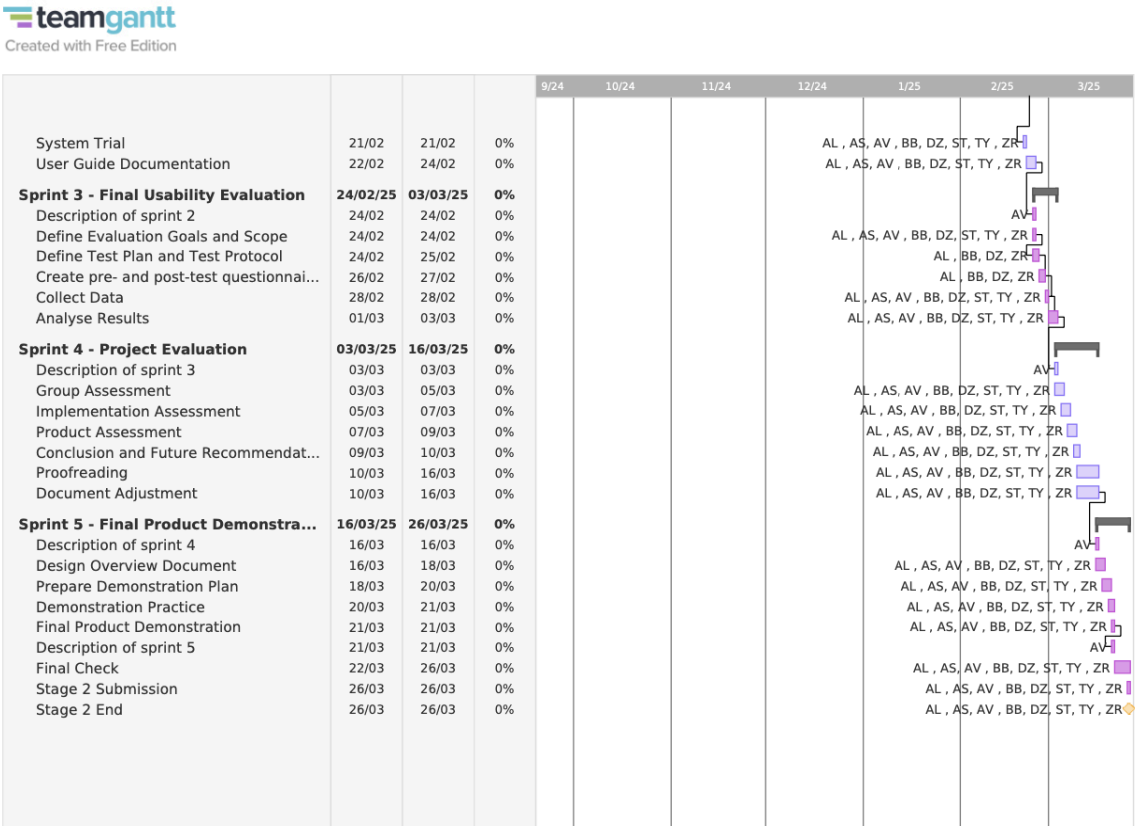
Gantt Chart for Stage 1 and Stage 2 Sprint 1 and 2



Software Engineering Group...	start	end	38%
Stage 1 Initiation	**20/09/24**	**24/09/24**	**100%**
Group Assignment	20/09	20/09	100%
Communication set up	20/09	20/09	100%
Group Familiarising	24/09	24/09	100%
Role Allocation	24/09	24/09	100%
Outline Introduction	24/09	24/09	100%
Outline overall system	24/09	24/09	100%
Requirement Specification	**24/09/24**	**08/10/24**	**100%**
Functional Requirements	24/09	01/10	100%
Non-Functional Requirements	01/10	08/10	100%
Product Manager Meeting	03/10	03/10	100%
Requirement Validations	04/10	04/10	100%
Line Manager Meeting	07/10	07/10	100%
Risk Analysis	**08/10/24**	**20/10/24**	**100%**
Risk Management Approach	08/10	08/10	100%
Risk Identification	09/10	14/10	100%
Risk Assessment	15/10	16/10	100%
Risk Mitigation Strategies	17/10	18/10	100%
Risk Monitoring	19/10	20/10	100%
Project Decision and Plan	**31/10/24**	**14/11/24**	**100%**
Overall Project Breakdown Structure	31/10	12/11	100%
Task Allocation	12/11	12/11	100%
Gantt Chart	12/11	14/11	100%
Project Costing	**02/11/24**	**10/11/24**	**100%**
Costing Breakdown Structure	02/11	02/11	100%
Cost Analysis	03/11	05/11	100%
Cost Calculations	05/11	07/11	100%
Line-Manager Meeting	07/11	07/11	100%
Revised Costing	07/11	10/11	100%
Revised Requirements Specification	07/11	10/11	100%
Revised Project Decision and Planning	07/11	10/11	100%
Usability Evaluation of Mock-ups	**10/11/24**	**14/11/24**	**100%**
Introduction	10/11	10/11	100%
Overview of study	10/11	10/11	100%
Mock-up Interface (Figma)	10/11	12/11	100%
Usability Test Plan	13/11	13/11	100%
Usability Test Protocol	13/11	13/11	100%
Usability Test Results Analysis	13/11	13/11	100%
Conclusion	14/11	14/11	100%
Finalisation	**15/11/24**	**22/11/24**	**31%**
Line-Manager Meeting	15/11	15/11	100%
Proofreading	16/11	22/11	30%
Document Adjustment	16/11	22/11	30%
Stage 1 Submission	22/11	22/11	0%
Stage 1 End	22/11	22/11	0%
Stage 2 Sprint 1 - Marketing Analy...	**13/01/25**	**20/01/25**	**0%**
General Discussion on Marketing Str...	13/01	13/01	0%
Review Final System Design	13/01	13/01	0%
Review Final Interface Design	13/01	13/01	0%
Finalise Project Requirements and I...	13/01	13/01	0%
Market Research	14/01	16/01	0%
Produce Marketing Materials	17/01	20/01	0%
Produce Marketing Strategy	17/01	20/01	0%
Sprint 2 - Final Application Design ...	**14/01/25**	**24/02/25**	**0%**
Final System Overview	14/01	21/01	0%
Description of Final System Design	14/01	21/01	0%
Create Dataflow, UML and Class Diag...	14/01	21/01	0%
Description of Final Interface Design	14/01	21/01	0%
Description of sprint 1	21/01	21/01	0%
Implement Interface and Final System	22/01	18/02	0%
System Trial Plan	19/02	20/02	0%

Figure C2

Gantt Chart for Stage 2 Sprint 3, 4 and 5



Appendix D
User Consent Form

Consent Form to Act as a Subject in an Upcoming Smart Home System

Principal Investigator: Dzuhair Hakimi

Description: The purpose of this study is to investigate the efficiency and level of difficulty and ease of use of the web-based applications developed to help homeowners and normal residents to monitor the energy generation and consumption in your home and manage the electronics in particular areas.

Your personal information will be kept confidential in a secured cloud server with password encrypted protection. Your participation will not affect any relationship with the University in any way.

You are free to decline to participate in this study. If you decide to participate, you are free to take the Questionnaire anytime with no time limit. Make sure to read each line of question carefully and answer as honestly as possible. Decisions made by you will not affect your status with the University in any way.

Voluntary Consent: I have certified that I have read the preceding and that I understand its contents. By signing here, I hereby voluntarily consent to the result being published for research purposes, and consent to the sharing of the recordings and transcripts of the sessions for research reasons, provided that my identity remains anonymous. If you have any further questions about the research, please contact the principal investigator.

( ) ( )

Signature Date

Investigator's acknowledgement:

Investigator Name Investigator Signature Date

( ) ( ) ( )

Appendix E
Mockup of the System

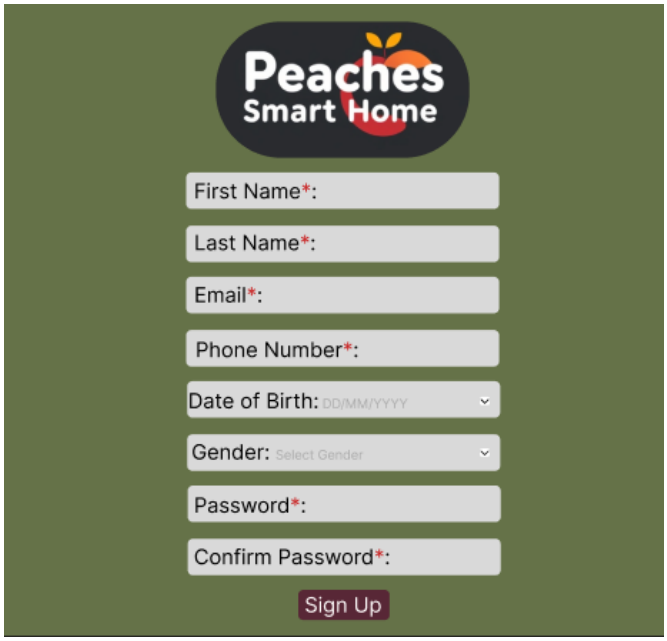
Figure E1

Login Page

Note. A page where users can log in, or if they forgot their passwords to their accounts, they can click on “Forgot Password” which brings the users to Figure E17.

Figure E2

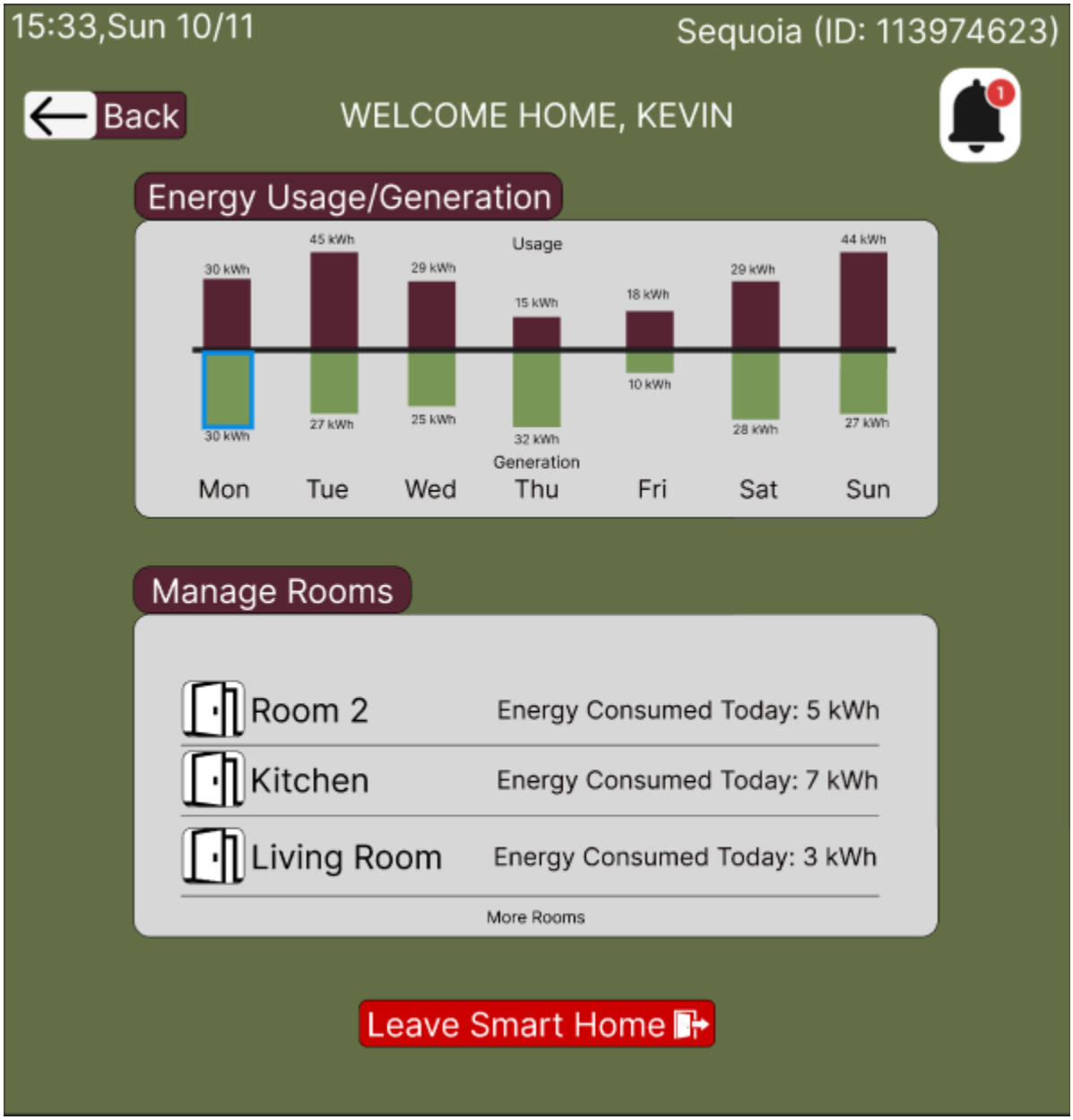
Register Page



Note. Users can register and sign up for a new account here.

Figure E3

Interface for Normal Users

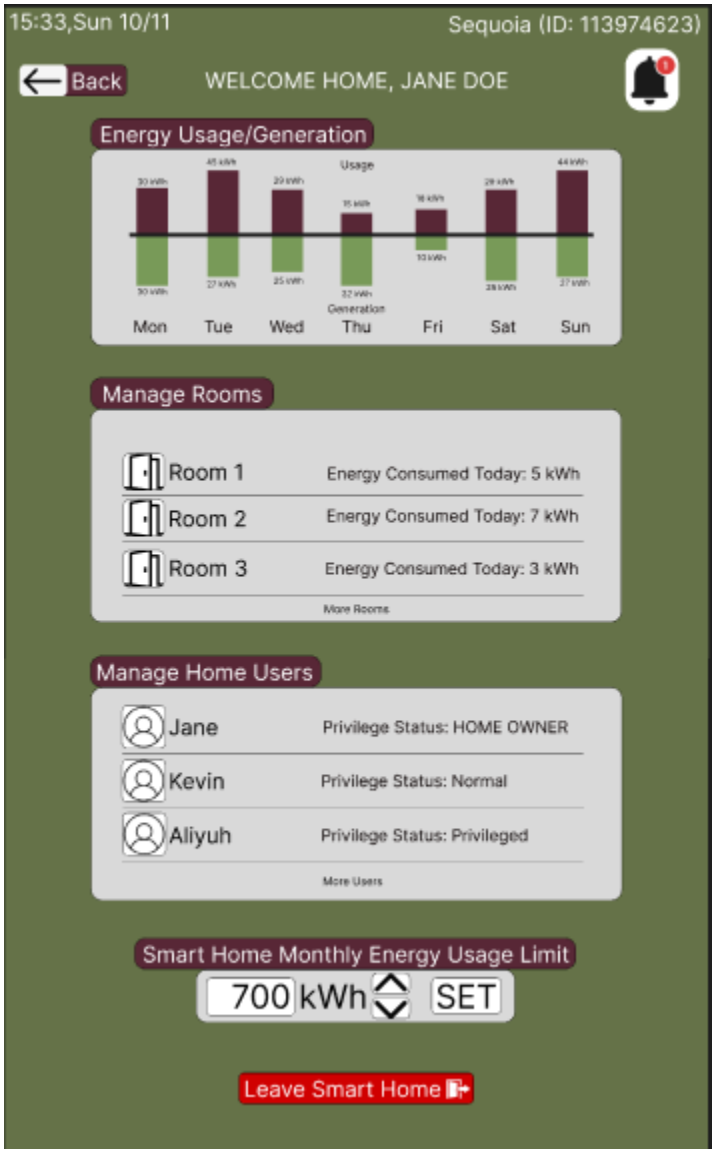


Note. User Interface of a Smart Home for normal users.

- Clicking on the "Energy Usage/Generation" brings users to the interface in Figure E15.
- Clicking on "Manage Rooms" brings users to the interface in Figure E6.
- Clicking on "Leave Smart Home" allows users to leave the Smart Home .

Figure E4

Interface for Privileged Users

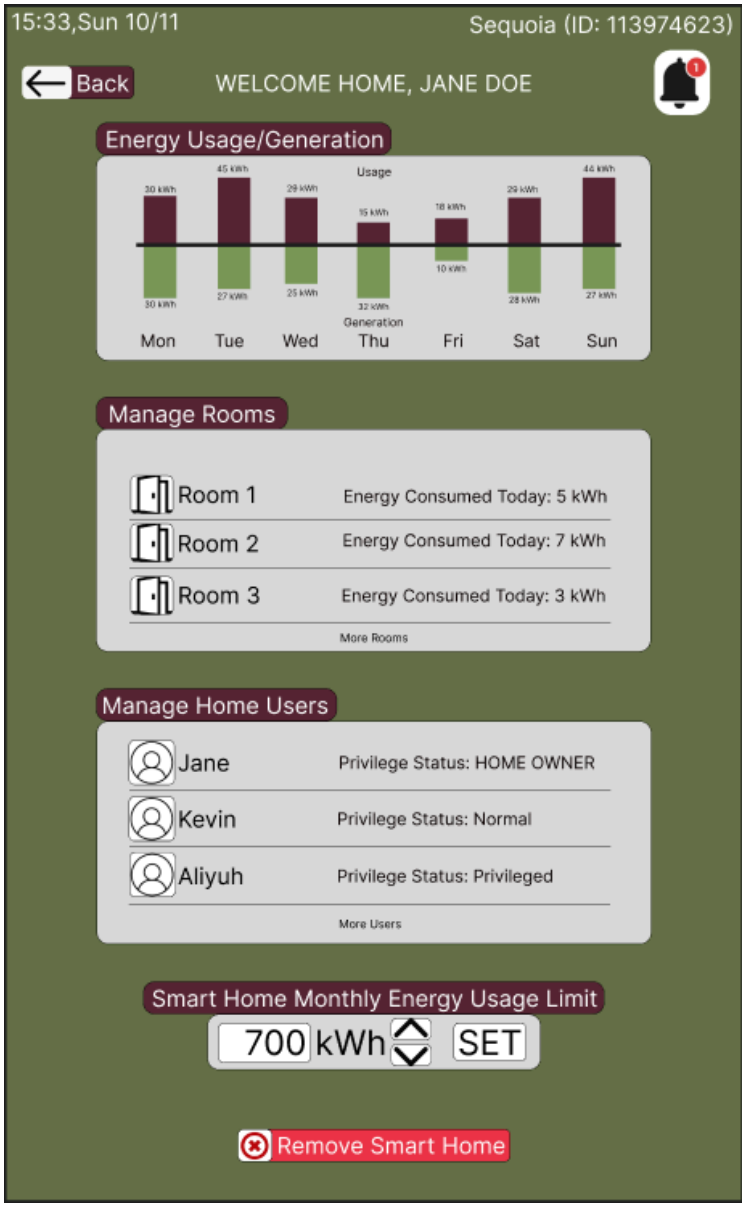


Note. User interface of a Smart Home for privileged users.

- Clicking on the "Energy Usage/Generation" brings users to the interface in Figure E15.
- Clicking on "Manage Rooms" brings users to the interface in Figure E11.
- Clicking on "Manage Home Users" brings users to the interface in Figure E9.
- Privileged users can interact with the "Smart Home Monthly Energy Usage Limit" to set the monthly energy limit of the Smart Home.
- Clicking on "Leave Smart Home" allows users to leave the Smart Home.

Figure E5

Interface for Homeowners



Note. User interface of a Smart Home for homeowners.

- Clicking on the "Energy Usage/Generation" brings users to the interface in Figure E15.
- Clicking on "Manage Rooms" brings users to the interface in Figure E11.
- Clicking on "Manage Home Users" brings users to the interface in Figure E9.
- Home owners can interact with the "Smart Home Monthly Energy Usage Limit" to set the monthly energy limit of the Smart Home.
- Home owners can click on "Remove Smart Home" to remove the entire Smart Home from the system (database).

Figure E6

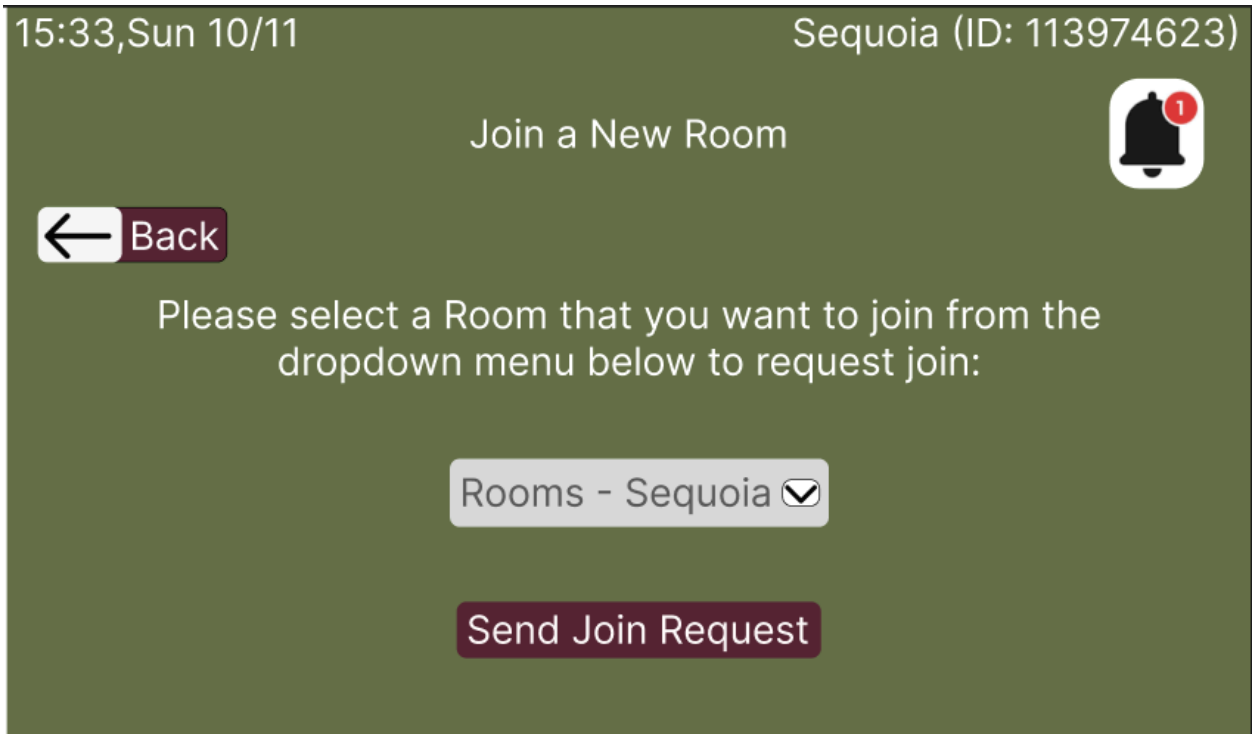
Core Functionalities for a Normal User - Manage Rooms Interface

Note. The interface shows rooms and open areas for a normal user.

- Clicking on any room will bring you to Figure E8.
- Users can view the statistics of every device in the particular room.
- Clicking on the “Request to Join a New Room” button will bring the user to the interface in Figure E7.

Figure E7

Core Functionalities for Normal Users - Interface for Joining a New Room

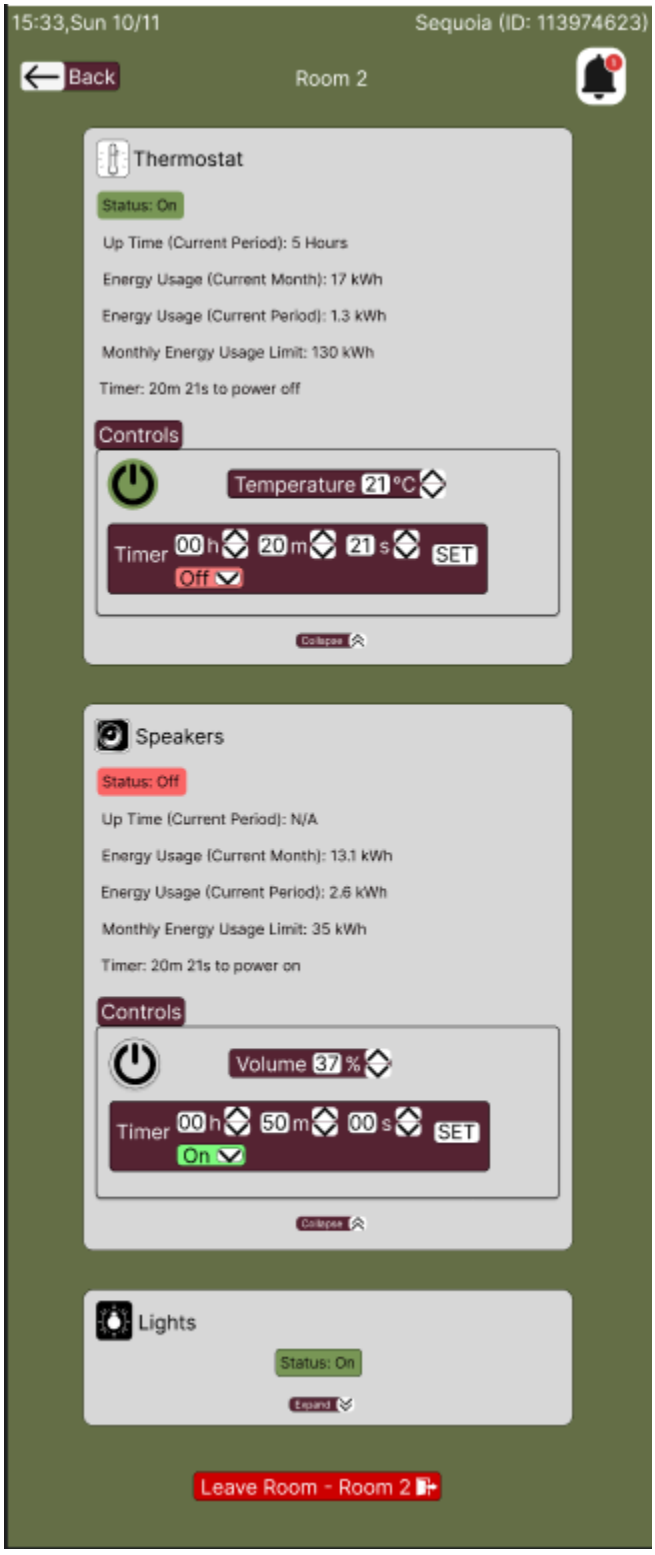


Note. The interface allows normal users to join a new room.

- Clicking on the drop down button leads to a list of rooms you can request to join.
- Clicking on the “Send Join Request” button will send a request to the privileged user requesting to join the room.

Figure E8

Core Functionalities for Normal Users - Room Interface

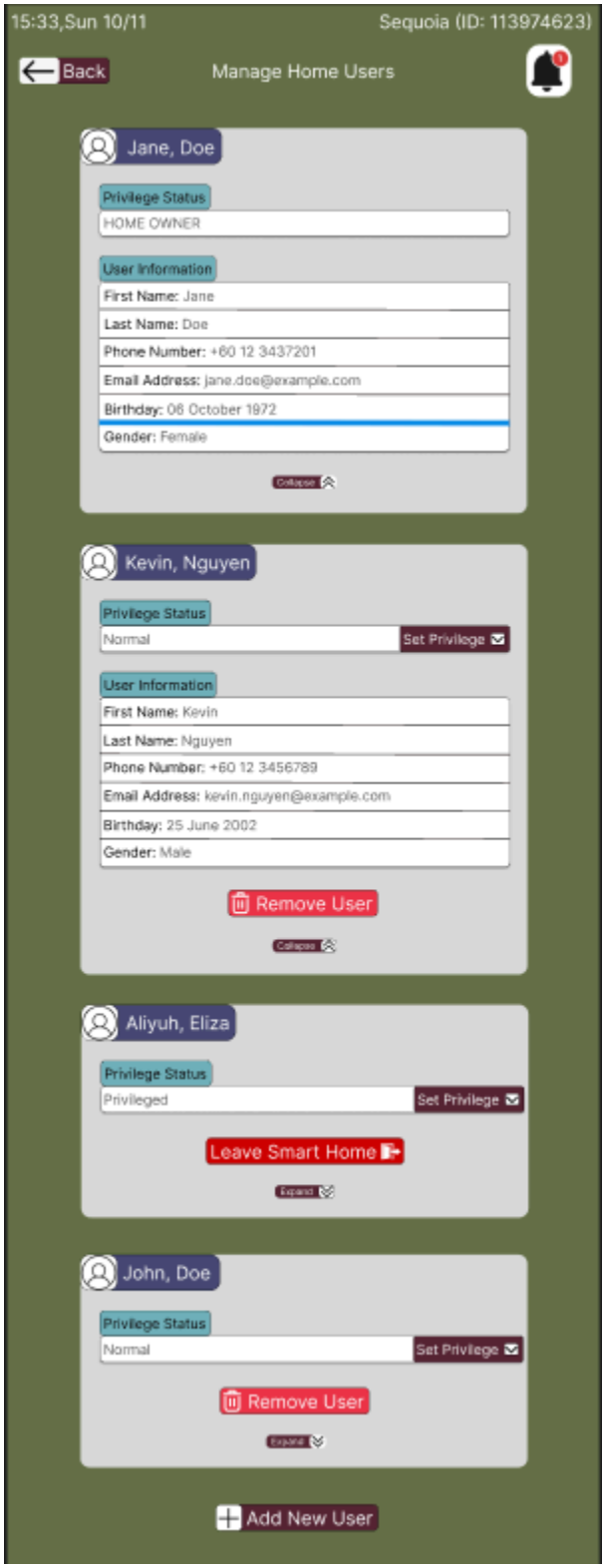


Note. User interface for “Room 2” and its connected devices.

- The room has 3 devices in which all three can be controlled.
- Clicking on the power button allows the user to turn the devices on and off.
- Clicking the arrow buttons adjusts values based on their function. They can be used to increase or decrease settings such as volume, temperature, or the hours, minutes, and seconds on the timer.
- The timer can be switched on by clicking on the “ON” button.
- Clicking on the “Leave Room 2” button can allow the user to leave the room.

Figure E9

Core Functionalities for Home Owners and Privileged Users - Manage Home Users Interface

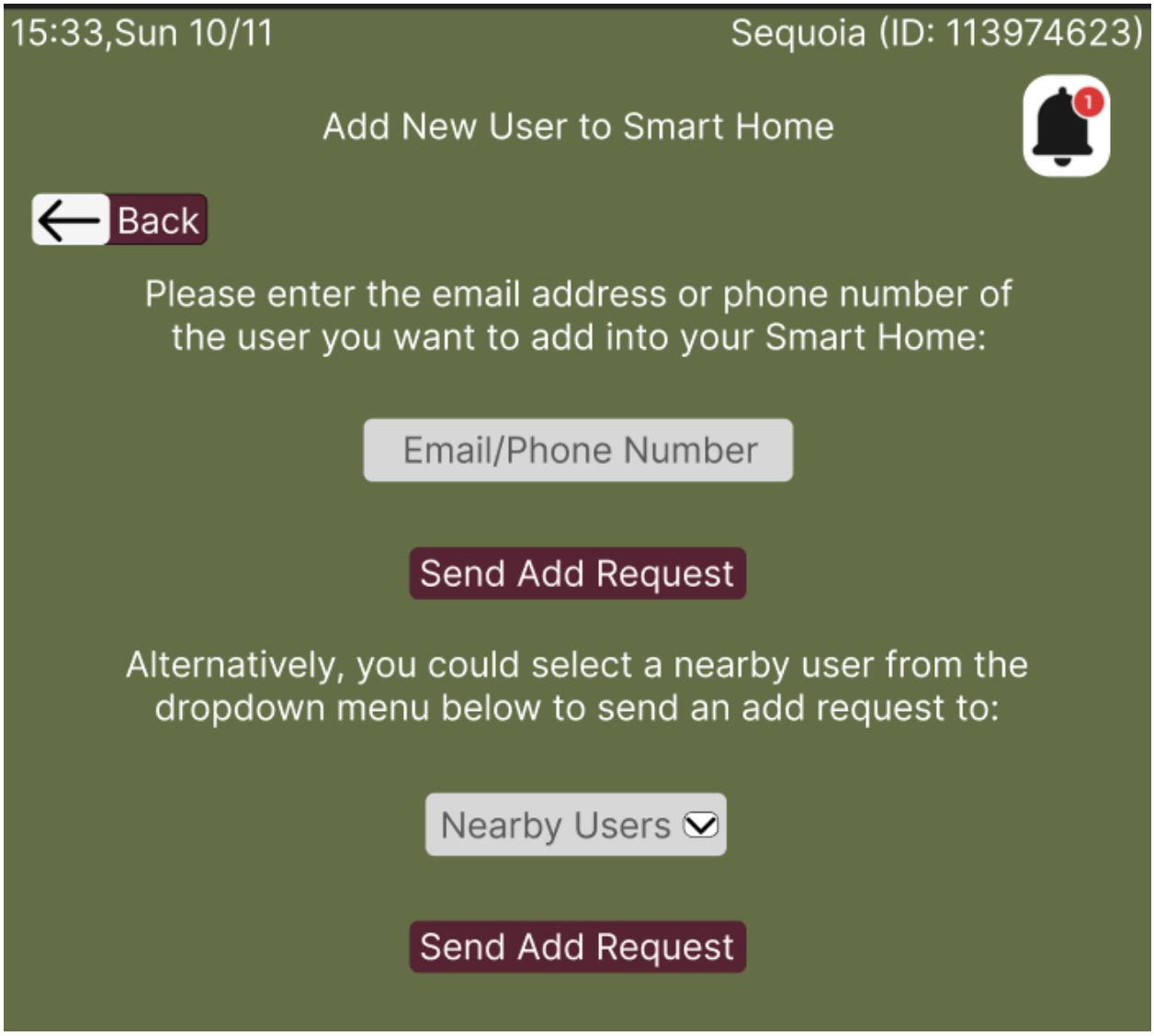


Note. The page shows the interface where privileged users and homeowners can manage other home users.

- Clicking on the “Add New User” button will lead to Figure E10.
- Information about homeowners, privileged users and normal users are on this page.
- By clicking on the “Privilege Status” dropdown menu, privileged users can set privileges for any users in this smart home, except homeowners.
- Privileged users can click the “Remove User” button to remove selected users from the Smart Home, except homeowners.
- By clicking on the “Leave Smart Home” button, the privileged user themself will be removed from the Smart Home.
- Home owners can remove everyone else in the Smart Home except for themselves.

Figure E10

Core Functionalities for Home Owners and Privileged Users - Interface to Add New Users to the Smart Home



Note. The page shows an interface where privileged users can add new users to the Smart Home.

- Privileged users can send requests to anyone with an email address or phone number to invite them to join the Smart Home.
- By clicking on the "Nearby Users" button, nearby users with an existing smart home account can be seen. Clicking on their profile will send a request to them to join the Smart Home.

Figure E11

Core Functionalities for Home Owners and Privileged Users - Manage Rooms Interface

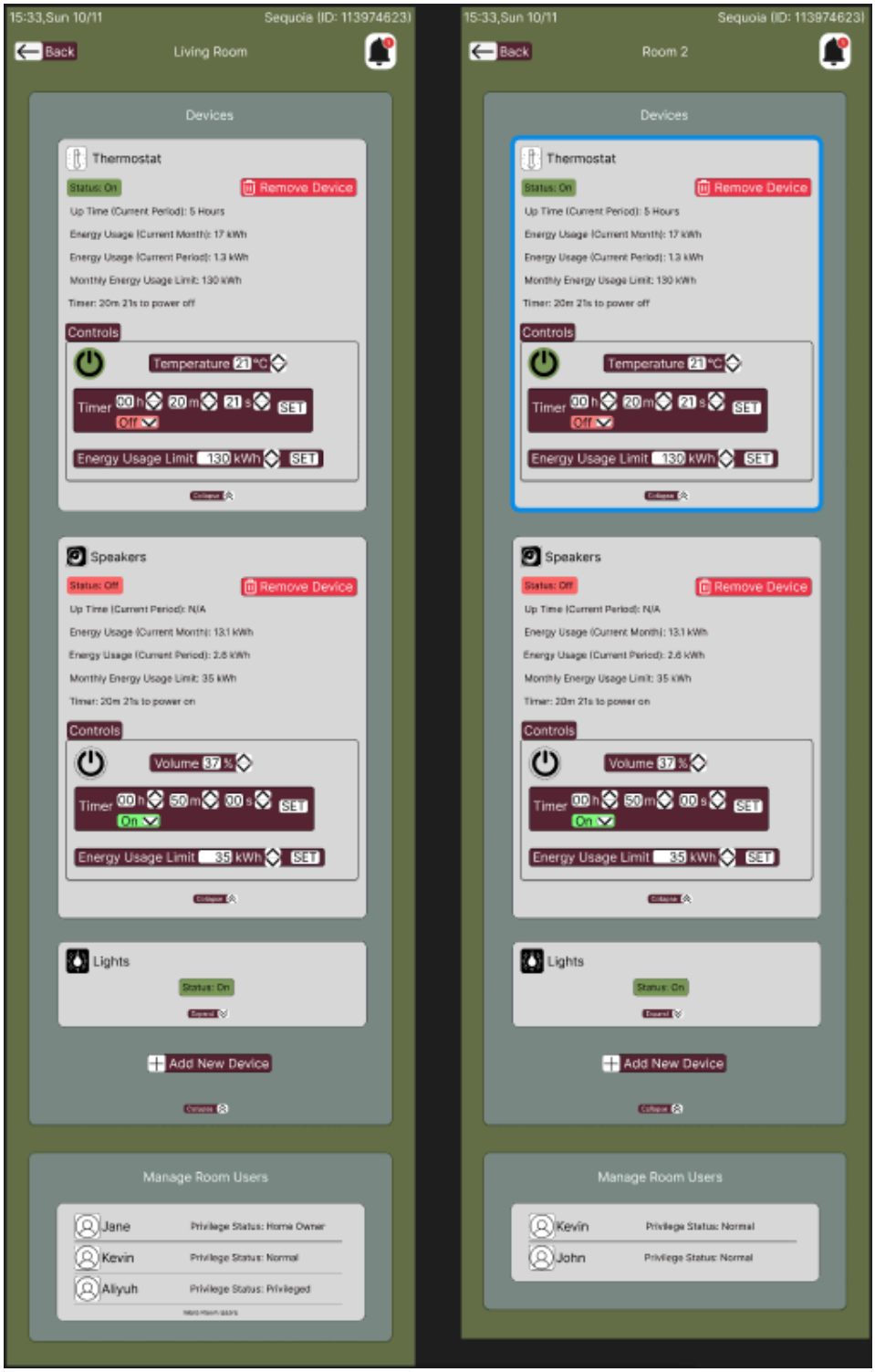
Note. The page depicts all the rooms and public areas of the Smart Home.

- Privileged users can control devices in every room in the Smart Home.

- Clicking on any room will bring the user to Figure E12.
- Home owners and privileged users can join any room by clicking on the “Join Room” button.

Figure E12

Core Functionalities for Home Owners and Privileged Users - Interface to Manage Specific Rooms

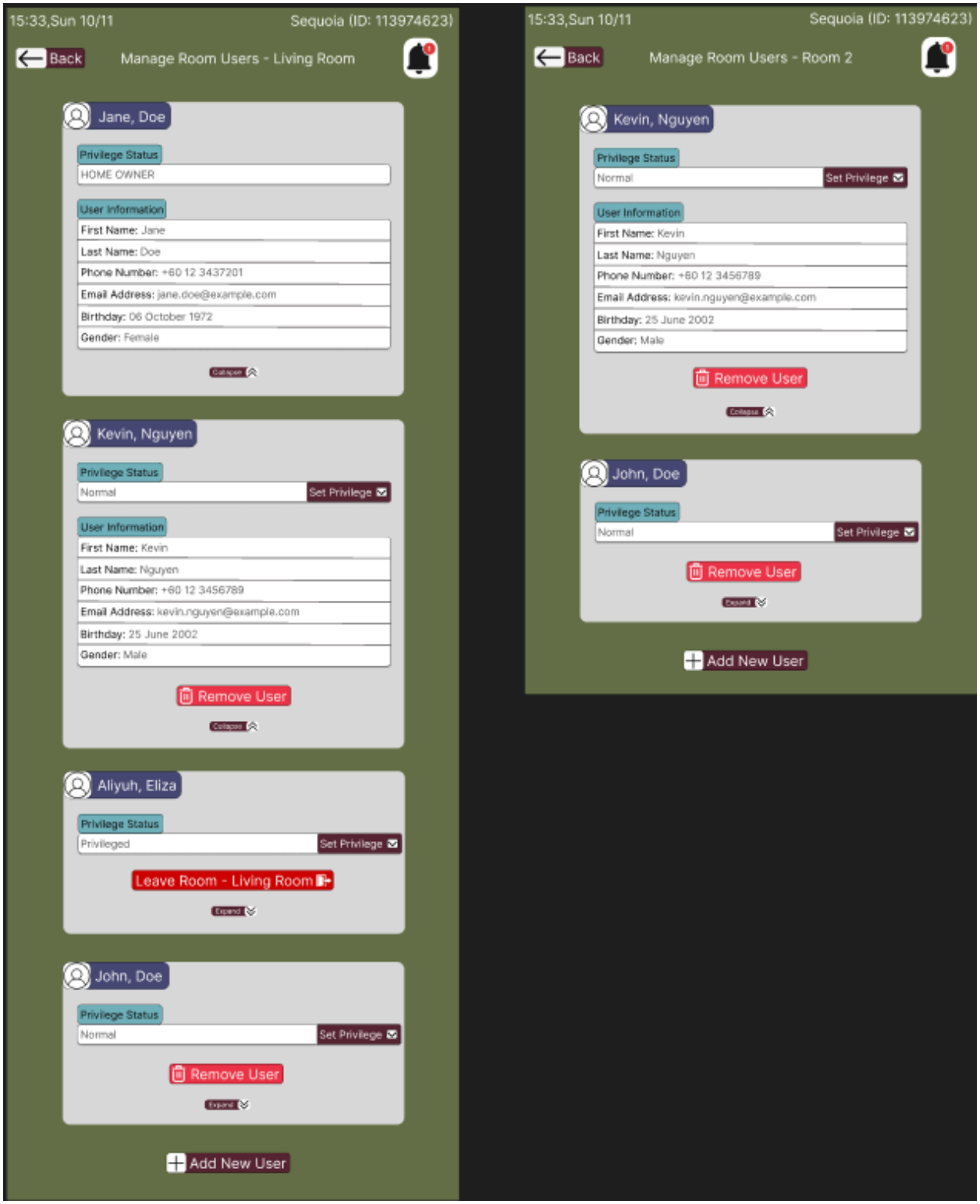


Note. The page shows devices and joined users in particular rooms.

- Clicking on “Add New Devices” will bring home owners or privileged users to Figure E14.
- Clicking on “Manage Room Users’ will bring the user to Figure E13.

Figure E13

Core Functionalities for Home Owners and Privileged Users - Manage Room Users Interface

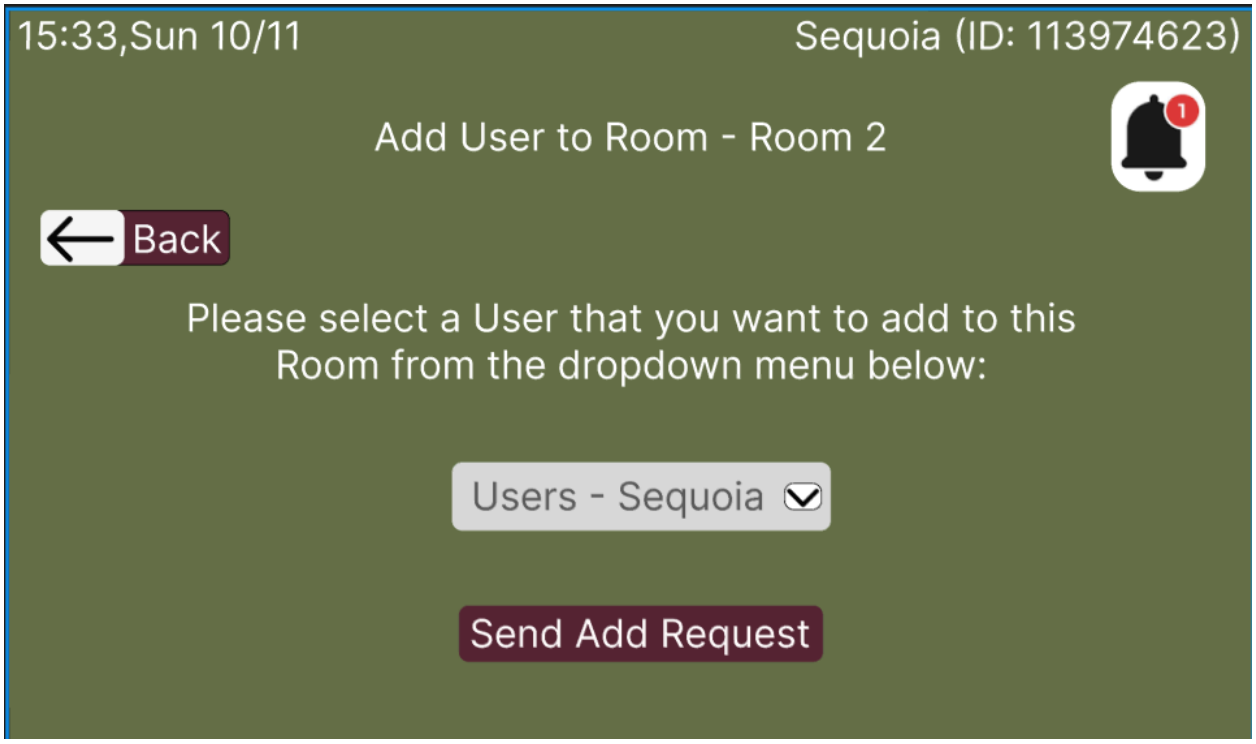


Note. User interface for showing every user in a particular room.

- The left part of the figure depicts the “Manage Rooms” interface when the privileged user or home owner has joined the room.
- The right part of the figure depicts the “Manage Rooms” interface when the privileged user or home owner has not joined the room.
- By clicking the “Set Privilege” button, privileged users can change the privileged status of any user in a room except for the homeowner (if the homeowner is in the room).
- Privileged users can remove any other users (except for the homeowner if the homeowner is in the room) or themselves from a room by clicking on the “Remove User” or “Leave Room” button.
- Home owners can set the privileges of every other user (except for other homeowners) in a room by clicking on the “Set Privilege” button.
- Home owners can remove any other users from a room by clicking on the “Remove User” button. They can also leave the room by clicking on the “Leave Room” button.
- Clicking on the “Add New User” button will bring users to Figure E14.

Figure E14

Core Functionalities for Home Owners and Privileged Users - Add User to a Room Interface

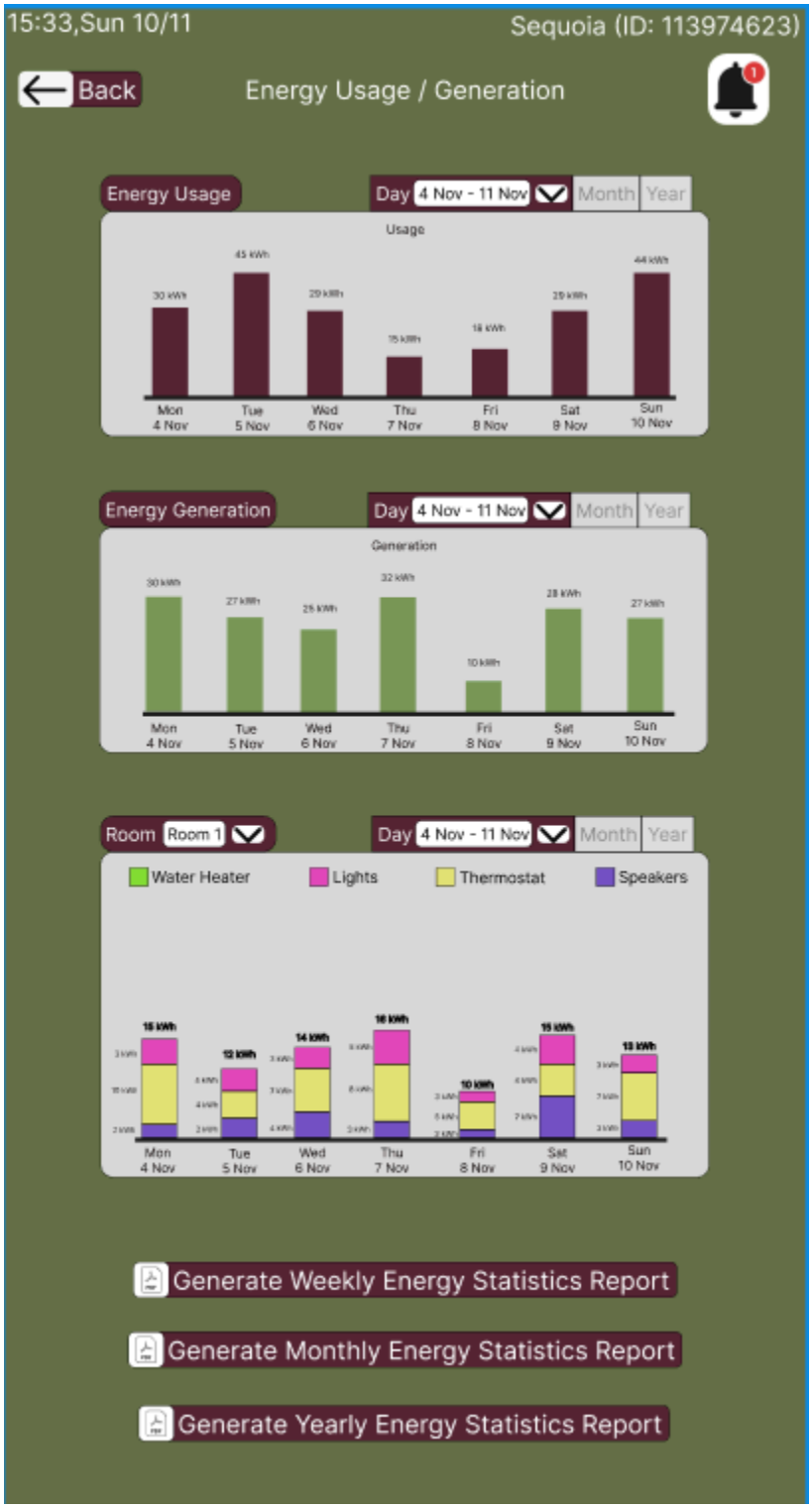


Note. User interface showing where privileged users can add new users to a room.

- By clicking the drop down button, every user in the Smart Home will be shown. By selecting a specific user, a request will be sent to the user asking them to join the room.

Figure E15

Functionalities of All Users - Energy Usage / Generation Interface



Note. User interface for showing overall energy usage, energy generation and energy usage of each device in a room.

- Data visualisation can be adjusted by clicking on “Day”, “Month”, or “Year”.
- By clicking on the “Room” drop down button, the room can be switched and data usage of every device in that room will be shown.
- Clicking the “Generate Weekly Energy Statistics Report” button exports a PDF file similar to the example shown above. The “Generate Monthly Energy Statistics Report” and “Generate Yearly Energy Statistics Report” button functions in the same way.

Figure E16

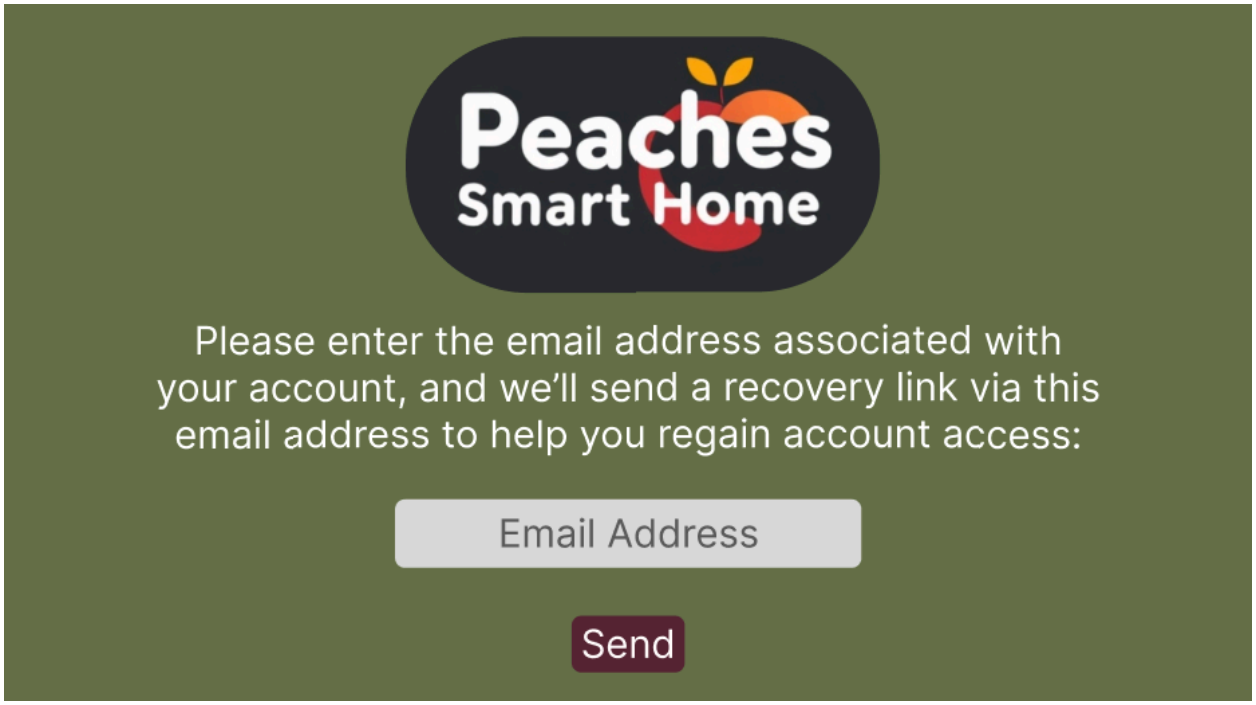
Landing Page

Note. This is the first page users will see when they open the software.

- Clicking “Sign In” will bring users to the interface in Figure E1.
- Clicking on “Register” will bring users to the interface in Figure E2.

Figure E17

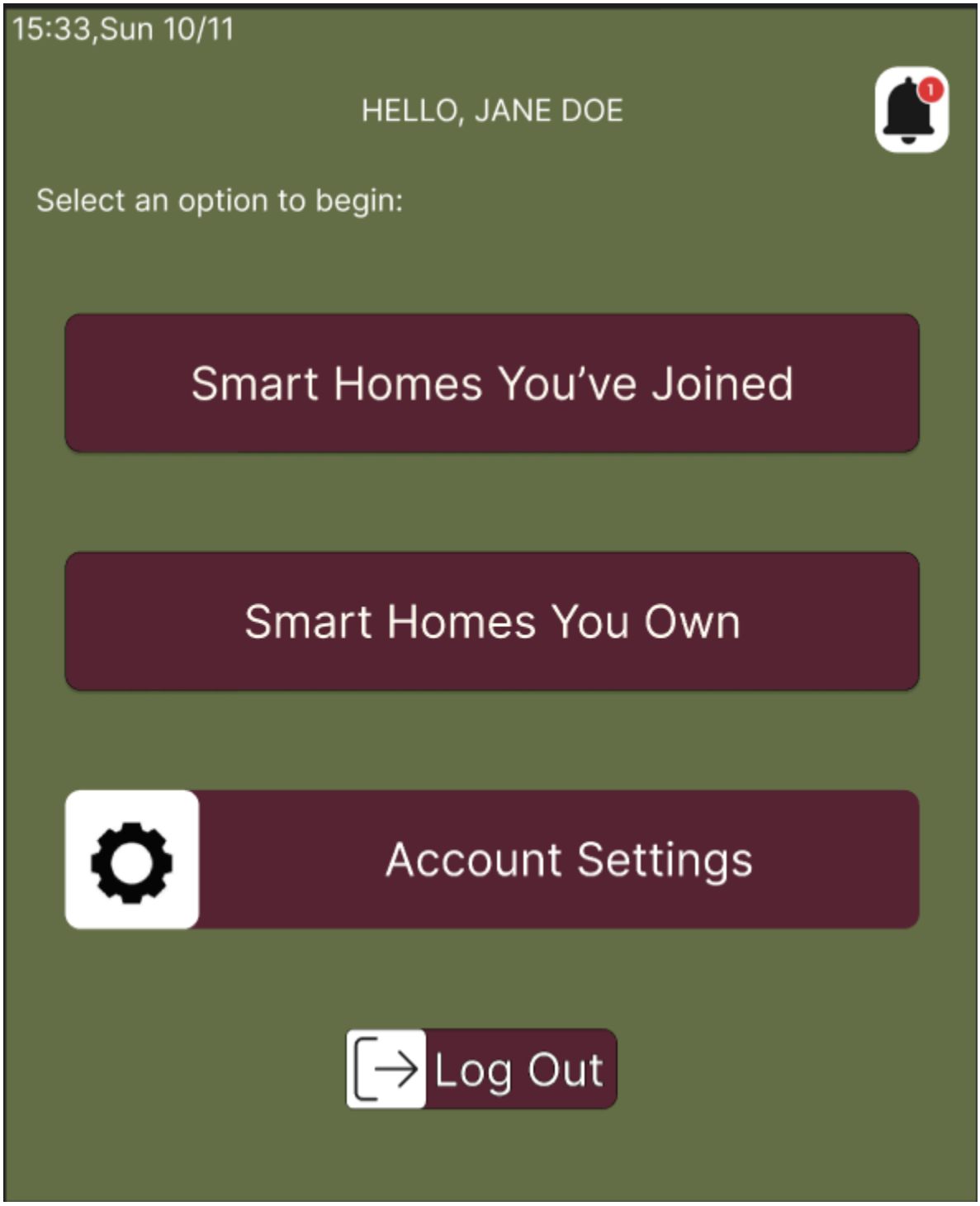
Recovery Page



Note. The page shows the recovery page for users that forgot their password.

Figure E18

Landing Page After Login



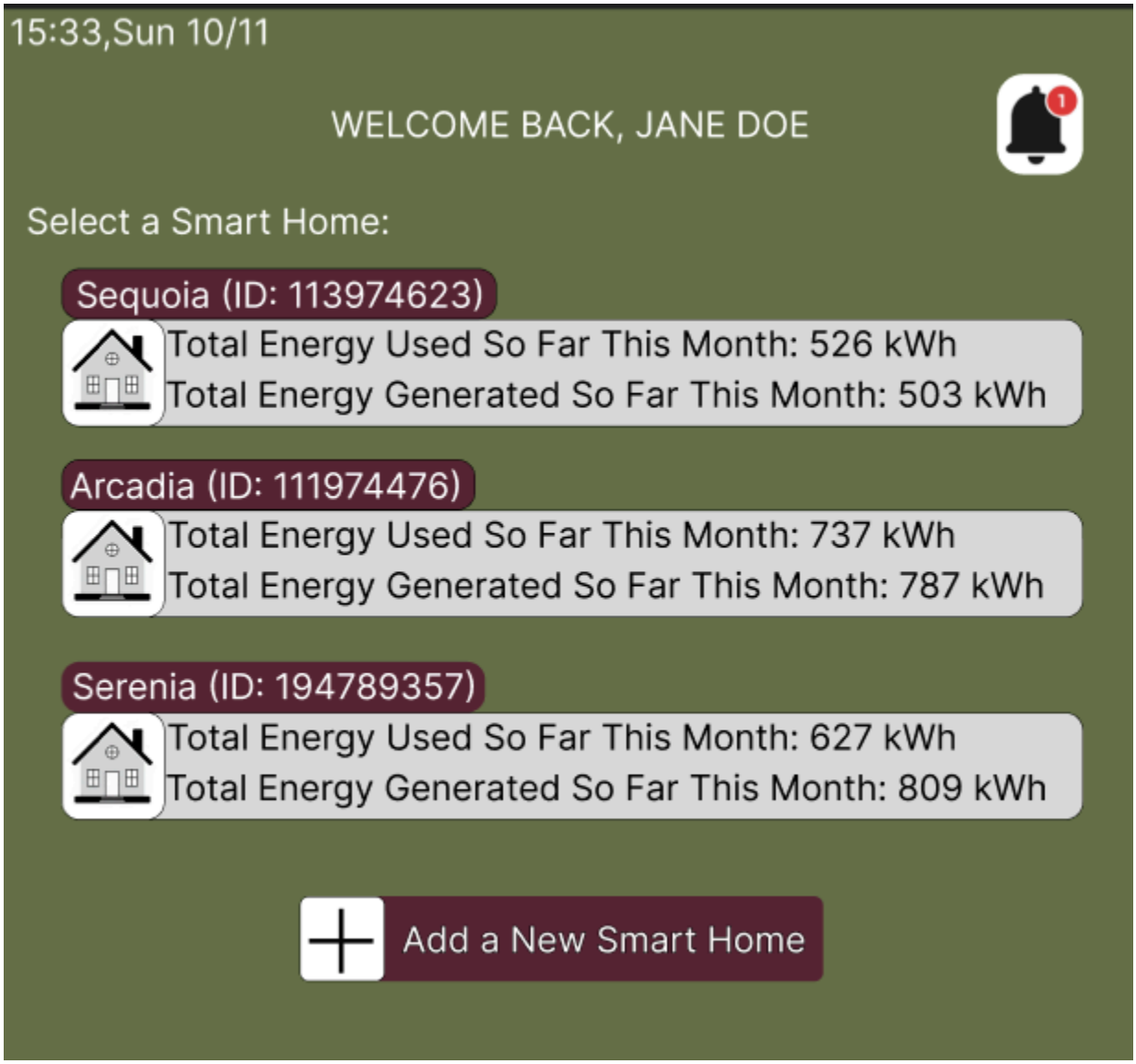
Note. First page users see after successful login.

- Clicking "Smart Homes You've Joined" will bring users to Figure E20.
- Clicking "Smart Homes You Own" will bring users to Figure E19.

- Clicking “Account Settings” will bring users to Figure E22.
- Clicking “Log Out” will bring users to Figure E16.

Figure E19

Interface for Smart Homes You Own

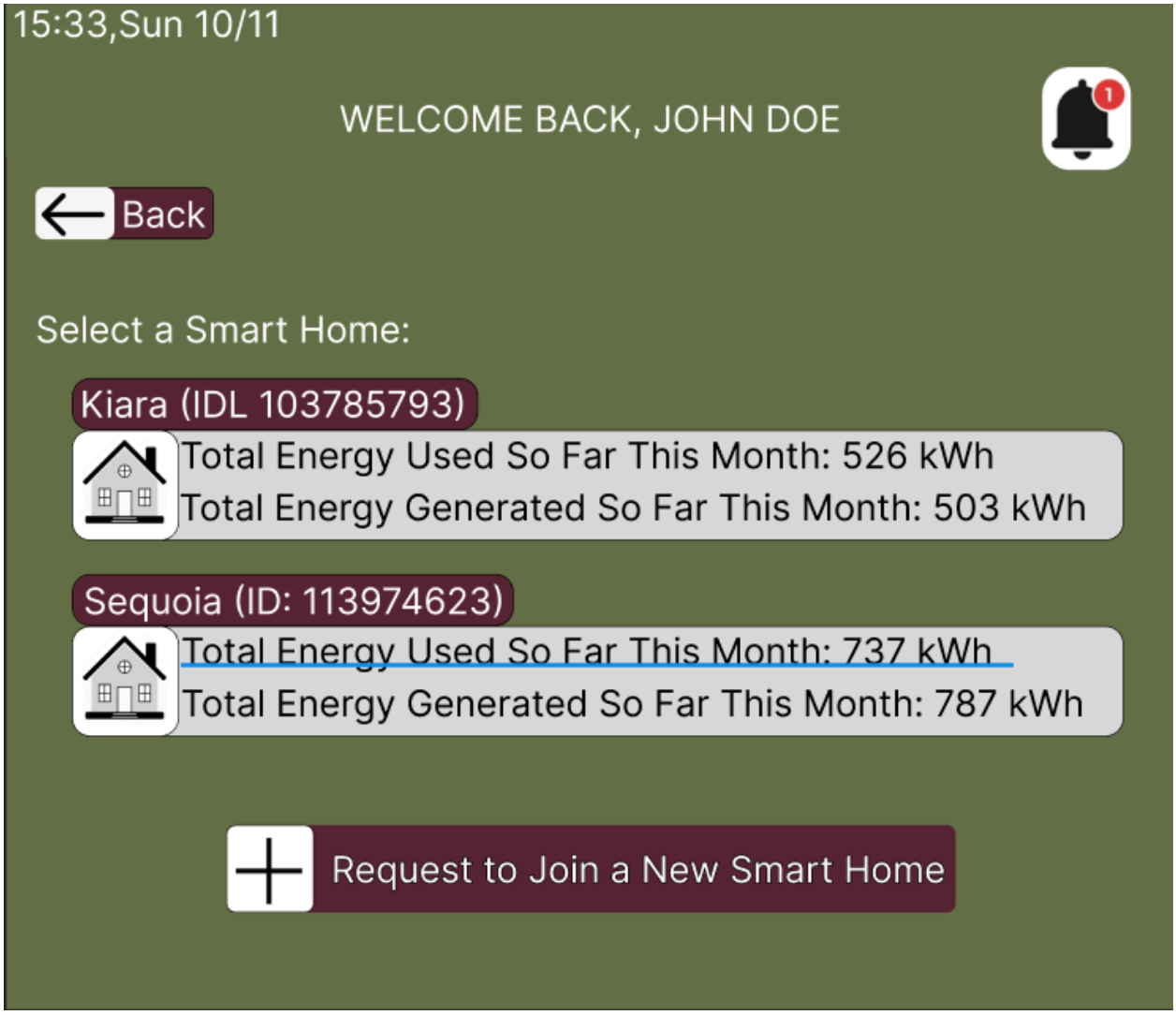


Note. User interface for smart homes the user owns. Owning a smart home automatically makes the user a homeowner.

- Clicking any smart home will bring the homeowner to Figure E5.
- Clicking the "Add a New Smart Home" button allows the user to add to the smart homes they own.

Figure E20

Interface for Smart Homes You've Joined

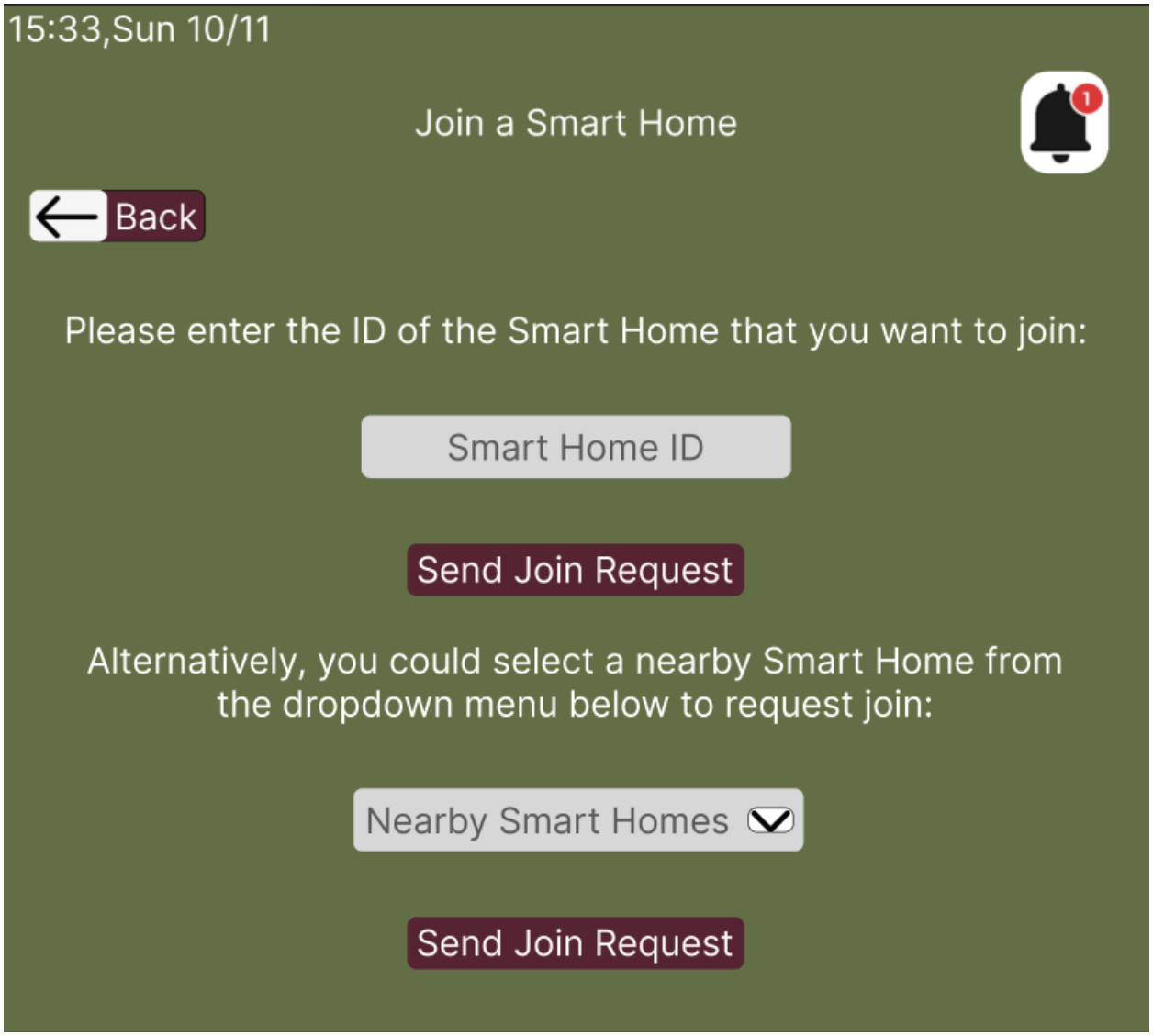


Note. User interface for smart homes the user is a part of.

- Clicking any smart home will bring the user to Figure E3.
- Clicking "Request to Join A New Smart Home" will bring the user to Figure E21.

Figure E21

Interface for Joining a New Smart Home

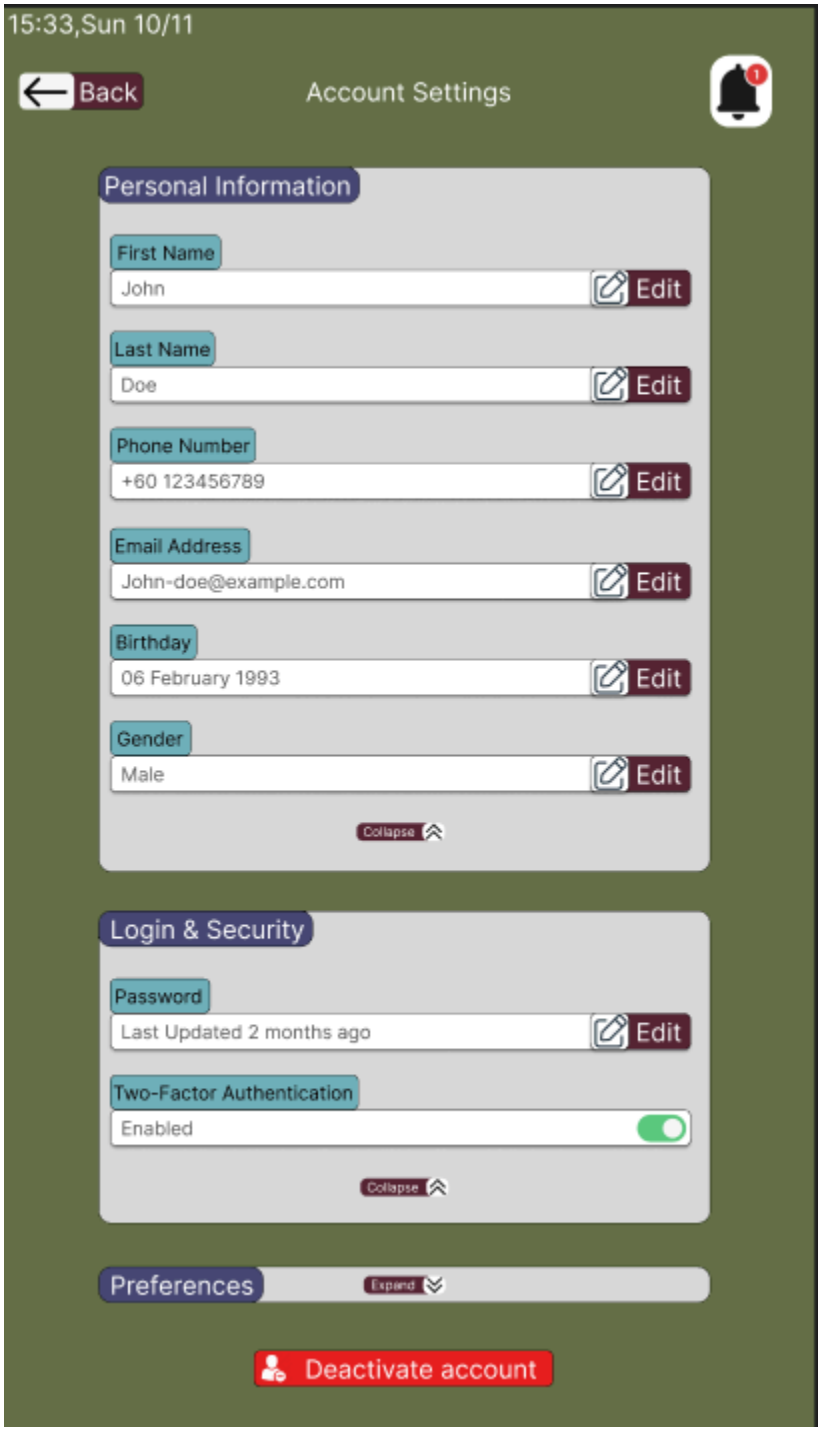


Note. User interface showing where users can join a new smart home.

- Users can join a smart home by entering the ID of the smart home that they want to join. Alternatively, they can request to join a nearby smart home from the dropdown menu.

Figure E22

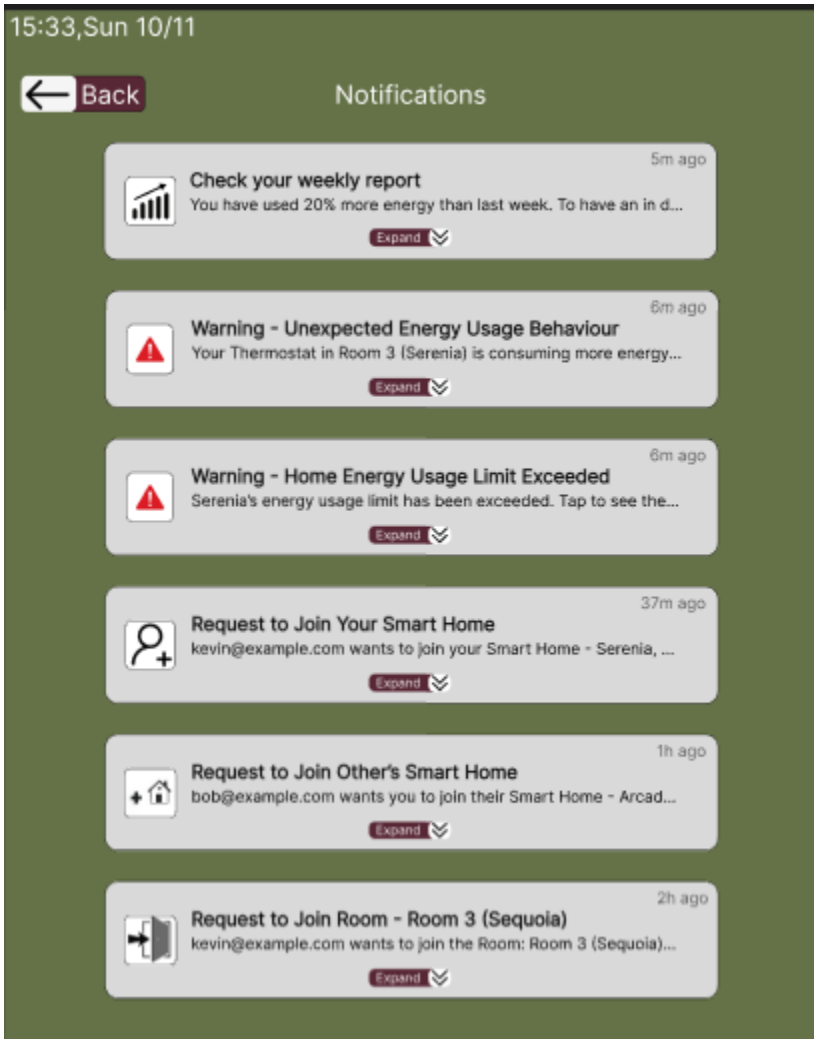
Interface for Account Settings



Note. User interface showing the user's account settings, including personal information, login password and security, and preferences.

Figure E23

Notification Interface



Note. Interface showing the notifications sent to the user's account.

- Notifications for weekly reports will be sent every Sunday, which will compare the current week's statistics to the previous week.
- Warning notifications will be sent to the user's account if any device in their joined room exceeds the set energy limit. This also applies to the overall home energy usage.
- All requests related to joining a smart home or room — whether initiated by the user or others — will be displayed on the page they are relevant to the user.

Appendix F
Link to the Interactive Mockup of the System (FIGMA)

Link F1.

Link to Figma

https://www.figma.com/design/wzFIszLK8ofS6W51GOTQQZ/Peaches-System-Interfaces?node-id=1-27&t=cpHppCsOy2JZIEzv-1

Appendix G
User's Survey Questions

Figure G1

Survey Questions

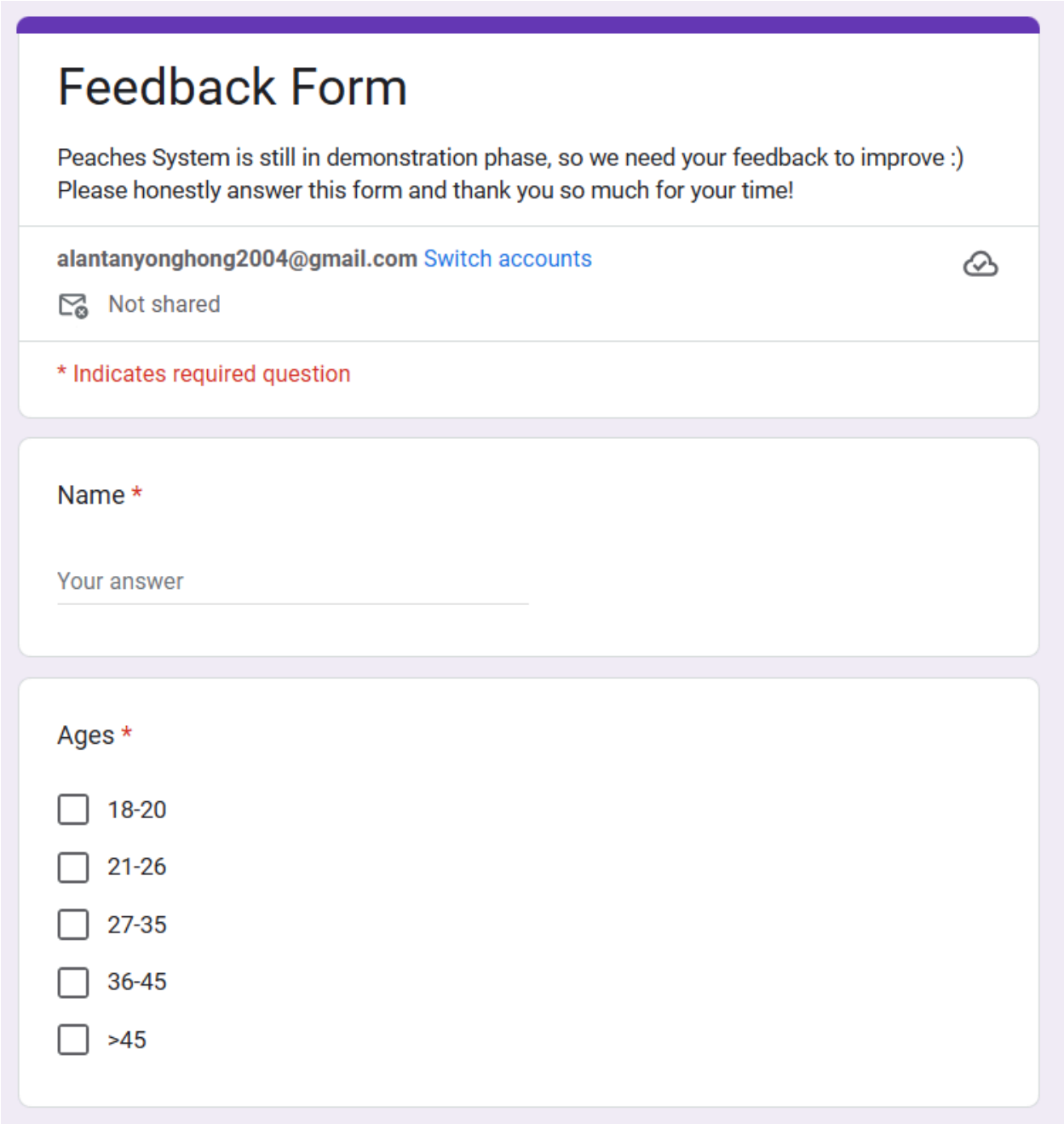


Figure G2

Continuation of Figure G1

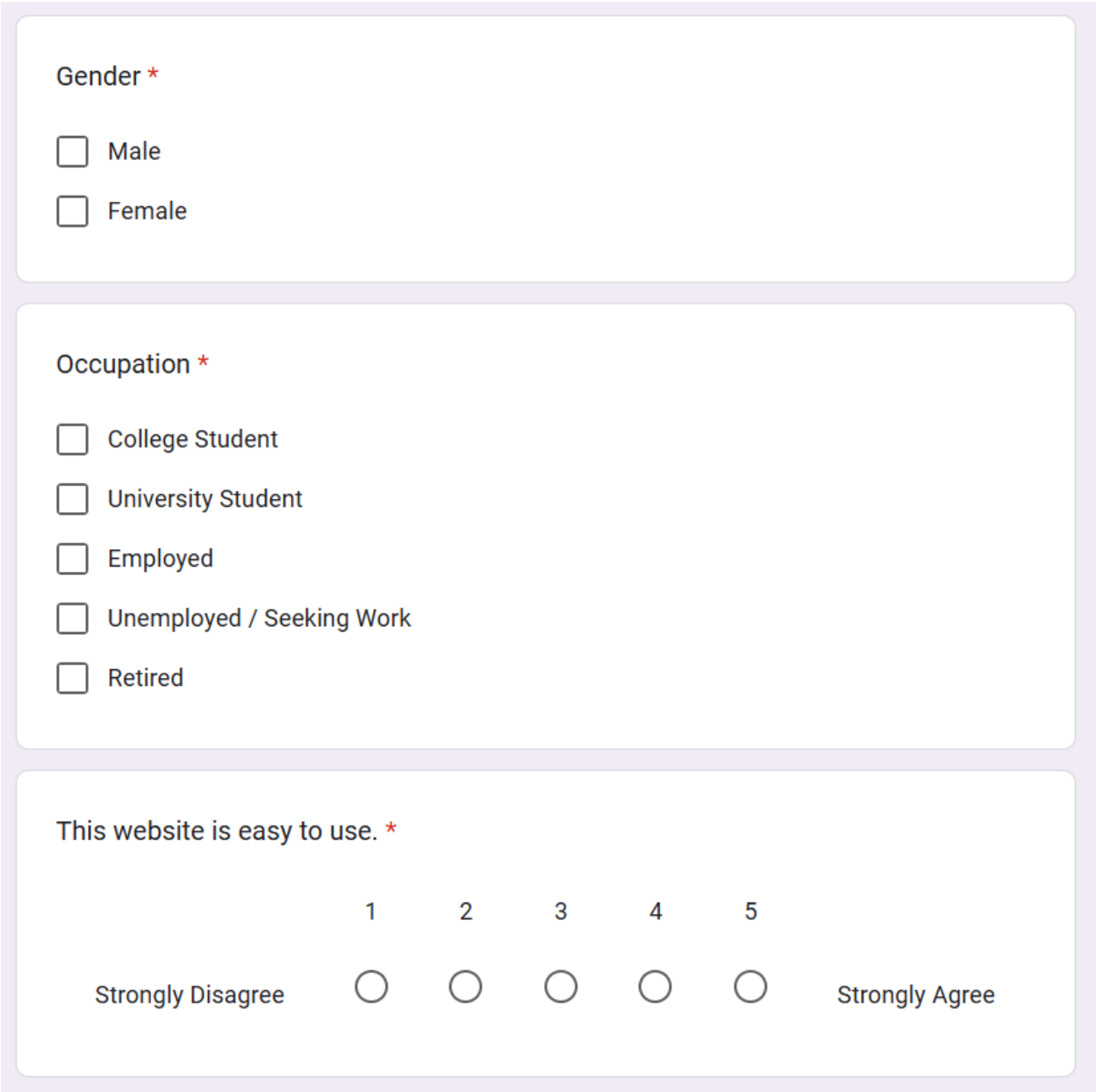


Figure G3

Continuation of Figure G2

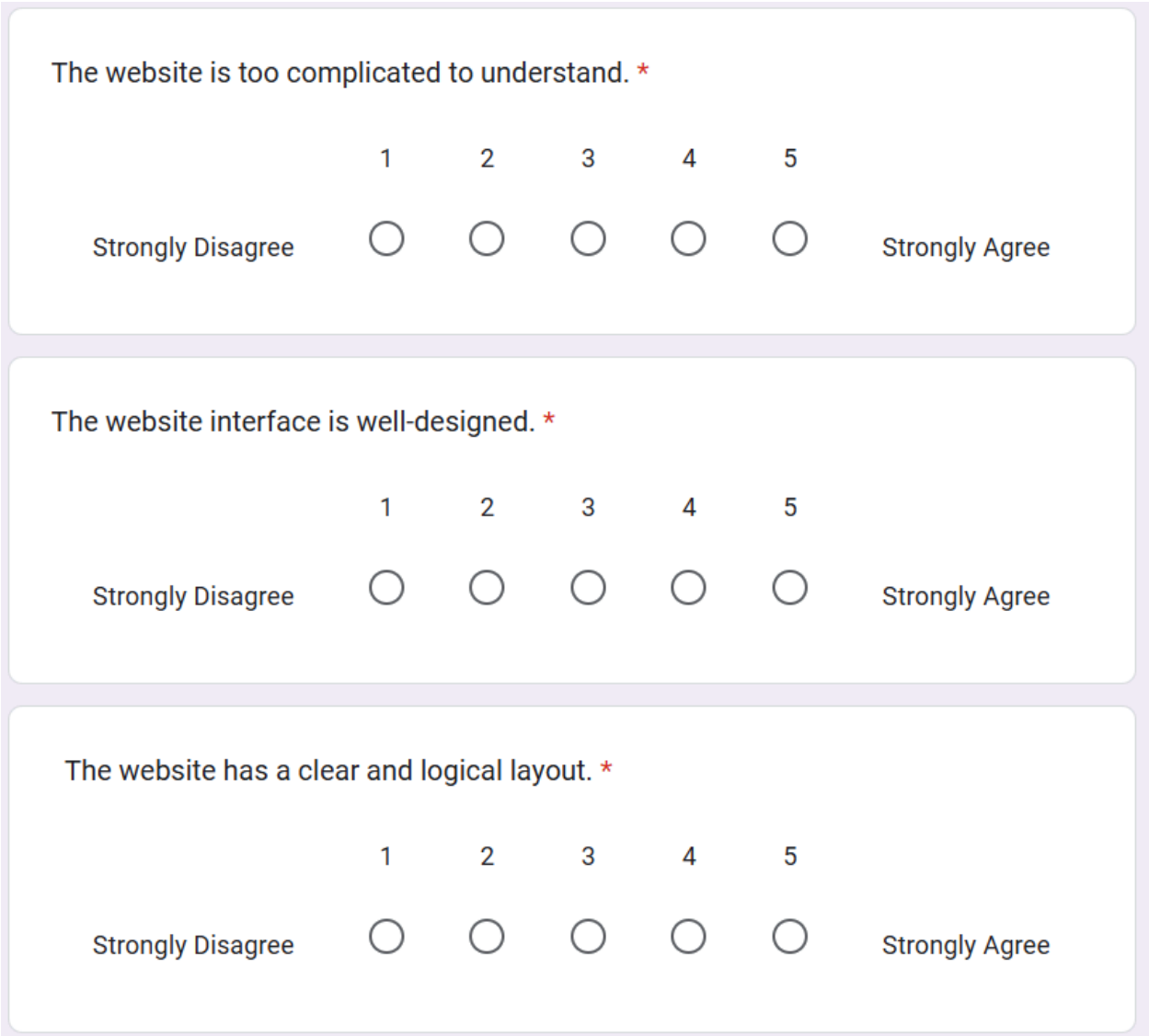
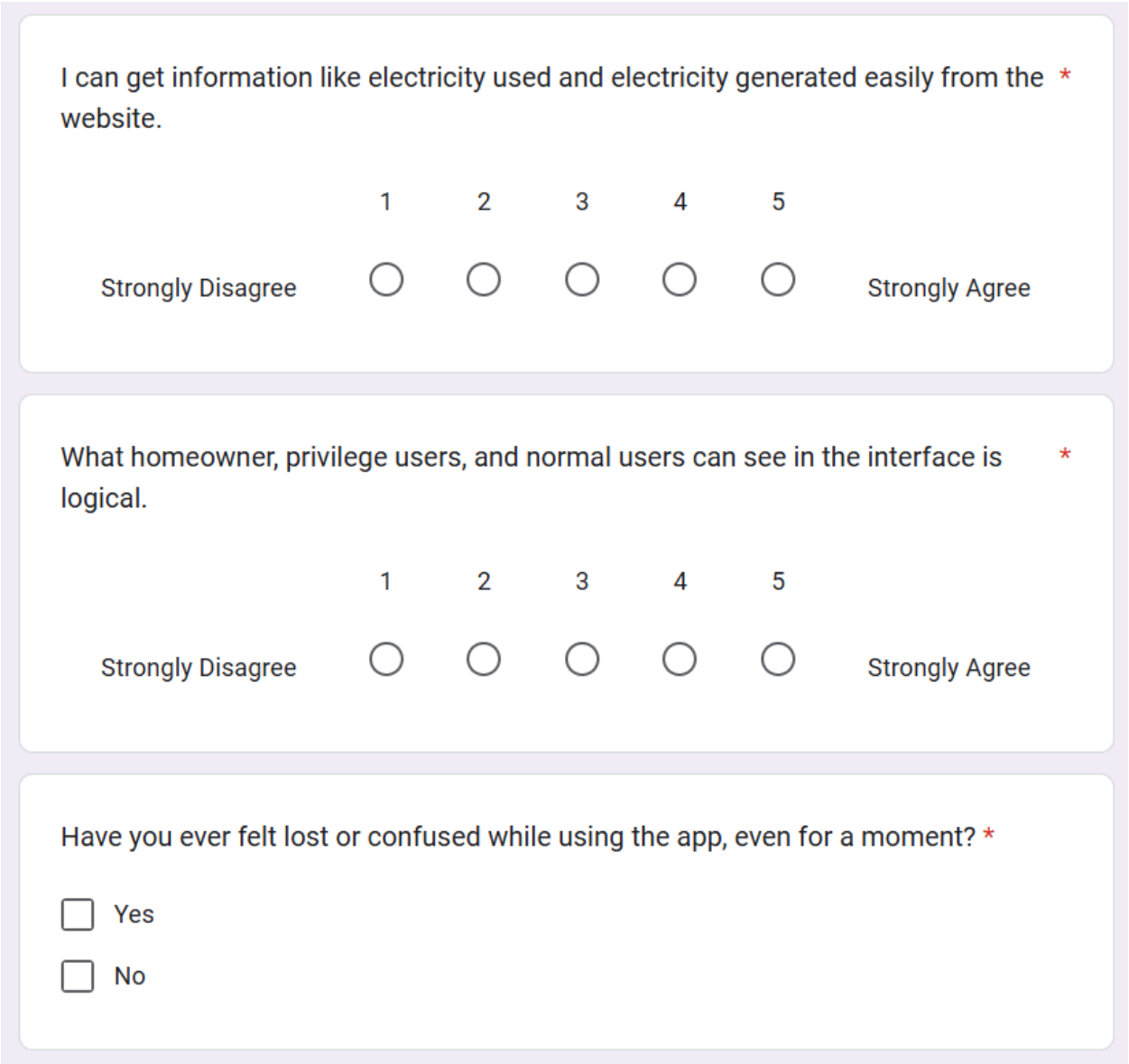


Figure G4

Continuation of Figure G3



I can get information like electricity used and electricity generated easily from the website. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

What homeowner, privilege users, and normal users can see in the interface is logical. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Have you ever felt lost or confused while using the app, even for a moment? *

- ☐ Yes
- ☐ No

Figure G5

Continuation of Figure G4